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ENERGY PROJECTIONS TO THE YEAR 2010

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A Technical Report in Support of the National Energy Policy Plan

October 1983

U.S. Department of Energy
Office of Policy, Planning, and Analysis

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Washington, D.C. 20585

PREFACE

This document provides energy projections developed within the U.S. Department of Energy by the Office of Policy, Planning, and Analysis. Underlying these projections are assumptions and results about key variables--world oil prices, economic growth, energy consumption, and production potential--which are described in this document. The projections are based on information available to the Office of Policy, Planning, and Analysis through June 1983.

Projecting U.S. energy supply, demand, and prices through the year 2010 is by nature a highly uncertain process. These projections try to account for uncertainty by providing a variety of scenarios that account for alternative future conditions (for example, high or low economic growth).

Projections should <u>not</u> be viewed as a statement of goals or targets. They represent an analysis of the possible evolution of U.S. energy markets, given current information and existing policies. As circumstances change in the future, projections will change as well.

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Data, table formats, definitions, and U.S. energy production.	Alex Haynes
Operation of energy models, high and low economic growth.	Douglas Tengdin
Comparison of energy projections.	Rich Young

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SUMMARY AND INTRODUCTION

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EXECUTIVE SUMMARY

There is considerable uncertainty associated with performing long-term analysis. The National Energy Policy Plan projections investigate a number of alternative scenarios which provide a range of results based upon different economic growth and energy market assumptions. Despite the uncertainties, the NEPP-1983 projections and other recent private and government energy studies provide some converging views about future energy trends.

- Similar to many other commodities, world oil prices are likely to follow an erratic future path with periods of rapid price increase followed by periods of declining real prices. Such erratic behavior results from fluctuations in oil demand and supply caused by a variety of factors such as economic cycles, changing weather patterns or consumer behavior, and oil supply disruptions.

- Although the outlook for future world oil prices is highly uncertain, most analysts now agree that, barring a significant oil supply disruption, world oil prices will most likely fall in real terms until the mid 1980's. From 1985 to 1990, prices will most likely increase in real terms. Beyond 1990, the outlook becomes increasingly uncertain.

- The oil price increases of 1973-1974 and 1979-1980 have set into motion powerful energy conservation forces that are likely to continue causing energy (especially oil) to be used more efficiently. To a large extent, energy conservation has become as important as the various sources of energy supply in determining the future evolution of the United States and world energy markets. Consequently, we need to pay continuing attention to analyzing and evaluating energy conservation trends in world economies.

- The recent decline in world oil prices has added a new dimension to the uncertainty about future market conditions. Prior to 1983, OPEC had never officially reduced the posted price of oil, but rather used the influence of inflation to allow prices to fall gradually in real terms during periods of excess world supply. Now, investment planners must not only be concerned about the potential for oil price shocks, which can send the oil price very high, but also about future price breaks which could send the price very low.

- Under all but extreme assumptions, both the United States and the rest of the world will remain dependent on liquid fuels, including oil supplies from OPEC, throughout at least the next 20 years. Given the unstable situation in the Middle East and elsewhere, the oil consuming nations must continue efforts to prepare for and try to prevent or reduce the effects of future oil supply disruptions.

- Finally, much uncertainty underlies these projections. Some analysts believe low world oil prices are most likely. Others believe high prices are most likely. Still others believe prices will start out low and then become high or vice versa. For planning purposes, no single price path is sufficient to account for various unforeseen events or future market conditions.

COMPARISON WITH PAST NATIONAL ENERGY PLANS

Nothing more clearly illustrates the difficulty in projecting future energy trends than does a review of past NEPP world oil price projections. Figure 1 shows historical world oil prices (the U.S. refiner acquisition cost of crude oil imports measured in 1982 dollars per barrel) from 1970 through 1982, and three separate projections of the world oil price:

- Projections prepared as part of the second National Energy Plan (NEP-1979) submitted to Congress in May 1979.
- Projections prepared as part of the National Energy Policy Plan (NEPP-1981) submitted to Congress in July 1981.
- Projections prepared in 1983 as part of the current National Energy Policy Plan (NEPP-1983).

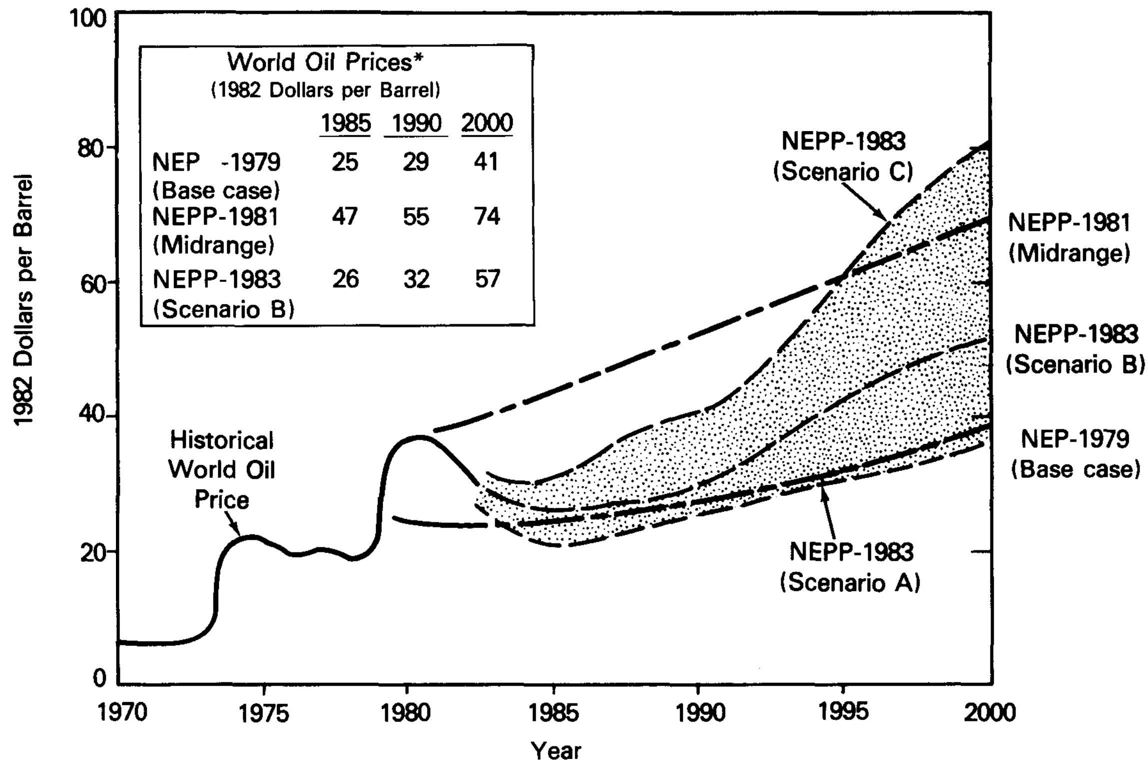
Each set of projections reflect the data and circumstances of the market and the views of many private and government analysts at a particular point in time. Although each was regarded as reasonable at the time of publication, in less than 5 years (1979 to 1983) the projections have changed dramatically. For example, the mid-case 1985 world oil price measured in 1982 dollars has varied from a high of about $47 (NEPP-1981) to a low of about $25 (both NEP-1979 and NEPP-1983). New information and changes in the world situation are the primary reasons for the variation in these recent world oil price projections.

NEP-1979 Projections

The NEP-1979 energy projections were developed at the time of the Iranian revolution, when U.S. net oil imports were close to 8 million barrels per day and OPEC production was over 30 million barrels per day. The assumption then was that any price increase resulting from the loss of Iranian production would be temporary and that prices would return to "normal" when Iranian production came back into the market.

Long-term, base case assumptions were that world oil prices in the year 2000 would equal the cost of conventional substitutes for crude oil such as shale oil, tar sands, and coal liquids. In 1979, these unconventional sources of liquid fuels were estimated to cost between $35 to $50 per barrel in 1982 dollars.

Figure 1
COMPARISON OF NATIONAL ENERGY PLAN WORLD OIL PRICE PROJECTIONS*



*U.S. Refiner Acquisition Cost of Crude Oil Imports.

Assuming the base case NEP-1979 price path, free-world oil demand was projected to increase by 1.5 to 2 percent per year, reaching about 70 million barrels per day by the year 2000. Given this oil demand pattern, the adequacy and security of oil supplies were major concerns. OPEC oil production would have had to increase from about 30 million barrels per day in 1979 to 37 million barrels per day to meet the then projected demand in 2000. Thus, increasing pressure on oil supplies and growing free-world dependence on OPEC oil exports was anticipated.

NEPP-1981 Projections

The NEPP-1981 projections (the highest mid-price case shown in Figure 1) were based upon a decidedly different view of the world. By 1981, world oil prices had doubled in real terms and a war had broken out between Iran and Iraq, reducing OPEC production capacity by more than 6 million barrels per day. Toward the end of 1980, spot crude oil prices (prices for individual crude transactions) were in excess of $40 per barrel. It was inferred from these events that oil prices could conceivably remain high for many years.

In 1981, OPEC's long-term pricing strategy group announced that OPEC should link future oil price increases to the economic growth of the Organization for Economic Cooperation and Development (OECD) and the value of the dollar. Trends at that time indicated that implementation of the OPEC formula would result in a 2 to 3 percent per year real increase in oil prices over time. Further, Saudi Arabia announced a willingness to reduce its oil production to support a long-term pricing strategy.

Given these conditions, it is not surprising that the midrange NEPP-1981 and other world oil price projections of this period, assumed a 2 to 3 percent per year real price increase into the future. Starting with a 1980 price of about $39 (1982 dollars), this assumption resulted in a projected year 2000 world oil price of about $74 per barrel.

When used as a basis for projections and coupled with the doubling of world oil prices in 1979-1980, the NEPP-1981 midrange price assumption caused free-world oil demand to decline slowly over the 1980 to 2000 period, rather than increase as projected in NEP-1979. With lower oil demand, OPEC production in NEPP-1981 was never projected to exceed 26 million barrels per day, implying considerable excess OPEC production capacity.

<u>NEPP-1983 Projections</u>

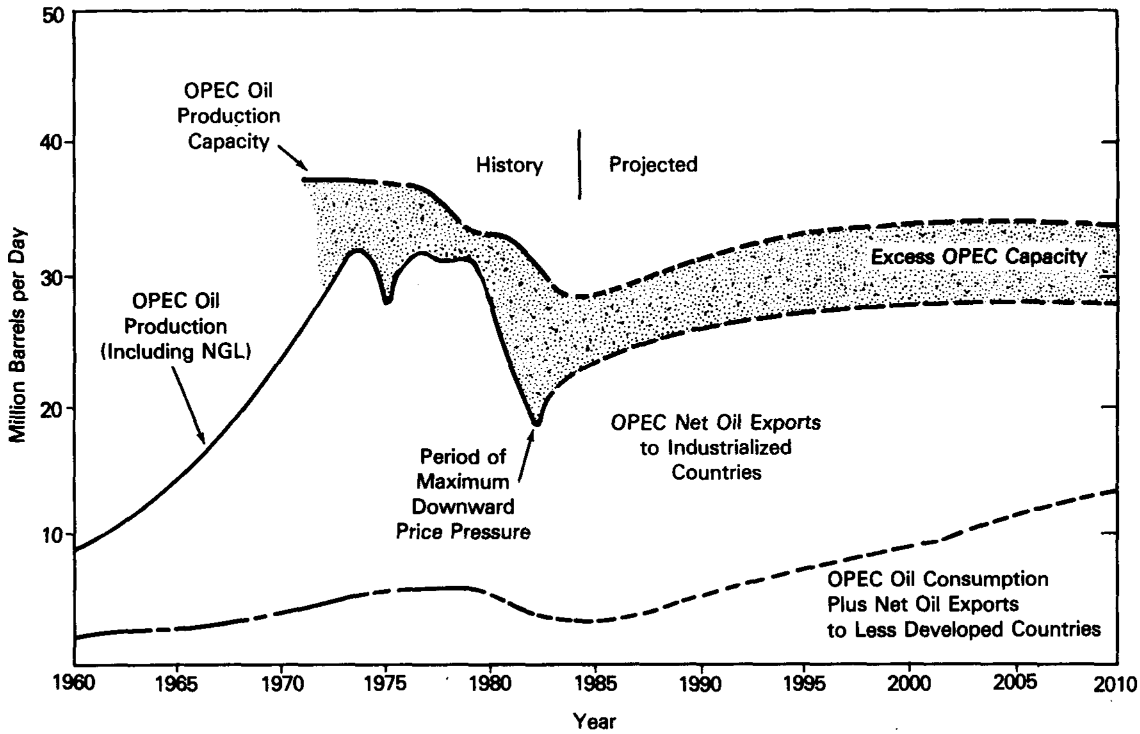
Since 1981, world oil prices have declined steadily rather than climbing as assumed in NEPP-1981. The main reason for the recent decline in oil prices has been unexpectedly low demand for OPEC oil (see Figure 2) caused primarily by:

- Higher than expected non-OPEC oil production and oil conservation and fuel switching in response to the oil price increases of 1973-1974 and 1979-1980;
- The worldwide recession in 1981-1982; and
- A worldwide drawdown of crude oil and petroleum product inventories.

A key question now is: How are current market conditions and trends likely to evolve in both the near and longer term?

A summary of the range of NEPP-1983 price projections is shown in Figure 3. Unexpected (or merely expected but unpredictable) events make it impossible to forecast the future correctly. Further, as has happened in the past, these projections will undoubtedly be revised to reflect the latest views and information. The world oil prices associated with Scenarios A, B, and C, and shown in Figure 3, reflect our current estimate of the range of price

Figure 2
OPEC OIL PRODUCTION AND PRODUCTION CAPACITY
(Scenario B)



paths which might occur. Scenario A combines high energy demand reduction potential with high energy supply potential resulting in relatively lower projected world oil prices. Scenario B is a reference case with assumptions between Scenarios A and C. Scenario C combines low energy demand reduction potential with low energy supply potential, resulting in relatively higher projected oil prices.

The 1970's demonstrated that world oil prices are highly volatile. Oil supply disruptions, economic recessions and recoveries, unusually cold or warm weather, and other erratic events that directly affect world oil demand and supply will ensure that oil prices, as in the past, exhibit volatile behavior with periods of rapid price increase followed by periods of stable or declining prices. Each smooth price scenario in Figure 3, consequently, should be viewed as an average of many equally plausible but erratic price scenarios--an average that shows underlying trends and helps focus attention on longer term issues. The short-term volatility of prices is important, however, because price fluctuations increase the uncertainty of energy consumers and producers concerning the true state of longer term price trends. In any given year, the world oil price could be considerably above or below its underlying long-term trend.

Although there are large inherent uncertainties about future world oil prices, some characteristics of these price ranges can be noted. World oil prices tend to fall in real terms until the middle to late 1980's. Beyond 1990, prices are projected to rise in reals term with the major issue being whether prices (after averaging out fluctuations) will rise only slightly faster than inflation or much more rapidly.

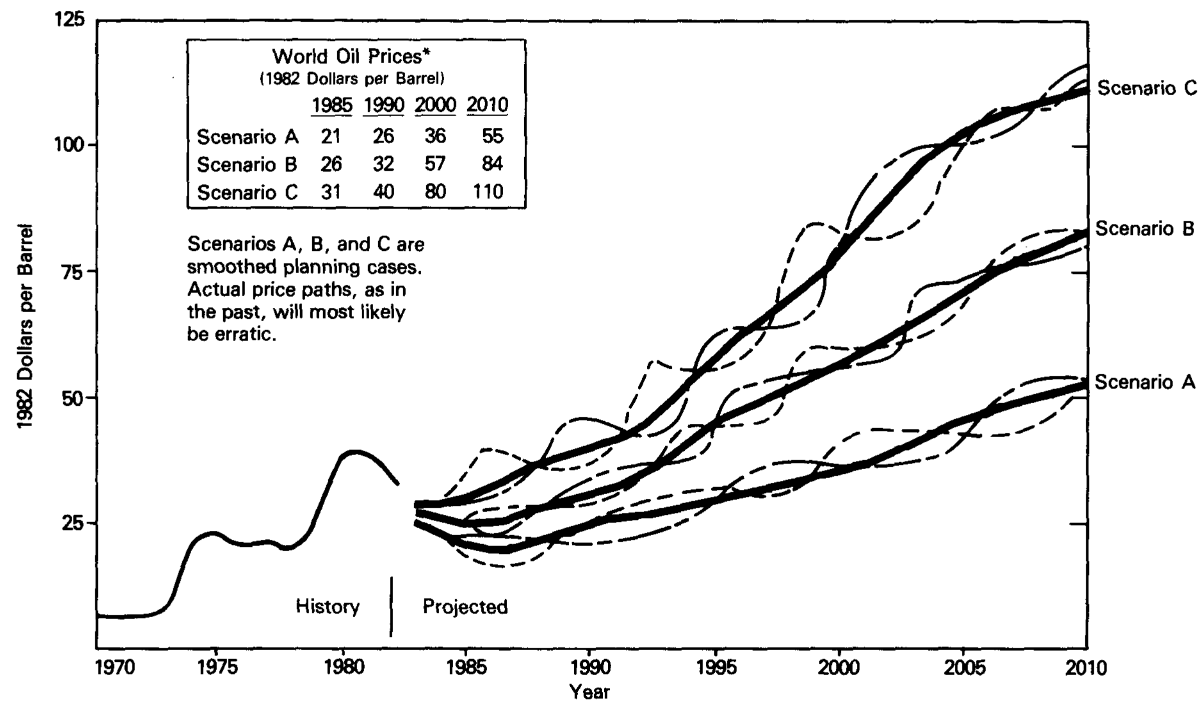
Some specific aspects of the price results shown in Figure 3 are:

- o Assuming the Iran-Iraq war continues, world oil prices will most likely stabilize in the $23 to $30 (1982 dollars) per barrel range in 1983 and 1984;

- o Between 1985 and 1990, demand for OPEC oil is expected to increase steadily as world economic activity expands. Sometime between 1986 and 1990, demand for OPEC oil could reach 24 to 26 million barrels per day. This could produce significant upward price pressure in the world oil market and create the potential for a temporary world oil price surge in the late 1980's;

Figure 3

NEPP-1983 WORLD OIL PRICE SCENARIOS*



*U.S. Refiner Acquisition Cost of Crude Oil Imports.

- By 1990, the world oil price will most likely be between $26 and $40 (1982 dollars) per barrel. Thus, the price in 1990 is expected to be about the same as the $34 per barrel price just prior to the sharp real price declines observed and projected for the 1982 to 1985 period;

- Although trying to anticipate long term trends is valuable in policy making, attempting to predict technological change makes detailed numerical projections beyond 1990 extremely uncertain and speculative. In the long term, world oil prices are projected to increase in real terms reaching between $36 and $80 per barrel (1982 dollars) by the year 2000 and between $55 and $110 per barrel by the year 2010;

- World oil prices are projected to rise between 1990 and 2010 in part because such an increase keeps demand for OPEC oil within the 24 million to 28 million barrels per day range. Higher demand for OPEC oil, unless met with a significant increase in OPEC production capacity, could eventually push world oil demand against an inelastic oil supply constraint, possibly causing world oil prices to increase abruptly and to a higher level than would otherwise occur; and

- Another reason for the 1990 to 2010 price increases is the assumption that the cost of unconventional oil sources such as shale oil and coal liquids will be in the $50 to $80 per barrel range (1982 dollars) as opposed, for example, to the $35 to $50 per barrel range assumed for NEP-1979.

Lower world oil prices could result from developments such as:

- Greater than expected willingness of OPEC countries to expand oil production and make investments to expand long-term production capacity;

- Higher than expected potential for oil conservation and switching to alternative fuels like natural gas, coal, renewables, and electricity;

- No long-term permanent reduction in oil supply potential because of wars and other political or social events;

- Remaining undiscovered oil and gas resources in non-OPEC countries being at the upper end of current estimates;

- Lower than expected world economic growth with reduced demand for energy in general and oil in particular;

- Lower production costs and/or lower water, environmental, capital, or other production constraints, resulting in higher than expected market potential for direct substitutes for conventional oil, such as coal liquids; and

- No development of serious problems which inhibit the availability or use of non-oil fuels (for example, stricter pollution standards or the discovery of new energy-related health hazards.)

Conditions that lead to higher oil prices are just the opposite of the above low price conditions.

The Scenario A oil price path in Figure 3 combines a number of low oil price conditions, while the Scenario C oil price path combines high price conditions.

EXPERTS SURVEY OF WORLD OIL PRICES

In developing the NEPP-1983 scenarios, assumptions were carefully chosen and widely reviewed mathematical energy models were operated. Mathematical models and model-generated results, however, are only one source of information about future energy conditions. To provide further information, the Department of Energy conducted a survey involving about 50 analysts and officials who study and use world oil price projections in government, universities, trade associations, private companies, and research groups. The survey was designed to generate judgmental probabilities to associate with the range of world oil price results from NEPP-1983 Scenarios A, B, and C. Each respondent was asked to provide probabilities for the world oil price in the years 1990, 2000, and 2010. Table 1 summarizes the survey results.

The following are some insights from the world oil price survey:

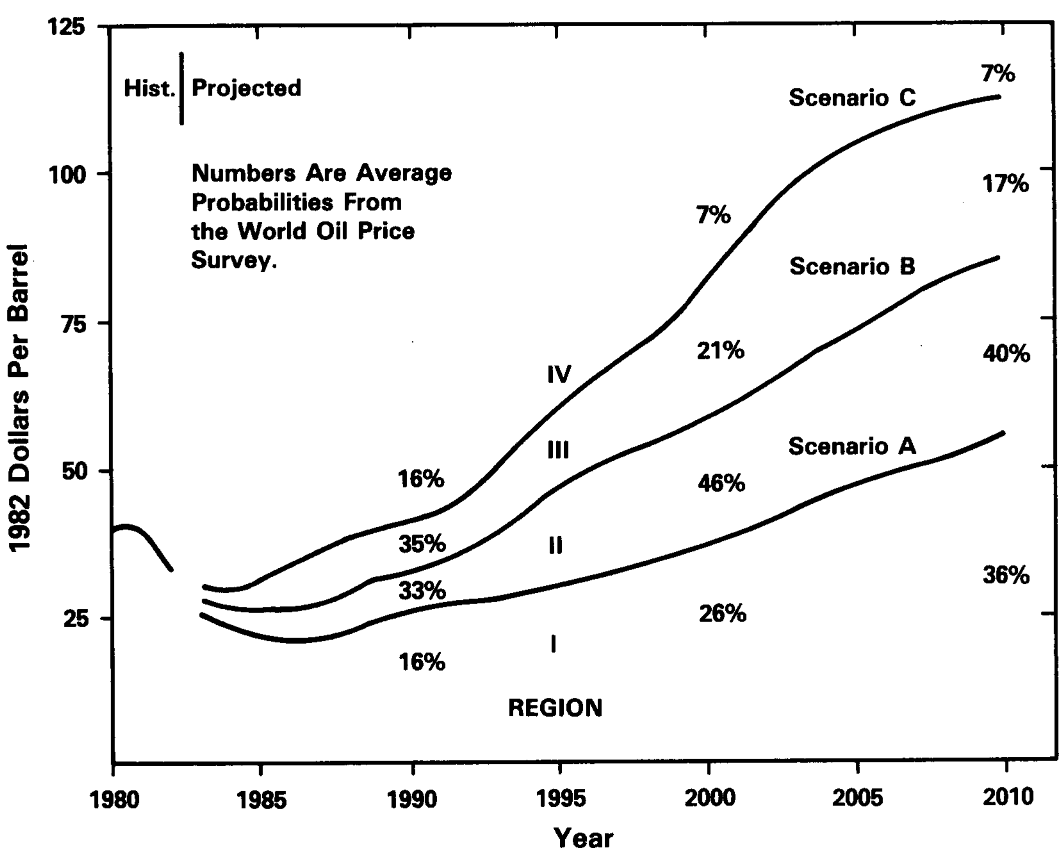
- One way to define a midrange world oil price is to pick a price where the probability of either being higher or lower is about equal (that is, 50 percent). Using this criterion, the experts survey indicates that Scenario B is a reasonable midrange in 1990, since the total probability of being lower (sum of regions I and II) equals an average of 49 percent. However, in the years 2000 and 2010, midrange values fall somewhere between Scenario A (low case) and Scenario B -- in 2000 about half-way between A and B or about $46 per barrel and in 2010 about one third above Scenario A or about $65 per barrel.

- Beyond 1990, respondents indicated a significantly greater probability that the world oil price will be lower than the lowest case (Scenario A) than the probability that prices will be higher than the highest case (Scenario C). For example, in 2010 the average response indicates a 36 percent likelihood of world oil prices being lower than $55 per barrel, but only a 7 percent probability of prices being higher than $110 per barrel. This indicates that the upper range of NEPP-1983 world oil prices in 2000 and 2010 is higher than the judgmental opinion of those participating in this survey.

TABLE 1: WORLD OIL PRICE SURVEY[1/]

REGION	1990 Price Range	1990 Avg. Prob.	1990 Lowest Highest	2000 Price Range	2000 Avg. Prob.	2000 Lowest Highest	2010 Price Range	2010 Avg. Prob.	2010 Lowest Highest
I Below Scenario A	Below $26	16%	0% 55%	Below $36	26%	0% 95%	Below $55	36%	0% 100%
II Between A and B	$26 to $32	33%	10% 60%	$36 to $57	46%	5%% 80%	$55 to $84	40%	0% 70%
III Between B and C	$32 to $40	35%	10% 70%	$57 to $80	21%	0% 50%	$84 to $110	17%	0% 50%
IV Above Scenario C	Above $40	16%	1% 75%	Above $80	7%	0% 30%	Above $110	7%	0% 25%
		100%			100%			100%	

1/ World oil price is defined as the average U.S. refiner acquisition cost of crude oil imports in 1982 dollars per barrel.



- A review of the lowest and highest responses shows that on average the range for each response varies between a low of about 1 percent probability and a high of about 65 percent. This indicates a very wide range of individual opinions about future world oil prices. For example, some respondents were 100 percent sure that prices in 2010 would be below $55 per barrel, while other respondents were 100 percent sure that prices in 2010 would be above $55 per barrel.

U.S. ENERGY TRENDS, SCENARIO B

The purpose of developing these energy projections is to reflect the uncertainty faced by U.S. energy markets and to provide a basis for analyzing domestic energy issues. Although there is a wide range of possible oil price paths, they all tend to be associated with similar trends regarding the quantities of energy consumed and produced in the U.S. (Table 2).

Primary Energy Consumed by the U.S.

From 1920 to 1950, energy consumed by the U.S. per dollar of real economic output dropped by about 25 percent, despite relatively low energy prices. This downward trend resulted primarily from technological innovations and structural changes in the economy. By contrast, from about 1950 to 1973 energy consumed per dollar of economic output remained fairly stable as both the amount of energy consumed and the Gross National Product (GNP) increased at about 3.8 percent per year. Between 1974 and 1982 in response to the energy price increases of the 1970's, energy consumed per dollar of real economic activity declined by about 18 percent. This improved energy efficiency trend is projected to continue. For example, between 1982 and 2000, the quantity of energy consumed is projected to increase at only about 1.3 percent per year, less than half the 2.8 percent per year rate of projected growth in U.S. GNP.

Improved energy efficiency in the economy is projected to be a very significant factor in determining long-term U.S. energy consumption patterns. Starting in 1982, if U.S. energy consumption were to grow at the pre-1973 trend (that is, at the 2.8 percent per year rate projected for economic growth), the amount of energy consumed in the year 2000 would be more than 121 quadrillion Btu's (quads), which is about 30 percent higher than the 93 quads projected under Scenario B conditions (see Figure 4).

From 1960 to 1977 reliance on oil imports steadily increased peaking at 24 percent of the total quantity of energy consumed by the U.S. (about 8.6 million barrels per day). Reaction to higher oil prices has reversed this trend. By the year 2000, U.S. net oil imports are projected to account for about 12 percent of total energy consumed (around 5 million barrels per day).

TABLE 2: SUMMARY OF U.S. ENERGY PROJECTIONS UNDER SCENARIO B ASSUMPTIONS (Quadrillion Btu Per Year)

	ESTI	Projected			
	1982	1985	1990	1995	2000
ENERGY SUPPLIED					
INDIGENOUS PRODUCTION					
Oil and NGL 1/	20.6	19.5	19.0	17.7	17.4
Natural Gas	17.8	18.9	18.2	17.2	16.3
Coal 2/	18.4	21.3	24.5	28.7	33.6
Nuclear	3.0	4.6	6.5	6.9	7.9
Hydro-Geoth.	3.5	3.2	3.4	3.8	4.1
Renewable	2.7	3.0	3.6	4.8	5.9
Subtotal	66.0	70.5	75.1	79.1	85.1
IMPORTS					
Oil	9.0	12.8	12.4	12.4	11.0
Natural Gas	0.9	1.2	1.9	2.4	2.6
Coal	-2.8	-2.8	-3.3	-4.4	-5.4
Subtotal 3/	7.2	11.3	11.1	10.5	8.3
ADJUSTMENTS 4/	-0.1	0.6	--	--	--
Total Supplied	73.3	81.1	86.2	89.6	93.4
ENERGY CONSUMED					
END USE CONSUMPTION					
Liquids	28.7	29.1	29.3	28.6	27.2
Gases	15.0	17.1	17.6	17.5	17.2
Coal Solids	2.8	3.4	3.8	4.3	4.8
Electricity	7.0	8.3	9.4	10.3	11.6
Renewable	2.7	3.0	3.5	4.1	4.8
Subtotal	56.2	60.9	63.6	64.8	65.6
CONVERSION LOSSES	17.1	20.1	22.7	24.9	27.8
Total Consumed	73.3	81.1	86.2	89.6	93.4

1/ Includes shale oil
2/ Includes coal used for synthetics
3/ Includes small amounts of coal coke and electricity
4/ Includes stock changes

Energy Produced by the U.S.

Oil (including natural gas liquids) and natural gas produced in the U.S. peaked at about 45 quads in the early 1970's (about half oil and half gas--see Figure 5). Increased investment in oil and gas reserve development is expected to maintain the level of domestic oil and gas produced at close to 37 to 40 quads per year through the 1980's. Beyond 1990, oil and gas are likely to become increasingly difficult to find and develop. Of course, unexpected discoveries of large quantities of oil or gas could alter the Scenario B oil and/or gas production paths.

Coal, nuclear, and renewable energy are projected to increase substantially over the long term. In particular, the quantity of coal produced is projected to increase in absolute terms more than that of any other fuel between 1980 and 2000. Contributing to coal's growth is an estimated 4 percent per year increase in U.S. coal exports (from about 90 million tons in 1980 to about 200 million tons by the year 2000).

Figure 4
U.S. PRIMARY ENERGY CONSUMPTION
(Scenario B)

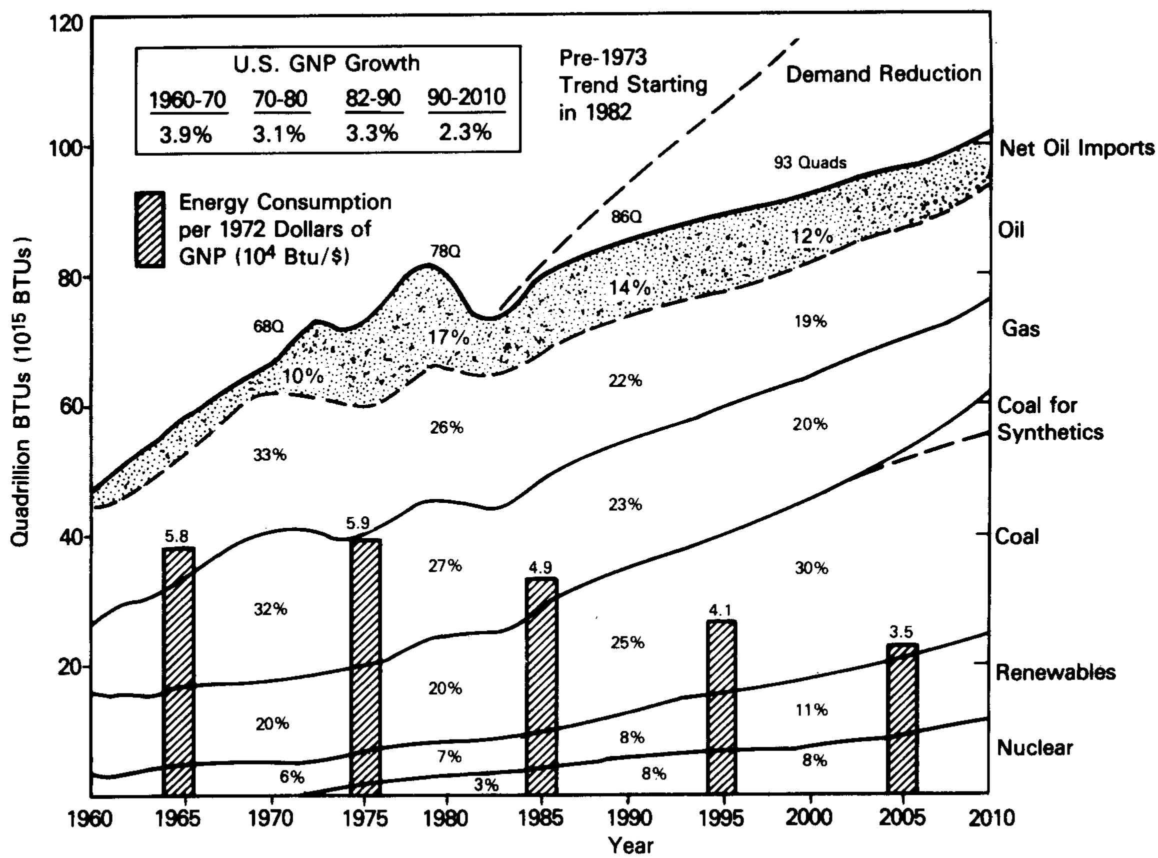
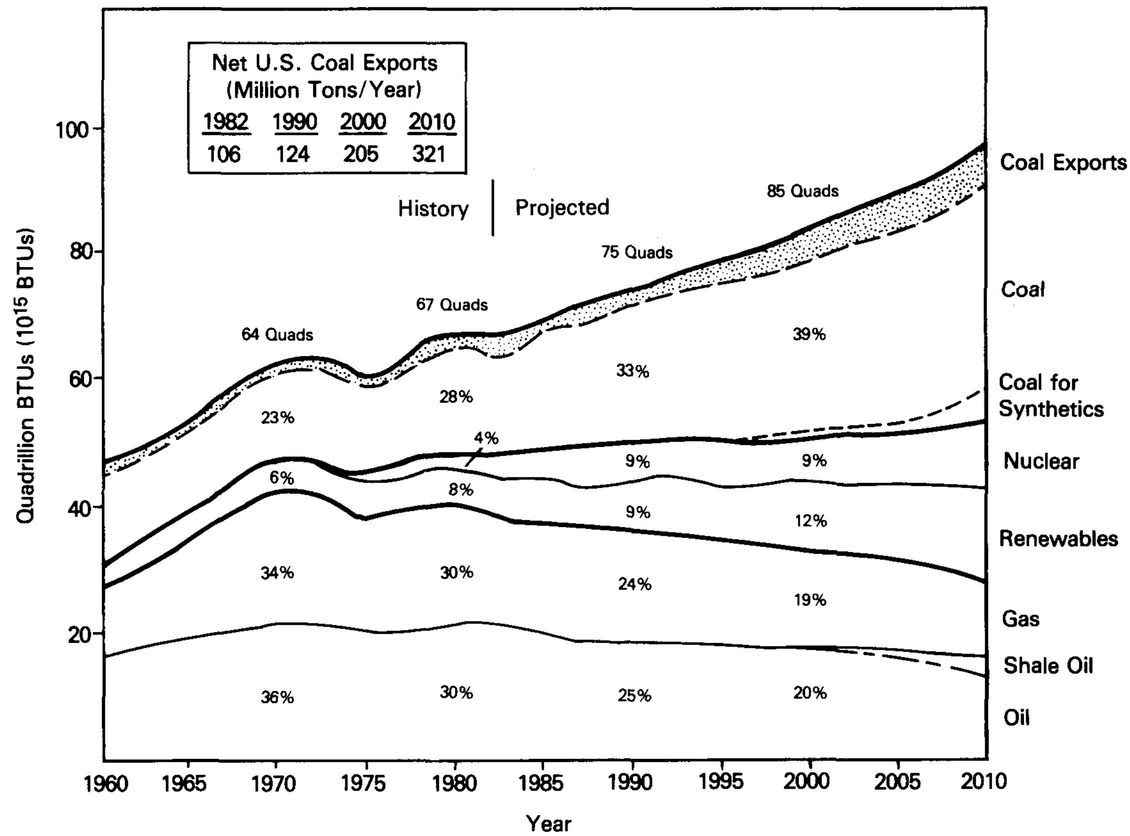


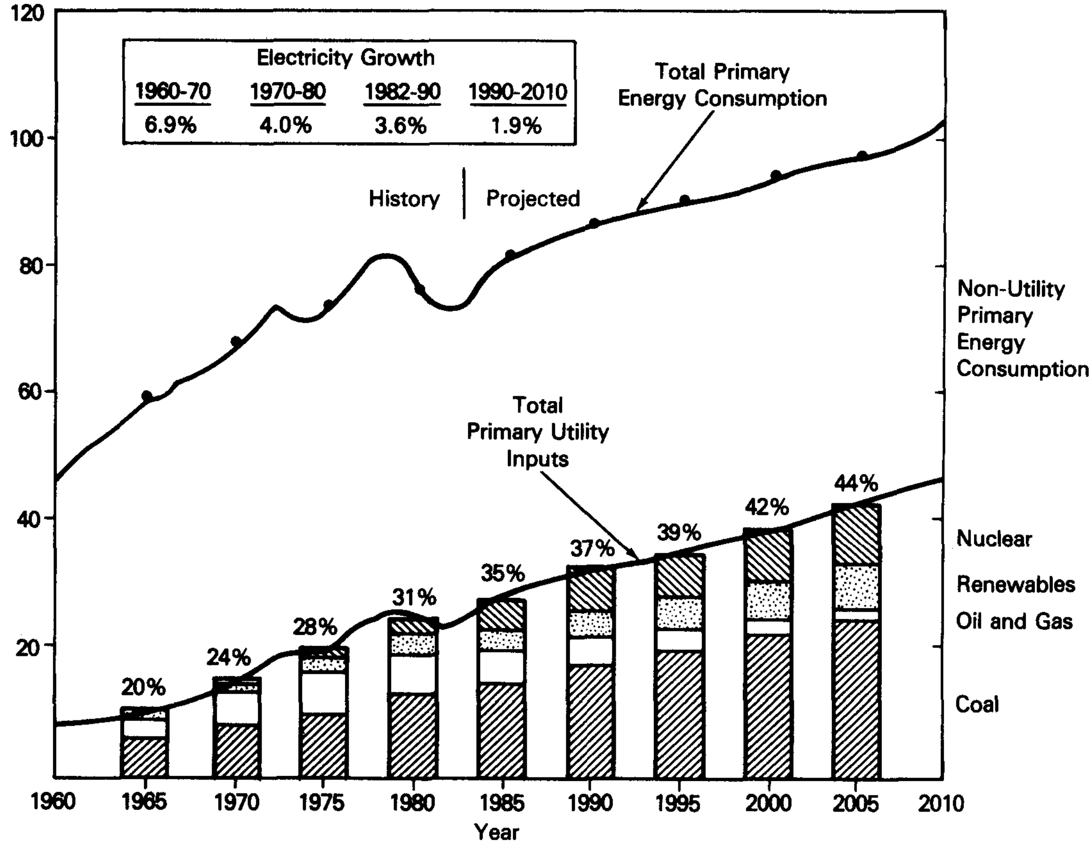
Figure 5
U.S. ENERGY PRODUCTION
(Scenario B)



U.S. Primary Electricity Inputs

Primary U.S. electricity inputs as a percent of total primary energy consumed increased from 18 percent in 1960 to 31 percent in 1980 and is projected to increase further reaching 42 percent by the year 2000 (see Figure 6). Coal's share of total electricity inputs is expected to increase from about 50 percent in 1980 to 59 percent by 2000. Oil and gas are projected to become priced out of most utility markets, with the use of oil and gas for electricity generation dropping from 27 percent in 1980 to about 8 percent in 2000. Although expansion is expected to slow temporarily once facilities currently under construction are completed in the early 1990's, nuclear's share of electricity inputs are projected to increase by over 25 percent in the first decade of the next century. Renewables (including hydropower) are expected to increase their share of the utilities market from 12 percent in 1980 to about 15 percent in 2010.

Figure 6
U.S. PRIMARY ELECTRIC UTILITY INPUTS
(Scenario B)



ALTERNATIVE ASSUMPTIONS

Most disparities among energy projections result from differences in key assumptions rather than differences in analytical methods or sophistication of approach. It is apparent from Scenarios A, B, and C (see Figure 3) that alternative world energy demand and supply assumptions can radically affect projections of future world oil prices. Other aspects of future energy markets also are sensitive to critical assumptions. To illustrate the importance of such assumptions, some insights derived from an analysis of how changes in economic growth can affect the future U.S. energy situation are briefly summarized below.

If it is assumed that U.S. economic growth is about 0.5 percent per year higher than the Scenario B assumption while all other assumptions are left unaltered, the results change as follows:

- Total energy consumption would increase and, given an assumption that electricity demand is strongly dependent on economic growth, electricity consumption would increase even faster. Assumed higher

U.S. economic growth could increase total primary energy consumption in the year 2000 by about 7 percent (6.7 quads) and could increase electricity consumption by 10 percent (1.2 quads) over Scenario B conditions.

- Oil and gas demand increase while production remains relatively unchanged, thus increasing imports to satisfy domestic demand. By the year 2000, for example, net U.S. oil imports could equal about 6.0 million barrels per day, about 16 percent higher than the Scenario B amount of 5.2 million barrels per day.

- U.S. gas imports also could rise significantly in the post-1990 time period. With higher economic growth, gas imports could increase from about 2.2 trillion cubic feet in 1990 to as much as 3.3 trillion cubic feet by 2000 as compared to about 1.8 trillion cubic feet and 2.6 trillion cubic feet respectively for Scenario B.

If U.S. economic growth were to be lower rather than higher than the Scenario B assumption, trends in energy consumption, oil and gas production, and oil and gas imports would go in the opposite direction of the trends described above.

ROLE OF ENERGY MODEL SIMULATIONS IN NEPP PROJECTIONS

A Department of Energy computer simulation model called WOIL was used in developing the NEPP-1983 energy projections. WOIL provides yearly calculations of world energy market conditions for the 1960 to 2010 timeframe. The model is tested by evaluating its ability to reproduce historical trends from 1960 through 1982.

Two of the many positive features of using a model such as WOIL to develop long-term energy projections are:

- The model provides a consistent and complete accounting framework to ensure that the amount of energy consumed equals the amount of energy supplied for all fuels in all free-world regions for all years between 1960 and 2010. This accounting feature explicitly includes net energy trade among regions and energy transformation processes to produce electricity and synthetic fuels; and

- WOIL is relatively inexpensive and easy to operate. Consequently, WOIL can be used to explore the implications of alternative scenarios by varying assumptions. For example, WOIL can be operated under higher or lower economic growth assumptions to develop insight into the impacts of alternative economic conditions on energy prices, and the quantities of energy consumed and supplied.

Use of a mathematical model does not guarantee the quality of results. The quality of the results from complex models depends directly on the quality of the judgment used in specifying the logical structure of the model and in selecting assumptions required to operate the model.

In using WOIL to develop the NEPP-1983 energy projections, we have tried to incorporate our best judgment in the choice of input assumptions to operate the model. Rather than relying on one midrange scenario, several scenarios have been developed with alternative assumptions and results. Finally, many helpful comments from a variety of energy experts who were asked to review these NEPP-1983 energy projections were incorporated into this report.

INTRODUCTION

The NEPP-1983 analysis is structured so that projected energy prices balance energy consumption and production, accounting for imports, exports, and stock changes. This introduction briefly reviews the structure of the NEPP-1983 analysis including:

- A description of energy scenarios and report organization;
- A description of the physical flows of energy in the U.S. economic system; and
- Comments on the data and mathematical models used in the analysis.

ENERGY SCENARIOS AND REPORT ORGANIZATION

In preparing energy projections for the 1983 National Energy Policy Plan, great effort was made to represent some of the uncertainties involved in projecting future energy conditions and behavior. To deal with uncertainties, we developed several energy scenarios to reflect a wide range of viewpoints about future world energy conditions. The salient features of the scenarios and the location in the report where each scenario is presented is summarized in Table 3. When using the NEPP-1983 scenarios, the following points should be kept in mind:

- The scenarios provide smooth world oil price paths for ease in application to planning--actual world oil prices will most likely be erratic;
- We provide three alternative world oil price views (Scenarios A, B, and C). Each view has certain merits and caveats. Although we use Scenario B as a reference case to compare with alternative views, we do not claim that any one scenario is more likely or represents a point prediction of future conditions. Readers are urged to use a variety of scenarios to perform project evaluation or other analysis; and
- In addition to world oil price views, we also include scenarios that alter economic growth assumptions. Lower or higher economic growth can radically alter energy market conditions.

We hope the inclusion of a variety of energy scenarios in this report provides the reader with useful information about future U.S. and world energy conditions--while emphasizing that no one view of the future is considerably more likely than a number of other views.

This report is divided into three parts. Part I is for readers desiring a deeper understanding of the NEPP-1983 energy projections. Chapter 1 discusses U.S. energy data and projections, while Chapter 2 provides a discussion of free-world data and projections.

TABLE 3: SUMMARY OF NEPP-1983 ENERGY SCENARIOS

	Location in Report	World Oil Price (1982 dollars/barrel) 1985	1990	2000	2010	Economic Growth 1982-2000 (Percent Per Year) U.S.	Free World
Scenario A							
Assumes high world energy demand reduction potential and high energy supply potential. Centrally Planned Economies remain net oil exporters.	Chapter 5	$21	$26	$36	$55	About equal to Scenario B	
Scenario B (Reference)							
Assumes no unusual decline in world energy or oil demand and midrange energy supply potential. Centrally Planned Economies become zero net oil exporters by 1990.	U.S. Chapter 3 World Chapter 4	$26	$32	$57	$84	2.8%	3.0%
Scenario C							
Assumes low world energy demand reduction potential and low energy supply potential. Centrally Planned Economies become net oil importers of up to 2.5 million barrels per day.	Chapter 5	$30	$40	$80	$110	About equal to Scenario B	
Low Free-World Economic Growth							
Scenario B assumptions but free-world (including U.S.) economic growth exogenously reduced about 0.5 percent per year. This decreases world oil demand resulting in lower oil prices than Scenario B.	Chapter 6 Section 6.1	$24	$28	$48	$66	2.3%	2.5%
High Free-World Economic Growth							
Scenario B assumptions but free-world (including U.S.) economic growth exogenously increased about 0.5 percent per year. This increases world oil demand considerably leading to higher oil prices than Scenario B.	Chapter 6 Section 6.1	$26	$36	$68	$104	3.2%	3.4%
Low U.S. Economic Growth							
Scenario B assumptions but U.S. economic growth exogenously reduced by about 0.5 percent per year. Non-U.S. economic growth not exogenously altered. This scenario lowers U.S. oil demand and moderately lowers world oil prices compared to Scenario B.	Chapter 6 Section 6.2	$25	$31	$56	$81	2.3%	2.8%
High U.S. Economic Growth							
Scenario B assumptions but U.S. economic growth exogenously increased by about 0.5 percent per year. Non-U.S. economic growth not altered. This scenario increases U.S. oil demand and moderately raises world oil prices compared to Scenario B.	Chapter 6 Section 6.2	$26	$32	$59	$86	3.2%	3.2%

Part II provides a complete set of Scenario B (Reference Case) U.S. and free-world energy projections for the years 1985, 1990, 1995, 2000, 2005, and 2010. Also included are data for 1960, 1965, 1970, 1975, 1980, and 1982. Readers interested solely in the numeric results of Scenario B should turn to Chapter 3 for U.S. and Chapter 4 for free-world data and projections.

To illustrate and quantify some of the uncertainty in making energy projections, Part III provides alternative views of how world and U.S. energy trends may evolve over time. Part III covers uncertainty related to:

- alternative world oil price views (Chapter 5) and
- alternative rates of economic growth (Chapter 6).

In addition, Chapter 7 in Part III provides a comparison of the NEPP-1983 energy projections both with previous National Energy Plan projections and with projections made by private and government groups. Chapter 7 also includes a discussion of how and why energy projections differ and how their accuracy is limited.

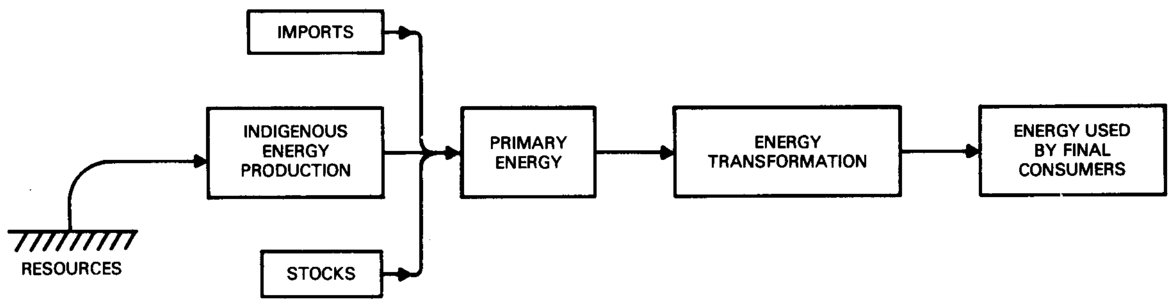
There are also four annexes to this report. Annex A provides conversion factors used in this analysis. Annex B provides a critique of the NEPP-1983 energy projections. Annex C provides detailed results of a world oil price survey conducted to elicit judgments regarding the world oil price Scenarios A, B, and C. Finally, Annex D provides a list of references used in the development of this report.

ENERGY PRICES AND ENERGY FLOWS

Energy markets and prices exist at each point where the ownership of energy changes. In this analysis, we focus on resource prices (the amount paid at the point of energy production such as the minemouth coal price) and delivered prices (the amount paid by final energy users, such as the price of gasoline at the pump). Differences between resource and delivered prices are attributable to such things as taxes, transportation fees, and profits for wholesalers, distributors, and retailers.

Energy prices and the flow of energy are interdependent. The flow of energy starts with resource recovery, moves through processing, and ends with final consumption (see Figure 7). Indigenous energy production equals fossil resource extraction (oil, gas, and coal), plus nuclear and renewable energy. The inclusion of net imports and stock changes yields the total primary energy supplied to the economy. Most of the primary energy then flows through energy transformation industries, where the energy is transformed into all of the products (gasoline, electricity, plastics, etc.) used by consumers. Considerable energy is consumed in the energy transformation process so that energy delivered to final consumers is less than total primary energy supplied to the U.S. economy. In addition to conventional energy sources, some renewable energy (for example, solar energy captured by hot-water heating systems) reaches final consumers directly.

Figure 7
U.S. ENERGY FLOWS



In this analysis final consumers of energy are aggregated into four sectors: residential, commercial, industrial and transportation. In each sector, energy is used to provide services such as heating, lighting and mechanical work. Considerable losses of energy occur during the final conversion of energy into useful services. Figure 8 is a graphical representation of U.S. energy flows in 1982.

DATA BASE

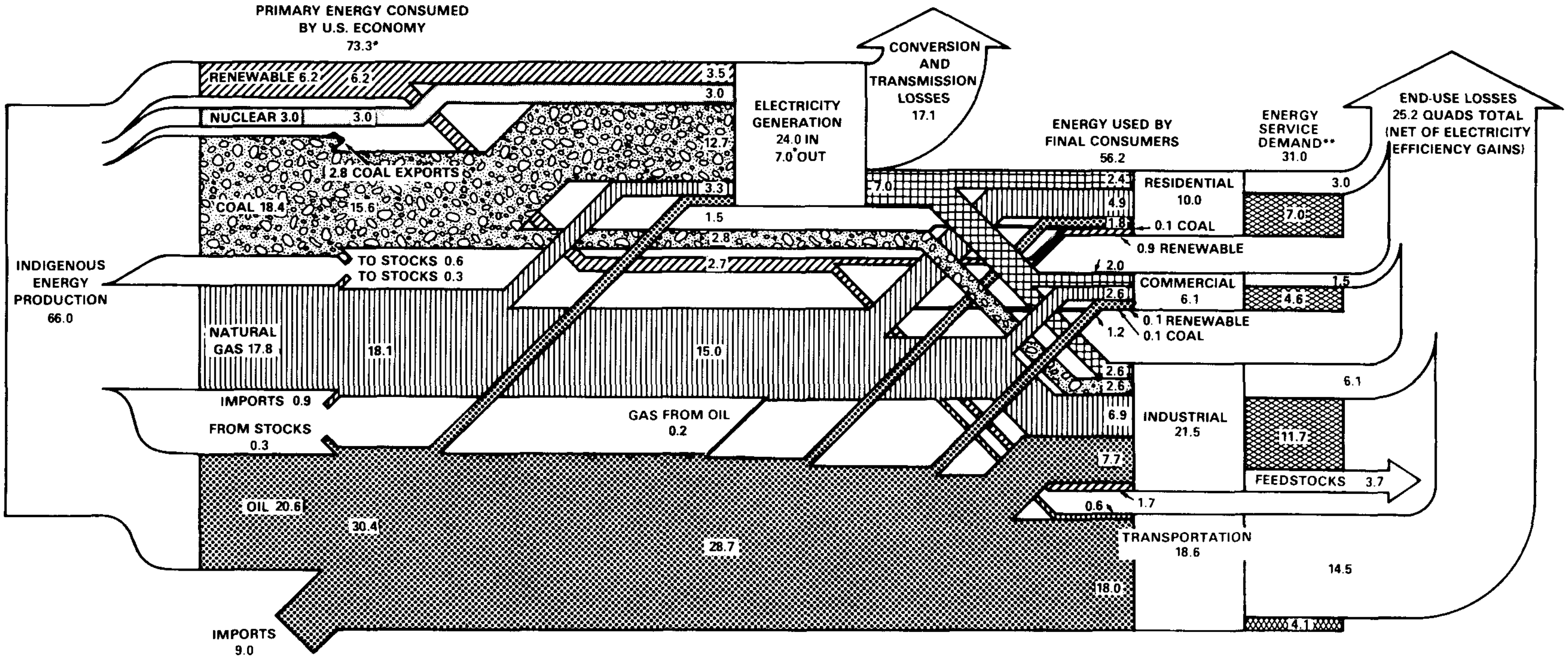
The historical data provided with the NEPP-1983 projections are derived from Energy Information Administration publications (including the Annual Report to Congress, Monthly Energy Review, State Energy Data Report, Short-Term Energy Outlook, and the International Energy Review) and other sources (see References). The data have been rearranged somewhat to conform to a new reporting format we have developed for this year's projections (see, for example, Tables 3-3 through 3-13). We believe that the new format is more internally consistent and useful compared to previous formats.

The primary units for reporting the data and results in this analysis are quadrillion British thermal units (quads) for the U.S. energy projections and million barrels per day of oil equivalent (MMBDOE) for the international projections. A quad equals 10^{15} British thermal units (Btu's). A Btu equals the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. A barrel of oil equivalent equals 42 U.S. gallons and contains 5.8 million British thermal units. Conversion factors are listed in Annex A. In 1982, total primary energy supplied to the U.S. economy equaled 73.3 quads or about 34.6 million barrels per day of oil equivalent. Net oil imports averaged about 4.2 million barrels per day.

Figure 8

U.S. ENERGY SOURCES AND USES IN 1982

(Quadrillion Btus)



* INCLUDES 0.1 QUADS OF IMPORTED HYDROELECTRIC POWER.

** INCLUDES 3.7 QUADS OF ENERGY RESOURCES USED AS FEEDSTOCKS FOR THE MANUFACTURE OF NON-ENERGY MATERIALS. BASED ON END-USE EFFICIENCIES FROM 1980 BROOKHAVEN DATA.

ENERGY MODELS

A Department of Energy computer simulation model called WOIL was used in developing the NEPP-1983 energy projections. WOIL is the most recent generation of a series of models which began with a model called COAL1. During the developmental process, these models have been extensively reviewed by energy experts. WOIL produces global fuel-specific energy projections. To do so, however, the model must be supplied with a detailed set of assumptions. Although WOIL improves our ability to produce projections, no model can predict the future. In fact, the limitations of what we believe to be a good model and the lack of consensus among analysts is illustrated in Annexes B and C of this report.

COAL1 was developed at Dartmouth College under a contract from the U.S. Department of the Interior. In 1977 COAL1 was improved under a contract from the Energy Research and Development Agency (ERDA) and was called FOSSIL1. FOSSIL1 included a variety of structural improvements which reflected comments from an in-depth review of the COAL1 model performed by a consultant company. Despite the title, FOSSIL1 was a model of the entire U.S. energy system including demand and supply of all fuels, not just fossil fuels. FOSSIL1 was revised to reflect assumptions and views of the U.S. Department of Energy, and in 1978 a new model called FOSSIL2 was developed. After an interagency governmental review of the structure and results of FOSSIL2, the model was used as the basis for developing the NEP-1979 energy projections. The world oil price was an exogenous input assumption to FOSSIL2. For NEPP-1981, the Department of Energy developed an international structure to add to FOSSIL2. The new international model was called WOIL, a model which endogenously calculates world oil prices.

Both WOIL and FOSSIL2 have undergone considerable review both within and outside the Department of Energy. For example, both WOIL and FOSSIL2 have been extensively reviewed in Stanford Energy Modeling Forum exercises (Stanford University). In those studies the structure and results of WOIL and FOSSIL2 were compared with other energy models.

WOIL provides yearly calculations of world energy market conditions for the 1960 to 2010 timeframe. Evaluating the model's ability to reproduce historical trends from 1960 through 1982 provides one test of WOIL's capabilities. The following world regions are represented in WOIL:

- United States;
- Non-U.S. OECD (Organization for Economic Cooperation and Development) countries;
- Mexico (although a separate region in WOIL, for simplicity Mexico is included under "Rest of the Free World" in the NEPP-1983 results);
- OPEC (Organization of Petroleum Exporting Countries);

- Rest of the Free World; and

- CPE's (Centrally Planned Economies--net energy trade only).

For each world region (except for the CPE's), WOIL projects primary energy supplied in terms of oil, gas, coal, nuclear and renewables (including production, net trade, and stock changes). Energy consumed is projected by fuel (including electricity) and by sector (residential, commercial, industrial, and transportation). Energy prices are calculated for both resource costs (for example, minemouth coal) and delivered energy prices (including taxes, delivery charges, and other markups).

To develop a scenario with WOIL requires many input assumptions. Critical assumptions include:

- Gross Domestic Product (GDP) by region;

- OPEC oil production capacity; and

- Net free-world oil, gas, and coal trade with the Centrally Planned Economies.

WOIL operates by iterating through the following sequence of calculations:

- The model starts with a specified set of initial conditions for energy prices, consumption, and production for all fuels in all regions. For NEPP-1983, the initial conditions were set for 1960;

- The model takes the input GDP assumption for each region and using a specified GDP elasticity (i.e. expected increase in total energy demand given an increase in economic activity) calculates a demand for energy;

- Given this demand for energy, delivered energy prices determine the amount of energy actually consumed, by sector and by fuel. The price effects include fuel switching because of relative price impacts and fuel conservation in response to price changes;

- A new set of energy prices is calculated for the next time period. Delivered energy prices are affected by the cost of energy (including capital costs), taxes, and profits. For regulated fuels (for example, electricity and historical natural gas prices), profits equal a specified "normal" rate of return. For other fuels, profits depend upon market conditions (including the price of fuels in international trade);

- The new energy prices affect the GDP input assumption for the next time period through a delivered price elasticity impact. Higher energy prices reduce economic activity and lower prices increase economic activity;

- The newly achieved GDP is calculated. The new GDP then acts through a GDP energy elasticity to create a new set of energy demand conditions--thus completing the cycle;

- WOIL advances through time, making the above sequence of calculations over and over.

Two positive features of using WOIL to develop long-term energy projections include:

- The model provides a consistent and complete accounting framework to ensure that the amount of energy consumed equals the amount of energy supplied for all fuels in all free-world regions for all years between 1960 and 2010. This accounting feature explicitly includes net energy trade among regions and energy transformation processes to produce electricity and synthetic fuels; and

- WOIL is relatively inexpensive and easy to operate. Consequently, WOIL can be used to explore the implications of alternative scenarios by varying assumptions. For example, WOIL can be operated under higher or lower economic growth assumptions to develop insight into the impacts of alternative economic conditions on energy prices and the quantities of energy consumed and supplied.

Use of a mathematical model does not guarantee the quality of results. The quality of the results from complex models depends directly on the quality of the judgment used in making assumptions required to operate the model. In using WOIL to develop the NEPP-1983 energy projections, we have tried to incorporate our best judgment in the choice of input assumptions to operate the model. Also, rather than relying on one scenario, we have developed several scenarios with alternative assumptions and results. Finally, we incorporated into this report many helpful comments from a variety of energy experts who were asked to review these NEPP-1983 energy projections. A summary of comments from the experts is in Annex B.

PART I: EXPLANATION OF ENERGY DATA AND PROJECTIONS

CONTENTS

CHAPTER 1: EXPLANATION OF U.S. ENERGY DATA AND PROJECTIONS

The analysis supporting the derivation of the NEPP-1983 U.S. energy projections depicts the U.S. energy market as an interaction of causes and effects in which energy prices play a key role in balancing domestic energy consumption, production, and trade. As long as government regulations and other factors do not inhibit the movement of prices, the energy market can operate effectively. Any event that alters either the demand for or supply of energy (for example, economic expansion or an oil supply disruption) will cause energy prices to change. These new energy prices in turn set in motion actions which will further alter energy supply and demand. Over time, the energy market will return to a stable situation. In this manner, the U.S. energy market evolves through time. Thus, although often discussed in isolation, energy prices, energy consumed by the economy, and energy supplied to the economy (through production or trade) are inextricably linked. This fact should always be kept in mind when considering U.S. energy data and trends.

The figures in this chapter depict the general trends which we believe will result from a wide range of assumptions regarding energy supply and demand. To make them simpler and easier to understand, each of the graphs shows historical data through 1982 and only one of the many possible projections of the 1983 to 2010 period. Scenario B (the reference case, presented in Chapters 3 and 4) was chosen to illustrate the points made in the text. Readers interested in other scenario trends are referred to Chapters 5 and 6.

1.1 U.S. ENERGY PRICES

Energy prices link the supply of a specific fuel with the demand for that fuel and link the supply and demand for one form of energy with the supply and demand for other forms. Changes in price expectations, perceptions about the long term availability of given fuels, the cost or efficiency of energy-consuming technologies or other factors can have impacts on supply, demand, and prices that are not completely felt throughout the energy system for decades. That being the case, energy prices faced by consumers during the next few decades may be affected by the multitude of energy changes which have occurred over the past decade.

1.1.1 The Role of Energy Prices

Energy is consumed by users to obtain the services which they desire. Further, there is flexibility regarding the amount of each fuel type which can be supplied through indigenous production or trade. In a turbulent environment where changes in demographics; economic activity; weather; the policies of the United States, OPEC, and other nations of the world; and many other factors each affect energy supply and demand behavior in their own way, price adjustments are what move the energy system toward a stable situation where supply and demand are in balance.

When the demand for a particular form of energy becomes higher than merchants are willing to sell at current prices, prices increase. To keep within their budget constraints, consumers lower their consumption of energy and nonenergy services. Examples of decreasing the consumption for energy services include turning down thermostats or driving less. Should consumers decide that higher prices will continue indefinitely, they eventually substitute capital improvements (insulation, fuel-efficient cars, etc.) for many of their behavioral changes. Receiving more for their goods, energy merchants are able to pay more to replenish their inventories. In turn, suppliers are then able to pay domestic and foreign producers more for energy to replenish their stocks. Higher profits for domestic producers stimulate and help finance energy exploration efforts which, after a time lag, may result in additional domestic production and lower imports. In this manner, delivered and resource prices change to encourage both demand reductions and production increases, stabilizing energy markets. The price mechanism works in both directions: lower prices will encourage more consumption (increased miles of driving, etc.) and discourage domestic exploration and production.

In deregulated markets, the pricing mechanism also helps to balance the use of substitutable fuels based on their relative availability. For example, as oil becomes increasingly scarce, its price will rise relative to coal which is more abundant and less expansive to produce. As a result, economics will encourage users to switch from oil to coal when feasible. It should be noted that the economics are based on the relative cost of providing an energy service (for example, space conditioning) not the relative cost of the fuels. This is important because technologies which use different fuels frequently differ in other ways as well. If technologies which use inexpensive energy require more fuel, higher pollution control expenditures, etc. than other types of equipment to provide the same energy service, the lowest total costs may not necessarily be associated with the least expensive fuel.

1.1.2 Price Behavior

As a result of current activities and events that have occurred since the early 1970's, a series of energy pricing adjustments is anticipated over the next 15 years. Demand for energy in general is presently depressed because of the recession. The market for electricity is expected to recover first, followed by oil and then gas. This phasing will produce interesting relative price patterns. Although coal demand is also expected to increase after a period of stability, huge U.S. coal reserves are expected to keep significant price increases from occurring within the projection period.

The last decade has been one of the most eventful in history, from an energy perspective:

- In the Middle East, the owners of the world's largest oil reserves took decisionmaking control of their assets away from the international oil companies, drastically changing the economic incentives driving oil production in the region;

- After years of controls, in January of 1981 the price of domestically produced oil was allowed to compete on the open market;

- With the passage of the Natural Gas Policy Act of 1978 (NGPA), the phased decontrol of some domestic natural gas prices began. Passage of the Administration's natural gas consumer regulatory reform legislation will speed up and improve this decontrol process;

- The Staggers' Rail Act of 1980 set in motion a gradual reduction of Interstate Commerce Commission oversight of railroad rates and is expected to contribute to higher coal transportation costs; and

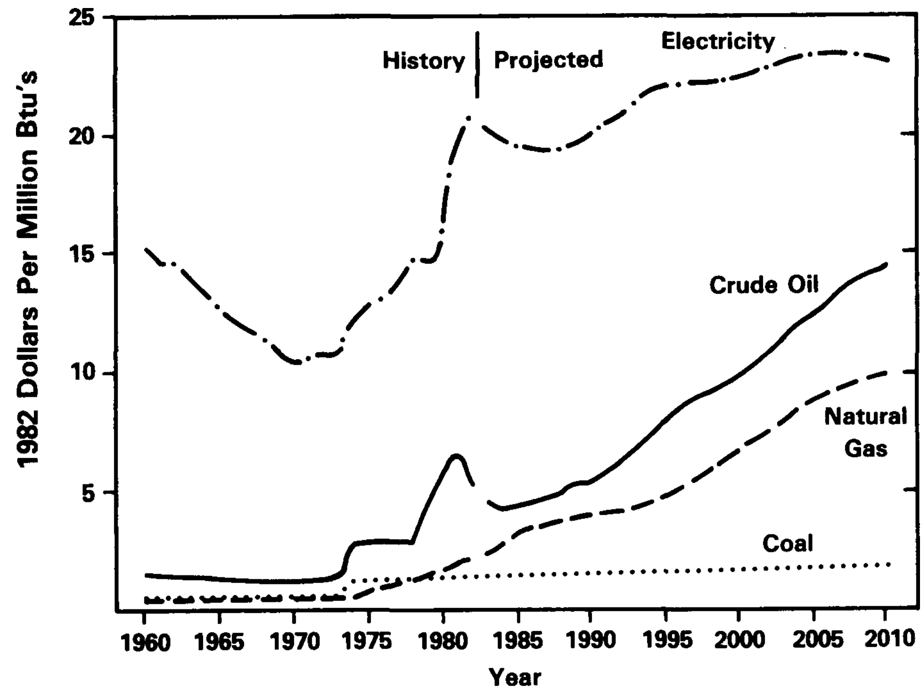
- The Three Mile Island nuclear accident plunged the nuclear industry into further turmoil, increasing electricity generating costs as reactors were shut down for safety modifications, and increasing the cost of new plants as a result of safety induced changes in design and construction methods.

In the 1960's, international oil companies kept Middle Eastern production high in order to maximize expected profits from what could be, and in fact was, a temporary operation. As a result, the prices of domestic petroleum products were relatively low throughout this period. In the 1970's the Middle Eastern nations took control of oil production in their countries, and in 1973 political events allowed them to increase their long-term profit potential by almost tripling the real world oil price. In the United States the price jump only slowed oil consumption growth temporarily. From 1975 to 1978 oil consumption grew at 5 percent per year, about the same rate as the 1970 to 1973 period. In fact, despite the decline from 1973 to 1975, U.S. oil consumption in 1978 was almost 30 percent higher than 1970 levels. The second-price jump of the 1970's contributed to the recession and resulted in significant fuel switching and lower oil consumption. Since natural gas can be substituted for oil in many applications, the price of these two forms of energy is linked in a major way through competition. Although controls kept sharp price jumps from occurring, natural gas prices did slowly increase in the mid 1970's (see Figure 1-1) and continued to increase under the NGPA. The increases in oil prices also contributed to the electricity price increases of the mid 1970's. Another contributing factor to increased electricity prices were capital investments aimed at meeting the anticipated high growth in electricity demand. Given the high price of oil, the unavailability of natural gas and federal regulations, this new capacity was predominantly coal and nuclear fueled. Higher prices for competitive fuels caused an increase in the demand for coal and allowed higher production costs, in part due to higher real wages, lower labor productivity, and stricter environmental and safety regulations, to be passed onto consumers. Although coal prices doubled, they still remained low, on a per Btu basis, relative to oil, electricity, and, after the late 1970's, natural gas.

Figure 1-1

U.S. RESOURCE AND AVERAGE ELECTRICITY PRICES

(Scenario B)



In 1982, the United States was in a recession with oil, gas, and coal consumption at least 9 percent less than only two years before and electricity sales declining for only the second time in 30 years. Although most energy prices also declined from 1980 to 1982, they were still 2 to 5 times higher than in the early 1970's.

As the recession ends, the electricity market is expected to be the first to recover. Although electricity is very expensive on a per Btu basis relative to other fuels, electricity provides some unique services and, given efficient new equipment, can often provide energy services at a lower cost than other energy forms. Increasing demand will necessitate investments in generating capacity, the expense of which, when combined with eventual increases in the utility acquisition cost of oil, may cause price increases from the mid 1980's through the mid 1990's (some utilities have experimented with "investments in conservation" and in some cases this has resulted in lower costs). In the late 1990's, electricity prices are projected to stabilize and perhaps actually decline slightly at the end of the projection period when expensive oil and gas may account for as little as 5 percent of utility fuel inputs. Demand for electricity is projected to double over the next 25 to 30 years, in part because the price of electricity is expected to improve relative to other energy prices. Since, on average, energy resource acquisition costs are a much smaller component of total generating costs (about 30 to 40 percent) than they are of, say, distillate production costs (over 75 percent), the price of electricity is not as directly affected by the impact of resource price increases as other delivered fuels.

World oil demand is expected to remain relatively low through the mid 1980's with a temporary tightening of the market in the late 1980's but no sustained major real world oil price increases until after 1990. The prices of delivered petroleum products are expected to follow approximately the world oil price path. Depending on the rate of growth in oil demand, world oil prices are projected to increase, in real terms by 3 to 8 percent per year in the early 1990's before stabilizing at about 4 percent per year for the rest of the projection period.

In the near term, natural gas prices are expected to increase more slowly under the newly proposed legislation than they would have under the NGPA. In the mid 1980's, natural gas is expected to compete successfully for market share with petroleum. With abundant supplies and a shrinking oil and gas market, the link between natural gas and oil prices is projected to weaken in the late 1980's. As a result, natural gas prices are projected to remain relatively stable from 1985 through 1995. As domestic natural gas production begins to decline more rapidly in the mid to late 1990's, however, gas prices are expected to increase following the path of their petroleum counterparts.

1.2 ENERGY CONSUMED BY THE U.S. ECONOMY

Energy is consumed in the U.S. economy to provide desired services (for example, space conditioning, lighting, mechanical drive), not to meet the demand for a specific fuel (for example, oil, gas, coal, electricity). In fact, often more than one fuel can provide a given service. To simplify presentation of the tremendous variety of energy services demanded by the economy, we group services together under five categories of users: residential, commercial, industrial, transportation (the end-use consumers) and users who transform energy from one form to another (primarily utilities and synthetic fuels plants).

Within each of the five categories of energy users, the demand for energy services is the result of two typically offsetting trends:

- An upward trend caused by an assumption of demographic change and economic growth which causes higher demand for energy services (more households, industrial output, and wealth); and

- A downward trend caused by increased efficiency in the use of energy stimulated by past and projected energy price increases.

Which of these trends will prove dominant is uncertain. An indicator of the downward trend from improved use of energy, however, is the current efficiency of the U.S. economy. We estimate that in 1982, the U.S. demand for energy services was about 31 Quadrillion Btu's (quads) including 5 quads of energy resources used as nonenergy feedstocks in the manufacture of plastics, fertilizer, asphalt, and other materials. Since automobiles, furnaces, and most other energy-consuming machines and appliances are not 100 percent efficient in converting fuels into energy services, considerably more than 31 quads of energy were required to provide the energy services demanded. In fact, almost twice this amount was actually consumed by the end-use sectors and, when utility conversion losses are included, about 73 quads of primary energy was actually used. It could therefore be said that equipment used by the U.S. economy was only about 40 percent efficient in using energy resources to satisfy the demand for energy services in 1982. Although a certain amount is always lost when converting energy into useful work, the U.S. economy apparently has plenty of room for further energy efficiency improvements.

1.2.1 Residential Sector

Total energy consumption by the residential sector is a function of the number of households and the amount of energy used per household. In order to understand historic and projected trends in the residential use of specific fuels, however, it may be best to think first about the decisions which have been and will be made by the owners of the nation's living units.

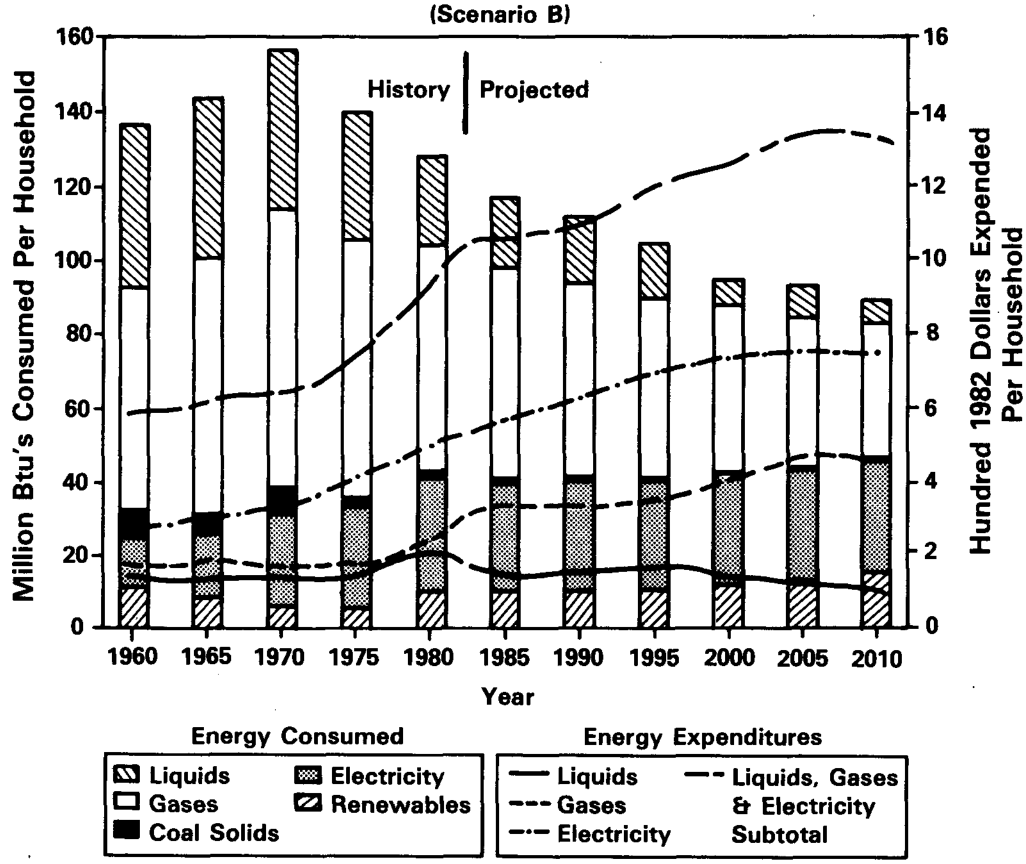
In 1970 the residential sector consumed 9.9 quadrillion Btu's (quads) of energy. In 1982, 10 quads were consumed. Although not apparent in these aggregate numbers, dramatic changes were actually taking place during this period. The number of households increased by about 2.5 percent per year, while energy consumption per household, which had been increasing in the 1960's (see Figure 1-2), was decreasing by 2.5 percent per year. This reduction in per household consumption was accomplished by adding insulation and/or making other improvements to the building structure (or "shell") and by purchasing new equipment which transforms energy into services more efficiently. By 1982 the average efficiency of residential equipment was estimated to have reached 70 percent.

Between 1982 and 2010, the Census Bureau estimates that the rate of increase in the number of households will gradually decrease to less than 1 percent per year. The rate at which efficiency improvements are made is projected to follow a similar pattern, with a slightly more rapid decline. Given over a 40-percent increase in the number of households and only a 25-percent decrease in consumption per household, a slow increase in total residential energy consumption is expected under Scenario B (reference) assumptions. Higher or lower economic growth as shown in Chapter 6, would increase or decrease residential energy consumption respectively because of both impacts on the size of households and the energy use per house.

Considerable changes are expected in the type of energy used in the residential sector. In homes throughout the country almost all lights and small appliances are currently electric powered. In those areas with access to inexpensive natural gas, it is used to heat water, dry clothes, and/or cook food in many households. However, most other major appliances, in almost

Figure 1-2

U.S. RESIDENTIAL SECTOR:
ENERGY CONSUMED AND ENERGY EXPENDITURES
(Scenario B)



all areas of the country are electric powered (a limited number of water heaters are currently wood or coal fueled or are solar systems). Again depending on the economics of each particular region of the country, households may be heated by electricity, natural gas, oil, coal, wood, or solar energy.

Ideally, as current equipment wears out, households will purchase replacements that are expected to provide the services desired at the least cost over the period the resident expects to use the item. Since most people move at least once every 6 to 8 years, this period of expected use may be far less than the estimated useful life of the equipment, thus leading some consumers to purchase lower cost, less efficient equipment. Although electricity is more expensive than other fuels on a per-delivered Btu basis, high-efficiency electric units may often be less expensive to operate than their counterparts which use other fuels. For example, electric heat pumps have an end-use efficiency of over 100 percent. This is accomplished by extracting heat from the air outside the building and transferring it inside or vice versa depending on the season. In this fashion, two to four times the Btu content of the electric energy purchased becomes available to satisfy the demand for space conditioning. As the relative price of electricity improves, the advantages of electricity will increase. In households where costs are rising but equipment is relatively new, the amount of energy required to provide the services desired or the amount of desired services can be reduced. This may be accomplished by actions such as adding insulation to the house or closing off rooms and lowering thermostat settings. In some cases it might even prove economical to replace equipment, which is still in good working order, with new more efficient equipment which uses the same or a different fuel.

As new homes are built, many will be all electric, some will have natural gas major appliances, a few if any will have oil heating systems, and an increasing number will take advantage of wood, coal, and/or solar space conditioning and/or water heating systems. The efficiency of equipment in new homes may depend on whether the potential owner or the builder is making the major appliance purchasing decisions. In the first case, costs over the period the owner expects to live in the house may be given more consideration than in the second case, where initial costs may be of more concern.

The United States is made up of millions of households. Over the projection period individual owners and residents will be faced with many of the decisions discussed above. Their choices will depend on their particular circumstances. For the Nation, their combined actions are expected to result in a continued increase in electricity and renewables consumption and a continued decrease in oil, gas, coal, and total energy consumption per household (see Figure 1-2). This decline is not expected, however, to be fast enough to offset energy price increases. Energy expenditures per household are, therefore, expected to climb in real terms at least through 2005. However, it is expected that increases in real income per household will be enough to offset the one percent per year real increases in energy expenditures projected for the 1982 to 2010 period. As a result of the shift away from the use of oil and gas and to electricity, almost all of these additional payments for energy will be made to electric utilities.

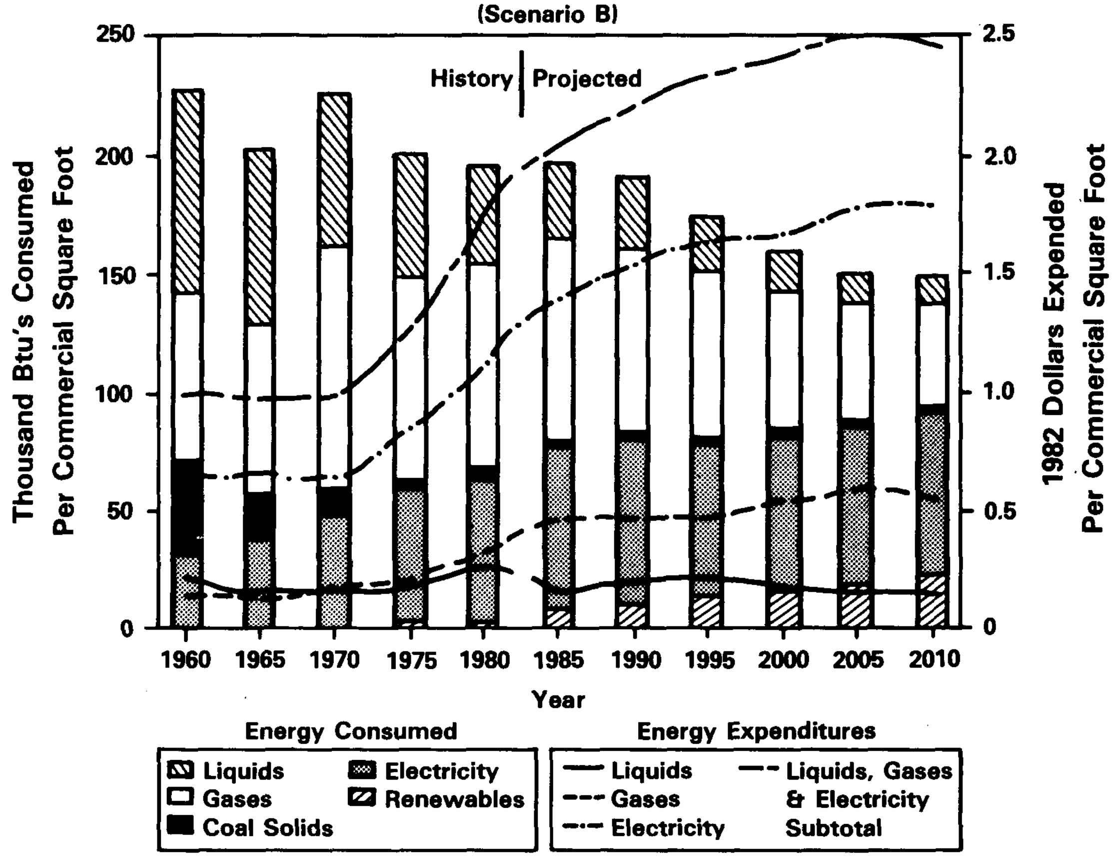
1.2.2 Commercial Sector

A commercial user also consumes energy for space conditioning, lighting, and the operation of appliances. However, much of the commercial equipment is already electric. As a result, the average end-use efficiency of commercial sector equipment in 1982 is estimated to have been 76 percent compared to 70 percent in the residential sector. Energy consumption per commercial establishment varies tremendously because of the large range in the size of commercial operations. A better indicator of commercial energy behavior may be usage per square foot of commercial space.

Since 1970, apparently in response to the energy price increases of the last decade, commercial energy use per square foot has been declining at a little less than 2 percent per year. This pattern is expected to continue through the projection period. Efforts by commercial users to maximize profits are

Figure 1-3

U.S. COMMERCIAL SECTOR:
ENERGY CONSUMED AND ENERGY EXPENDITURES
(Scenario B)



expected to cause a further dramatic shift away from liquids and natural gas to electricity and especially to wood, solar, and other forms of renewable energy (see Figure 1-3). The net result may be a decrease in per square foot commercial sector payments to oil suppliers and a leveling of per square foot payments to natural gas, and electricity suppliers, despite the projected increase in energy prices.

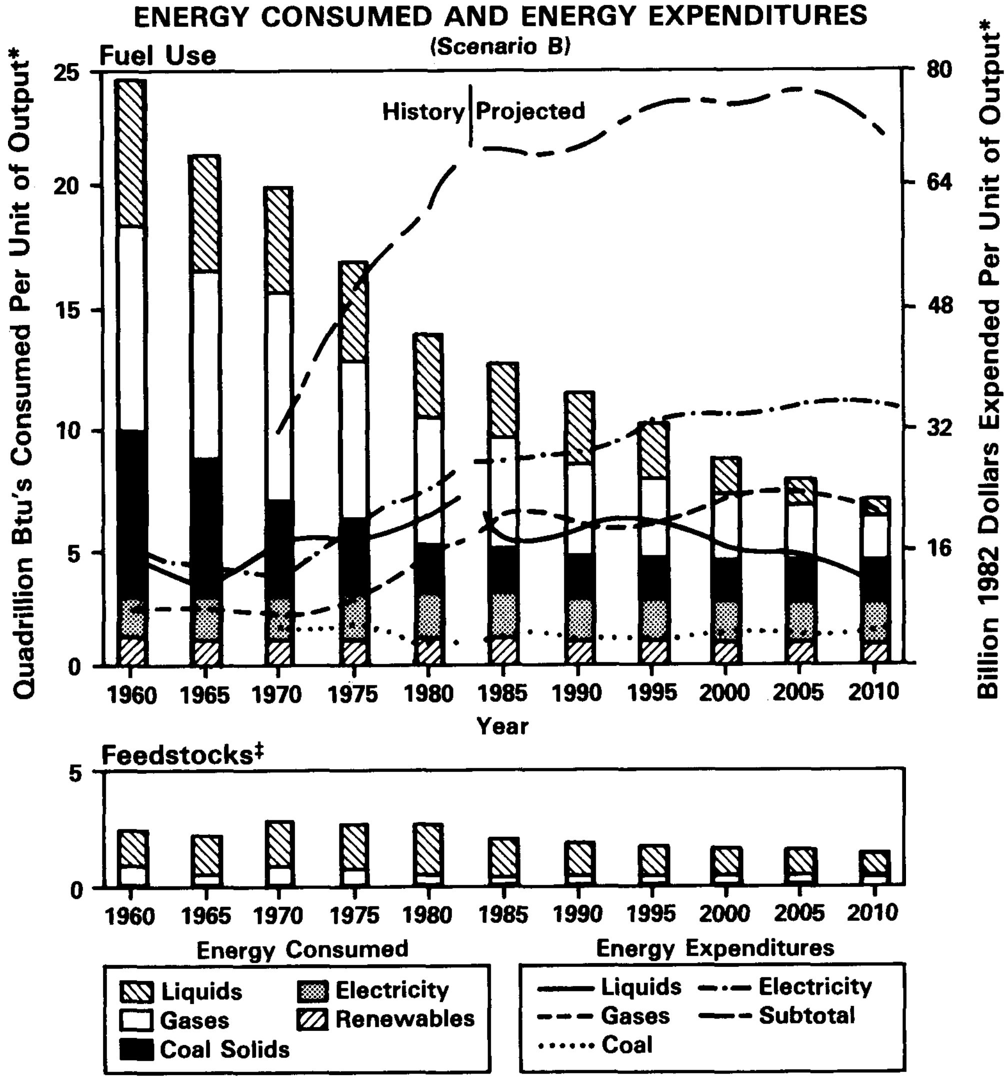
1.2.3 Industrial Sector

The industrial sector consumes energy resources for space conditioning, lighting, the operation of machinery, and for feedstocks used to manufacture certain products. All these uses are dependent upon the level of industrial output. The type and the amount of non-feedstock energy used is also a function of production costs. Both the production costs and the quantity of specific items being produced affect feedstock consumption.

Although energy use per unit of industrial output declined by an average of 2 percent per year in the 1960's, with the energy price increases of the 1970's, this decline accelerated to an average of 4 percent per year. It is projected that the rate of energy improvements has peaked and will decline in the future, averaging 2 percent per year over the next three decades. Decreased energy use per unit of output is projected to result from improved process efficiency and a change in the mix of products being produced with energy intensive products decreasing as a share of total output. As the future cost of industrial production is minimized, a shift to more efficient coal, electric, and renewable technologies is expected to cause these fuels to maintain or increase their share of the market while liquids and natural gas use per unit of industrial output drops significantly (see Figure 1-4). Similar to the residential sector, industrial non-renewable fuel-use

Figure 1-4

U.S. INDUSTRIAL SECTOR:
ENERGY CONSUMED AND ENERGY EXPENDITURES
(Scenario B)



*Industrial Output Index, 1967 = 100.
‡Excludes Asphalt.

expenditures are expected to increase at less than 1 percent per year from 1982 to 2005 (despite average increases of 3 or 4 percent per year in delivered energy prices) before leveling off or declining in latter years. Once again most of the slight post 1985 increase in fuel payments will go to the electric companies. Projected liquids and natural gas price increases are, for the most part, expected to be countered by reductions in their use while coal prices and coal use per unit of output are projected to remain stable.

Non-asphalt feedstock use per unit of industrial output is expected to decline slowly over the next 30 years, as manufactures change the products they make and/or learn to make products in ways that require less coal, less natural gas, and considerably less liquids as an input. Although included as an industrial feedstock for recording purposes, asphalt is not used in industrial production but is used for paving roads, parking lots, etc. As a result, asphalt demand is independent of industrial output. Demand for asphalt is assumed to grow very slowly throughout the projection period.

1.2.4 Transportation Sector

Energy can be consumed to transport people and goods in a number of ways. About one-fourth of the energy demanded by this sector is used in pipeline operation or for air, rail, and marine transportation. The remaining three-fourths is used to fuel cars, trucks, and other vehicles.

In their operation, natural gas and oil pipelines consume some of the fuel being transported. These amounts have been and are expected to remain fairly stable. Jet fuel demand has also remained stable with efficiency gains balancing increased air traffic. This trend too is expected to continue. Although there will be slow shifts in the fuels used by marine and rail users, with electricity gaining and distillate and residual fuel losing share, the total consumption is also expected to remain essentially flat or decline slightly because of improved efficiency.

The use of energy by motor vehicles is not only the largest transportation use, but also the most interesting. Because of improvements in both the design and mechanics of vehicles, it is estimated that the road miles per gallon (as opposed to Environmental Protection Agency estimates) of new vehicles has increased by as much as 85 percent since the early 1970's. This has translated into less than a 2-mile-per-gallon improvement for the entire fleet, however, because of the slow turnover rate of vehicles. Despite these improvements, it is estimated that only about 20 percent of the Btu's contained in the fuel is actually being used to provide transportation services. Virtually all of this fuel undergoes a transformation from heat to mechanical work, a change which, according to the second law of thermodynamics (Carnot cycle efficiency), results in considerable and unavoidable losses. Modern engines (excluding drive train, accessories, and all other losses) can, however, achieve 30 to 40 percent efficiency, while experimental engines promise 50 percent in the near future. Given these mechanical improvements as well as design changes (size, areodynamics, materials, etc.) the average road miles per gallon of new vehicles (cars and trucks) is expected to increase from its present value of around 18 miles per gallon to a plateau of around 26 miles per gallon in the late 1990's (see: The Highway Fuel Consumption Model, Ninth Quarterly Report, DOE/PE, February 1983). As a result, the average fleet road mpg will continue to increase beyond 2010.

Unlike the other sectors where the expansion of the economy is projected to more than compensate for demand reductions, transportation sector total demand is actually expected to decline until 1995. At this point, it is anticipated that the rate of demand reductions per year will slow (see Figure 1-5) and total transportation energy demand will begin to increase.

1.2.5 Energy Transformation (Electric Utilities and Synthetic Fuel Plants)

Some of the energy used in the end-use sectors undergoes a transformation between the time it is produced and the time it is consumed. There are two significant transformation industries: electric utilities and synthetic fuels. Both of these industries experience considerable conversion losses.

The electric utility industry transforms various energy sources into mechanical work (for example, via a turbine) and then into electricity. As explained earlier, such a procedure results in large unavoidable energy losses. In terms of energy actually delivered to the end-use sector, the utility industry has been, for at least the last 20 years, and is expected to continue to be, around 32 percent efficient. This is not to say that little has changed or will change in the utility industry. In looking at fuel inputs used per unit of electricity produced (see Figure 1-6), one can see the results of utility attempts to control their life cycle capital, operation, and maintenance costs and improve their return on investment. In the 1960's coal and hydro facilities lost share to oil and natural gas. In the 1970's this movement was reversed, and oil and natural gas lost share to coal and newly completed nuclear facilities. This trend is expected to continue through the year 2000. From 2000 to 2010, coal will again begin to lose some of its share this time to nuclear, hydro, and other renewables.

Synthetic fuels are projected to remain insignificant until 1995 or 2000. Even in 2010 synthetic fuels production is expected to use only 6 percent of total energy consumed by the transformation sector (transformation losses). The process of transforming coal into liquids and gases is more efficient than the transformation to electricity (over 50 percent compared to around 32 percent). Because of both technological and environmental constraints, however, the cost of this transformation is a limiting factor. In fact, recent low world oil price projections have pushed the anticipated date when synthetic fuels would become cost competitive much further into the future than previously expected.

1.2.6 End-Use and Primary Energy Consumed

Total end-use energy consumed is the sum of residential, commercial, industrial, and transportation sector energy use. Total primary energy consumed is end-use energy consumed plus consumption by the transformation

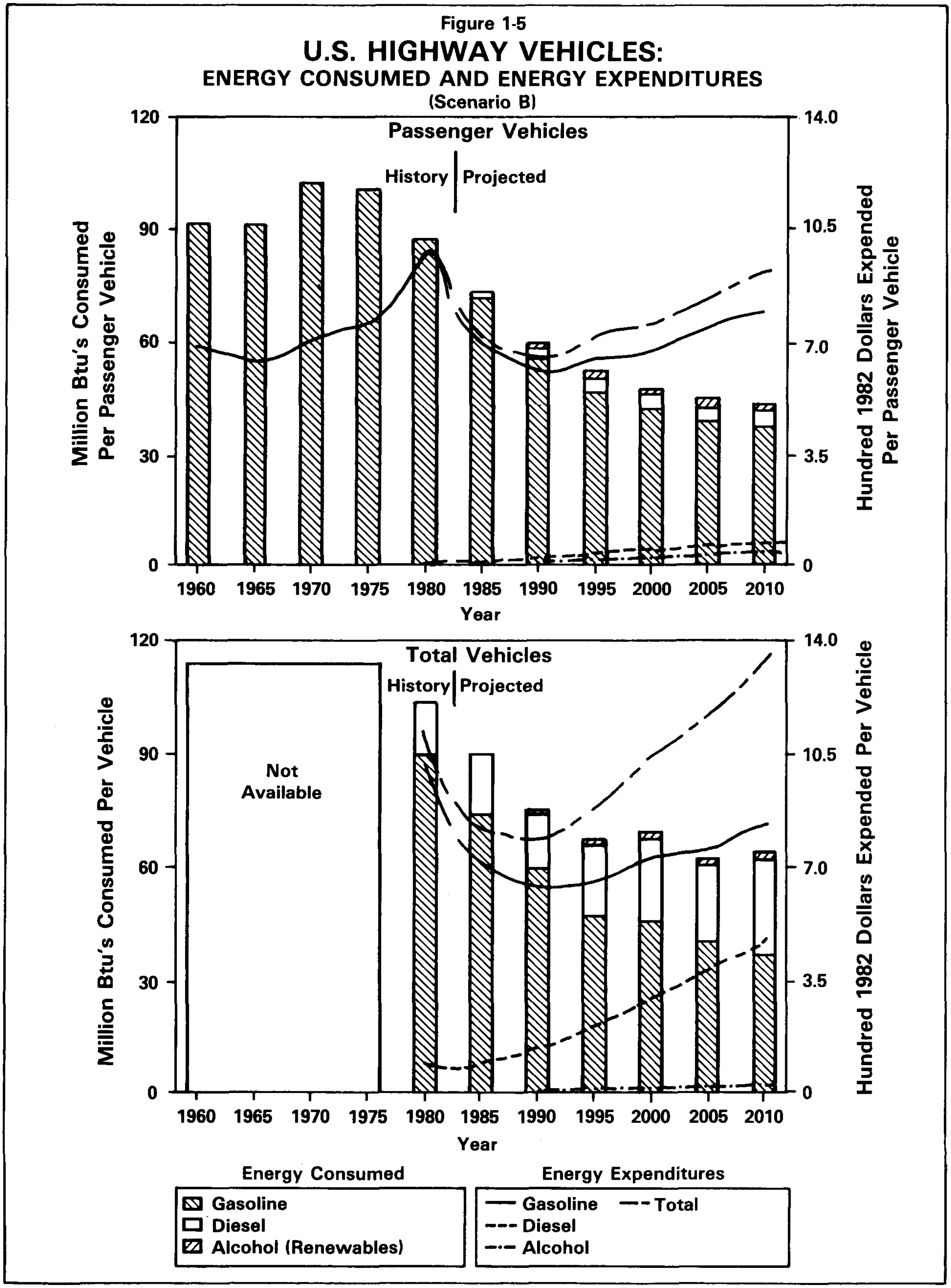


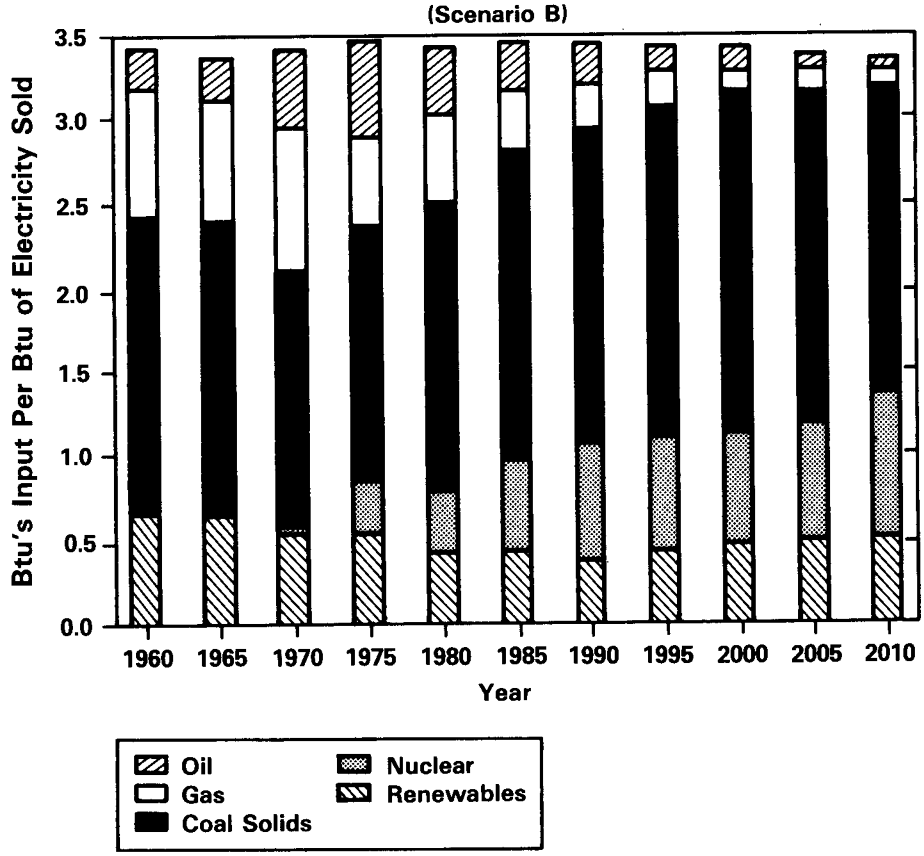
Figure 1-5
U.S. HIGHWAY VEHICLES:
ENERGY CONSUMED AND ENERGY EXPENDITURES
(Scenario B)
Passenger Vehicles
History
Projected
Million Btu's Consumed Per Passenger Vehicle
Hundred 1982 Dollars Expended Per Passenger Vehicle
120
90
60
30
0
14.0
10.5
7.0
3.5
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year
Total Vehicles
History
Projected
Not Available
Million Btu's Consumed Per Vehicle
Hundred 1982 Dollars Expended Per Vehicle
120
90
60
30
0
14.0
10.5
7.0
3.5
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year
Energy Consumed
Gasoline
Diesel
Alcohol (Renewables)
Energy Expenditures
Gasoline
Total
Diesel
Alcohol

Figure 1-6

U.S. TRANSFORMATION SECTOR:

ELECTRIC UTILITY INPUTS

(Scenario B)

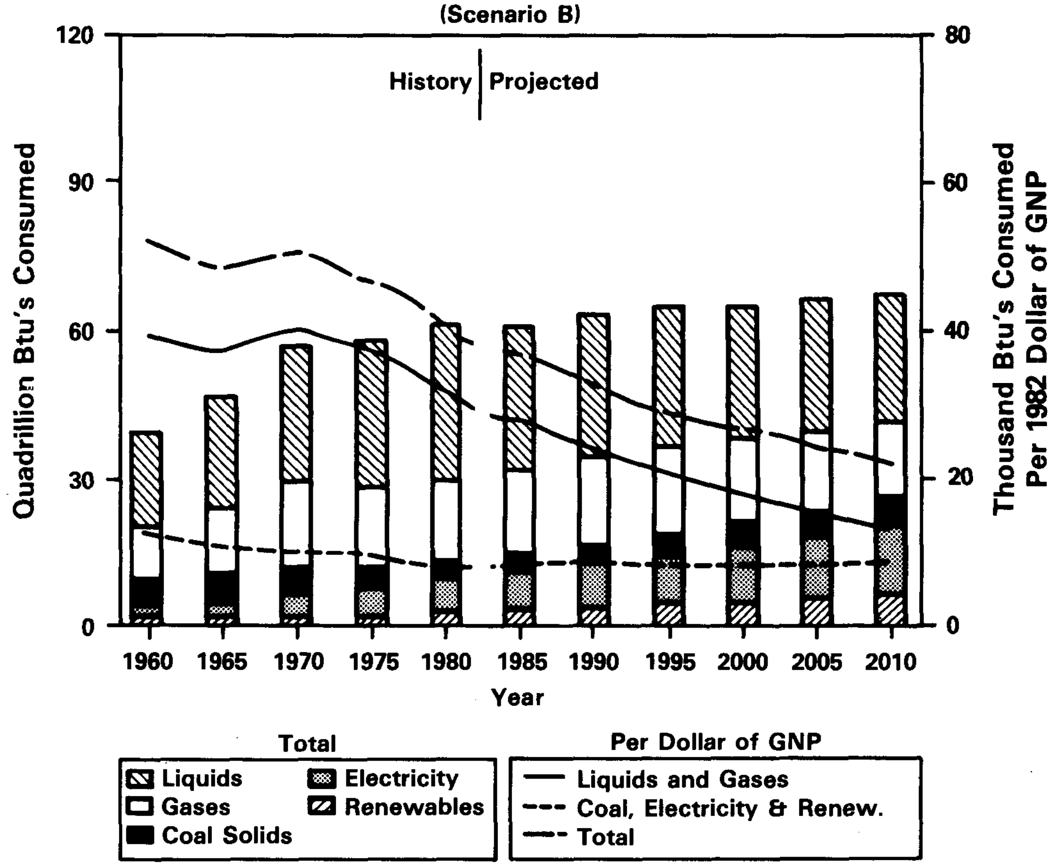


sector (transformation losses). An alternative way to calculate primary energy consumed is to add non-electricity and synfuels end-use sector energy consumed to the oil, gas, coal, renewable, and nuclear energy inputs to the transformation industries. Perhaps the most insightful way to view aggregate totals such as end-use and primary energy consumed is on a per dollar of gross national product (GNP) basis. This is a reasonable measure since GNP reflects population growth, commercial and industrial activity, and other factors which directly affect sectoral demand.

During the 1960's, even though energy prices were falling in real terms, end-use energy consumed per dollar of GNP showed a slight decline (see Figure 1-7). In part, this was the result of the further electrification of the U.S. economy. Given the efficiency of most electrically powered equipment, the amount of electricity purchased to provide end-use services is often less than the amount of most other forms of energy needed to provide the same services. With the price increases of the 1970's, demand reductions and greater electricity market penetration than in previous decades combined to decrease rapidly the amount of energy consumed by end users per dollar of GNP. Although the rate of electricity penetration is expected to

Figure 1-7

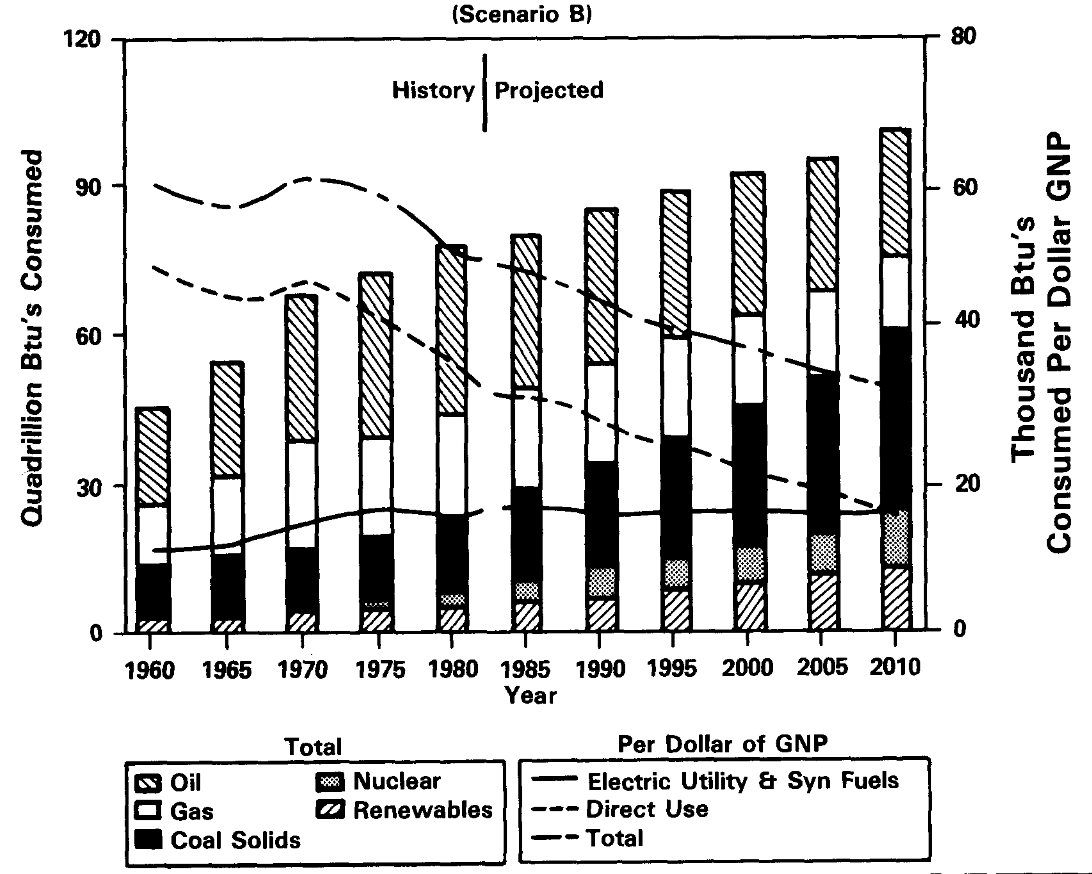
ENERGY USED BY FINAL U.S. CONSUMERS:
TOTAL AND PER 1982 DOLLAR OF GNP
(Scenario B)



slow somewhat in the future, the overall pattern of lower per dollar GNP consumption is expected to continue at a pace that will reduce total end-use energy consumption increases to minimal levels. Almost all of this savings will be in oil and gas consumption which, on a per dollar of GNP basis, is expected to decline by more than 50 percent during the projection period. The fall in primary energy consumed per dollar of GNP was not as rapid over the past 20 years and is not anticipated to be as rapid over the next 30 years as the projected decline in end-use energy consumed (see Figure 1-8). The reason for this is also electricity's increasing market share. More electricity generation means more transformation losses. In fact, while direct use per dollar of GNP is anticipated to fall to about half its 1983 level by the year 2010, utility and synthetic fuels inputs per dollar of GNP are expected to remain constant. As a result of these trends, while total end-use consumption is increasing at only 0.2 quads per year after 1990, primary consumption is projected to increase at four times that rate.

Figure 1-8

U.S. PRIMARY ENERGY CONSUMED:
TOTAL AND PER DOLLAR OF GNP
(Scenario B)



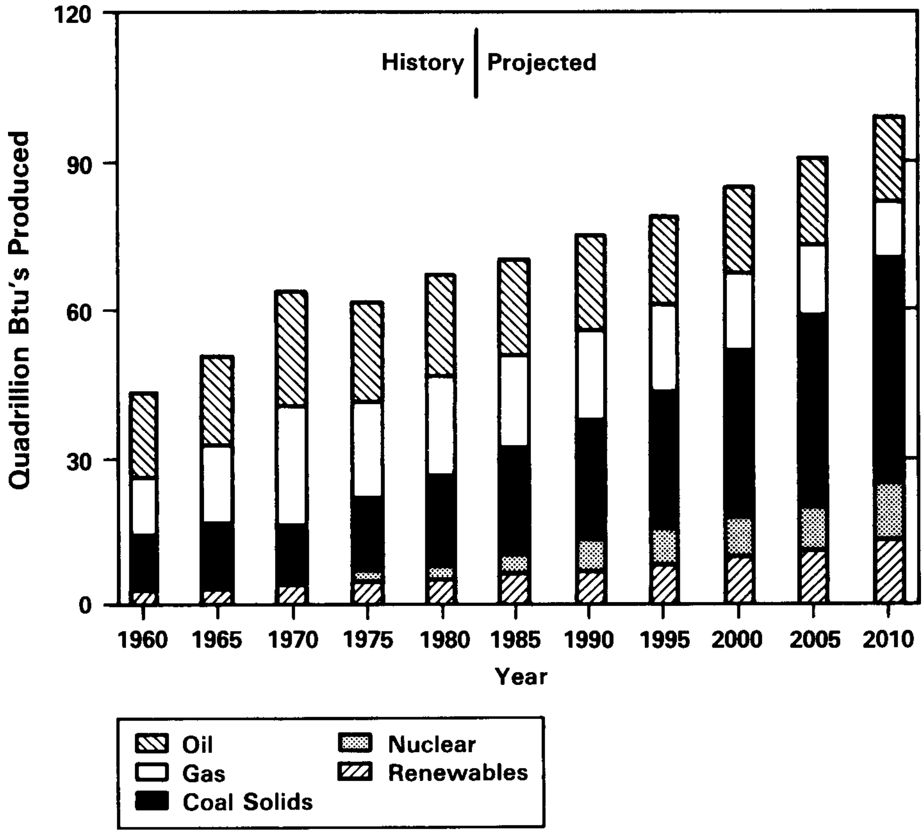
1.3 ENERGY SUPPLIED TO THE U.S. ECONOMY

The consumption patterns described require that energy resources of the correct types and quantities be supplied. Sources of such supplies include indigenous production, trade with other countries, and changes in energy inventories. The United States has been endowed with both an abundance and a variety of energy resources. Therefore, historically most of this country's energy needs have been met with domestically produced energy (Figure 1-9 show the historic and projected growth of U.S. energy production). In fact, United States energy production was over 90 percent of consumption in the 1960's, fell slightly below 80 in the 1970's and is estimated to have increased to about 90 percent in 1982. This pattern of relative self sufficiency is expected to continue. In fact, after a brief increase as a result of the economic recovery, U.S. net energy imports are expected to decline throughout the projection period. In order to simplify the analysis, it has been assumed that after 1985 inventories remain at approximately current levels.

Figure 1-9

U.S. INDIGENOUS ENERGY PRODUCTION

(Scenario B)



1.3.1 Indigenous Production

Each form of energy has unique characteristics which affect production. Oil and gas production is mostly limited by the volume of proven reserves. U.S. coal reserves, on the other hand, are so plentiful that production is primarily limited by domestic and international demand for U.S. coal. Nuclear and renewables are generally capital intensive, with production limited by the technology's cost competitiveness.

1.3.1.1 Oil

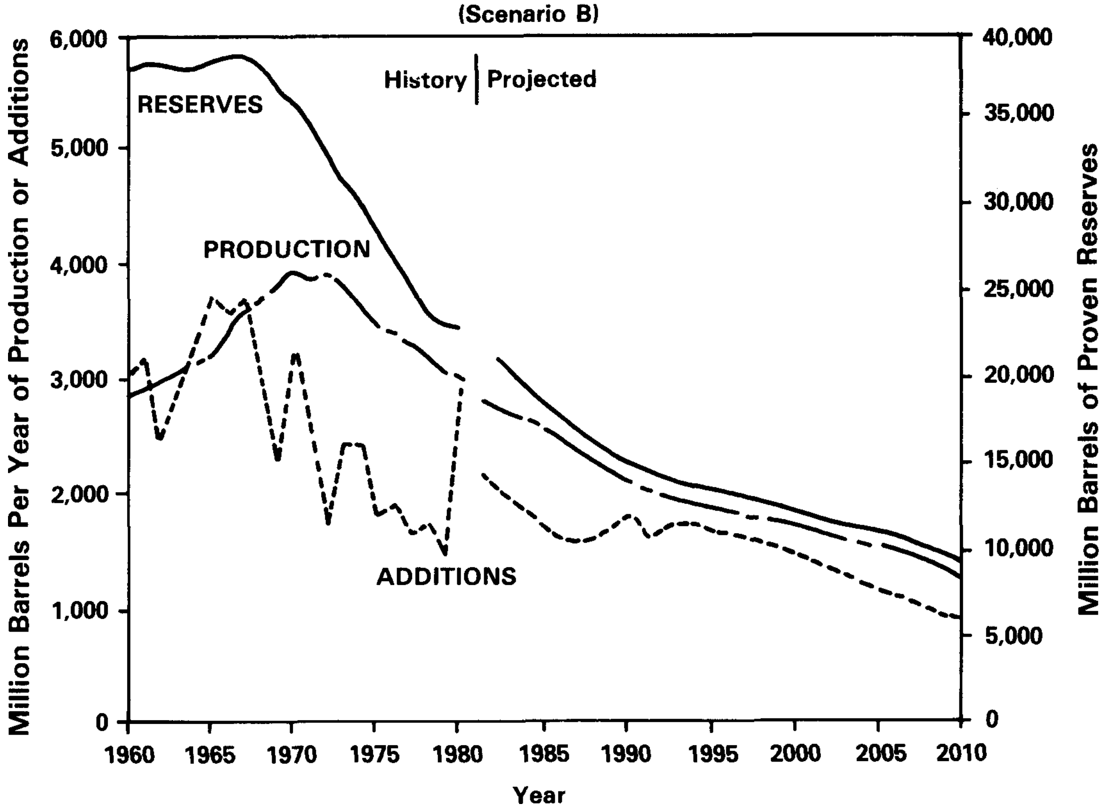
Projections of future oil production depend on assumptions regarding the size and economics of the resource base, production costs, and the rate of technological development. There are important additional factors which must be considered when estimating future production in North Alaska. These factors all reflect climatic and transportation differences between this frontier area and the lower-48 states.

Each year, new reserves of oil and natural gas liquids (NGL) are discovered. The amount added to total reserves depends on the amount of exploration and the size of newly discovered pools. Exploration increases when oil prices are rising and a good return on investment seems probable. The average size of the pools has tended to decrease over time since larger pools are generally easier to find than smaller ones and are therefore usually discovered sooner. The long-term trend over the past thirty years, indicates a gradual decline in additions to reserves within the lower-48 states (see Figure 1-10). Production from these reserves has exceeded additions for about the last 15 years causing total proven reserves also to decline. Assuming no technological breakthroughs, as remaining resources decline, the cost of production is projected to increase and the level of production to decrease. Although decreased production will contribute to increased prices and thus provide incentives for increased exploration, it is not expected that new discoveries will be of sufficient size to offset this downward trend. The higher prices will, however, make unconventional sources of oil, such as shale and coal synthetics, cost effective. If there is sufficient demand

Figure 1-10

U.S. LOWER-48 CRUDE OIL AND NGL RESERVES, ADDITIONS AND PRODUCTION

(Scenario B)



for liquids after the year 2000, when world oil prices are projected to be in the $36 to $80 per barrel range (1982 dollars), coal liquids and shale oil are expected to compensate for declines in lower-48 conventional oil production, NGL production, and enhanced oil recovery.

The most significant additional factor that must be dealt with when projecting North Alaskan production is transportation. Production is constrained by the peak capacity of the existing pipeline, about 2 MMBD. The projected slight increase in production through 2000 reflects a number of secondary assumptions. The technical problems of dealing with the harsh Alaskan climate and the conflicts between producers and environmental interest groups are presumed to be resolved. Projected increases in the world oil price are assumed to encourage sufficient exploration to keep production close to pipeline capacity. Finally, it is assumed that projected world oil prices will not provide sufficient economic incentives for investment in pipeline expansion.

The net result of these various behavior patterns is 1 to 1.5 percent per year decline in total U.S. domestic oil production for the next 10 to 15 years. In the long term, however, total liquids production (including coal liquids) is expected to stabilize as increases in unconventional liquids production offset declines in conventional production.

1.3.1.2 Gas

Like our projections of future oil production, projections of gas production depend on resource and production assumptions. Also as with oil, unconventional gas production is not expected until around the turn of the century when prices are expected to be sufficiently high to make such efforts profitable. The natural gas market is further complicated, however, by uncertainties with respect to natural gas prices and policies. This analysis is based on an assumption that the Administration's natural gas consumer regulatory reform legislation is approved by Congress.

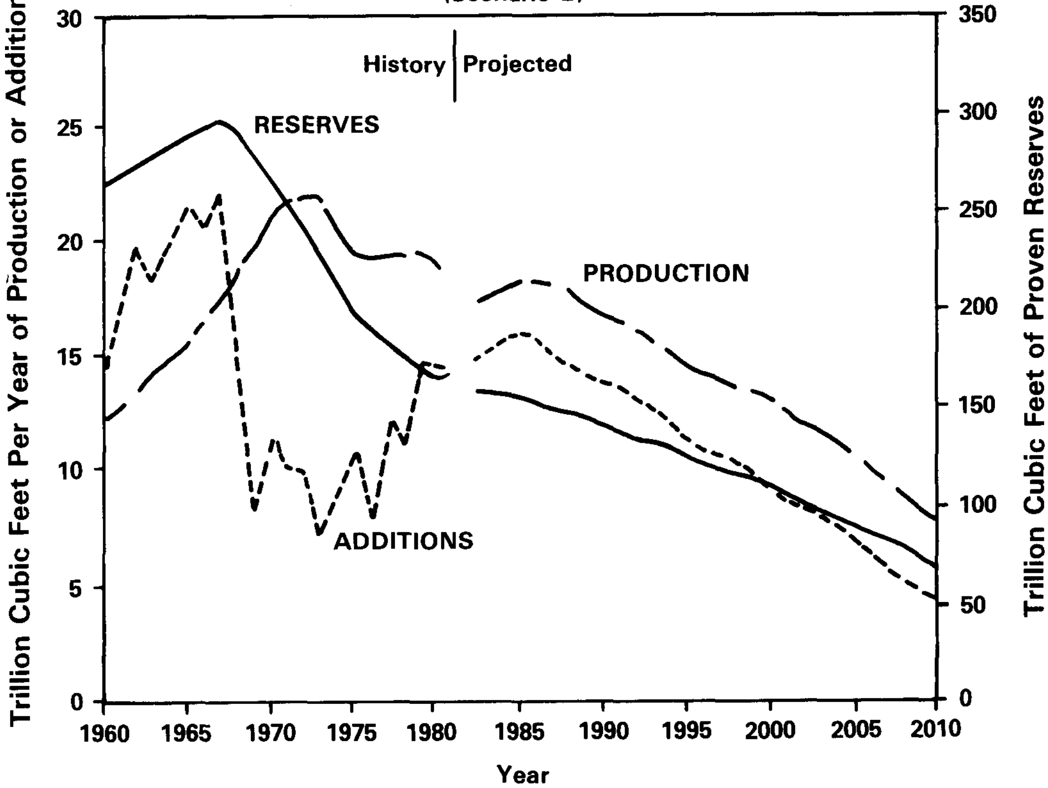
Conventional gas production includes both associated dissolved gas (which either lies in contact with, or is dissolved in, crude oil) and non-associated gas. Projections of associated gas production depend on the level of crude oil production. Projections of non-associated gas depend on the gas resource base and production assumptions. The history of U.S. lower-48 natural gas reserve additions and production is similar to that of oil and NGL (see Figure 1-11). However, the rate at which new gas reserves are discovered is expected to decrease more rapidly than oil. As a result, it is anticipated that conventional lower-48 gas production will begin declining in the late 1980's. Although some of this may be partially compensated for by North Alaskan gas once the Alaskan Natural Gas Pipeline is completed, U.S. conventional natural gas production is projected to decline at 2 to 5 percent per year from 1990 to 2010.

The drop in conventional production will contribute to price increases in the 1990's, which will provide incentives for unconventional and synthetic gas production. Unconventional gas production is expected to come on line

Figure 1-11

U.S LOWER-48 NATURAL GAS RESERVES, ADDITIONS AND PRODUCTION

(Scenario B)



in the early 1990's, reaching around 1 trillion cubic feet (Tcf) by 1995. The price at which synthetics become economic is not expected to be reached until at least the turn of the century with between 0.5 and 2 Tcf of production projected in 2010.

Natural gas price controls and the economic recession contributed to about a 2 Tcf drop in total natural gas production from 1980 to 1982. After a 1 to 1.5 Tcf rebound by 1985 (primarily as a result of the economic recovery), total natural gas production is expected to drop slowly through 1990. Although synthetic gas production may slow the decline after 2000, unless unanticipated reserves of natural gas are discovered, total natural gas production declines are expected to continue for the remainder of the projection period.

1.3.1.3 Coal

Coal is our most abundant fossil energy resource. Despite some difficulties in applying this fuel source cleanly enough to maintain environmental quality standards, coal is expected to serve as an important transitional element in U.S. energy supply over the next 30 years. For example, as explained in the section on "Energy Transformation" (section 1.2.5) the coal-generated percentage of total electricity sales will increase until after the year 2000, when nuclear and renewable technologies are able to take on more of this burden. Future U.S. coal production will depend primarily on the dynamics of coal demand. Existing coal mines and transportation facilities are estimated to have the capacity to produce and deliver about 1.0 to 1.2 billion tons of coal per year (175-375 million tons greater than estimated 1982 production). Given this estimate of coal capacity, producers could provide the projected 30-percent increase in coal production between now and 1990 with little or no expansion of their capacity. In the long term, some U.S. coal reserves could be uneconomic to mine because of their location (under highways or cities), high state severance taxes, or strict environmental laws. However, even if the development of as much as 50 percent of estimated reserves proves to be economically prohibitive, coal production is expected to be adequate to meet projected demand.

1.3.1.4 Nuclear

The nuclear power projections included in this report are based on plant-by-plant analyses, which are prepared by the Energy Information Administration and updated each year. This year's projections are lower than those issued in the past. This reflects current slowdowns in nuclear plant construction, the cancellation of some plants as much as 30 percent completed and several years without any new orders for nuclear plants. This behavior is the result of lower electricity demand expectations, financial constraints on utilities, and higher construction costs. The latter two are, in part, a result of increased industry and government vigilance regarding plant safety following the Three Mile Island incident. Orders for some new nuclear plants are expected in the late 1980's when electricity generating capacity is projected to be more highly utilized than at present.

There is much uncertainty regarding the number of orders, construction times, and other factors which will affect nuclear capacity after 1990. For example, the EIA analysis used in NEPP-1983, assumes only existing nuclear policies and programs. The Administration has a variety of nuclear-related policy proposals before Congress aimed in part at restoring stability to the Federal nuclear powerplant licensing process. If successful, such regulatory reform could result in a higher reliance on nulcear power than EIA projects under midrange assumptions (see Table 1-1 for a range of nuclear capacities based on alternative assumptions).

Although not significant in terms of contribution to total electricity production, several domestic commercial fast-breeder reactors could be in operation by 2010. Beyond 2010, breeder reactors and the eventual development and commercialization of fusion reactors could become an increasingly important source of U.S. and world electricity production.

Table 1-1

Alternative Projections of U.S. Nuclear Capacity
(Gigawatts)

	1990	1995	2000
Lower Projection[1/]	112	113	110
Mid Projection	114	122	130
Higher Projection[2/]	121	127	140

[1/] The lower case reflects continued utility financial problems leading to nuclear construction delays and cancellations. This case assumes cancellation of units with less than 30 percent construction completed or for which construction has been indefinitely deferred.

[2/] The higher case reflects improvement in utility financial conditions and other changes in nuclear investment and construction which result in few cancellations and the start of new orders for additional nuclear capacity starting in the late 1980's.

Source: "Estimates of Future U.S. Nuclear Power Growth," Energy Information Administration, Service Report SR-NAFD-83-01, Pre-Publication Draft, January 1983

1.3.1.5 Renewables

Renewable energy technologies can be used to generate electricity in central-station powerplants or to produce energy used directly by end-use consumers. In this analysis central-electric data is presented in terms of the equivalent primary energy inputs required to generate electricity in conventional steam-turbine plants. Dispersed renewables cannot be presented in these terms, however, since it is often impossible to determine the conventional fuel form being replaced in a given application and conversion efficiencies vary widely. For example, if space heating requirements are provided with renewables and a 300-percent efficient electric heat pump is being replaced (current technology is approaching this level of efficiency), given an average electric utility conversion efficiency of 32 percent, primary inputs to the electric utilities are being displaced on about a one-for-one basis. However, if electric resistance heat, which is about 100 percent efficient, is being replaced, then 3 units of primary inputs are being replaced for each unit of renewables recorded. Thus, although dispersed renewables are recorded in terms of the Btu's of energy service they supply, this method of measurement will almost always understate their contribution as a replacement of primary energy. It should be noted that passive solar energy systems, which range from window shades to architectural and site modifications, and might therefore most properly be considered an aspect of energy conservation, are considered to be a dispersed renewable technology in this analysis.

Almost all central-electric renewables production in 1982 was from hydro-electric generators. The potential for increasing hydro-power is, however, limited by the availability of appropriate sites. The next renewable form to make a significant contribution to central-electric generation is expected to be wood. This technology is not, however, expected to make a large penetration into the market. Projected price increases of oil and then gas, in the 1990's, are expected to stimulate the development of large-scale wind, photovoltaic, and perhaps solar central-electric technologies. Such advances are projected to reduce hydro's share of the central-electric renewables market from almost 100 percent in 1980 to between 45 and 75 percent in 2010.

Just as central-electric renewables are currently dominated by hydro, dispersed renewables are dominated by wood use. The major renewables consumer is the pulp and paper industry, which uses wood and wood waste as a source of process heat. The potential for large-scale increases in biomass use outside the wood products industry is dampened by the comparatively high costs of gathering, transporting, and processing raw biomass material. Modest increases are anticipated in the use of wood for residential heating and of grain for the production of alcohol. The price increases of the 1970's instigated a great deal of dispersed renewable technology development. On a national level, significant amounts of solar equipment are expected to be in place in the mid 1980's, with geothermal and then wind playing a role in the 1990's. Photovoltaics are projected to be a promising late-comer to the renewables scene, jumping from less than 0.05 quads in the mid 1990's to around 0.5 quads in 2010. As was the case with central electric, the market share of the dominant technology of the early 1980's (in this case biomass) is projected to fall significantly (to around 65 percent) by the year 2010.

Major cost and technical feasibility uncertainties affect renewables projections. Factors such as the future cost of competing energy sources, the rate of economic growth, and consumer acceptance of new technologies in the marketplace also affect future renewables supply. The role of renewables in the national energy equation is, therefore, highly uncertain. Renewables could develop from a modest current contribution to a significant energy supply source by 2010, depending on factors which are difficult or impossible to quantify at this time.

1.3.2 Trade

As consumers seek to meet their energy requirements in the least expensive manner, it is often found that the cost of using energy produced in other countries, including transportation expenses, is less than the cost of providing additional energy from domestic sources. Thus, international energy trade takes place. Since the early 1950's, the United States has been a net importer of energy. Over this period, U.S. energy imports have been mostly oil with some natural gas and very small amounts of electricity. For decades, the U.S. has been the world's primary exporter of coal.

From 1969 till they reached their peak in 1977, U.S. oil imports grew at almost 13 percent per year despite the doubling of real oil prices in 1973. The second doubling of prices in the late 1970's combined with the decontrol of domestic oil and the economic recession to cause a sharp decline in imports over the last few years. Most of the fluctuation in U.S. imports has been accommodated by OPEC suppliers. While the total has remained relatively constant, the makeup of the United States' non-OPEC suppliers has shifted over the last decade. During this period Canada's exports to the U.S. decreased by almost two-thirds while Mexican exports increased to fill much of the gap. Net U.S. imports of oil are projected to increase, in the near term, as the economy recovers. After reaching a new peak in the 1985 to 1995 period (1 to 3 MMBD below the 1977 high of 8.6 MMBD), net oil imports are expected to stabilize for at least 5 years and then start a long decline.

Although a large net importer of petroleum, the U.S. does export a significant quantity of petroleum. U.S. petroleum exports remained relatively stable for about 15 years at around 200 thousand barrels per day and then tripled in the past 6 years. More than half of this increase was a result of growing exports from the continental U.S. to Puerto Rico, the Virgin Islands and other U.S. possessions which have traditionally been included in the non-U.S. OECD statistics. Some crude exported to U.S. territories is refined into products such as gasoline and imported back into the continental U.S. for final consumption. Despite the recent increase in exports, the U.S. is still a net oil importer from its territories. The other half of the petroleum exports increase reflects sales to Mexico, non-U.S. OECD countries, and a few other nations. In 1982 the U.S. exported 16 percent of the amount of petroleum it imported.

Unlike oil, which can be loaded onto common carriers in its raw form and transported from one part of the world to another, natural gas must be transported via pipeline or be liquified before shipment. This greatly reduces the flexibility of international gas trade and helps to explain why the U.S. exchanges natural gas almost exclusively with Mexico and Canada. Small amounts of Liquified Natural Gas (LNG) are purchased from Algeria, while some U.S. LNG is sold to Japan. Although the United States does export some natural gas to Mexico and Canada, it is far less than the amount we import from these nations. In recent years, decreasing demand and the high prices charged by Mexico and Canada have caused our net gas imports to decline by over 15 percent per year. It has been estimated that, if the economics of the market place made it desirable, the physical capacity in place would allow more than a doubling of U.S. imports from these neighboring nations. It is not, however, expected that net imports will reach this level until after the turn of the century.

During the 1960's and early 1970's, U.S. coal exports slowly increased. The world oil price increases of 1973 caused a temporary surge in the international demand for U.S. coal. This was followed by just under a doubling of coal exports when oil prices increased again in the late 1970's. Almost all U.S. coal trade is with Canada, Western Europe, and Japan. Canadian imports of U.S. coal have remained relatively stable over the last 20 years. Over the past 10 years, Western European imports of U.S. coal have responded dramatically to changes in oil prices and the inability of other major coal-producing countries to expand production to statisfy the resulting increased coal demand. In the late 1960's, the Japanese began purchasing large quantities of coal from the United States. In the 1970's, Japanese demand for U.S. coal fluctuated as they attempted to minimize their costs by shifting from one source to another. Given the high cost of importing U.S. coal, it is anticipated that the United States will continue to be the coal source of last resort. With stable or falling oil prices in the near term, U.S. coal exports are expected to be stable until about 1990. As oil and then gas prices increase, stimulating global coal demand, U.S. coal exports could more than double 1982 levels by 2000 and then double again by 2010. As in the past, Canadian imports of U.S. coal are expected to remain relatively constant with most of the increased demand generated in Europe and Japan. Because the United States is projected to be the world's marginal supplier of coal, small changes in world oil prices and world economic growth could radically alter projected U.S. coal exports (see, for example, Chapter 6).

U.S. net imports of electricity are a small and slowly growing share of total electric supply. In the early 1980's, U.S. net electricity imports were less than 34 billion kilowatt-hours. This total resulted from about 34 billion killowatt-hours of net imports from Canada and some minor exports to Mexico. The import of electricity is particularly significant in some regions of the United States which border Canada. For example in 1981, imports amounted to over 11 percent of New York's electricity supply. Although the Nation as a whole is projected to continue to import only about 1 percent of its electricity needs, changing conditions could lead to increased U.S. electricity imports from Canada.

CHAPTER 2: EXPLANATION OF FREE-WORLD DATA AND PROJECTIONS

Energy markets are becoming increasingly integrated and global in scale as oil, coal, and natural gas trade increases. Therefore, to place the U.S. energy situation into its proper global context, it is necessary to understand important aspects of world energy prices, consumption, supply, and trade. It is difficult to understand changing global patterns of energy behavior, however, without dividing the world into groups of nations with meaningful similarities. The most common major division is between the "Free World" and the "Centrally Planned Economies" (CPE's). The free world can be usefully subdivided into the Organization for Economic Cooperation and Development (OECD) member countries (most of the industrialized nations), the Organization of Petroleum Exporting Coutries (OPEC), and the Rest of the Free World (mostly developing nations). Since this report focuses on the United States, the OECD has been subdivided into U.S. and non-U.S. portions (U.S. territories are included in the non-U.S. OECD).

2.1 WORLD ENERGY PRICES

The prices of different energy fuels depend on the unique characteristics of each fuel. Some of the most important of these are as follows:

- Oil--OPEC is the world's marginal supplier of oil. Under some circumstances, members of OPEC (acting independently or as a cartel) can have a strong direct impact on the world oil price. This control of world oil prices is limited, however, since OPEC countries must account for the impacts their actions will have on world economic conditions and since many important determinants of future world oil market conditions are not directly controllable;

- Natural Gas--Although a good substitute for oil and coal for use in boilers and other non-transportation applications, natural gas is limited by high transportation costs. Typically, gas prices are strongly linked to delivered petroleum product prices through competition. In those areas where gas is readily available, however, gas prices could become decoupled from oil prices and compete more directly with coal;

- Coal--The U.S. is the world's marginal supplier of steam coal. Thus the price of delivered U.S. coal is assumed to have a strong impact on world coal prices. Because of large coal reserves and competitive markets, U.S. coal prices are assumed to depend on production costs (including the cost of safety and environmental regulations) plus distribution and delivery charges (including normal profit);

- Electricity--Electricity has unique uses (e.g., lighting and motor drive), is expensive to transport long distances, and is typically a regulated commodity. For these and other reasons, it is assumed that, like U.S. coal prices, electricity prices depend primarily on production costs plus distribution and delivery charges (including a normal profit); and

- Renewables--Prices of renewable energy resources are set largely by the characteristics of the form of the renewable source: liquid renewables compete with petroleum products and have prices directly linked to oil prices; centralized-electric renewables have prices linked to the cost of other energy forms used to generate electricity.

Prices act to balance supply and demand. Energy supply and demand projections are uncertain. As the residual of two uncertain variables, energy price projections are very uncertain. In general, however, it is assumed that oil and natural gas are supply constrained and that, as a result, the prices of these fuels will increase markedly within the projection period. Other energy prices are projected to increase more slowly since production is, over the long term, expected to be adequate to meet demand.

2.1.1 Oil Prices

After decades of stable or gradually declining real world oil prices, world oil markets have witnessed more than 10 years of volatile price behavior. The future world oil price path will probably also be marked by a series of sharp increases followed by periods of price stability or decline. Since it is very difficult to predict the timing and magnitude of these fluctuations, it is perhaps better, for policy analysis purposes, to use smooth scenarios that approximate an average of the infinite number of erratic oil price path possibilities. In developing such world oil price scenarios for this analysis, we represented OPEC behavior in a manner that emphasizes OPEC's role as the free-world's marginal supplier of oil. As a check on the assumptions made in this analysis, the impact of alternative price paths on OPEC revenues was tested.

The objective of this analysis is to develop scenarios which bound our best estimate of the range of uncertainty faced by U.S. markets and can thus be used in the evaluation of domestic issues. Therefore, the world oil prices discussed in this report are defined as the average U.S. refiner acquisition cost of crude oil imports. As such, the prices given include insurance and transportation costs required to deliver crude oil to domestic refiners (referred to as cost, insurance, and freight or C.I.F.).

2.1.1.1 World Oil Price Fluctuations

Small changes in free-world oil supply or demand can lead to large short-term oil price fluctuations. Accurately predicting the timing and magnitude of such changes or projecting the resulting short-term price responses is close to impossible. For planning purposes, however, attempts are made to project long-term world oil price trends.

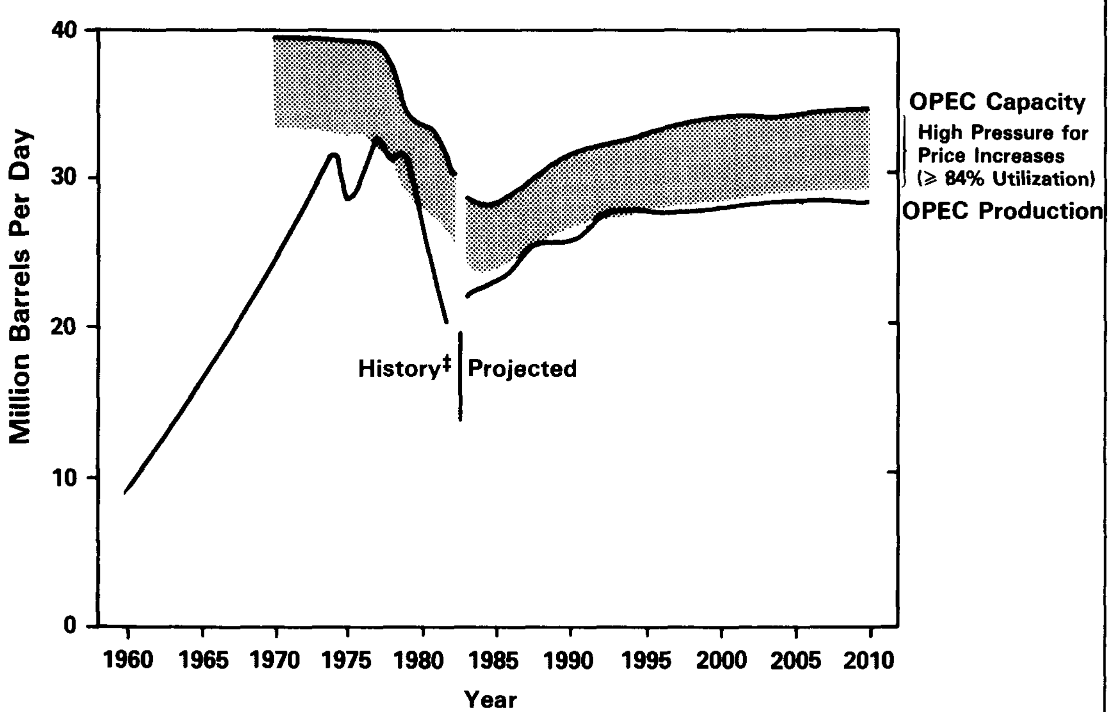
Two forms of supply fluctuations have affected world oil markets over the past 10 years and will continue to affect them into the forseeable future. The first is the planned adjustment of OPEC production capacity. Since gaining control over oil production facilities, OPEC countries have been lowering their production capacity (see Figure 2-1). This has lowered their costs, forced importers to use inventories to meet seasonal demand peaks (thus leveling OPEC production) and reduced the production buffer (i.e. the difference between capacity and actual production), which had helped keep prices stable for many years. The second is an unexpected supply disruption. Oil supply disruptions can be caused by terrorist acts, wars, or political actions such as the 1973 embargo. Although no one can foresee when such disruptions will occur or their severity, we believe that the price impacts of disruptions are short term in nature with most of the effects dissipated within 5 to 10 years (see Figure 2-2).

Demand fluctuations tend to be more gradual than supply disruptions since they usually result from cycles in the economy. When economic growth is at a cyclical peak, demand for all forms of energy, including oil, is usually also at a cyclical peak. As free-world oil demand increases, OPEC capacity utilization increases (see Figure 2-3). To reduce production to desired levels, OPEC might respond to these increases by substantially increasing the price of its oil (Figure 2-4). Even with these insights, however, the irregularity of business cycles makes them hazardous to include when doing

Figure 2-1

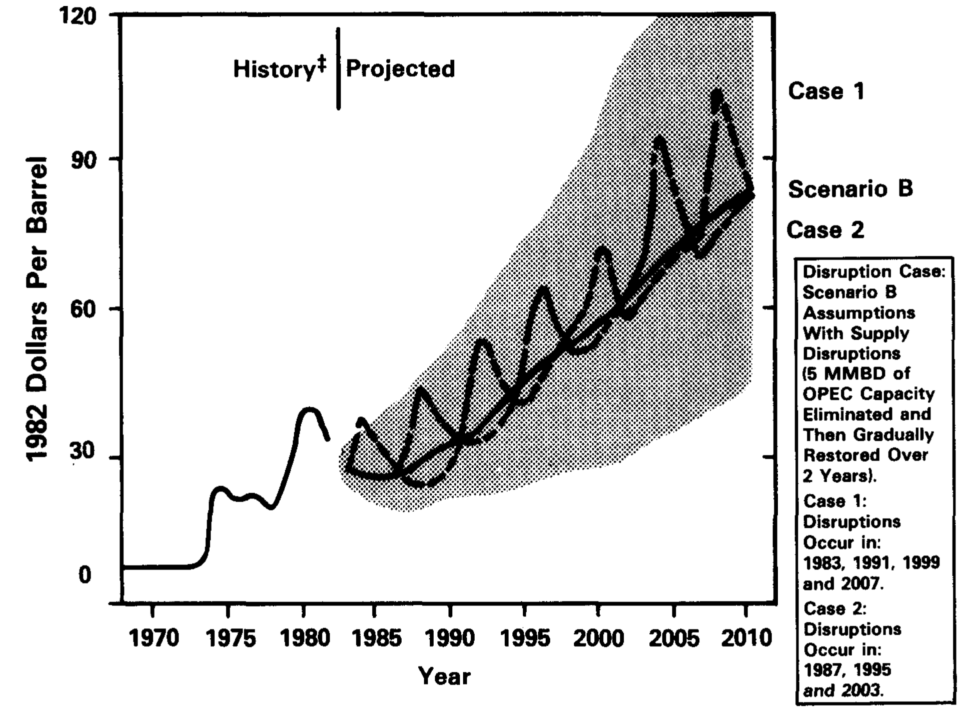
OPEC OIL PRODUCTION CAPACITY AND PRODUCTION

(Scenario B)



‡International Data is Often Incomplete and Subject to Frequent Revision.

Figure 2-2
EFFECT OF DISRUPTIONS ON THE WORLD OIL PRICE*



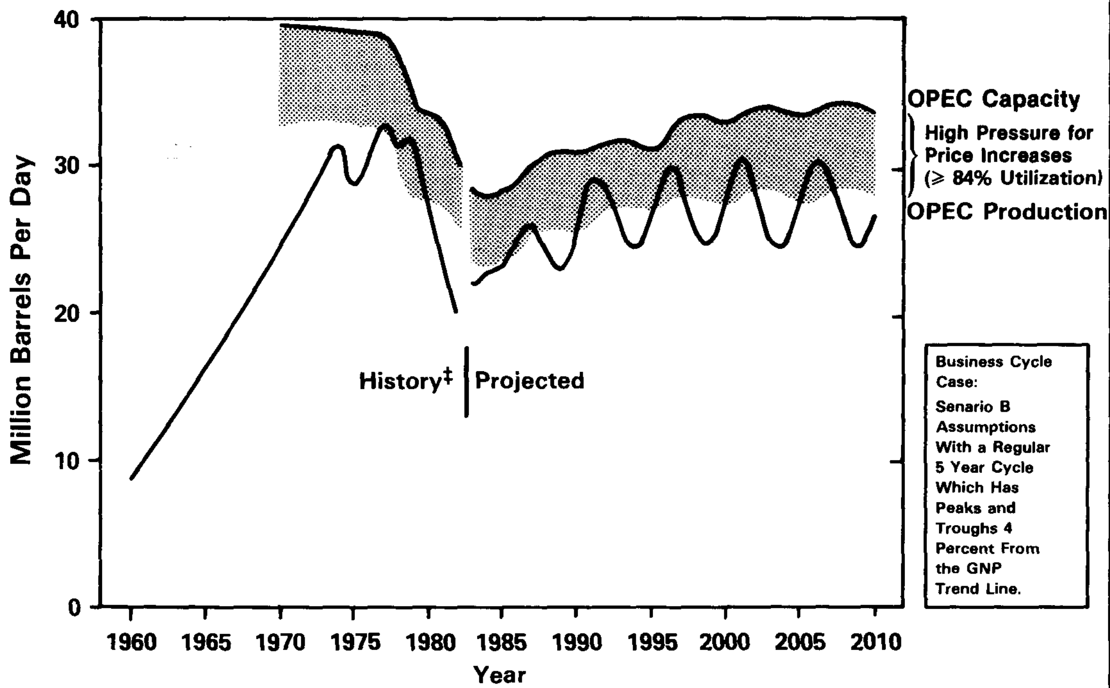
*U.S. Refiner Acquisition Cost of Crude Oil Imports. The Disruption Paths Shown Reflect the Sensitivity of the WOIL Model to the Assumption Changes Noted and Not A Detailed Analysis of the Potential Impacts of a Disruption. The Shaded Region Illustrates the Range of Prices Resulting From Combinations of All of the Assumptions Tested.
‡International Data Is Often Incomplete and Subject to Frequent Revision.

long-term energy projections. In fact, if one were to assume regular 4-year business cycles and 5-year cycles actually occurred, then after 10 years the predicted cycles would be 180 degrees out of phase with what was observed. At that point this price projection could be about twice as far off as a projection which had ignored the short-term impacts of business cycles.

The purpose of the NEPP-1983 world oil price projections is to provide input into long-term planning decisions such as synthetic fuel loan guarantees and energy research and development policy. Temporary supply and demand fluctuations can have dramatic short-term effects on oil prices, making them rapidly rise or fall. We believe it is more useful for our purposes, however, to attempt to capture the long-term economic pressures for world oil price change rather than present the multitude of plausible price paths which might occur as a result of these random fluctuations. Therefore, only smooth projected world oil price paths are discussed in the remainder of this report.

Figure 2-3

EFFECT OF BUSINESS CYCLES ON OPEC PRODUCTION*



*The Results Shown Reflect the Sensitivity of the WOIL Model to the Assumption Change Noted and Not a Detailed Analysis of the Potential Impacts of Business Cycles.
‡International Data Is Often Incomplete and Subject to Frequent Revision.

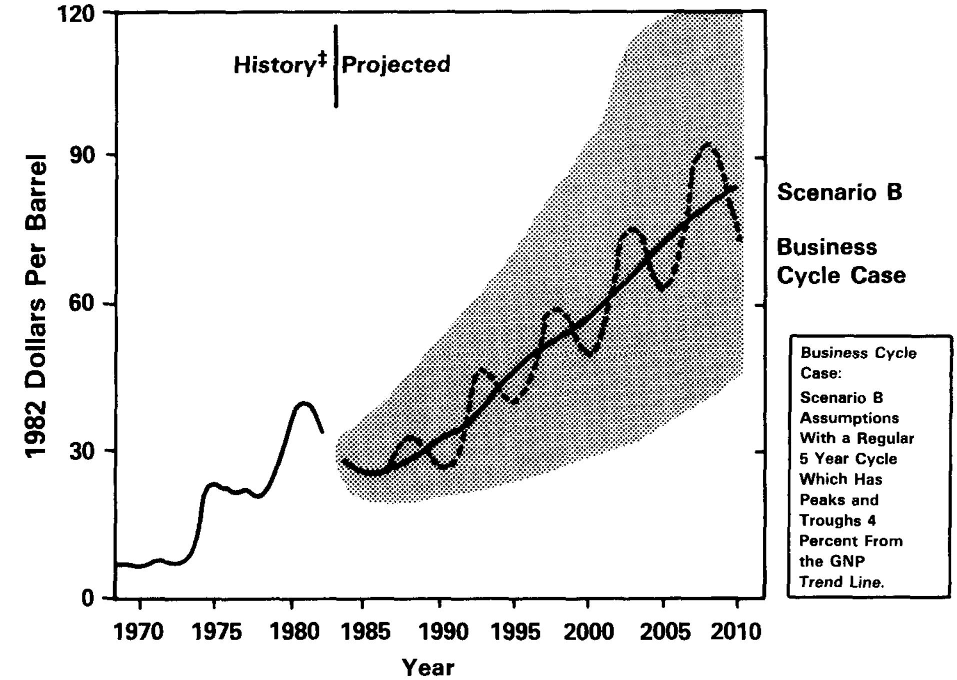
2.1.1.2 OPEC Behavior

The Organization of Petroleum Exporting Countries (OPEC) is commonly referred to as a cartel. Market forces have limited the impact of most cartels. None the less, oil prices are much higher today than prior to the emergence of this oil cartel in the early 1970's. If market forces also have limited the impact of this cartel, there must be other factors which have contributed to the price increases experienced. An understanding of how these factors interrelate can serve as the basis for developing expectations about future world oil prices.

Developing countries, such as the members of OPEC, generally export primary products to pay for their development. The governments of less developed countries tend to argue that the prices of their primary goods are too low compared to the prices of manufactured goods which they must buy. For at least 50 years, such countries have attempted to stabilize and raise the price of their goods through "commodity agreements" or cartels. OPEC is the most recent example of this practice. Difficulties arise in the execution of such a policy because the control of prices requires the control of

Figure 2-4

EFFECT OF BUSINESS CYCLES ON THE WORLD OIL PRICE*



*U.S. Refiner Acquisition Cost of Crude Oil Imports. The Business Cycle Path Shown Reflects the Sensitivity of the WOIL Model to the Assumption Change Noted and Not a Detailed Analysis of the Potential Impacts of Business Cycles. The Shaded Region Illustrates the Range of Prices Resulting From Combinations of All of the Assumptions Tested.
‡International Data Is Often Incomplete and Subject to Frequent Revision.

production. Other things equal, at a higher price less of a good will be demanded, and incentives will be created for non-cartel member countries to increase production and for cartel members to cheat by increasing production. Attempting to set prices above competitive levels therefore usually leads to lower demand for the cartel's goods and, as a result, lower prices, much lower production by cartel members (if they hope to maintain their price), or both.

The 1973 embargo marked the final transition of Middle Eastern oil production management from international oil companies to the oil-producing nations. These nations have different perspectives and different needs than the oil companies and thus base their decisions on a different set of objectives. Further, each OPEC member has a unique combination of characteristics which cause the prices and quantities it would find most desirable to be different from the prices and quantities any other member would find most desirable. Libya, for example, has rather limited reserves, rather ambitious political objectives, and a relatively high population. This means that Libya has a high absorptive capacity for revenues. Saudi Arabia, on the other hand, has sufficient reserves to allow it to continue to sell oil well into the next century as well as a relatively low population. For

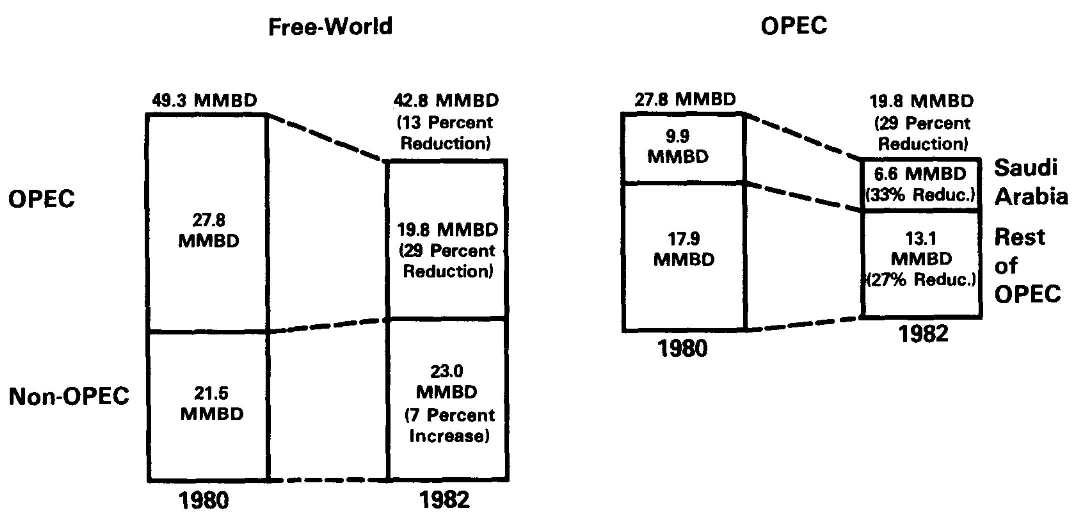
Libya, there are incentives to try to maximize short-term revenues by increasing prices. For Saudi Arabia, there are incentives to keep prices at moderate levels. This would allow the Saudis to maintain their long-term market while gradually industrializing in an orderly manner. To operate effectively as a cartel, OPEC needs to convince all members that they will benefit from a cooperative effort to maintain a given price/production level. Recently, OPEC prices and production have fallen dramatically. High prices directly and indirectly (by surpressing economic growth) caused lower demand and higher non-OPEC production than would have occurred otherwise. This resulted in lower demand for OPEC oil. For a variety of reasons, including the fact that they have the most oil reserves, a relatively low population, low revenue needs, and a desire to stabilize the Middle East and avoid invasion or revolution, Saudi Arabia has absorbed much of this loss (see Figure 2-5).

Although OPEC has not been able to escape the problems inherent in cartels, the price of oil, in constant dollars, is over four times what it was in 1970 and is projected to continue to increase in the future. The reason for this lies partly in the cartel, partly in the change of oil production decision-makers, partly in the change in expectations which has taken place since the early 1970's, and partly in continued global development. Under limited circumstances OPEC has had and will continue to have an effect on world oil prices. The production incentives of companies producing oil from leased reserves are different from those of countries producing oil from reserves they own. Thus the individual members of OPEC also have an impact on the oil market. In the 1970's analysts began noting that projected oil production would soon outstrip projected oil reserve additions. Discussions

Figure 2-5

FREE-WORLD AND OPEC OIL PRODUCTION*

1980 AND 1982



*Includes Natural Gas Liquids (NGL).

of how soon "scarce" oil resources would be depleted became commonplace. Whether correct or not, such "conventional wisdom" has an impact on the decisions of both oil users and producers as they hedge against the future. Expectations about the cost of manufacturing alternatives have become more pessimistic. In 1979, estimates were that synfuels would be competitive once oil prices were between $35 and $50 per barrel (1982 dollars). Current estimates are in the $50 to $80 range. Finally, as economies continue to expand, they consume more energy. Therefore, unless oil prices increase at a rate sufficient to cause demand reductions and fuel-switching, the demand for oil could grow beyond free-world supply capabilities. Actions taken by the cartel, production decisions being made by the individual members of OPEC to meet their revenue needs, expectations of depleting oil reserves, higher priced alternatives to oil, and higher oil demand caused by economic growth all have contributed and will continue to contribute to an upward world oil price trend.

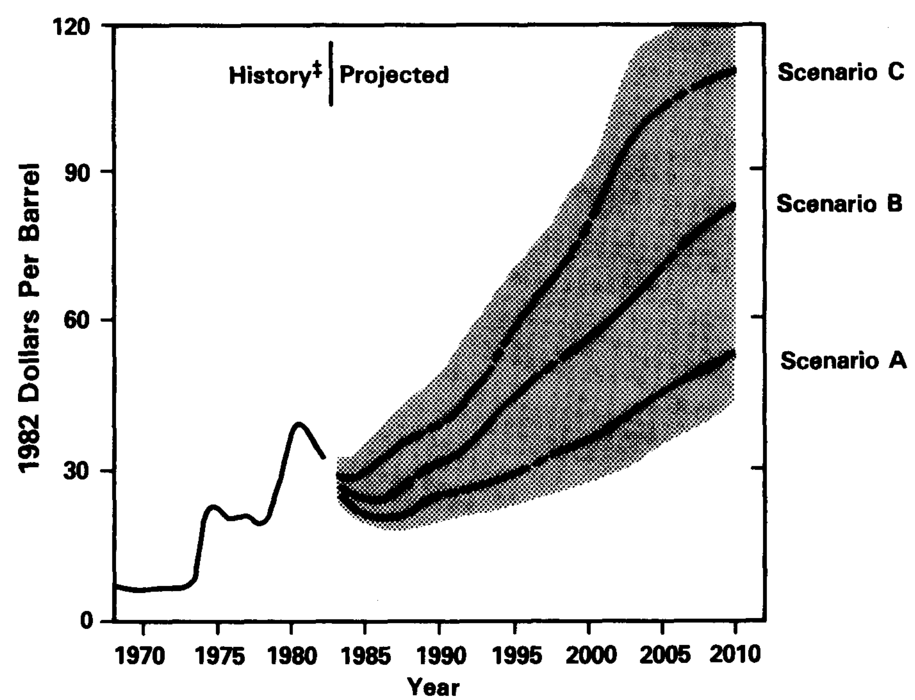
Historical evidence indicates that when markets are tight OPEC raises prices and expands capacity, and when markets are soft it lowers prices and reduces capacity. All of the previously discussed difficult to quantify factors influence the magnitude and timing of this behavior. For this analysis, this qualitative understanding had to be converted into a quantitative estimate of future world oil prices. We believe that the most useful indicator of world oil price movements and OPEC's flexibility is OPEC oil capacity utilization (production divided by production capacity). When their capacity utilization is around 80 percent (for example, production of 26 MMBD and capacity of 32 MMBD), OPEC countries (especially Saudi Arabia) have the most leverage over world oil price movements. They can substantially increase or decrease production in order to achieve desired prices, revenues, or general market conditions. However, when their capacity utilization is significantly higher than 80 percent, OPEC countries, either acting together as a cartel or individually, have limited ability to hold down price increases through expanded production. OPEC countries tend to follow the spot market at such times, even though they may cause the contract price to exceed the long-term equilibrium price and cause a subsequent oil glut. The 1979/1980 period is illustrative of such behavior: OPEC capacity utilization was high because of the loss of Iranian capacity, and world oil prices rose rapidly. On the other hand, when its capacity utilization is significantly below 80 percent (perhaps as a result of previous price increases), OPEC's ability to slow price decreases by contracting production is limited and it again has little control over the market. Indeed, when production is very low, declining revenues can lead to cash-flow problems for some OPEC nations which could in turn weaken member cooperation and lead to rapid price declines. Such behavior was evident in late 1982 and early 1983.

This view of world oil price behavior provided the basis for estimating the price path necessary to balance projected free-world oil supply and demand. For the next several years production capacity expansion in Iran and Iraq and demand increases resulting from a global economic recovery and the replenishment of depleted oil inventories are projected to create a situation where nominal prices remain stable (which means prices are declining somewhat in real terms). Five years or more of declining or constant real world oil prices and a global economic recovery are projected to cause increasingly rapid growth in oil consumption by the mid to late 1980's. With easily accomplished OPEC oil production capacity expansion completed, a brief tightening of the oil market is expected. It is projected that this tight market may result in 5 to 10 percent per year real world oil price increases. After 1990, assumptions about factors such as the level of demand reduction which can be expected at a given price and the amount of ultimately recoverable oil reserves will dictate the oil price expectations of individuals making or using energy projections. If demand is expected to be low and resources high (Scenario A), projected price increases need only be high enough to compensate for economic growth assumptions. Under such circumstances, real oil prices may not return to the 1980 level until after the turn of the century (see Figure 2-6). If, on the other hand, demand is expected to be high and resources low (Scenario C), rapid world oil price increases could occur. Under these circumstances, real oil prices could be twice the 1980 value by the year 2000.

2.1.1.3 OPEC REVENUES

The potential impact of world oil prices on OPEC revenues is an important consideration in analyzing OPEC behavior. OPEC is more likely to take actions to support high rather than low revenue scenarios. Consequently,

Figure 2-6
WORLD OIL PRICES*

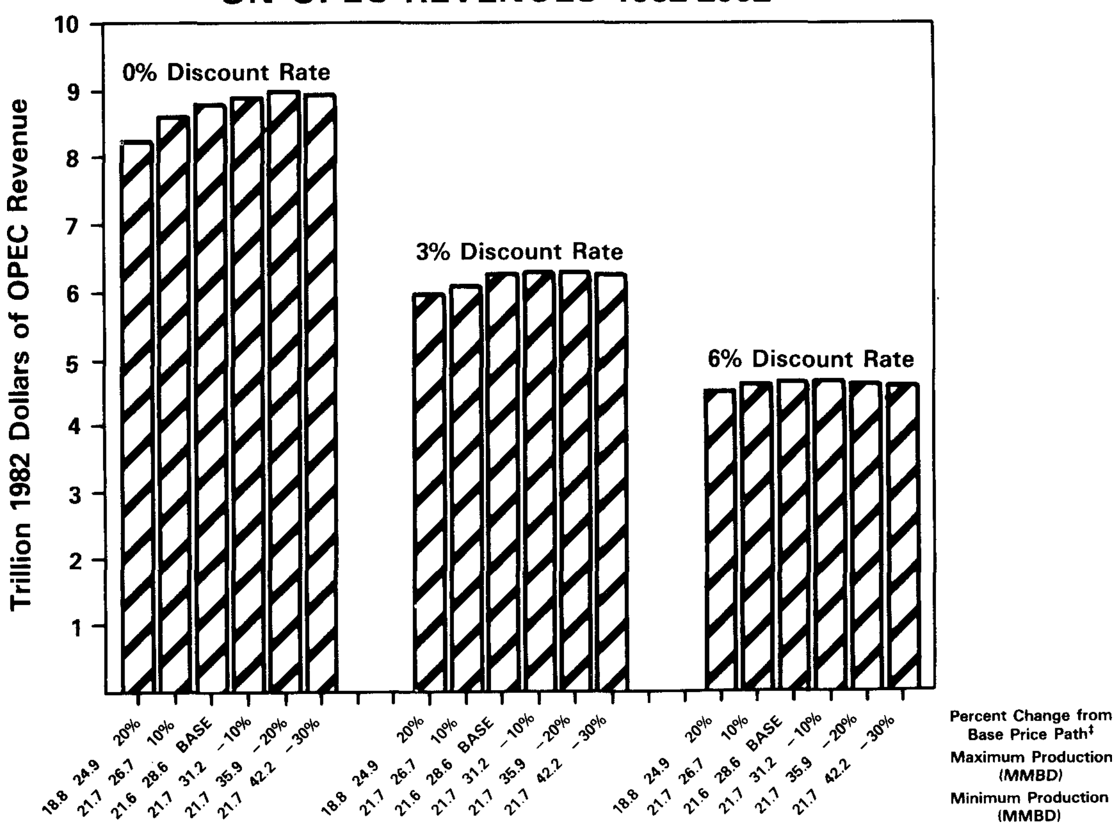


*U.S. Refiner Acquisition Cost of Crude Oil Imports. The Shaded Region Illustrates the Range of Prices Resulting From Combinations of Assumptions Tested.
‡International Data Is Often Incomplete and Subject to Frequent Revision.

world oil price scenarios resulting in higher OPEC oil revenues seem more plausible than low revenue scenarios. As a test of the methods used to develop the price paths presented in this report, the production levels and the net present value of OPEC revenues generated under a variety of price paths and discount rates were determined. The price paths used in this revenue test were derived by taking a reference case (Base) similar to Scenario B and then shifting the entire price path up and down by the percentage increments shown on Figure 2-7. The OPEC revenues presented are only a very rough indicator since they do not take account of changes in OPEC production costs over time or the value of OPEC oil reserves remaining at the end of the time frame (i.e. 2002). Despite the tentative nature of the analysis, three significant observations can be noted: (1) regardless of the price path or the discount rate, OPEC stands to make a very large amount of money over the next 20 years; (2) prices that are continuously too low or too high result in what are considered by many analysts to be unlikely quantities of OPEC oil production (that is, less than 20 MMBD or more than 32 MMBD); and (3) OPEC revenues are not greatly affected by significant shifts in the world oil price path. This test indicates that the world oil prices resulting from our analysis are plausible in that they produce credible OPEC revenues while causing OPEC oil production to remain within reasonable limits.

Figure 2-7

EFFECT OF ALTERNATIVE WORLD OIL PRICE PATHS ON OPEC REVENUES 1982-2002*



*Actually an Indicator Equal to OPEC Exports Times the World Oil Price.
‡The Base Price Path Used Here Was an Early Preliminary Estimate and Not One of the Scenarios Shown Elsewhere in This Document. If any of Those Paths Were Used, However, the Important Insights Would Be the Same.

2.1.2 Natural Gas Prices

International natural gas trade, and the resulting interrelationship of international natural gas markets, is limited by transportation constraints. Unless liquefied and transported in special ships, a relatively expensive technique, natural gas can only be traded between countries connected by a pipeline. Thus, natural gas markets tend to be localized, with prices established through the competition of natural gas with locally available fuels. Natural gas typically competes as a fuel for stationary uses such as boilers. This means that for the foreseeable future delivered gas prices should be competitive with delivered residual fuel oil prices (since residual fuel oil is a primarily boiler fuel). In the long term, the use of oil for stationary uses is expected to be reduced to maintain its availability for transportation purposes. Consequently, natural gas prices are likely, in some regions of the world, to be set in competition with fuels cheaper than oil, such as coal.

2.1.3 Other Energy Prices

The prices of other energy forms (coal, electricity and renewables) are expected to rise at a considerably slower rate than oil prices. The reasons for this are:

- Since the U.S. is the free-world's marginal supplier, world coal prices are expected to be tied to the cost of providing U.S. coal. With more than sufficient coal reserves to last well into the next century, it is not expected that coal extraction costs will rise much because of depletion. Factors contributing to coal price increases are, therefore, expected to be rising labor costs, taxes, transportation charges, and other fees. Delivered coal prices in the U.S. industrial sector, for example, are projected to increase less than 2 percent per year in real terms through 2010;

- Feedstock costs are a much smaller fraction of delivered electricity prices than of other delivered energy prices. Increased feedstock costs have, therefore, less of an impact on electricity prices than on other delivered fuel prices. Further, utility feedstocks are primarily coal and nuclear, both of which have slow projected cost increases. Consequently, average electricity prices are not projected to rise as rapidly as oil and natural gas prices; and

- Renewable costs are tied more to technology than to a depletable resource base. As such, renewable costs are likely to decrease in the future with technological innovation. Consequently, the price of using renewable energy may decrease rather than increase as other energy prices are projected to do.

Oil and natural gas prices are projected to rise more rapidly than other fuel prices. As a result, their use will continue to drop relative to the use of coal, electricity and renewables as consumers try to pay less for energy services. Eventually, only uses of oil or natural gas which depend on the special characteristics of these fuels will remain economic. Such uses include certain industrial processes, nonenergy feedstocks and, especially for oil, transportation.

2.2 ENERGY CONSUMED BY THE FREE WORLD

Energy is consumed to provide a desired service. A country's desired services from energy depend, in turn, on the country's state of industrial development. One would therefore expect a different relationship between economic activity and energy consumption in developed countries as compared with less developed countries. The total demand of developed and developing countries for differing fuels define global energy markets. The most important of these is the oil market. Although we have learned a great deal over the past decade, there is still considerable debate regarding the type of demand behavior that can be expected in the future.

After remaining nearly constant from 1960 to 1970, energy use per dollar of GDP for the industrialized countries (the U.S. and other OECD), is projected to continue its present decline through the end of the century and beyond (see Figure 2-8). A major cause of this decrease is the steady rise in real energy prices projected for that time frame. Also, because the OECD countries underwent industrialization during a period when energy prices were relatively low, those economies now use energy relatively inefficiently given current and projected energy prices. As energy prices rise, the OECD countries can, therefore, implement energy-efficiency improvements which allow economic activity to expand without a one-for-one increase in energy consumption. Because infrastructure, housing, and some types of capital equipment can last over 60 years, this process of improved energy-efficiency could continue well into the next century.

A very different trend has been seen and is projected for the less developed countries, which include the countries within OPEC. Energy consumption per dollar of GDP in the less developed countries actually increased significantly from 1970 to 1975. From 1975 to 2010 it is expected that, after some slight decline, energy consumption per dollar of GDP will stabilize or perhaps grow slightly. These countries are in the process of becoming industrialized. They do not now consume a lot of energy, so the potential for energy conservation is limited. Most have yet to develop the infrastructure (power lines, etc.) needed to use the most efficient energy consuming technologies. Further, the oil-exporting countries in this group often subsidize domestic energy prices, thereby reducing conservation activity.

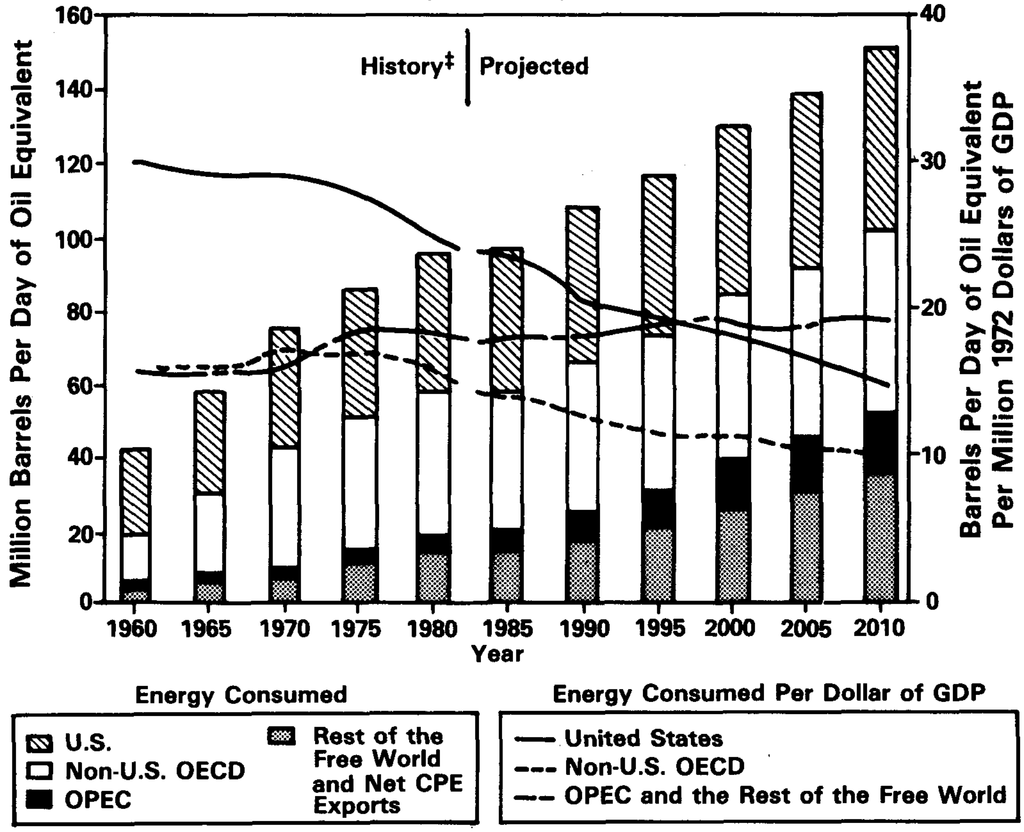
As to the consumption patterns for individual fuels, coal, nuclear and renewable energy consumption has been relatively stable per dollar of world GDP since the mid 1970s. Globally the ratio for oil and natural gas use has been decreasing over this period (see Figure 2-9). Both these trends are expected to continue. A cause of this divergent pattern of fuel consumption can be found in the relatively high rate of price increases for oil and gas as compared to other fuels (see Section 2.1).

Figure 2-8

PRIMARY ENERGY CONSUMED BY THE FREE WORLD

BY REGION

(Scenario B)



‡ International Data Is Often Incomplete and Subject to Frequent Revision.

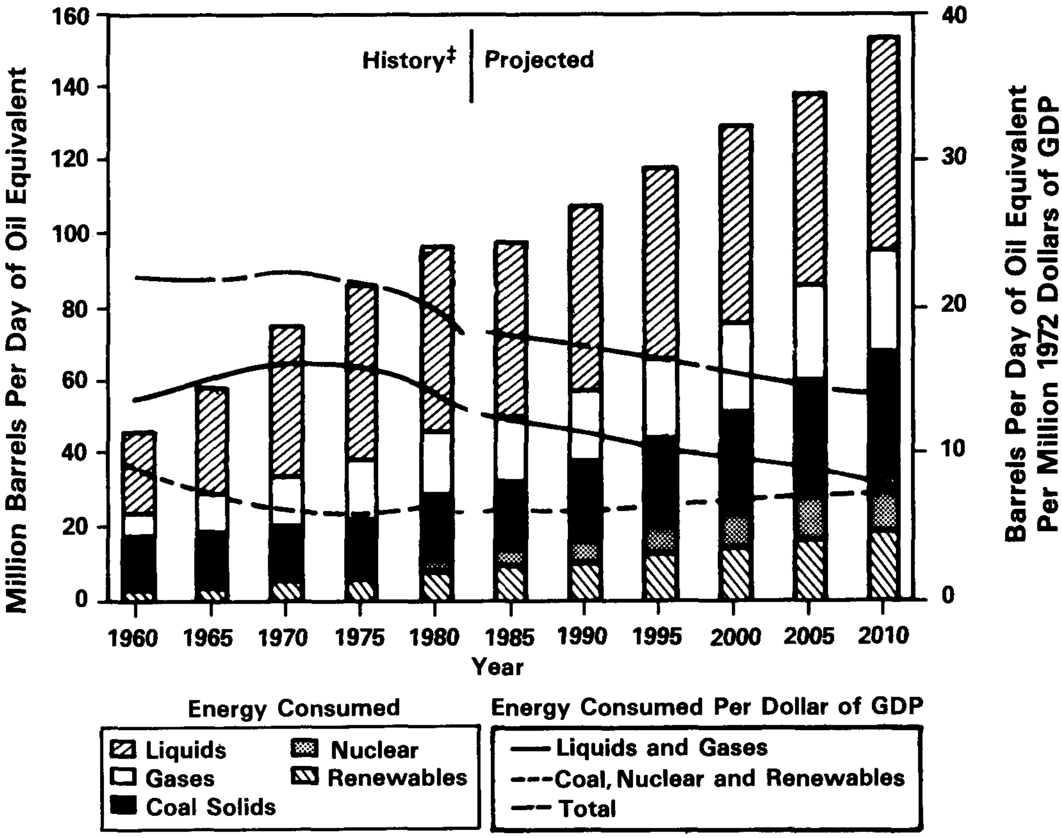
Of all the fuels, the oil consumption pattern undergoes the most change during the 1960 to 2010 time frame. From 1960 to 1980, oil consumption increased dramatically (see Figure 2-10). Partly because of the global recession, however, oil consumption is actually projected to decline from 1980 to 1985. It is then expected to increase moderately before leveling off after the turn of the century. The sharp break in the oil consumption trend of the 1960's and 1970's is a result of the dramatic real oil price increases of 1973/74 and 1979/80. Although the long-term, total free-world oil consumption trend remains fairly stable, there are marked differences in behavior between the industrialized countries and the developing countries. The most recent downward trend in oil consumption per dollar of GDP for the developed countries began after the 1973/74 price increases. The price jump only slowed the rate of increase in the developing countries. The second price jump in 1979 did produce a slight turn-around, however. Even so, while total oil consumption in developed regions is projected to decline from the mid 1980's through 2010, total consumption in developing countries is projected to increase. Some reasons for this are:

Figure 2-9

PRIMARY ENERGY CONSUMED BY THE FREE WORLD

BY FUEL TYPE

(Scenario B)



‡ International Data Is Often Incomplete and Subject to Frequent Revision.

- o OPEC and other less developed countries are growing faster than developed countries and thus need additional energy;
- o As mentioned, OPEC members, Mexico and other oil exporting countries often subsidize local petroleum product prices thus stimulating consumption;
- o Less developed countries have less ability to raise the capital needed to build electric generating facilities and thus use alternative energy sources like nuclear, coal and renewables;
- o The needs of a newly urbanizing society have allowed oil to maintain its market share at the expense of coal and other solid fuels such as agricultural wastes.

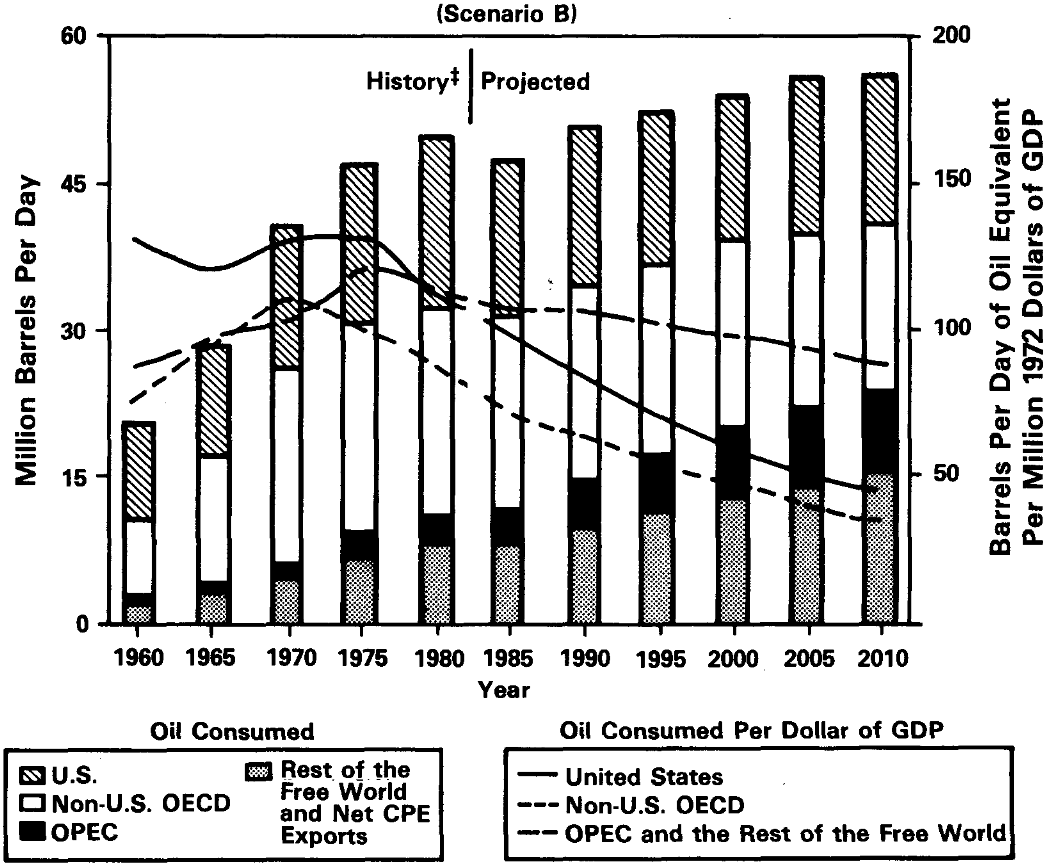
Many analysts seem to agree with the direction of the demand trends described above. There is a large range of opinion, however, regarding the rate at which these changes will take place. For example, in recent years

Figure 2-10

OIL CONSUMED BY THE FREE WORLD

BY REGION

(Scenario B)



‡ International Data Is Often Incomplete and Subject to Frequent Revision.

new data have caused some analysts to reevaluate and increase their estimates of energy conservation potential. Two key demand issues about which there is great uncertainty are the level of conservation possible given anticipated energy prices and the rate at which less developed countries can proceed with their industrialization programs in the face of rapidly increasing energy prices.

2.3 ENERGY SUPPLIED TO THE FREE WORLD

Energy supplied to the free world comes from indigenous production, stock changes, and trade with Centrally Planned Economies. The indigenous production of energy is constrained by the quantity and location of oil and other energy resources. Given our knowledge of these reserves, estimates of future production can be made. There are, however, many uncertainties regarding both reserves and the manner in which they will be exploited. To simplify our analysis, trade with the Centrally Planned Economies is an exogenous assumption (see Chapter 4), and after 1985 stock levels are assumed to remain constant.

Oil is not uniformly distributed around the globe. Now, as in the early 1970's, about 70 percent of the world's proven oil reserves are found in OPEC countries. There have been some significant changes, however, in non-OPEC reserves over this same period. While OECD and, after the mid 1970's, non-Mexican developing countries have been depleting their oil resources, Mexico's proven reserves have increased ten-fold. Approximately 9 percent of the world's proven oil reserves can now be found within Mexico's borders.

The distribution of other energy supplies have also been changing. Proven reserves of natural gas in the OECD countries peaked in the early 1970's despite the addition of the North Sea and Alaskan fields. The largest increases in proven gas reserves were in Mexico (doubling since 1970), the other developing countries (tripling), and the U.S.S.R.. The coal situation has not changed significantly over the last decade. The U.S. has the world's largest base (about 24 percent of the world's coal resources) followed by the U.S.S.R. (about 16 percent), China (about 13 percent), Western Europe (about 11 percent), and Australia (about 3 percent). Investments in nuclear energy have caused global nuclear capacity to increase seven-fold since 1970. The increase in nuclear production (from less than 1 percent of free-world energy supplies in 1970 to almost 4 percent in 1982) was, however, almost exclusively in the OECD countries. Finally, the use of renewables and other forms of energy has increased by over 65 percent since 1970, amounting to more than 9 percent of free-world energy supplies in 1982.

Given past and anticipated resource development, the most significant trends in historical and projected regional energy production are:

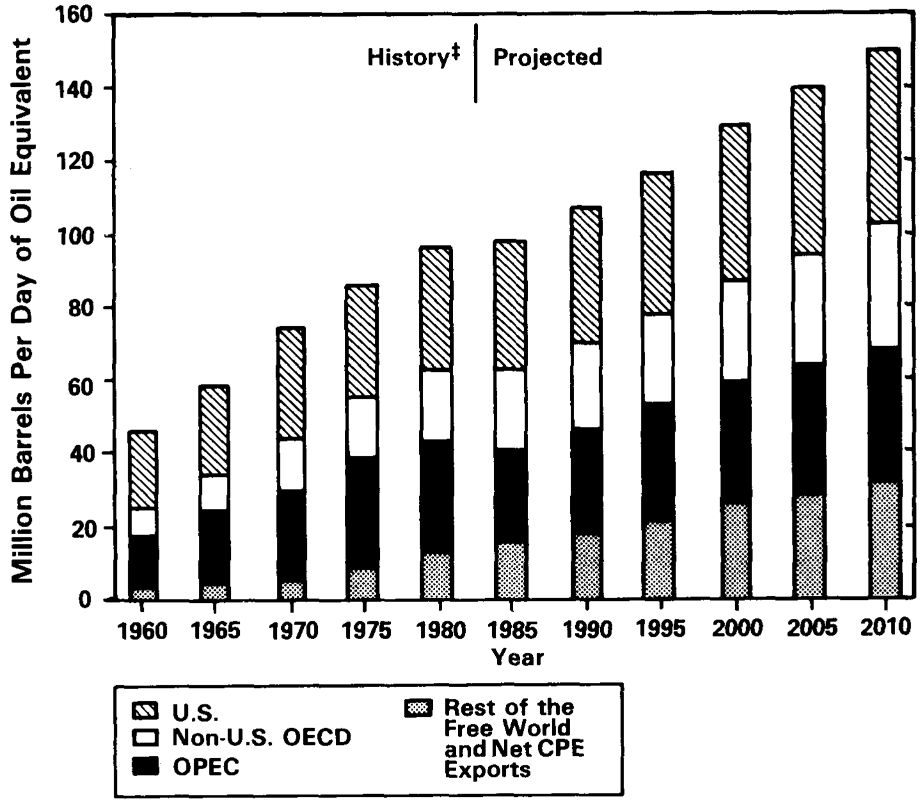
- OECD energy production grew by only about 25 percent from 1970 to 1982 and is projected to increase by about 50 percent in the next 30 years (see Figure 2-11). This growth contrasts considerably with the doubling of energy production in the Rest of the Free World countries (excluding OPEC) for the 1970 to 1982 period and the projected further doubling by 2010;

- Non-OPEC oil production has grown by about 6 MMBD since 1970 and is projected to increase by another 3.5 MMBD before starting to decline after 2000 (see Figure 2-12). OECD oil production, however, is projected to peak in the 1980's. Thus most of the increase in non-OPEC oil production will come from Rest of the Free World countries, such as Mexico;

- OPEC oil production is projected to increase rapidly in the 1982 to 1990 time frame in response to rising world oil demand. We expect OPEC oil production to remain stable in the 24 to 28 MMBD range from 1990 through 2010.

Figure 2-11

ENERGY SUPPLIED TO THE FREE WORLD BY REGION (Scenario B)



‡ *International Data Is Often Incomplete and Subject to Frequent Revision.*

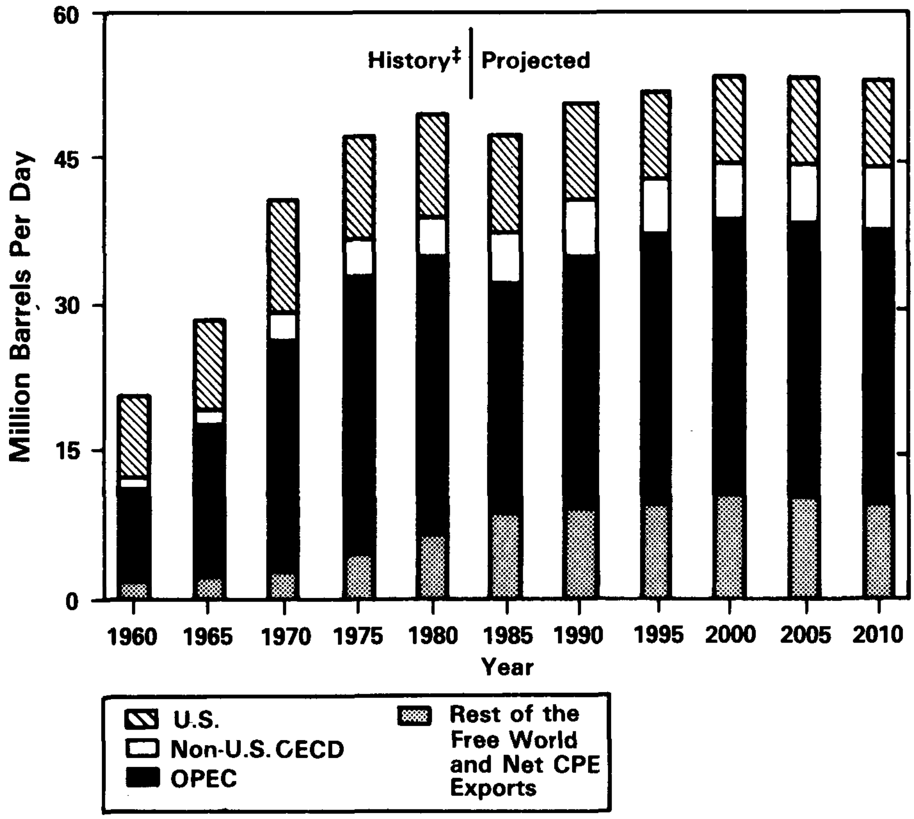
Not only is there uncertainty regarding the anticipated rates of change in the supply trends described above, for some fuels during some periods there is even disagreement about the direction of the changes. One reason for this disparity is differences in resource discovery expectations. Large oil and other energy deposits may or may not be found in the developing regions of the world. A second reason for this disparity is uncertainty caused by the potential impact that political and economic conditions may have on the development of known reserves in countries such as Mexico and China.

2.4 WORLD ENERGY TRADE

Oil and coal are the most conveniently traded forms of energy because they can be shipped using existing common carriers. Natural gas, on the other hand, is more expensive to transport because it requires large capital expenditures either for a pipeline or for special ships to carry liquefied natural gas. Renewables and electricity are also rarely traded because of

Figure 2-12

OIL PRODUCED BY THE FREE WORLD BY REGION (Scenario B)



‡ International Data Is Often Incomplete and Subject to Frequent Revision.

the expense of their transport. Although there is significant world trade in uranium, the feedstock for nuclear energy, it was not considered necessary to include this factor in developing these projections.

It is expected that OPEC will remain the free-world's primary exporter of oil and the U.S. will remain the primary exporter of coal. OPEC oil exports are expected to peak in the early 1990's at 21 to 22 MMBD and then slowly decline for the remainder of the projection period. U.S. coal exports are expected to increase through the turn of the century and beyond, growing from 106 million tons in 1982 to between 200 and 450 million tons in 2010.

PART II: SCENARIO B--REFERENCE PROJECTIONS

CONTENTS

CHAPTER 3: SCENARIO B--U.S. PROJECTIONS

These Scenario B energy projections represent but one of many possible U.S. energy futures. Part III of this report explores alternative scenarios including those which result in lower and higher world oil prices (Chapter 5) and those which result from lower and higher economic growth assumptions (Chapter 6). The purpose of Scenario B is not to provide a point prediction of future conditions, but rather to provide a reasonable, internally consistent and in-depth reference case or starting point for performing energy analysis. Readers are encouraged to use other scenarios besides the reference case to evaluate other possibilities concerning future world oil prices and economic growth.

This chapter presents key U.S. assumptions and results without any discussion of underlying causes, rationale or implications. Readers desiring such information are referred to the introduction and Chapter 1 of this report.

3.1 CONTEXT OF THE SCENARIO B U.S. PROJECTIONS

Key factors affecting the U.S. energy future include world oil prices, economic growth and domestic energy policies. Assumptions used in the development of the Scenario B NEPP-1983 projections are summarized in Table 3-1.

3.1.1 World Oil Prices

With Scenario B assumptions, a world oil price path results in which:

- OPEC is successful in stabilizing the world oil price at about $29 per barrel, nominal, in 1983 and 1984;

- after 1984 the world oil market tightens because of rising world oil demand spurred by economic recovery and relatively low oil prices. OPEC oil production (including natural gas liquids) reaches about 24 MMBD by 1986 (in part caused by free-world petroleum stock building--see Table 4-6 in Chapter 4);

- beyond 1985 world oil prices start to rise in real terms reaching about $32 per barrel by 1990, $57 per barrel by 2000 and $84 by 2010 (1982 dollars);

- how high prices go in the long term is affected in part by the cost and availability of alternatives to conventional oil (e.g. shale oil and coal liquids). We expect production of unconventional sources of oil to become economic with world oil prices between $50 and $80 dollars per barrel (1982 dollars).

Chapter 4 provides details on the Scenario B world oil price path, including projections of world energy consumption, production and trade. Changing world conditions have a major impact on our perception of what is a reasonable world oil price case. Major uncertainties affecting world oil prices include the rate and amount of oil demand increase accompanying world economic recovery, the willingness of OPEC members to maintain production ceilings and price floors to increase price pressures, and the rate of increase in non-OPEC oil and other non-oil energy production. Chapter 5 in Part III provides analysis of low and high world oil price scenarios for those readers interested in alternative world oil price views.

TABLE 3-1: SCENARIO B--KEY U.S. DATA AND ASSUMPTIONS

YEAR	SCENARIO B WORLD OIL PRICE[1/] NOMINAL DOLLARS PER BBL	SCENARIO B WORLD OIL PRICE[1/] 1982 DOLLARS PER BBL	GNP 1982 BILLION DOLLARS
HIST.			
1960	N/A	N/A	1527
1965	N/A	N/A	1925
1970	2.96	6.70	2249
1975	13.93	22.94	2551
1980	33.89	39.30	3053
1981	37.05	39.26	3113
ESTI.			
1982	33.59	33.59	3056
PROJ.			
1983	28.60	27.40	3126
1984	28.60	25.90	3271
1985	30.10	25.90	3439
1986	32.20	25.90	3553
1987	35.90	27.10	3665
1988	41.10	29.20	3771
1989	46.00	30.90	3874
1990	50.00	31.90	3978
1995	N/A	46.50	4526
2000	N/A	57.40	5065
2005	N/A	72.20	5671
2010	N/A	83.60	6275

DOMESTIC POLICIES

- o Implementation of the Administration's Natural Gas Consumer Regulatory Reform Legislation.
- o No major changes in current environmental laws.
- o No major changes to tax incentives provided under current law.
- o Continuation of Federal land leasing programs at current levels.
- o Continuation of Federal support for long-term Research and Development efforts.
- o Continuation of Synthetic Fuels Corporation efforts at current levels.

ECONOMICALLY RECOVERABLE ENERGY RESERVES AS OF 1980

RESOURCE	DISCOVERED[2/]	UNDISCOVERED	TOTAL
CRUDE OIL (Billion Barrels)	29.8	28-73	58-103
NATURAL GAS (Trillion Cu. Ft.)	199	393-689	592-888
COAL (Billion Tons)	246	200-400	446-646

1/ Refiner acquisition cost of crude oil imports.
2/ Excludes resources already recovered. Also excludes natural gas liquids (NGL) estimated at about 4.9 billion barrels of oil equivalent.

3.1.2 Economic Growth

Projected U.S. economic growth (under Scenario B assumptions) is shown in Table 3-2. For high and low economic growth assumptions and resulting energy projections, see Chapter 6.

TABLE 3-2: SCENARIO B--GROWTH RATES OF INTEREST

PERIOD	REAL GROWTH RATE (Percent per Year)			
	WORLD OIL PRICE	U.S. ECONOMIC GROWTH	U.S. PRIMARY ENERGY CONSUMPTION	U.S. ELECTRICITY CONSUMPTION
1960-1970	N/A	+3.9	+4.1	+6.9
1970-1980	+17.7	+3.1	+1.4	+4.1
1980-1982	-7.8	0.0	-3.4	-1.4
1982-1990	-0.6	+3.3	+2.0	+3.7
1990-2000	+5.9	+2.4	+0.8	+2.1
2000-2010	+3.8	+2.1	+0.9	+2.0
1982-2000	+3.0	+2.8	+1.3	+2.8
1982-2010	+3.3	+2.6	+1.2	+2.5

For Scenario B, U.S. economic recovery begins in 1983 with average growth from 1982 to 1985 equalling a little under 4 percent per year. Beyond 1985, U.S. economic growth slows slightly as the economy moves toward a stable long-term growth path.

3.1.3 Domestic Energy Policy

The Scenario B U.S. energy projections do not assume the implementation of any major new policies, with the exception that we do account for passage of natural gas legislation which conforms to the Administration goals of allowing competitive pricing of well-head natural gas and a complete decontrol of all categories of natural gas by 1986. Other major domestic energy related policies included are listed in Table 3-1.

3.1.4 Other Assumptions

Other assumptions which may be of interest to the reader are shown on Tables 3-14, 3-15, and 3-16.

3.2 U.S. ENERGY PROJECTIONS

We have included historical data going back to 1960 to aid the reader in understanding energy-use trends and to facilitate the comparison of our projections with other data. Historical energy data beginning in 1960 and projections of U.S. energy prices, production, and consumption to the year 2010 are shown in Tables 3-3 through 3-13. A guide to using the tables is shown in Figure 3-1 indicating which part of the energy system is detailed in each table. After the first table on energy prices, the tables appear in a sequence similar to the flow of energy in the U.S. economy. Totals shown in the tables, and elsewhere in this document, may not add due to independent rounding.

Questions always arise about the classification of specific energy information, such as where asphalt is included and how other feedstocks are accounted for. The Energy Information Administration (EIA) recently shifted asphalt from the commercial sector to the industrial sector. We also now use this convention. There is some controversy over where coal coke should be included. We consider coal coke to be used for energy purposes (as opposed to being a non-energy feedstock) even though a portion of the carbon in the coke is involved in a non-energy chemical reaction in steel making. All non-energy feedstocks are now included in the industrial sector. Also for the first time this year, electricity generation is treated as part of an energy transformation process which includes the production of synthetic fuels. This concept is particularly useful as the production of synthetic fuels becomes increasingly significant in the future. It is important to account properly for the production and consumption of synthetic fuels within an economy in order to avoid double counting their contribution. Finally, we have attempted to account for all renewable energy consumed in the U.S. economy (both commercial and non-commercial uses). For example, we have added estimates of historical wood energy use from an EIA report, Estimates of U.S. Wood Energy Consumption from 1949-1981. Since most other groups, (including EIA) do not include some types of renewable energy in their data and projections, both our historical data and projections of renewable energy may not be directly comparable with other studies.

TABLE 3-3: SCENARIO B--U.S. FUEL PRICE SUMMARY BY SECTOR[1/]
(1982 Dollars per Million Btu)

YEAR	WORLD OIL PRICE[2/] (1982$ /Bbl)	RESOURCE PRICES: REFINER CRUDE COST	RESOURCE PRICES: WELLHEAD GAS PRICE	RESOURCE PRICES: MINEMOUTH COAL PRICE	DELIVERED PRICES: RESIDENTIAL SECTOR: DISTILLATE	RESIDENTIAL: LIQUID GASES	RESIDENTIAL: NATURAL GAS	RESIDENTIAL: ELECTRICITY	COMMERCIAL SECTOR: DISTILLATE	COMMERCIAL: RESID FUEL OIL	COMMERCIAL: LIQUID GASES	COMMERCIAL: NATURAL GAS	COMMERCIAL: ELECTRICITY	INDUSTRIAL SECTOR: DISTILLATE	INDUSTRIAL: RESID FUEL OIL	INDUSTRIAL: LIQUID GASES	INDUSTRIAL: NATURAL GAS	INDUSTRIAL: COAL	INDUSTRIAL: ELECTRICITY	TRANSPORTATION SECTOR: GASOLINE	TRANSPORTATION: DIESEL[3/]	TRANSPORTATION: RESID FUEL OIL	TRANSPORTATION: JET FUEL
HIST.																							
1960	N/A	1.49	0.43	0.63	3.32	3.26	3.02	21.86	2.83	1.87	2.89	2.02	21.01	2.92	1.84	2.89	0.84	N/A	8.53	7.51	N/A	1.84	N/A
1965	N/A	1.36	0.44	0.55	3.15	2.90	2.84	18.39	2.92	1.53	2.51	1.92	17.02	2.73	1.53	2.51	0.89	N/A	7.33	6.94	N/A	1.53	N/A
1970	6.70	1.33	0.39	0.63	3.02	2.72	2.40	13.95	3.41	1.45	2.36	1.70	12.96	2.54	1.45	2.36	0.75	0.95	6.30	6.84	2.40	1.45	1.97
1975	22.94	2.95	0.74	1.42	4.48	4.13	2.75	15.48	4.28	3.72	3.84	2.18	15.23	4.27	3.71	3.84	1.42	1.87	9.27	7.54	4.65	3.71	3.53
1980	39.30	5.61	1.89	1.28	8.18	8.25	4.16	18.29	7.57	5.30	6.08	3.83	16.06	7.00	4.45	6.08	2.74	1.55	12.54	11.32	7.30	4.45	7.68
ESTI.																							
1982	33.59	5.49	2.36	1.32	8.47	9.26	5.39	20.11	7.80	5.60	6.20	5.00	20.11	7.90	4.90	6.20	3.60	1.65	14.51	10.24	7.25	4.90	8.51
PROJ.																							
1985	25.90	4.39	3.18	1.47	6.75	6.42	5.83	19.65	6.14	4.55	5.46	5.47	20.32	6.11	4.40	5.46	4.35	1.97	14.51	9.69	6.46	4.30	6.14
1990	31.90	5.49	3.90	1.55	7.89	6.94	6.22	21.13	7.20	5.59	6.74	5.91	22.24	7.07	5.43	6.74	4.91	2.16	16.13	11.13	7.97	5.43	7.21
1995	46.50	8.02	4.80	1.64	10.81	9.46	7.19	23.76	9.95	7.96	9.36	6.88	25.13	9.73	7.71	9.36	5.83	2.28	18.52	13.82	11.01	7.71	10.38
2000	57.40	9.90	6.75	1.76	12.99	11.34	9.28	24.07	12.00	9.73	11.31	8.97	25.56	11.72	9.40	11.31	7.87	2.43	19.03	16.00	13.27	9.40	12.74
2005	72.20	12.46	8.83	1.79	15.94	13.88	11.53	24.98	14.78	12.13	13.96	11.21	26.55	14.41	11.71	13.96	10.06	2.50	19.79	18.82	16.35	11.71	15.95
2010	83.60	14.41	10.02	1.89	18.20	15.83	12.82	24.67	16.91	13.97	15.98	12.49	26.22	16.47	13.47	15.98	11.32	2.63	19.54	20.98	18.70	13.47	18.40

1982 DOLLARS PER PHYSICAL UNITS

YEAR	PER BBL	PER BBL	PER MCF	PER TON	PER GAL	PER GAL	PER MCF	PER KWH	PER GAL	PER BBL	PER GAL	PER MCF	PER KWH	PER GAL	PER BBL	PER GAL	PER MCF	PER TON	PER KWH	PER GAL	PER GAL	PER BBL	PER GAL
ESTI.																							
1982	33.55	31.87	2.42	29.63	1.17	0.88	5.52	0.069	1.08	35.21	0.59	5.13	0.069	1.10	30.81	0.59	3.69	42.90	0.049	1.28	1.00	30.81	1.15
PROJ.																							
1985	25.90	25.44	3.26	33.80	0.93	0.61	5.97	0.067	0.85	28.62	0.52	5.61	0.069	0.85	27.65	0.53	4.45	49.67	0.049	1.21	0.89	27.02	0.83
1990	31.90	31.90	4.00	35.92	1.09	0.66	6.37	0.072	1.00	35.14	0.64	6.05	0.076	0.98	34.12	0.64	5.03	54.08	0.055	1.39	1.10	34.12	0.97
1995	46.50	46.50	4.93	38.06	1.50	0.89	7.36	0.081	1.38	50.07	0.88	7.05	0.086	1.35	48.45	0.88	5.97	57.16	0.063	1.74	1.53	48.45	1.40
2000	57.40	57.40	6.92	40.66	1.80	1.07	9.51	0.082	1.66	61.19	1.07	9.18	0.087	1.62	59.13	1.07	8.05	60.80	0.065	2.00	1.84	59.13	1.72
2005	72.20	72.20	9.06	41.40	2.21	1.31	11.80	0.085	2.05	76.27	1.32	11.47	0.091	2.00	73.61	1.32	10.30	62.45	0.068	2.35	2.27	73.61	2.15
2010	83.60	83.60	10.28	43.84	2.52	1.50	13.12	0.084	2.34	87.81	1.51	12.79	0.089	2.28	84.68	1.51	11.59	66.00	0.067	2.62	2.60	84.68	2.48

1/ Projected delivered prices are resource prices plus estimated markups for processing and distribution.
2/ U.S. average refiner acquisition cost of imported crude oil.
3/ Excludes taxes.

Figure 3-1

U.S. ENERGY SOURCES AND USES—1982 (IN QUADS)
(GUIDE TO TABLES 3-4 THRU 3-13)

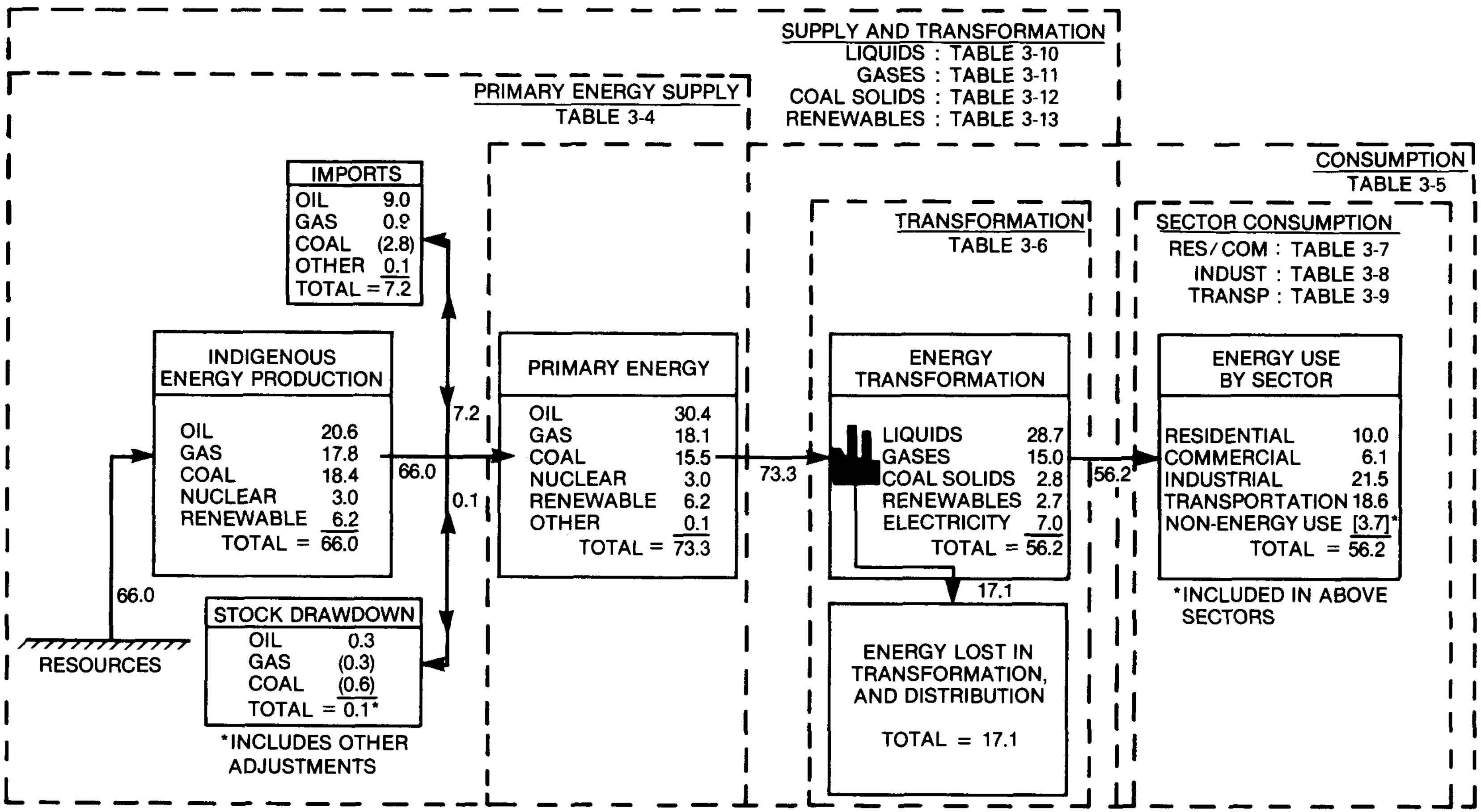


TABLE 3-4: SCENARIO B--PRIMARY ENERGY SUPPLIED TO THE U.S. ECONOMY

(QUADS)

YEAR	INDIGENOUS ENERGY PRODUCTION						NET IMPORTS 1/					ADJUSTMENTS 2/					PRIMARY ENERGY SUPPLIED TO U.S. ECONOMY
												STOCK CHANGES					
	OIL	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL	OIL	GAS	COAL	OTHER 3/	TOTAL	OIL	GAS	COAL	OTHER 4/	TOTAL	TOTAL
HIST.																	
1960	16.4	12.7	11.1	--	2.9	43.1	3.6	0.1	-1.0	--	2.7	+0.1	-0.3	+0.1	-0.3	-0.4	45.4
1965	18.4	15.8	13.4	--	3.4	51.0	5.0	0.4	-1.4	--	4.1	--	-0.2	--	-0.5	-0.7	54.3
1970	22.9	21.7	15.0	0.2	4.1	64.0	6.9	0.8	-1.9	--	5.7	-0.2	-0.4	-0.3	-0.5	-1.4	68.3
1975	20.1	19.6	15.2	1.9	4.9	61.8	12.5	0.9	-1.8	0.1	11.7	-0.3	-0.4	-0.7	+0.3	-1.1	72.4
1980	20.5	19.9	18.6	2.7	5.5	67.2	13.5	1.0	-2.4	0.1	12.2	-0.3	--	-0.5	-0.1	-0.9	78.5
ESTI.																	
1982	20.6	17.8	18.4	3.0	6.2	66.0	9.0	0.9	-2.8	0.1	7.2	+0.3	-0.3	-0.6	+0.7	+0.1	73.3
PROJ.																	
1985	19.5	18.9	21.3	4.6	6.2	70.5	12.8	1.2	-2.8	0.1	11.3	-0.6	--	--	--	-0.6	81.1
1990	19.0	18.2	24.5	6.5	7.0	75.1	12.4	1.9	-3.3	0.1	11.1	--	--	--	--	--	86.2
1995	17.7	17.2	28.7	6.9	8.6	79.1	12.4	2.4	-4.4	0.1	10.5	--	--	--	--	--	89.6
2000	17.4	16.3	33.6	7.9	10.0	85.1	11.0	2.6	-5.4	0.1	8.3	--	--	--	--	--	93.4
2005	17.2	14.5	38.5	9.2	11.6	91.0	10.2	2.7	-6.9	0.1	6.1	--	--	--	--	--	97.1
2010	17.0	11.6	45.7	12.0	13.5	99.9	8.2	3.0	-8.5	0.1	2.8	--	--	--	--	--	102.7

PHYSICAL UNITS

YEAR	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	MILLION BDOE	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	MILLION BDOE	MILLION BDOE	MILLION BDOE
ESTI.																	
1982	10.2	17.4	824	290	2.9	31.2	4.2	0.9	-106	0.1	3.4	+0.1	-0.3	-25	+0.3	--	34.6
PROJ.																	
1985	9.7	18.6	954	432	2.9	33.3	6.1	1.1	-108	0.1	5.1	-0.3	--	--	--	-0.3	38.1
1990	9.4	17.9	1098	611	3.3	35.3	5.9	1.8	-124	0.1	5.1	--	--	--	--	--	40.4
1995	8.7	16.9	1286	648	4.1	37.7	5.9	2.3	-167	0.1	4.6	--	--	--	--	--	42.2
2000	8.5	16.0	1502	742	4.7	40.5	5.2	2.6	-205	0.1	3.5	--	--	--	--	--	44.0
2005	8.4	14.3	1711	864	5.5	43.0	4.8	2.7	-261	0.1	2.6	--	--	--	--	--	45.6
2010	8.3	11.4	2025	1130	6.4	46.8	3.9	2.9	-321	0.1	1.2	--	--	--	--	--	48.0

1/ Including Strategic Petroleum Reserve.
2/ Negative numbers indicate a reduction in energy supplied and positive numbers indicate an increase in energy supplied to the economy.
3/ Includes small amounts of coal coke and electricity.
4/ A balancing item. Includes unaccounted for oil, gas and coal private stock changes, losses, gains, miscellaneous blending componets, unaccounted for supply and anthracite shipped overseas to U.S. Armed Forces.

TABLE 3-5: SCENARIO B--ENERGY CONSUMED BY THE U.S. ECONOMY

(QUADS)

YEAR	PRIMARY ENERGY CONSUMED BY U.S. ECONOMY: OIL	GAS	COAL	NUCLEAR	RENEWABLE	NET ELECTRICITY IMPORTS	TOTAL	ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES: TOTAL	ENERGY USED BY FINAL CONSUMERS EXCLUDING INPUTS TO UTILITIES AND SYNTHETICS: LIQUIDS	GASES	COAL SOLIDS	ELECTRICITY	RENEWABLE 1/	TOTAL	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION
HIST.																		
1960	19.9	12.4	10.1	--	2.9	--	45.4	-5.9	19.3	10.6	5.9	2.4	1.4	39.5	7.2	3.6	18.3	10.5
1965	23.2	15.8	11.9	--	3.4	--	54.3	-7.8	22.5	13.4	6.0	3.3	1.4	46.5	8.3	4.1	21.8	12.3
1970	29.5	21.8	12.6	0.2	4.1	--	68.3	-11.5	27.4	17.7	5.4	4.8	1.5	56.7	9.9	5.5	25.3	16.0
1975	32.7	19.9	12.8	1.9	4.9	--	72.4	-14.5	29.5	16.7	4.1	6.0	1.7	57.9	10.0	5.7	24.1	18.2
1980	34.2	20.4	15.5	2.7	5.5	0.1	78.5	-17.3	31.6	16.6	3.3	7.2	2.6	61.2	10.2	6.2	25.2	19.7
ESTI.																		
1982	30.4	18.1	15.5	3.0	6.2	0.1	73.3	-17.1	28.7	15.0	2.8	7.0	2.7	56.2	10.0	6.1	21.5	18.6
PROJ.																		
1985	31.7	20.1	18.4	4.6	6.2	0.1	81.1	-20.1	29.1	17.1	3.4	8.3	3.0	60.9	10.9	7.0	25.0	18.1
1990	31.4	20.1	21.2	6.5	7.0	0.1	86.2	-22.7	29.3	17.6	3.8	9.4	3.5	63.6	11.4	7.6	27.0	17.5
1995	30.1	19.6	24.3	6.9	8.6	0.1	89.6	-24.9	28.6	17.5	4.3	10.3	4.1	64.8	11.5	7.7	28.1	17.4
2000	28.3	18.9	28.2	7.9	10.0	0.1	93.4	-27.8	27.2	17.2	4.8	11.6	4.8	65.6	11.4	8.0	28.4	17.7
2005	27.4	17.2	31.6	9.2	11.6	0.1	97.1	-30.6	26.6	16.1	5.5	12.8	5.6	66.5	11.1	8.3	29.2	18.0
2010	25.2	14.6	37.3	12.0	13.5	0.1	102.7	-35.1	25.7	15.3	5.9	14.1	6.6	67.6	11.2	8.7	29.7	18.0

PHYSICAL UNITS

YEAR	MILLION BPD	TRILLION CU. FT.	MILLION TONS	MILLION BDOE	MILLION BDOE	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BDOE			
ESTI.																		
1982	15.3	17.7	714	1.4	2.9	29	34.6	-8.1	14.5	14.7	117	2051	1.3	26.5	4.7	2.9	10.2	8.8
PROJ.																		
1985	16.0	19.7	847	2.2	2.9	29	38.1	-9.5	14.8	16.8	143	2400	1.4	28.8	5.1	3.3	11.8	8.6
1990	15.8	19.7	974	3.1	3.3	29	40.4	-10.7	14.9	17.2	160	2700	1.6	30.0	5.4	3.6	12.8	8.3
1995	15.1	19.2	1119	3.3	4.0	29	42.2	-11.8	14.4	17.2	178	3000	2.0	30.6	5.4	3.6	13.3	8.2
2000	14.2	18.6	1297	3.7	4.8	29	44.0	-13.1	13.7	16.8	202	3400	2.3	31.0	5.4	3.8	13.5	8.4
2005	13.7	17.0	1450	4.3	5.5	29	45.6	-14.5	13.3	15.8	228	3700	2.6	31.4	5.2	3.9	13.8	8.5
2010	12.7	14.3	1704	5.7	6.4	29	48.0	-16.6	12.9	15.0	248	4100	3.1	31.9	5.3	4.1	14.1	8.5

1/ Renewable central electric is included in electricity column.

TABLE 3-6: SCENARIO B--ENERGY TRANSFORMATION IN THE U.S. ECONOMY

(QUADS)

YEAR	ELECTRIC UTILITIES: ENERGY INPUT: OIL[1/]	ENERGY INPUT: GAS	ENERGY INPUT: COAL	ENERGY INPUT: NUCLEAR	ENERGY INPUT: RENEW-ABLE	ENERGY INPUT: TOTAL	ENERGY TRANS-FOR-MATION AND DISTRI-BUTION LOSSES[2/]	NET ELEC-TRIC IMPORTS	SALES: TOTAL	SYNTHETIC FUELS: ENERGY INPUT: OIL FOR SYNTH. GAS	ENERGY INPUT: COAL FOR SYNTH. GAS	ENERGY INPUT: COAL FOR SYNTH. LIQUIDS	TRANS-FOR-MATION LOSSES TOTAL	SALES: LIQUIDS	SALES: GASES: SNG	SALES: GASES: COAL GAS	SALES: GASES: TOTAL	ENERGY TRANS-FOR-MATION AND DISTRI-BUTION LOSSES TOTAL
HIST.																		
1960	0.6	1.8	4.2	--	1.6	8.2	-5.9	--	2.4	--	--	--	--	--	--	--	--	-5.9
1965	0.8	2.4	5.8	--	2.1	11.1	-7.8	--	3.3	--	--	--	--	--	--	--	--	-7.8
1970	2.1	4.1	7.2	0.2	2.6	16.3	-11.5	--	4.8	--	--	--	--	--	--	--	--	-11.5
1975	3.2	3.2	8.8	1.9	3.2	20.4	-14.5	0.1	6.0	--	--	--	--	--	--	--	--	-14.5
1980	2.7	3.6	12.1	2.7	3.0	24.3	-17.3	0.1	7.2	--	--	--	--	--	--	--	--	-17.3
ESTI.																		
1982	1.5	3.3	12.7	3.0	3.5	24.0	17.1	0.1	7.0	0.2	--	--	--	--	0.2	--	0.2	-17.1
PROJ.																		
1985	2.3	3.2	15.0	4.6	3.2	28.3	-20.1	0.1	8.3	0.2	--	--	--	--	0.2	--	0.2	-20.1
1990	2.0	2.6	17.3	6.5	3.5	31.9	-22.6	0.1	9.4	0.1	--	--	--	--	0.1	--	0.1	-22.7
1995	1.6	2.1	20.0	6.9	4.5	35.0	-24.8	0.1	10.3	--	--	0.1	-0.1	--	--	--	--	-24.9
2000	1.3	1.8	23.0	7.9	5.2	39.1	-27.6	0.1	11.6	--	0.1	0.3	-0.1	0.2	--	0.1	0.1	-27.8
2005	1.2	1.6	24.7	9.2	6.1	42.7	-30.0	0.1	12.8	--	0.7	0.7	-0.6	0.4	--	0.4	0.4	-30.6
2010	1.0	1.4	25.4	12.0	7.0	46.9	-32.9	0.1	14.1	--	3.4	2.5	-2.3	1.5	--	2.1	2.1	-35.1

PHYSICAL UNITS

YEAR	MILLION BPD	TRILLION CU. FT.	MILLION TONS	MILLION BDOE				BILLION KWH		MILLION BPD	MILLION TONS		MILLION BDOE	MILLION BDOE	TRILLION CU. FT.			MILLION BDOE
ESTI.																		
1982	0.7	3.2	597	1.4	1.7	11.3	-8.1	29	2051	0.1	--	--	--	--	0.2	--	0.2	-8.1
PROJ.																		
1985	1.1	3.1	704	2.2	1.5	13.4	-9.5	29	2400	0.1	--	--	--	--	0.2	--	0.2	-9.5
1990	0.9	2.6	813	3.1	1.6	15.1	-10.7	29	2700	--	--	--	--	--	0.1	--	0.1	-10.7
1995	0.	2.1	937	3.3	2.1	16.5	-11.7	29	3000	--	--	4	--	--	--	--	--	-11.8
2000	0.6	1.8	1078	3.7	2.5	18.5	-13.0	29	3400	--	4	3	--	0.1	--	0.1	0.1	-13.1
2005	0.5	1.5	1161	4.3	2.9	20.2	-14.1	29	3700	--	31	31	-0.3	0.2	--	0.3	0.4	-14.5
2010	0.5	1.4	1194	5.7	3.3	22.2	-15.5	29	4100	--	151	111	-1.1	0.7	--	2.0	2.0	-16.6

1/ Includes petroleum coke.
2/ Includes utility own use and transmission losses.

TABLE 3-7: SCENARIO B--U.S. ENERGY CONSUMPTION BY THE RESIDENTIAL AND COMMERCIAL SECTORS
(QUADS)

YEAR	RESIDENTIAL LIQUIDS	RESIDENTIAL GASES	RESIDENTIAL COAL SOLIDS	RESIDENTIAL ELECTRICITY 1/	RESIDENTIAL RENEWABLE	RESIDENTIAL TOTAL	COMMERCIAL LIQUIDS	COMMERCIAL GASES	COMMERCIAL COAL SOLIDS	COMMERCIAL ELECTRICITY 1/	COMMERCIAL RENEWABLE	COMMERCIAL TOTAL	RESIDENTIAL AND COMMERCIAL LIQUIDS	RESIDENTIAL AND COMMERCIAL GASES	RESIDENTIAL AND COMMERCIAL COAL SOLIDS	RESIDENTIAL AND COMMERCIAL ELECTRICITY 1/	RESIDENTIAL AND COMMERCIAL RENEWABLE	RESIDENTIAL AND COMMERCIAL TOTAL
HIST.																		
1960	2.3	3.2	0.4	0.7	0.6	7.2	1.3	1.1	0.6	0.5	--	3.6	3.6	4.3	1.0	1.2	0.6	10.8
1965	2.5	4.0	0.3	1.0	0.5	8.3	1.5	1.5	0.4	0.8	--	4.1	4.0	5.5	0.7	1.8	0.5	12.4
1970	2.8	5.0	0.2	1.6	0.4	9.9	1.6	2.5	0.3	1.2	--	5.5	4.4	7.5	0.5	2.8	0.4	15.5
1975	2.5	5.0	0.1	2.0	0.4	10.0	1.3	2.6	0.1	1.6	0.1	5.7	3.8	7.6	0.2	3.6	0.5	15.7
1980	2.0	4.9	0.1	2.5	0.8	10.2	1.3	2.7	0.1	1.9	0.1	6.2	3.3	7.6	0.2	4.4	0.9	16.4
ESTI.																		
1982	1.8	4.9	0.1	2.4	0.9	10.0	1.2	2.6	0.1	2.0	0.1	6.1	3.0	7.5	0.2	4.4	1.0	16.1
PROJ.																		
1985	1.9	5.2	0.1	2.7	1.0	10.9	1.2	3.0	0.1	2.4	0.3	7.0	3.1	8.2	0.2	5.1	1.3	17.9
1990	1.9	5.3	0.1	3.0	1.1	11.4	1.1	3.1	0.1	2.8	0.4	7.6	3.1	8.4	0.2	5.8	1.5	19.1
1995	1.8	5.2	0.1	3.2	1.2	11.5	1.1	3.0	0.1	2.9	0.6	7.7	2.9	8.2	0.2	6.1	1.8	19.2
2000	1.3	5.1	0.1	3.5	1.4	11.4	0.9	2.9	0.1	3.3	0.8	8.0	2.2	8.0	0.2	6.8	2.2	19.4
2005	1.0	4.8	0.1	3.6	1.6	11.1	0.7	2.8	0.1	3.7	1.0	8.3	1.7	7.6	0.2	7.3	2.6	19.4
2010	0.8	4.6	0.1	3.8	1.9	11.2	0.5	2.6	0.1	4.1	1.4	8.7	1.3	7.2	0.2	7.9	3.3	19.9

PHYSICAL UNITS

YEAR	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE
ESTI.																		
1982	0.9	4.8	4.2	700	0.4	4.7	0.6	2.5	4.2	590	--	2.9	1.6	7.4	8.3	1290	0.5	7.6
PROJ.																		
1985	0.9	5.1	4.2	790	0.5	5.1	0.6	2.9	4.2	700	0.1	3.3	1.5	8.0	8.3	1490	0.6	8.5
1990	1.0	5.2	4.2	880	0.5	5.4	0.6	3.0	4.2	820	0.2	3.6	1.5	8.2	8.3	1700	0.7	9.0
1995	0.9	5.1	4.2	940	0.6	5.4	0.6	2.9	4.2	850	0.3	3.6	1.4	8.0	8.3	1790	0.9	9.1
2000	0.6	5.0	4.2	1030	0.7	5.4	0.4	2.8	4.2	970	0.4	3.8	1.0	7.8	8.3	1990	1.0	9.2
2005	0.5	4.7	4.2	1060	0.8	5.2	0.3	2.7	4.2	1080	0.5	3.9	0.8	7.5	8.3	2140	1.2	9.2
2010	0.4	4.5	4.2	1110	0.9	5.3	0.3	2.5	4.2	1200	0.7	4.1	0.6	7.1	8.3	2310	1.6	9.4

1/ Excludes generation, transmission and distribution losses.

TABLE 3-8: SCENARIO B--U.S. ENERGY CONSUMPTION BY THE INDUSTRIAL SECTOR

(QUADS)

YEAR	INDUSTRIAL: ENERGY USE (Excluding Non-Energy Feedstocks) LIQUIDS	GASES	COAL SOLIDS	ELECTRICITY 1/	RENEWABLE	TOTAL	NON-ENERGY USE 2/: LIQUIDS ASPHALT	LIQUIDS OTHER	LIQUIDS TOTAL	GASES	COAL SOLIDS	TOTAL	ENERGY AND NON-ENERGY USE: LIQUIDS	GASES	COAL SOLIDS	ELECTRICITY 1/	RENEWABLE	TOTAL
HIST.																		
1960	4.0	5.6	4.6	1.1	0.7	16.1	0.7	1.0	1.7	0.4	0.1	2.2	5.7	6.0	4.7	1.1	0.7	18.3
1965	4.4	7.0	5.3	1.5	0.9	19.0	0.9	1.5	2.4	0.3	0.1	2.8	6.8	7.3	5.4	1.5	0.9	21.8
1970	4.7	8.8	4.7	2.0	1.1	21.4	1.1	2.0	3.1	0.7	0.2	3.9	7.8	9.5	4.9	2.0	1.1	25.3
1975	4.8	7.8	3.7	2.4	1.2	19.9	1.1	2.3	3.4	0.7	0.1	4.2	8.2	8.5	3.8	2.4	1.2	24.1
1980	5.2	7.8	3.0	2.8	1.6	20.4	1.0	3.1	4.1	0.6	0.1	4.8	9.3	8.4	3.1	2.8	1.6	25.2
ESTI.																		
1982	4.7	6.3	2.5	2.6	1.7	17.8	0.8	2.2	3.0	0.6	0.1	3.7	7.7	6.9	2.6	2.6	1.7	21.5
PROJ.																		
1985	5.2	7.6	3.1	3.2	1.8	20.9	0.9	2.4	3.3	0.7	0.1	4.1	8.5	8.3	3.2	3.2	1.8	25.0
1990	5.7	7.6	3.5	3.5	2.0	22.3	1.0	2.7	3.7	0.9	0.1	4.7	9.4	8.5	3.6	3.5	2.0	27.0
1995	5.1	7.6	4.0	4.0	2.2	22.9	1.0	3.0	4.0	1.1	0.1	5.2	9.1	8.7	4.1	4.0	2.2	28.1
2000	3.8	7.4	4.5	4.7	2.4	22.8	1.1	3.2	4.3	1.2	0.1	5.6	8.2	8.6	4.6	4.7	2.4	28.4
2005	3.2	6.8	5.2	5.3	2.7	23.2	1.2	3.5	4.7	1.2	0.1	6.0	7.9	8.0	5.3	5.3	2.7	29.2
2010	2.5	6.3	5.6	6.0	3.0	23.4	1.2	3.7	4.9	1.3	0.1	6.3	7.4	7.6	5.7	6.0	3.0	29.7

PHYSICAL UNITS

YEAR	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE	MILLION BPD			TRILLION CU. FT.	MILLION TONS	MILLION BDOE	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE
ESTI.																		
1982	2.3	6.2	104	760	0.8	8.4	0.3	1.1	1.4	0.6	4	1.7	3.8	6.8	108	760	0.8	10.2
PROJ.																		
1985	2.5	7.4	129	940	0.9	9.9	0.4	1.2	1.6	0.7	4	1.9	4.2	8.1	133	940	0.9	11.8
1990	2.8	7.4	146	1030	0.9	10.5	0.4	1.3	1.7	0.9	4	2.2	4.7	8.3	150	1030	0.9	12.8
1995	2.5	7.4	167	1170	1.0	10.8	0.4	1.5	1.9	1.1	4	2.5	4.5	8.5	171	1170	1.0	13.3
2000	1.9	7.3	188	1380	1.1	10.8	0.5	1.6	2.1	1.2	4	2.6	4.1	8.4	192	1380	1.1	13.5
2005	1.6	6.7	217	1550	1.3	11.0	0.5	1.7	2.2	1.2	4	2.8	3.9	7.8	221	1550	1.3	13.8
2010	1.2	6.2	234	1760	1.4	11.1	0.5	1.8	2.3	1.3	4	3.0	3.7	7.5	238	1760	1.4	14.1

1/ Excludes generation, transmission and distribution losses.
2/ Energy resources utilized in the manufacture of non-energy materials (asphalt, fertilizers, etc.).

TABLE 3-9: SCENARIO B--U.S. ENERGY CONSUMPTION BY THE TRANSPORTATION SECTOR

(QUADS)

YEAR	TRANSPORTATION									
	LIQUIDS					GASES	COAL SOLIDS	ELECTRICITY 2/	RENEWABLE	TOTAL
	HIGHWAY FUELS		JETFUEL	OTHER 1/	TOTAL					
	GASOLINE	DIESEL								
HIST.										
1960	7.1	0.3	0.7	1.9	10.0	0.4	0.1	--	--	10.5
1965	8.3	0.6	1.2	1.7	11.8	0.5	--	--	--	12.3
1970	10.7	0.9	2.0	1.7	15.3	0.7	--	--	--	16.0
1975	12.5	1.3	2.0	1.8	17.6	0.6	--	--	--	18.2
1980	12.5	2.0	2.2	2.3	19.0	0.7	--	--	--	19.7
ESTI.										
1982	12.0	2.1	2.1	1.8	18.0	0.6	--	--	--	18.6
PROJ.										
1985	10.8	2.3	2.3	2.1	17.5	0.6	--	--	--	18.1
1990	9.3	2.9	2.3	2.2	16.7	0.7	--	--	0.1	17.5
1995	8.7	3.5	2.3	2.0	16.5	0.6	--	0.1	0.2	17.4
2000	8.4	4.1	2.4	1.9	16.8	0.6	--	0.1	0.2	17.7
2005	8.2	4.7	2.4	1.7	17.0	0.5	--	0.2	0.3	18.0
2010	8.0	5.2	2.3	1.5	17.0	0.5	--	0.2	0.3	16.0

PHYSICAL UNITS

YEAR	MILLION BPD	MILLION BPD	MILLION BPD	MILLION BPD	MILLION BPD	TRILLION CU. FT.	MILLION TONS	BILLION KWH	MILLION BDOE	MILLION BDOE
ESTI.										
1982	6.3	1.0	1.1	0.8	9.1	0.6	--	--	--	8.8
PROJ.										
1985	5.6	1.1	1.2	0.9	8.8	0.6	--	--	--	8.6
1990	4.9	1.4	1.2	0.9	8.4	0.7	--	--	--	8.3
1995	4.5	1.6	1.2	1.0	8.3	0.6	--	30	0.1	8.2
2000	4.4	1.9	1.2	1.0	8.5	0.6	--	30	0.1	8.4
2005	4.3	2.2	1.2	0.8	8.6	0.5	--	60	0.1	8.5
2010	4.2	2.4	1.2	0.7	8.6	0.5	--	60	0.1	8.5

1/ Includes residual and non-highway distillate fuels.
2/ Excludes generation, transmission and distribution losses.

TABLE 3-10: SCENARIO B--U.S. LIQUIDS SUPPLY AND TRANSFORMATION
(QUADS)

YEAR	INDIGENOUS OIL PRODUCTION: CONVENTIONAL OIL: CONTINENTAL U.S.[1/]	INDIGENOUS OIL PRODUCTION: CONVENTIONAL OIL: NORTH ALASKA	ENHANCED OIL RECOVERY	SHALE OIL	NATURAL GAS LIQUIDS	TOTAL	ADDITIONAL SOURCES: NET IMPORTS	STOCK CHANGES	OTHER[2/]	PRIMARY OIL TOTAL	TRANSFORMATION: TO ELECTRICITY	SYNTHETICS: TO GAS	SYNTHETICS: FROM COAL	LIQUIDS USED BY FINAL CONSUMER TOTAL	TOTAL LIQUIDS SUPPLIED TO U.S. ECONOMY[3/]
HIST.															
1960	14.9	--	--	--	1.5	16.4	3.6	+0.1	-0.2	19.9	-0.6	--	--	19.3	19.9
1965	16.5	0.1	--	--	1.9	18.4	5.0	--	-0.2	23.2	-0.8	--	--	22.5	23.2
1970	19.9	0.5	--	--	2.5	22.9	6.9	-0.2	-0.1	29.5	-2.1	--	--	27.4	29.5
1975	17.3	0.4	--	--	2.4	20.1	12.5	-0.3	+0.5	32.7	-3.2	--	--	29.5	32.7
1980	14.0	3.4	0.8	--	2.3	20.5	13.5	-0.3	+0.5	34.2	-2.7	--	--	31.6	34.2
ESTI.															
1982	14.0	3.6	0.8	--	2.2	20.6	9.0	+0.3	+0.5	30.4	-1.5	-0.2	--	28.7	30.4
PROJ.															
1985	13.0	3.5	0.9	--	2.1	19.5	12.8	-0.6	--	31.7	-2.3	-0.2	--	29.1	31.7
1990	11.4	3.6	1.9	--	2.0	19.0	12.4	--	--	31.4	-2.0	-0.1	--	29.3	31.4
1995	10.7	3.7	1.6	--	1.7	17.7	12.4	--	--	30.1	-1.6	--	--	28.6	30.1
2000	10.1	3.8	1.9	0.2	1.4	17.4	11.0	--	--	28.3	-1.3	--	0.2	27.2	28.5
2005	9.1	4.1	1.8	1.1	1.1	17.2	10.2	--	--	27.4	-1.2	--	0.4	26.6	27.8
2010	7.4	3.8	1.7	3.1	1.0	17.0	8.2	--	--	25.2	-1.0	--	1.5	25.7	26.7

PHYSICAL UNITS

YEAR	MILLION BPD														MMBPD
ESTI.															
1982	6.6	1.6	0.4	--	1.6	10.2	4.2	+0.1	+0.7	15.3	-0.7	-0.1	--	14.5	15.3
PROJ.															
1985	6.1	1.6	0.4	--	1.5	9.7	6.1	-0.3	+0.5	16.0	-1.1	-0.1	--	14.8	16.0
1990	5.4	1.7	0.9	--	1.4	9.4	5.9	--	+0.5	15.8	-0.9	--	--	14.9	15.8
1995	5.1	1.7	0.8	--	1.2	8.7	5.9	--	+0.5	15.1	-0.7	--	--	14.4	15.1
2000	4.8	1.8	0.9	0.1	1.0	8.5	5.2	--	+0.5	14.2	-0.6	--	0.1	13.7	14.3
2005	4.3	1.9	0.9	0.5	0.8	8.4	4.8	--	+0.5	13.7	-0.5	--	0.2	13.3	13.9
2010	3.5	1.8	0.8	1.5	0.7	8.3	3.9	--	+0.5	12.7	-0.5	--	0.7	12.9	13.4

1/ Includes South Alaskan oil.
2/ A balancing item. Includes unaccounted for private stock changes, losses, gains, miscellaneous blending componets and unaccounted for supply. Accounts for refinery gains only in the physical units table, 1982-2010.
3/ Primary oil plus synthetic oil from coal. Includes oil used to produce electricity and synthetic gas.

TABLE 3-11: SCENARIO B--U.S. GASES SUPPLY AND TRANSFORMATION

(QUADS)

YEAR	INDIGENOUS PRODUCTION: CONVENTIONAL GAS: CONTINENTAL U.S.[2/]	INDIGENOUS PRODUCTION: CONVENTIONAL GAS: NORTH ALASKA	INDIGENOUS PRODUCTION: CONVENTIONAL GAS: TOTAL	INDIGENOUS PRODUCTION: UNCONVENTIONAL GAS[3/]	INDIGENOUS PRODUCTION: TOTAL	ADDITIONAL SOURCES: NET IMPORTS	ADDITIONAL SOURCES: STOCK CHANGES	ADDITIONAL SOURCES: OTHER[4/]	PRIMARY GAS TOTAL	TRANSFORMATION: TO ELECTRICITY	TRANSFORMATION: SYNTHETICS[1/]: FROM OIL (SNG)	TRANSFORMATION: SYNTHETICS[1/]: FROM COAL	TRANSFORMATION: SYNTHETICS[1/]: TOTAL	GAS USED BY FINAL CONSUMERS TOTAL	TOTAL GASES SUPPLIED TO U.S. ECONOMY[5/]
HIST.															
1960	12.7	--	--	--	12.7	0.1	-0.3	-0.1	12.4	-1.8	--	--	--	10.6	12.4
1965	15.8	--	--	--	15.8	0.4	-0.2	-0.3	15.8	-2.4	--	--	--	13.4	15.8
1970	21.7	--	--	--	21.7	0.8	-0.4	-0.2	21.8	-4.1	--	--	--	17.7	21.8
1975	19.6	--	--	--	19.6	0.9	-0.4	-0.2	19.9	-3.2	--	--	--	16.7	19.9
1980	19.9	--	--	--	19.9	1.0	--	-0.5	20.4	-3.8	--	--	--	16.6	20.4
ESTI.															
1982	17.8	--	17.8	--	17.8	0.9	-0.3	-0.3	18.1	-3.3	0.2	--	0.2	15.0	18.3
PROJ.															
1985	18.9	--	18.9	--	18.9	1.2	--	--	20.1	-3.2	0.2	--	0.2	17.1	20.3
1990	17.5	0.7	18.2	0.1	18.2	1.9	--	--	20.1	-2.6	0.1	--	0.1	17.6	20.2
1995	15.4	0.8	16.2	1.0	17.2	2.4	--	--	19.6	-2.1	--	--	--	17.5	19.6
2000	13.8	0.8	14.6	1.7	16.3	2.6	--	--	18.9	-1.8	--	0.1	0.1	17.2	19.0
2005	11.5	0.8	12.3	2.2	14.5	2.7	--	--	17.2	-1.6	--	0.4	0.4	16.1	17.7
2010	8.5	0.8	9.3	2.3	11.6	3.0	--	--	14.6	-1.4	--	2.1	2.1	15.3	16.7

PHYSICAL UNITS

YEAR	TRILLION CU. FT.														TCF
ESTI.															
1982	17.2	--	17.4	--	17.4	0.9	-0.3	-0.3	17.7	-3.2	0.2	--	0.2	14.7	17.9
PROJ.															
1985	18.6	--	18.6	--	18.6	1.1	--	--	19.7	-3.1	0.2	--	0.2	16.8	19.9
1990	17.1	0.7	17.8	0.1	17.9	1.8	--	--	19.7	-2.6	0.1	--	0.1	17.2	19.8
1995	15.1	0.8	15.9	1.0	16.9	2.3	--	--	19.2	-2.1	--	--	--	17.2	19.2
2000	13.5	0.8	14.3	1.6	16.0	2.6	--	--	18.6	-1.8	--	0.1	0.1	16.8	18.6
2005	11.3	0.8	12.1	2.2	14.3	2.7	--	--	17.0	-1.5	--	0.4	0.4	15.8	17.3
2010	8.4	0.8	9.2	2.2	11.4	2.9	--	--	14.3	-1.4	--	2.0	2.0	15.0	16.4

1/ Synthetic gas is included in primary gas supply, 1960-80.
2/ Includes South Alaskan gas.
3/ Includes gas from tight sands, Devonian shale, coal seams and geopressurized brines.
4/ A balancing item. Includes unaccounted for stock changes, losses, gains and supply.
5/ Primary gas plus synthetic gas from oil and coal. Includes gas used to produce electricity.

TABLE 3-12: SCENARIO B--U.S. COAL SOLIDS SUPPLY AND TRANSFORMATION

(QUADS)

YEAR	INDIGENOUS PRODUCTION: PRIMARY COAL PRODUCED TOTAL	ADDITIONAL SOURCES: NET IMPORTS	STOCK CHANGES	OTHER 1/	PRIMARY COAL TOTAL	TRANSFORMATION: TO ELECTRICITY	TO SYNTHETIC FUELS	COAL SOLIDS USED BY FINAL CONSUMERS TOTAL	TOTAL COAL SOLIDS SUPPLIED TO U.S. ECONOMY 2/
HIST.									
1960	11.1	-1.0	+0.1	-0.1	10.1	-4.2	--	5.9	10.1
1965	13.4	-1.4	--	-0.1	11.9	-5.8	--	6.0	11.9
1970	15.0	-1.9	-0.3	-0.2	12.6	-7.2	--	5.4	12.6
1975	15.2	-1.8	-0.7	+0.1	12.8	-8.8	--	4.1	12.8
1980	18.6	-2.4	-1.5	-0.2	15.5	-12.1	--	3.3	15.5
ESTI.									
1982	18.4	-2.8	-0.6	+0.5	15.5	-12.7	--	2.8	15.5
PROJ.									
1985	21.3	-2.8	--	--	18.4	-15.0	--	3.4	18.4
1990	24.5	-3.3	--	--	21.2	-17.3	--	3.8	21.2
1995	28.7	-4.4	--	--	24.3	-20.0	-0.1	4.3	24.3
2000	33.6	-5.4	--	--	28.2	-23.0	-0.4	4.8	28.2
2005	38.5	-6.9	--	--	31.6	-24.7	-1.4	5.5	31.6
2010	45.7	-8.5	--	--	37.3	-25.4	-5.9	5.9	37.3

PHYSICAL UNITS

YEAR	MILLION TONS								MMT
ESTI.									
1982	824	-106	-23	+19	714	-597	--	117	714
PROJ.									
1985	954	-108	--	--	847	-704	--	143	847
1990	1098	-124	--	--	974	-813	--	160	974
1995	1286	-167	--	--	1119	-937	-4	178	1119
2000	1502	-205	--	--	1297	-1078	-17	202	1297
2005	1711	-261	--	--	1450	-1161	-61	228	1450
2010	2025	-321	--	--	1704	-1194	-262	248	1704

1/ A balancing item. Includes unaccounted for private stock changes, losses, gains, unaccounted for supply and anthracite shipped overseas to U.S. Armed Forces.

2/ Includes coal used to produce electricity and synthetic fuels.

TABLE 3-13: SCENARIO B--U.S. RENEWABLE ENERGY PRODUCTION AND CONSUMPTION
(QUADS)

YEAR	INDIGENOUS PRODUCTION: CENTRAL ELECTRICITY INPUTS: HYDRO/ GEOTH.	WOOD	SOLAR THERMAL	PHOTO-VOLTAIC	WIND	TOTAL	DISPERSED: BIOMASS: WOOD	BIOMASS: OTHER 1/	ACTIVE SOLAR HEATING/ COOLING	PASSIVE SOLAR HEATING/ COOLING	AGRIC. INDUST. PROCESS HEAT	GEO-THERMAL	PHOTO-VOLTAIC	WIND	TOTAL	PRIMARY RENEW-ABLES TOTAL	TRANSFORMATION: TO CENTRAL ELEC-TRICITY	TO ALCOHOL FUELS 2/	RENEW-ABLES USED BY FINAL CON-SUMERS TOTAL
HIST.																			
1960	1.6	--	--	--	--	1.6	1.3	--	--	--	--	--	--	--	1.4	2.9	-1.6	--	1.4
1965	2.1	--	--	--	--	2.1	1.3	--	--	--	--	--	--	--	1.4	3.4	-2.1	--	1.4
1970	2.6	--	--	--	--	2.6	1.4	--	--	--	--	--	--	--	1.5	4.1	-2.6	--	1.5
1975	3.2	--	--	--	--	3.2	1.5	0.2	--	--	--	--	--	--	1.7	4.9	-3.2	--	1.7
1980	3.0	--	--	--	--	3.0	2.2	0.3	--	--	--	--	--	--	2.6	5.5	-3.0	--	2.6
ESTI.																			
1982	3.5	--	--	--	--	3.5	2.3	0.3	--	--	--	--	--	--	2.7	6.2	-3.5	--	2.7
PROJ.																			
1985	3.2	--	--	--	--	3.2	2.3	0.4	0.1	0.2	--	--	--	--	3.0	6.2	-3.2	--	3.0
1990	3.4	0.1	--	--	--	3.5	2.3	0.6	0.1	0.3	0.1	0.1	--	--	3.5	7.0	-3.5	0.1	3.5
1995	3.8	0.3	--	--	0.4	4.5	2.5	0.8	0.2	0.3	0.2	0.1	--	0.1	4.1	8.6	-4.5	0.2	4.1
2000	4.1	0.3	--	--	0.8	5.2	2.7	0.9	0.2	0.4	0.3	0.2	--	0.1	4.8	10.0	-5.1	0.2	4.8
2005	4.2	0.3	0.1	0.3	1.2	6.1	3.0	1.0	0.2	0.4	0.4	0.3	0.2	0.1	5.6	11.6	-6.1	0.3	5.6
2010	4.4	0.3	0.1	0.7	1.5	7.0	3.2	1.1	0.2	0.5	0.5	0.5	0.5	0.2	6.6	13.5	-7.0	0.3	6.6

PHYSICAL UNITS

YEAR	MILLION BDOE																		
ESTI.																			
1982	1.6	--	--	--	--	1.6	1.1	0.2	--	--	--	--	--	--	1.3	2.9	-1.6	--	1.3
PROJ.																			
1985	1.5	--	--	--	--	1.5	1.1	0.2	--	0.1	--	--	--	--	1.4	2.9	-1.5	--	1.4
1990	1.6	--	--	--	--	1.6	1.1	0.3	--	0.1	0.1	--	--	--	1.6	3.3	-1.6	--	1.6
1995	1.8	0.1	--	--	0.2	2.1	1.2	0.4	0.1	0.1	0.1	0.1	--	--	1.9	4.0	-2.1	0.1	1.9
2000	1.9	0.2	--	--	0.4	2.5	1.3	0.4	0.1	0.2	0.2	0.1	--	--	2.3	4.8	-2.5	0.1	2.3
2005	2.0	0.2	--	0.1	0.5	2.9	1.4	0.5	0.1	0.2	0.2	0.1	0.1	--	2.6	5.5	-2.9	0.1	2.6
2010	2.1	0.2	0.1	0.3	0.7	3.3	1.5	0.6	0.1	0.2	0.2	0.2	0.2	0.2	3.1	6.4	-3.3	0.1	3.1

1/ Includes sewer and landfill gas, municipal and agricultural waste, and biomass alcohol inputs.
2/ Included in renewables used by final consumers.

TABLE 3-14: SCENARIO B--KEY ECONOMIC DATA AND ASSUMPTIONS

	U.S.			
YEAR	INDUSTRIAL PRODUCTION INDEX 1982=100	POPULATION MILLIONS	HOUSEHOLDS MILLIONS	COMMERCIAL FLOOR SPACE BILLION SQ. FT.
HIST.				
1960	47.6	180.6	52.8	15.8
1965	64.6	194.3	57.4	20.3
1970	77.6	204.9	63.4	24.3
1975	84.7	213.6	71.1	28.3
1980	106.0	227.0	79.7	31.6
ESTI.				
1982	100	232	86.9	31.8
PROJ.				
1985	117	239	92.5	35.1
1990	141	250	101	40.0
1995	165	260	109	44.7
2000	189	268	116	50.0
2005	213	276	120	55.0
2010	237	283	125	60.0

TABLE 3-15: SCENARIO B--U.S. ENERGY RESERVES AND GENERATING CAPACITY

	OIL 1/ (QUADS)		GAS 1/ (QUADS)		ELECTRIC GENERATING CAPACITY (GW)		
YEAR	PROVEN RESERVES	ADDITIONS	PROVEN RESERVES	ADDITIONS	FOSSIL 2/	NUCLEAR	HYDRO/GEO. 3/
HIST.							
1960					135	0.3	32.4
1965					191	0.9	43.8
1970					279	6.5	55.2
1975					402	36.0	66.5
1980	133	14.3	170	16.0	480	55.0	77.4
ESTI.							
1982	127	13.2	165	16.0	501	60	79.4
PROJ.							
1985	111	10.0	158	16.6	537	80	80
1990	89.7	9.6	149	15.8	542	114	88
1995	81.3	10.1	135	11.8	587	122	113
2000	74.4	8.6	115	10.0	648	130	130
2005	66.0	7.4	91	7.0	680	163	150
2010	56.0	5.6	67	4.0	688	195	173

1/ Lower 48 states.
2/ Includes conventional steam, internal combustion and gas turbine capacity.
3/ Includes other renewable capacity.

TABLE 3-16: SCENARIO B--HIGHWAY VEHICLE DATA AND ASSUMPTIONS[1/]

	PASSENGER VEHICLES				ALL VEHICLES			
YEAR	OPERATING VEHICLES MILLION	TOTAL VEHICLE MILES BILLION	FUEL CONSUMPTION BILLION GALLONS	ROAD MPG	OPERATING VEHICLES MILLION	TOTAL VEHICLE MILES BILLION	FUEL CONSUMPTION BILLION GALLONS	ROAD MPG
HIST.								
1960	57.1	588	41.0	14.4	67.9	719	57.9	12.4
1965	68.9	706	49.7	14.2	82.0	888	71.1	12.5
1970	80.5	891	65.6	13.6	98.2	1121	92.3	12.1
1975	95.2	1028	76.0	13.5	120.0	1330	109.0	12.2
1980	104.6	1112	73.4	15.1	139.9	1521	114.9	13.2
ESTI.								
1982	106.9	1169	69.2	16.9	143.9	1531	111.0	13.8
PROJ.								
1985	105	1206	62	19.4	146	1606	103	15.6
1990	115	1366	55	24.9	165	1867	96	19.4
1995	125	1549	52	29.8	184	2153	96	22.4
2000	130	1614	50	32.6	196	2312	98	23.6
2005	132	1595	47	33.7	200	2352	100	23.4
2010	133	1596	47	34.3	203	2405	104	23.2

1/ Historical data are from the Monthly Energy Review and are not directly comparable with data underlying the projections due to definitional differences. For example, data for MPG values consistent with the projections are:

	Passengers Vehicles (MPG)	All Vehicles (MPG)
1975	15.1	12.9
1980	15.8	13.0
1982	16.9	13.8

CHAPTER 4: SCENARIO B--FREE-WORLD PROJECTIONS

These Scenario B energy projections represent but one of many possible free-world energy futures. Part III of this report explores alternative scenarios including those which result in lower and higher world oil prices (Chapter 5) and those which result from lower and higher economic growth assumptions (Chapter 6). The purpose of Scenario B is not to provide a point prediction of future conditions, but rather to provide a reasonable, internally consistent and in-depth reference case or starting point for performing energy analysis. Readers are encouraged to use other scenarios besides the reference case to evaluate other possibilities concerning future world oil prices, economic growth, and other factors.

This chapter presents key assumptions and results without a detailed discussion of underlying causes, rationale or implications. Readers desiring such information are referred to the introduction and Chapter 2 of this report.

4.1 CONTEXT FOR THE SCENARIO B FREE-WORLD PROJECTIONS

As explained in Chapter 2, the world is not homogeneous. It is, therefore, difficult to understand changing global patterns of energy behavior without dividing the world into groups of nations with meaningful similarities. For this analysis, the "Centrally Planned Economies" (CPE's) were included only in terms of their net energy exports to the free world. The free world was divided into the United States, the U.S. territories and other members of the Organization for Economic Cooperation and Development (non-U.S. OECD), the members of the Organization of Petroleum Exporting Countries (OPEC), and the Rest of the Free World. Assumptions regarding economic growth or other factors which affect pricing, production, and consumption behavior differ depending on the characteristics of the country group being discussed.

4.1.1 Economic Growth

Energy is consumed to produce goods and provide services which are sold to consumers. In using the goods, owners may consume additional energy. Since the purchase and use of goods and services is related to the amount of economic activity in an economy, the gross domestic product (GDP) of a nation is a major indicator of that nation's energy demand. The near-term economic growth assumptions used in this study were developed after reviewing a number of economic forecasts, including those of Wharton Econometrics; Chase Econometrics; Data Resources, Incorporated (DRI); the International Monetary Fund and the World Bank. Beyond 1995, we assume that slower world population growth and other factors will cause economic growth for each region to slow, eventually reaching the point where the yearly increase in GDP is constant (see Table 4-1 for an index of GDP and Table 4-7 for GDP growth rates).

The recent economic growth of the OECD has been greatly influenced by movements in the price of oil. Following the rapid price increases of 1979/1980, these industrialized nations experienced several years of poor economic

TABLE 4-1: SCENARIO B--KEY FREE-WORLD DATA AND ASSUMPTIONS

YEAR	GDP INDEX (1982=1.00)						MAXIMUM SUSTAINABLE OPEC CAPACITY1/ (MMBD)		NET CPE EXPORTS (MMBDOE)		
	OECD			OPEC	REST OF FREE-WORLD	TOTAL	LOW	HIGH	OIL	GAS	COAL
	U.S.	OTHER	SUB-TOTAL								
HIST.											
1970	0.736	0.710	0.723	0.403	0.619	0.688	N/A	N/A	0.8	0.1	0.3
1975	0.835	0.844	0.835	0.677	0.759	0.821	39.3	39.3	1.1	0.1	0.4
1980	0.999	0.991	0.994	0.933	0.942	0.983	33.5	33.5	1.2	0.4	0.5
ESTI.											
1982	1.000	1.000	1.000	1.000	1.000	1.000	30.6	30.6	1.5	0.4	0.5
PROJ.											
1983	1.02	1.03	1.03	1.05	1.00	1.02	27.8	31.0	1.0	0.4	0.4
1984	1.07	1.06	1.07	1.11	1.01	1.06	27.3	33.0	0.9	0.4	0.5
1985	1.12	1.10	1.11	1.16	1.04	1.10	26.8	35.1	0.7	0.4	0.5
1990	1.30	1.27	1.29	1.56	1.27	1.30	29.0	35.7	0.0	0.5	0.6
1995	1.48	1.46	1.47	2.02	1.54	1.51	29.0	35.7	0.0	0.8	0.9
2000	1.65	1.66	1.66	2.52	1.81	1.72	29.0	36.1	0.0	1.3	1.1
2005	1.85	1.86	1.86	3.01	2.08	1.94	29.0	36.1	0.0	1.7	1.3
2010	2.05	2.06	2.06	3.51	2.36	2.16	29.0	36.1	0.0	1.8	1.5

1/ Includes natural gas liquids (NGL).

performance. As the current price decline continues, OECD nations are expected to recover and see several years of high economic recovery. Following this period, OECD economic growth is expected to stablize at just over 3 percent per year for the rest of the 1980's, and then slowly decline for the remainder of the projection period.

The revenue generated by the world oil price increases of the 1970's allowed OPEC to invest heavily in economic development projects. Recently, however, reduced oil revenues have contributed to lower OPEC economic expansion: less than 3 percent per year. When the assumed economic recovery and sustained growth of non-OPEC nations results in increased global demand for oil, the rapid industrialization of OPEC is assumed to resume, with economic growth expected to peak at over 6 percent per year in the late 1980's.

The economic growth of most non-OPEC developing countries was markedly slowed by the 1979/1980 price increases. Partially because a rapid expansion of primarily Mexican oil production (about a million barrels per day from 1980 to 1982 for the group) and the resulting decrease in net oil imports, the average economic growth for the non-OPEC developing countries remained relatively high. Increasing balance of payments and debt problems in many of these countries, however, indicate little prospect for near term economic growth. After a few years, we expect that most of these countries will be able to resume their industrialization programs, however, and that this part of the world will experience about 10 years of strong economic activity before their growth rates begin a gradual decline. The rapid population growth of many nations in this group contributes to making their economic growth rates higher than those assumed for the OECD countries.

4.1.2 OPEC Production Capacity

As explained in Chapter 2, Section 2.1.1, we assume that one of the most useful indicators of world oil price movements is OPEC oil capacity utilization (oil production divided by production capacity). Assumptions about OPEC capacity are critical, therefore, in projecting world energy behavior.

Depending on who uses them, the words "OPEC capacity" can take one of several meanings. For this analysis we define OPEC capacity as the maximum production rate OPEC can maintain for several months. Generally, maximum sustainable capacity is about 95 percent of installed capacity. We estimate that OPEC capacity has declined by almost 25 percent over the past 10 years, dropping from about 40 MMBD to just over 30 MMBD. Although this decline is expected to continue in the near term (see Table 4-1), capacity will probably increase after the end of the Iran-Iraq war as these two cash-drained countries attempt to expand production. We assume that OPEC capacity will reach at least 29 MMBD by 1990, although it may return to a high of about 36 MMBD. Unless an oil supply disruption occurs, capacity is not expected to again fall below 29 MMBD for the remainder of the projection period.

Given these bounds, we assume that OPEC production capacity for a given year depends on the circumstances in that year. If OPEC oil demand is low and oil prices are falling (as in the current situation), we assume that OPEC capacity slowly moves toward the lower end of the range. If OPEC oil demand is high and oil prices are rising, we assume that OPEC countries will make the necessary investments to increase capacity toward the upper end of the range.

4.1.3 Net CPE Energy Exports

Although the energy production and consumption by the Centrally Planned Economies (CPE's) was not explicitly included in this analysis, the net energy trade from these countries was included as an input assumption. The net CPE oil, gas, and coal export assumptions for Scenario B, shown in Table 4.1, were the product of discussions with experts on the subject both inside and outside of the Department of Energy. Scenario A and C in Chapter 5 use alternative assumptions for CPE energy trade.

4.1.4 Other Assumptions

Many assumptions about supply (in addition to OPEC capacity) and demand have to be made to produce global fuel-specific projections of regional energy production and consumption. In our attempt to reflect uncertainty, for each global region we have made low, midrange, and high assumptions for factors affecting non-OPEC oil and gas production; free-world coal, nuclear, and renewables production; the rate at which non-coal consumers can switch to coal; the market penetration potential of electricity as income increases; the price elasticities of energy demand; and the effect of energy price changes on economic growth. The impact of changing these assumptions to generate alternative scenarios (A and C) is reviewed in Chapter 5.

4.2 FREE-WORLD PROJECTIONS

Estimates of regional fuel-specific free-world energy statistics (1970-1982) and projections (1985-2010) are presented in Tables 4-2 through 4-7. The world oil price necessary to balance Scenario B world oil supply and demand is shown in Table 4-2. Energy consumed by the free world, energy supplied to the free world (net CPE exports and free-world production plus stock withdrawals) and net energy trade are shown on Tables 4-3, 4-4, and 4-5 respectively. Table 4-6 presents the specifics of liquids consumption and supply. Finally, some of the more significant growth rates are shown in Table 4-7. Totals in these tables, as elsewhere in the document, may not add because of independent rounding.

TABLE 4-2: SCENARIO B--WORLD OIL PRICE1/

YEAR	1982 DOLLARS PER BBL	NOMINAL DOLLARS PER BBL	U.S. GNP DEFLATOR2/ (1982=100)
HIST.			
1970	6.70	2.96	44.1
1975	22.94	13.93	60.7
1980	39.30	33.89	86.2
1981	39.26	37.05	94.4
ESTI.			
1982	33.59	33.59	100
PROJ.			
1983	27.40	28.60	104
1984	25.90	28.60	110
1985	25.90	30.10	116
1986	25.90	32.20	124
1987	27.10	35.90	132
1988	29.20	41.10	141
1989	30.90	46.00	149
1990	31.90	50.00	157
1995	46.50	N/A	N/A
2000	57.40	N/A	N/A
2005	72.20	N/A	N/A
2010	83.60	N/A	N/A

1/ Refiner acquisition cost of crude oil imports. For a range in world oil prices see Chapter 5.
2/ To convert deflator to traditional 1972=100 form, multiply by 2.0715.

TABLE 4-3: SCENARIO B--ENERGY CONSUMED BY THE FREE-WORLD[1/]
(Million Barrels per Day of Oil-Equivalent)

YEAR	LIQUIDS[2/] (Includes Coal Liquids)						GAS (Includes Synthetics)						COAL (Excludes Synthetic Feedstocks)						COAL SYNTHETICS CONVERSION LOSS
	OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD		
	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL	
ESTI.																			
1970	14.7	19.9	34.6	1.3	4.8	40.7	10.3	1.8	12.2	0.6	0.6	13.5	6.0	7.2	13.2	0.0	1.9	15.1	0.0
1975	16.3	21.2	37.5	2.2	7.2	46.9	9.4	3.9	13.4	0.9	1.3	15.6	6.0	6.4	12.4	0.0	2.3	14.7	0.0
1980	17.1	21.4	38.5	2.7	8.3	49.5	9.6	5.2	14.8	1.1	2.2	18.1	7.3	7.5	14.8	0.0	3.0	17.8	0.0
ESTI.																			
1982	15.3	18.6	33.9	2.9	8.7	45.4	8.5	5.1	13.6	1.2	1.8	16.6	7.3	7.2	14.5	0.0	2.5	17.0	0.0
PROJ.																			
1985	16.0	19.7	35.7	3.4	8.3	47.3	9.5	5.7	15.1	1.4	1.8	18.4	8.7	7.1	15.8	0.0	2.6	18.4	0.0
1990	15.8	20.2	36.0	4.6	10.0	50.6	9.5	5.9	15.4	2.1	2.2	19.8	10.0	7.4	17.4	0.0	3.1	20.6	0.0
1995	15.1	19.7	34.8	5.9	11.3	52.1	9.3	6.5	15.8	3.1	2.8	21.6	11.4	7.9	19.3	0.0	4.1	23.5	0.1
2000	14.3	19.3	33.6	7.2	12.7	53.5	9.0	7.3	16.3	4.2	3.3	23.8	13.1	9.0	22.1	0.0	5.1	27.3	0.2
2005	13.9	17.8	31.7	8.0	14.1	53.8	8.3	7.4	15.7	5.3	4.2	25.2	14.3	10.5	24.8	0.1	6.6	31.4	0.4
2010	13.4	17.3	30.7	8.4	15.1	54.1	7.9	7.4	15.3	6.3	5.2	26.7	14.8	11.7	26.5	0.1	8.4	35.0	1.4

YEAR	NUCLEAR						RENEWABLES/OTHER						TOTAL PRIMARY					
	OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD	
	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC		TOTAL
ESTI.																		
1970	0.1	0.2	0.4	0.0	0.0	0.5	1.9	2.7	4.6	0.0	0.6	5.2	33.0	31.8	64.9	2.0	8.0	74.9
1975	0.9	0.7	1.6	0.0	0.1	1.7	2.4	3.2	5.6	0.0	0.9	6.5	35.0	35.4	70.5	3.1	11.8	85.4
1980	1.3	1.6	2.9	0.0	0.1	3.0	2.6	3.7	6.4	0.1	1.5	8.0	37.9	39.4	77.4	3.9	15.1	96.4
ESTI.																		
1982	1.4	2.1	3.5	0.0	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	35.4	36.8	72.2	4.3	14.8	91.2
PROJ.																		
1985	2.2	2.6	4.8	0.0	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	39.2	39.0	78.2	4.9	14.7	97.9
1990	3.1	3.4	6.5	0.0	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	41.6	41.0	82.6	7.0	18.3	108.0
1995	3.3	4.0	7.3	0.0	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	43.2	42.7	86.9	9.3	22.5	117.7
2000	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	44.9	45.9	90.8	11.8	26.7	129.3
2005	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	46.6	47.5	94.1	13.8	31.3	139.2
2010	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	49.2	50.1	99.3	15.6	36.1	151.0

1/ Totals may not add due to independent rounding.
2/ Also includes natural gas liquids. Units are physical barrels.
3/ Includes U.S. territories.

TABLE 4-4: SCENARIO B--ENERGY SUPPLIED TO THE FREE-WORLD[1/]
(Million Barrels per Day of Oil-Equivalent)

	OIL[2/] (Excludes Coal Liquids)							GAS (Excludes Synthetics)							COAL[3/]						
	OECD							OECD							OECD						
YEAR	U.S.[4/]	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	NET CPE EXPTS.[5/]	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	NET CPE EXPTS.[5/]	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	NET CPE EXPTS.[5/]	TOTAL
ESTI.																					
1970	11.5	3.0	14.5	23.3	2.0	0.8	40.7	9.9	1.9	11.8	0.8	0.9	0.1	13.5	6.9	5.9	12.8	0.0	2.0	0.3	15.1
1975	10.5	3.5	14.0	28.1	3.7	1.1	46.9	9.1	3.9	13.0	1.4	1.1	0.1	15.6	6.9	5.2	12.1	0.0	2.2	0.4	14.7
1980	10.7	4.1	14.8	27.8	5.7	1.2	49.5	9.1	4.9	14.0	1.6	2.0	0.4	18.1	8.5	5.8	14.3	0.0	3.0	0.5	17.8
ESTI.																					
1982	11.1	6.0	17.1	19.8	7.0	1.5	45.4	8.1	4.5	12.6	1.3	2.3	0.4	16.6	8.6	5.4	14.0	0.0	2.5	0.5	17.0
PROJ.																					
1985	9.9	5.3	15.2	23.2	8.1	0.7	47.3	8.9	5.3	14.2	1.4	2.3	0.4	18.4	10.0	5.4	15.4	0.0	2.5	0.5	18.5
1990	9.9	5.6	15.5	25.7	9.3	0.0	50.5	8.6	5.4	14.0	2.3	3.0	0.5	19.8	11.5	5.5	17.0	0.0	3.0	0.6	20.7
1995	9.2	5.5	14.7	27.3	9.9	0.0	51.9	8.1	5.5	13.6	3.5	3.7	0.8	21.6	13.5	5.6	19.1	0.0	3.6	0.9	23.7
2000	9.0	5.7	14.7	27.7	10.8	0.0	53.2	7.7	5.7	13.4	4.8	4.3	1.3	23.8	15.9	6.4	22.3	0.0	4.5	1.1	27.8
2005	8.9	5.8	14.7	28.1	10.3	0.0	53.2	6.9	5.4	12.3	5.9	5.2	1.7	25.0	18.1	7.5	25.6	0.0	5.5	1.3	32.5
2010	8.8	6.3	15.1	28.0	9.7	0.0	52.8	5.5	5.2	10.7	7.0	6.2	1.8	25.7	21.6	8.8	30.4	0.0	6.8	1.5	38.7

	NUCLEAR						RENEWABLES/OTHER						TOTAL PRIMARY						
	OECD						OECD						OECD						
YEAR	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	NET CPE EXPTS.[5/]	TOTAL
ESTI.																			
1970	0.1	0.2	0.4	0.0	0.0	0.5	1.9	2.7	4.6	0.0	0.6	5.2	30.3	13.7	44.0	24.1	5.5	1.2	74.9
1975	0.9	0.7	1.6	0.0	0.1	1.7	2.3	3.2	5.6	0.0	0.9	6.5	29.7	16.5	46.3	29.5	8.0	1.6	85.4
1980	1.3	1.7	3.0	0.0	0.1	3.0	2.6	3.7	6.4	0.1	1.5	8.0	32.2	20.2	52.5	29.5	12.3	2.1	96.4
ESTI.																			
1982	1.4	2.1	3.5	0.0	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	32.1	21.8	53.9	21.3	13.6	2.4	91.2
PROJ.																			
1985	2.2	2.6	4.8	0.0	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	34.0	22.5	56.5	24.8	15.0	1.6	97.9
1990	3.1	3.4	6.5	0.0	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	36.4	24.0	60.4	28.2	18.2	1.0	108.0
1995	3.3	4.0	7.3	0.0	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	38.3	25.2	63.5	31.1	21.4	1.7	117.7
2000	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	41.0	28.0	69.0	32.8	25.0	2.4	129.3
2005	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	43.8	30.6	74.4	34.5	27.4	3.0	139.2
2010	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	47.9	33.8	81.7	35.8	30.1	3.3	151.0

1/ Supply from each region includes production, stock changes and adjustments. Totals may not add due to independent rounding.
2/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil and natural gas liquids. Units are physical barrels.
3/ Includes coal production for synthetics.
4/ Includes about 0.5 MMBD of refinery gain (see Table 3-10), and excludes U.S. territories which are included as part of the other OECD.
5/ Net exports from Centrally Planned Economies.

TABLE 4-5: SCENARIO B--NET ENERGY TRADE[1/]
(Million Barrels per Day of Oil-Equivalent)

YEAR	NET OIL EXPORTS: OECD U.S.	NET OIL EXPORTS: OECD OTHER[2/]	NET OIL EXPORTS: SUB-TOTAL	NET OIL EXPORTS: OPEC	NET OIL EXPORTS: REST OF FREE-WORLD	NET OIL EXPORTS: CENTRALLY PLANNED ECONOMIES	NET GAS EXPORTS: OECD U.S.	NET GAS EXPORTS: OECD OTHER[2/]	NET GAS EXPORTS: SUB-TOTAL	NET GAS EXPORTS: OPEC	NET GAS EXPORTS: REST OF FREE-WORLD	NET GAS EXPORTS: CENTRALLY PLANNED ECONOMIES
ESTI.												
1970	-3.2	-16.9	-20.1	22.0	-2.8	0.8	-0.4	0.0	-0.3	0.1	0.3	0.1
1975	-5.8	-17.7	-23.5	25.9	-3.5	1.1	-0.4	0.0	-0.4	0.5	-0.2	0.1
1980	-6.4	-17.3	-23.7	25.1	-2.6	1.2	-0.5	-0.3	-0.8	0.5	-0.2	0.4
ESTI.												
1982	-4.2	-12.3	-16.5	16.9	-2.0	1.5	-0.4	-0.6	-1.0	0.1	0.5	0.4
PROJ.												
1985	-6.1	-14.4	-20.4	19.8	-0.1	0.7	-0.5	-0.4	-0.9	0.0	0.5	0.4
1990	-5.9	-14.6	-20.5	21.1	-0.6	0.0	-0.9	-0.6	-1.5	0.2	0.8	0.5
1995	-5.9	-14.2	-20.1	21.4	-1.3	0.0	-1.1	-1.1	-2.2	0.4	0.9	0.8
2000	-5.2	-13.5	-18.7	20.5	-1.8	0.0	-1.2	-1.6	-2.8	0.5	1.0	1.3
2005	-4.8	-11.7	-16.5	20.2	-3.7	0.0	-1.3	-2.0	-3.3	0.6	1.0	1.7
2010	-3.9	-10.6	-14.5	19.6	-5.1	0.0	-1.4	-2.2	-3.6	0.8	1.0	1.8

YEAR	NET COAL EXPORTS: OECD U.S.	NET COAL EXPORTS: OECD OTHER[2/]	NET COAL EXPORTS: SUB-TOTAL	NET COAL EXPORTS: OPEC	NET COAL EXPORTS: REST OF FREE-WORLD	NET COAL EXPORTS: CENTRALLY PLANNED ECONOMIES	NET ENERGY TRADE: OECD U.S.	NET ENERGY TRADE: OECD OTHER[2/]	NET ENERGY TRADE: SUB-TOTAL	NET ENERGY TRADE: OPEC	NET ENERGY TRADE: REST OF FREE-WORLD	NET ENERGY TRADE: CENTRALLY PLANNED ECONOMIES
ESTI.												
1970	0.9	-1.3	-0.3	0.0	0.0	0.3	-2.7	-18.1	-20.8	22.1	-2.5	1.2
1975	0.9	-1.2	-0.3	0.0	-0.1	0.4	-5.4	-18.9	-24.3	26.4	-3.7	1.6
1980	1.1	-1.7	-0.5	0.0	0.0	0.5	-5.7	-19.2	-24.9	25.6	-2.8	2.1
ESTI.												
1982	1.3	-1.8	-0.5	0.0	0.0	0.5	-3.3	-14.7	-18.0	17.0	-1.5	2.4
PROJ.												
1985	1.3	-1.7	-0.4	0.0	-0.1	0.5	-5.3	-16.5	-21.8	19.8	0.3	1.6
1990	1.6	-1.9	-0.3	0.0	-0.2	0.6	-5.2	-17.0	-22.2	21.3	-0.1	1.0
1995	2.1	-2.3	-0.2	0.0	-0.7	0.9	-4.9	-17.6	-22.5	21.8	-1.1	1.7
2000	2.6	-2.8	-0.2	0.0	-0.9	1.1	-3.9	-17.9	-21.8	21.0	-1.7	2.4
2005	3.3	-3.2	0.1	-0.1	-1.3	1.3	-2.8	-16.9	-19.7	20.7	-4.0	3.0
2010	4.0	-3.5	0.5	-0.1	-1.8	1.5	-1.3	-16.2	-17.5	20.2	-6.0	3.3

1/ Totals may not add due to independent rounding.
2/ Includes U.S. territories.

TABLE 4-6: SCENARIO B--LIQUIDS CONSUMED BY AND SUPPLIED TO THE FREE-WORLD[1/]
(Million Barrels per Day)

	LIQUIDS CONSUMED						LIQUIDS SUPPLIED									
							OIL PRODUCTION[2/] (Excludes Coal Liquids)									
	OECD						NON-OPEC									
YEAR	U.S.	OTHER[3/]	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL	U.S.[4/]	NON-U.S. OECD[3/]	REST OF FREE-WORLD	SUB-TOTAL	OPEC	TOTAL	COAL LIQUIDS	STOCK CHANGES AND OTHER ADJUST.[5/]	NET CPE OIL EXPTS.[6/]	TOTAL
ESTI.																
1970	14.7	19.9	34.6	1.3	4.8	40.7	11.7	1.8	2.0	15.5	23.3	38.8	0.0	1.1	0.8	40.7
1975	16.3	21.2	37.5	2.2	7.2	46.9	10.5	2.9	3.5	16.9	28.1	45.0	0.0	0.8	1.1	46.9
1980	17.1	21.4	38.5	2.7	8.3	49.5	10.8	4.9	5.8	21.5	27.8	49.3	0.0	-1.0	1.2	49.5
1981	16.1	20.0	36.1	2.8	8.4	47.3	10.7	4.9	6.4	21.9	23.7	45.6	0.0	-0.5	1.2	47.3
ESTI.																
1982	15.3	18.6	33.9	2.9	8.7	45.4	10.7	5.2	7.0	23.0	19.8	42.8	0.0	1.1	1.5	45.4
PROJ.																
1983	15.5	19.1	34.6	3.0	8.3	45.9	10.7	5.4	7.2	23.3	22.0	45.3	0.0	-0.5	1.0	45.9
1984	15.7	19.5	35.2	3.2	8.2	46.6	10.5	5.5	7.7	23.7	22.8	46.5	0.0	-0.8	0.9	46.6
1985	16.0	19.7	35.7	3.4	8.3	47.3	10.2	5.6	8.1	23.9	23.2	47.1	0.1	-0.6	0.7	47.3
1986	16.0	20.2	36.2	3.6	8.7	48.5	10.0	5.6	8.4	24.0	23.8	47.8	0.1	0.0	0.6	48.5
1987	16.0	20.5	36.5	3.9	9.1	49.5	9.8	5.7	8.7	24.2	24.9	49.0	0.1	0.0	0.4	49.5
1988	15.9	20.5	36.4	4.1	9.5	50.0	9.8	5.7	8.9	24.4	25.4	49.7	0.1	0.0	0.3	50.0
1989	15.8	20.4	36.2	4.4	9.8	50.4	9.8	5.7	9.2	24.6	25.5	50.2	0.1	0.0	0.1	50.4
1990	15.8	20.2	36.0	4.6	10.0	50.6	9.9	5.6	9.3	24.8	25.7	50.5	0.1	0.0	0.0	50.6
1995	15.1	19.7	34.8	5.9	11.3	52.1	9.2	5.5	9.9	24.6	27.3	51.9	0.1	0.0	0.0	52.1
2000	14.3	19.3	33.6	7.2	12.8	53.5	9.0	5.7	10.8	25.6	27.7	53.3	0.3	0.0	0.0	53.5
2005	13.9	17.8	31.7	8.0	14.2	53.8	8.9	5.8	10.4	25.1	28.1	53.2	0.6	0.0	0.0	53.8
2010	13.4	17.3	30.7	8.4	15.1	54.1	8.8	6.3	9.7	24.8	28.0	52.8	1.3	0.0	0.0	54.1

1/ Totals may not add due to independent rounding.
2/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil and natural gas liquids.
3/ Includes U.S. Territories.
4/ Includes about 0.5 MMBD of refinery gain, see Table 3-10.
5/ Negative numbers indicate a reduction in supply, positive numbers an addition to supply. Adjustments are a balancing item and include unaccounted for private stock changes, losses, gains, miscellaneous blending components and unaccounted for supply.
6/ Net oil exports from Centrally Planned Economies.

TABLE 4-7: SCENARIO B--GROWTH RATES

(Percent Per Year)

	LIQUIDS CONSUMED						PRIMARY ENERGY CONSUMED						ECONOMIC GROWTH					
	OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD		OECD				REST OF FREE-WORLD	
PERIOD	U.S.	OTHER	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC		TOTAL
HIST.																		
1970-1980	1.5	0.7	1.1	7.3	5.5	2.0	1.4	2.1	1.8	6.7	6.4	2.5	3.1	3.3	3.2	8.4	4.2	3.6
1980-1982	-5.6	-7.0	-6.4	3.6	2.4	-4.3	-3.5	-3.5	-3.5	4.9	-1.0	-2.8	0.1	0.5	0.3	3.4	3.0	0.9
PROJ.																		
1982-1990	0.4	1.0	0.8	5.8	1.7	1.4	2.0	1.4	1.7	6.1	2.7	2.1	3.3	3.0	3.2	5.6	3.0	3.3
1990-2000	-1.0	-0.5	-0.7	4.5	2.4	0.6	0.8	1.1	0.9	5.2	3.7	1.8	2.4	2.4	2.4	4.8	3.5	2.8
2000-2010	-0.7	-1.1	-0.9	1.5	1.7	0.1	0.9	0.9	0.9	2.8	3.0	1.6	2.1	2.1	2.1	3.3	2.7	2.3
1982-2000	-0.4	0.2	0.0	5.1	2.1	0.9	1.3	1.2	1.3	5.6	3.3	1.9	2.8	2.8	2.8	5.1	3.3	3.0
1982-2010	-0.5	-0.3	-0.4	3.8	2.0	1.0	1.2	1.1	1.1	4.6	3.2	1.8	2.6	2.6	2.6	4.5	3.1	2.8

PART III: ALTERNATIVE VIEWS

CONTENTS

CHAPTER 5: SCENARIOS A AND C--ALTERNATIVE WORLD VIEWS

Having access to the same data, assuming about the same level of economic growth and using similar pricing theories, different analysts can develop significantly different global energy projections. The differences in projections often result from differing views or judgments about likely future conditions. Some analysts, for example, will tend to choose assumptions which correspond to higher world oil prices; others hold views which lead them to select assumptions consistent with lower world oil prices. In this chapter, we present two internally consistent scenarios which reflect very different world views:

> Scenario A--assumes a high potential for energy demand reduction and a high energy supply potential leading to world oil prices which are low relative to Scenario B (the reference case) throughout the projection period.
>
> Scenario C--assumes a low potential for energy demand reduction and a low energy supply potential leading to world oil prices which are high relative to Scenario B throughout the projection period.

To generate Scenarios A and C, many of the underlying assumptions of Scenario B (discussed in Chapters 3 and 4) were varied simultaneously. The correct manner of using and interpreting Scenarios A, B, and C is, consequently, to view each as a totally independent but internally consistent "base case" for use in energy analysis.

5.1 ALTERNATIVE ASSUMPTIONS

There are a number of supply and demand assumptions which can be made for each type of energy used in each free-world region (U.S., Non-U.S. OECD, OPEC and the Rest of the Free World). Changing such assumptions produces a range of results, with the range of oil prices being particularly wide. Given the many potential scenarios, two were chosen as bounding what we believe is a reasonable range of results for use as inputs to the long-term planning process.

For this analysis, only one variable which could affect the supply or demand for each fuel in each region was varied (see Table 5-1). The range of supply and demand uncertainty tested in this manner is presented in Figure 5-1 for the year 2000. As illustrated in this figure, the supply and demand curves embodied in Scenario A are different from those embodied in Scenarios B or C. It is therefore not appropriate to estimate implied elasticities by comparing prices, supply and demand among scenarios. The world oil prices which are associated with these scenarios are the result of shifts in the supply and demand curves, not movement along an individual curve.

TABLE 5-1: ASSUMPTIONS CHANGED TO CREATE SCENARIOS A AND C[1/]

VARIABLE CHANGED (Increased for Scenario A, Decreased for Scenario C)
Demand Assumptions
Energy Price to Demand Elasticity
Income to Electricity Demand Elasticity
Capital Equipment Turnover Rate
Oil Production Potential
Natural Gas Production Potential
Coal Production Potential
Nuclear Production Potential
Renewables Production Potential
Synthetic Fuels Production Potential
Trade Assumptions
Net CPE Oil Exports
Net CPE Natural Gas Exports
Net CPE Coal Exports

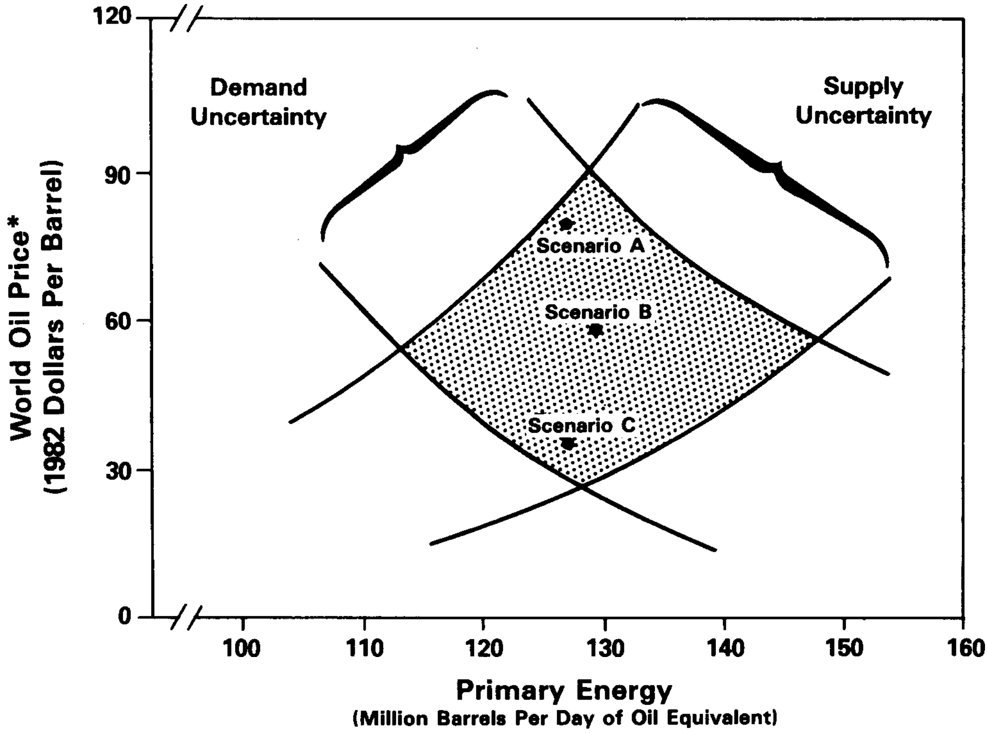
1/ A range was established for each variable for each global region. The range on most of these variables was gradually increased, eventually reaching plus and minus 12.5 to 15 percent of the Scenario B assumption.

The range of world oil prices generated in the analysis is shown by the shaded region on Figure 5-2. This wide range indicates that small changes in energy demand and supply assumptions can cause large changes in world oil prices. World oil prices tend to react strongly to changes in other assumptions in part because oil is projected to remain the world's "swing" fuel. Small shifts in non-oil energy supply and demand can result in large shifts in oil demand, causing large oil price impacts.

After reviewing the variety of possible results given the tested range of assumptions, two scenarios, A and C, were developed as alternatives to Scenario B. The range on the individual variables used for Scenarios A and C generally accounted for 80 percent of the full uncertainty interval tested. This narrowed range reflects the low probability that all of the tested variables will simultaneously fall at the extreme end of what, for each variable individually, is considered a reasonable range. The economic assumptions for Scenarios A and C were also adjusted to keep achieved economic growth relatively constant across the three cases. The 80 percent

Figure 5-1

FREE-WORLD SUPPLY AND DEMAND UNCERTAINTY IN 2000



*U.S. Refiner Acquisition Cost of Crude Oil Imports.

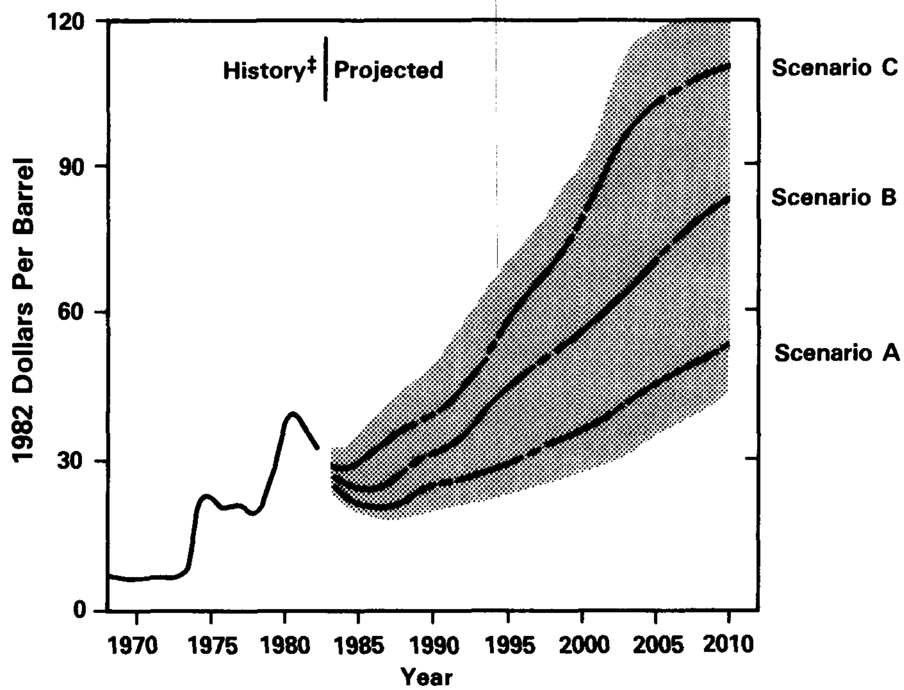
range for the supply and demand variables reflects an assumption of increasing uncertainty over time. In most cases the range eventually reaches plus and minus 15 percent of the Scenario B assumptions.

5.2 ALTERNATIVE RESULTS

Because in Scenarios A, B, and C many assumptions were varied simultaneously, comparisons across scenarios can be misleading. For example, non-OPEC oil production varies only a small amount between Scenarios A and C, despite a very large difference in the world oil price. This occurs because the oil resource base is assumed to be much larger in Scenario A than in C. Therefore, despite the highest oil prices, free-world oil production is lowest in Scenario C. From an economic point of view, we have shifted the oil supply curve in moving from Scenario A to C. The most significant impact of the alternative assumptions is on the world oil price projections. The assumptions also, however, have significant impacts on other energy conditions.

Although the shapes of the world oil price paths under the various scenarios are similar, the timing and magnitude of the increases are not. World prices fall further in 1983 in Scenario A than in the other cases, and they

Figure 5-2
WORLD OIL PRICES*



*U.S. Refiner Acquisition Cost of Crude Oil Imports. The Shaded Region Illustrates the Range of Prices Resulting From Combinations of Assumptions Tested.
‡International Data Is Often Incomplete and Subject to Frequent Revision.

continue to fall slowly, in real terms, through 1986. After 1986, Scenario A prices increase rapidly for a few years in response to a tightening world oil market. Scenario C prices begin to increase in nominal terms in mid-1983. Without as big an early 1980's real decline, prices grow more gradually in the late 1980's than in the other two scenarios. The rate of price increase is about the same in all three scenarios after 1990. Starting from different base values, however, the long-term results are quite different. By 2010, the Scenario A world oil price is 30 dollars per barrel (1982 dollars) below and the Scenario C price is 25 dollars per barrel above the reference price (Scenario B). In the long term, prices resulting from the Scenario A, B and C assumptions begin to converge due to feedbacks in the economy: low near-term prices stimulate energy demand which eventually pushes up prices, while high near-term prices have the opposite effect.

Compared to the Scenario B projections, other significant results of the Scenario A and C assumptions include:

- o Total energy consumed is lower in oil-importing regions under Scenario C, in part due to higher energy prices;

- Total energy supplied by the Rest of the Free World and, until 2000, the Non-U.S. OECD, is higher in Scenario A because assumed increases in potential supply with accompanying lower energy production costs allow higher production even with lower prices. Despite more plentiful and cheaper resources, higher near-term production eventually depletes the resources, resulting in lower long-term production;

- Total energy supplied by the U.S., OPEC and eventually the Non-U.S. OECD is higher under Scenario C primarily due to incentives created by higher prices;

- The demand for OPEC oil and thus OPEC oil production is higher under Scenario A and lower under Scenario C; and

- U.S. electricity consumption is lower under Scenario A and higher under Scenario C.

Projections resulting from the Scenario A, B and C assumptions are shown on the following Tables. World oil prices are shown on Table 5-2 and economic growth conditions on Table 5-3. Energy consumed, energy supplied, energy traded and a liquids balance for the free world are shown on Tables 5-4 through 5-7. United States delivered fuel prices, energy supplied, energy consumed and energy transformed are shown on Tables 5-8 through 5-11.

TABLE 5-2: WORLD OIL PRICE UNDER ALTERNATIVE WORLD VIEWS

YEAR	WORLD OIL PRICE 1/ 1982 DOLLARS PER BARREL SCENARIO A 3/	SCENARIO B	SCENARIO C 4/	NOMINAL DOLLARS PER BARREL 2/ SCENARIO A 3/	SCENARIO B	SCENARIO C 4/
ESTI.						
1982	33.59	33.59	33.59	33.59	33.59	33.59
PROJ.						
1983	25.20	27.40	29.70	26.30	28.60	31.00
1984	22.60	25.90	28.90	25.00	28.60	31.90
1985	21.00	25.90	30.50	24.40	30.10	35.50
1986	20.30	25.90	32.60	25.20	32.20	40.65
1987	20.50	27.10	35.30	27.20	35.90	46.80
1988	22.20	29.20	37.70	31.20	41.10	53.00
1989	24.40	30.90	39.40	36.30	46.00	58.60
1990	25.60	31.90	40.30	40.20	50.00	63.30
1995	30.30	46.50	59.50	N/A	N/A	N/A
2000	36.00	57.40	80.30	N/A	N/A	N/A
2005	46.50	72.20	104.00	N/A	N/A	N/A
2010	54.60	83.60	111.40	N/A	N/A	N/A

1/ Refiner acquisition cost of crude oil imports.
2/ For GDP deflators see Table 4-2.
3/ Assumes high supply and conservation potential.
4/ Assumes low supply and conservation potential.

TABLE 5-3: ECONOMIC GROWTH UNDER ALTERNATIVE WORLD VIEWS

	GDP INDEX (1982=1.00)					
	OECD					
YEAR	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL
1982	1.00	1.00	1.00	1.00	1.00	1.00
PROJ.						
1985						
CASE A	1.13	1.10	1.11	1.16	1.04	1.11
CASE B	1.12	1.10	1.11	1.16	1.04	1.10
CASE C	1.12	1.10	1.11	1.17	1.04	1.10
1990						
CASE A	1.31	1.28	1.30	1.55	1.28	1.30
CASE B	1.30	1.27	1.28	1.56	1.27	1.30
CASE C	1.29	1.26	1.27	1.57	1.27	1.28
1995						
CASE A	1.47	1.45	1.46	1.95	1.52	1.49
CASE B	1.48	1.46	1.47	2.02	1.54	1.51
CASE C	1.46	1.45	1.45	2.03	1.52	1.48
2000						
CASE A	1.62	1.61	1.61	2.37	1.75	1.66
CASE B	1.65	1.66	1.66	2.52	1.81	1.72
CASE C	1.62	1.64	1.63	2.54	1.79	1.69
2005						
CASE A	1.81	1.80	1.81	2.83	2.02	1.87
CASE B	1.85	1.86	1.86	3.01	2.09	1.94
CASE C	1.81	1.83	1.82	3.05	2.06	1.90
2010						
CASE A	2.00	1.99	2.00	3.30	2.28	2.08
CASE B	2.05	2.06	2.06	3.51	2.36	2.16
CASE C	2.01	2.04	2.03	3.56	2.35	2.13

TABLE 5-4: ENERGY CONSUMED BY THE FREE WORLD UNDER ALTERNATIVE WORLD VIEWS [1/]

(Million Barrels per Day of Oil-Equivalent)

	LIQUIDS [2/] (Includes Coal Liquids)						GAS (Includes Synthetics)						COAL (Excludes Synthetic Feedstocks)						
	OECD						OECD						OECD						
YEAR	U.S.	OTHER[3/]	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER[3/]	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	COAL SYNTHETICS CONVERSION LOSS
ESTI.																			
1982	15.3	18.6	33.9	2.9	8.7	45.4	8.5	5.1	13.6	1.2	1.8	16.6	7.3	7.2	14.5	--	2.5	17.0	--
PROJ.																			
1985																			
CASE A	15.9	20.2	36.1	3.4	8.2	47.7	9.5	5.6	15.1	1.4	1.7	18.2	8.5	6.9	15.4	--	2.5	17.9	--
CASE B	16.0	19.7	35.7	3.4	8.2	47.3	9.5	5.7	15.1	1.4	1.8	18.4	8.7	7.1	15.8	--	2.6	18.4	--
CASE C	15.9	19.3	35.2	3.4	8.3	46.9	9.4	5.8	15.2	1.4	1.8	18.5	8.7	7.3	16.0	--	2.6	18.6	--
1990																			
CASE A	16.0	21.9	37.9	4.5	10.1	52.6	9.6	5.8	15.4	2.1	2.0	19.5	9.5	6.9	16.4	--	3.0	19.4	--
CASE B	15.8	20.2	36.0	4.6	10.0	50.6	9.5	5.9	15.4	2.1	2.2	19.8	10.0	7.4	17.4	--	3.1	20.6	--
CASE C	15.3	19.0	34.3	4.7	9.9	48.8	9.3	5.9	15.2	2.1	2.2	19.6	10.1	8.0	18.1	--	3.3	21.4	--
1995																			
CASE A	15.8	22.1	37.9	5.4	11.0	54.3	9.4	6.6	16.0	2.9	2.3	21.2	10.3	6.9	17.2	--	3.8	21.0	0.1
CASE B	15.1	19.7	34.8	5.9	11.3	52.1	9.3	6.5	15.8	3.1	2.8	21.6	11.4	7.9	19.3	--	4.1	23.5	0.1
CASE C	14.3	18.2	32.5	6.0	11.3	49.9	8.9	6.4	15.3	3.1	2.8	21.2	11.8	8.6	20.4	--	4.3	24.8	0.1
2000																			
CASE A	15.5	22.9	38.4	6.2	11.7	56.3	9.1	7.3	16.4	3.8	2.7	22.8	10.9	7.1	18.0	--	4.5	22.7	0.2
CASE B	14.3	19.3	33.6	7.2	12.7	53.5	9.0	7.3	16.3	4.2	3.3	23.8	13.1	9.0	22.1	--	5.1	27.3	0.2
CASE C	13.0	17.9	30.9	7.5	12.8	51.1	8.4	7.0	15.4	4.2	3.2	22.9	13.7	10.7	24.4	--	5.6	30.0	0.2
2005																			
CASE A	15.6	21.7	37.3	6.9	12.4	56.6	8.7	7.4	16.1	4.6	3.5	24.2	11.3	7.5	18.8	0.1	5.6	24.5	0.3
CASE B	13.9	17.8	31.7	8.0	14.1	53.8	8.3	7.4	15.7	5.3	4.2	25.2	14.3	10.5	24.8	0.1	6.6	31.4	0.4
CASE C	12.0	16.9	28.9	8.1	13.7	50.6	7.7	7.2	14.9	5.5	4.3	24.8	15.0	12.6	27.6	0.1	7.4	35.1	0.3
2010																			
CASE A	15.5	20.2	35.7	7.3	13.0	56.1	8.2	7.1	15.3	5.4	4.4	25.1	11.4	7.9	19.3	0.2	6.9	26.4	0.7
CASE B	13.4	17.3	30.7	8.4	15.1	54.1	7.9	7.4	15.3	6.3	5.2	26.7	14.8	11.7	26.5	0.1	8.4	35.0	1.4
CASE C	11.6	16.4	28.0	8.7	14.8	51.5	7.3	7.3	14.6	6.8	5.7	27.1	15.8	14.3	30.1	0.1	9.5	39.9	1.1

TABLE 5-4 (continued): ENERGY CONSUMED BY THE FREE WORLD UNDER ALTERNATIVE WORLD VIEWS

(Million Barrels per Day of Oil-Equivalent)

	NUCLEAR						RENEWABLE/OTHER						TOTAL PRIMARY					
	OECD						OECD						OECD					
YEAR	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL
ESTI.																		
1982	1.4	2.1	3.5	--	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	35.4	36.8	72.2	4.3	14.8	91.2
PROJ.																		
1985																		
CASE A	2.1	2.6	4.7	--	0.1	4.8	2.9	4.0	6.9	0.2	2.0	9.2	38.9	39.3	78.2	4.9	14.6	97.8
CASE B	2.2	2.6	4.8	--	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	39.2	39.0	78.2	4.9	14.7	97.9
CASE C	2.2	2.7	4.9	--	0.1	5.0	2.9	3.8	6.7	0.2	1.9	8.7	39.2	38.8	78.0	5.0	14.8	97.7
1990																		
CASE A	3.0	3.4	6.4	--	0.4	6.8	3.3	4.4	7.7	0.2	2.7	10.7	41.4	42.3	83.7	6.9	18.4	109.0
CASE B	3.1	3.4	6.5	--	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	41.6	41.0	82.6	7.0	18.3	108.0
CASE C	3.2	3.4	6.6	--	0.2	6.9	3.2	3.7	6.9	0.2	2.4	9.5	41.1	40.0	81.1	7.0	18.0	106.2
1995																		
CASE A	3.1	4.0	7.1	0.1	0.5	7.8	3.9	5.0	8.9	0.2	4.2	13.3	42.7	44.5	87.2	8.7	21.8	117.7
CASE B	3.3	4.0	7.3	--	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	43.2	42.7	86.9	9.3	22.5	117.7
CASE C	3.3	3.8	7.1	--	0.4	7.6	4.1	4.2	8.3	0.2	3.3	11.8	42.4	41.3	83.7	9.4	22.2	115.4
2000																		
CASE A	3.6	4.8	8.4	0.3	0.9	9.6	4.5	5.9	10.4	0.3	5.0	15.6	43.7	48.0	91.7	10.6	24.8	127.2
CASE B	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	44.9	45.9	90.8	11.8	26.7	129.3
CASE C	3.6	4.4	8.0	--	0.7	8.8	4.8	5.0	9.8	0.2	3.9	13.9	43.6	45.0	88.6	12.0	26.4	126.9
2005																		
CASE A	4.3	5.5	9.8	0.6	1.6	11.9	5.0	6.6	11.6	0.3	5.3	17.2	45.1	48.6	93.7	12.6	28.4	134.8
CASE B	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	46.6	47.5	94.1	13.8	31.3	139.2
CASE C	4.0	5.0	9.0	0.1	1.1	10.1	6.0	5.9	11.9	0.2	4.3	16.3	44.8	47.7	92.5	13.9	30.8	137.2
2010																		
CASE A	5.4	6.3	11.7	0.9	2.2	14.8	5.7	7.3	13.0	0.3	6.0	19.3	46.8	48.9	95.7	14.2	32.5	142.4
CASE B	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	49.2	50.1	99.3	15.6	36.1	151.0
CASE C	4.3	5.7	10.0	0.3	1.3	11.6	7.6	6.8	14.4	0.3	4.7	19.5	47.4	50.8	98.2	16.2	36.2	150.7

1/ The Case A Scenario assumes high energy supply and conservation potential. The Case C scenario assumes low energy supply and conservation potential. Totals may not add due to independent rounding.
2/ Also includes natural gas liquids. Units are physical barrels.
3/ Includes U.S. territories.

TABLE 5-5: ENERGY SUPPLIED TO THE FREE WORLD UNDER ALTERNATIVE WORLD VIEWS [1/]

(Million Barrels per Day of Oil-Equivalent)

	OIL [2/] (Excludes Coal Liquids)							GAS (Excludes Synthetics)							COAL [3/]						
	OECD							OECD							OECD						
YEAR	U.S. [4/]	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS. [5/]	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS. [5/]	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS. [5/]	TOTAL
ESTI.																					
1982	11.1	6.0	17.1	19.8	7.0	1.5	45.4	8.1	4.5	12.6	1.3	2.3	0.4	16.6	8.6	5.4	14.0	--	2.5	0.5	17.0
PROJ.																					
1985																					
CASE A	9.8	5.2	15.0	23.5	8.1	1.1	47.6	9.0	5.3	14.3	1.4	2.2	0.3	18.2	9.4	5.3	14.7	--	2.5	0.8	18.0
CASE B	9.9	5.3	15.2	23.2	8.1	0.7	47.3	8.9	5.3	14.2	1.4	2.3	0.4	18.4	10.0	5.4	15.4	--	2.5	0.5	18.5
CASE C	10.2	5.6	15.8	22.8	8.1	0.1	46.8	8.9	5.3	14.2	1.6	2.2	0.4	18.5	10.4	5.5	15.9	--	2.6	0.3	18.7
1990																					
CASE A	9.6	5.8	15.4	26.2	9.5	1.4	52.5	8.7	5.4	14.1	2.1	2.8	0.4	19.5	10.3	5.2	15.5	--	3.0	1.0	19.5
CASE B	9.9	5.6	15.5	25.7	9.3	--	50.5	8.6	5.4	14.0	2.3	3.0	0.5	19.8	11.5	5.5	17.0	--	3.0	0.6	20.7
CASE C	10.0	5.5	15.5	25.2	9.0	-1.0	48.7	8.5	5.2	13.7	2.6	2.8	0.4	19.6	12.5	5.7	18.2	--	3.0	0.3	21.5
1995																					
CASE A	8.8	5.9	14.7	27.0	10.6	1.7	54.1	8.3	5.9	14.2	2.9	3.4	0.7	21.2	10.8	5.4	16.2	--	3.5	1.4	21.2
CASE B	9.2	5.5	14.7	27.3	9.9	--	51.9	8.1	5.5	13.6	3.5	3.7	0.8	21.6	13.5	5.6	19.1	--	3.6	0.9	23.7
CASE C	9.1	5.2	14.3	27.2	9.2	-1.0	49.7	7.7	5.1	12.8	4.1	3.7	0.6	21.2	15.2	5.8	21.0	--	3.6	0.4	25.0
2000																					
CASE A	8.5	6.1	14.6	27.5	11.9	2.0	56.0	7.8	6.4	14.2	3.8	3.8	1.2	22.9	11.7	5.6	17.3	--	4.2	1.6	23.2
CASE B	9.0	5.7	14.7	27.7	10.8	--	53.2	7.7	5.7	13.4	4.8	4.3	1.3	23.8	15.9	6.4	22.3	--	4.5	1.1	27.8
CASE C	8.6	5.3	14.9	28.1	9.8	-1.0	50.8	6.8	5.2	12.0	5.5	4.5	0.8	22.8	18.5	6.8	25.3	--	4.4	0.6	30.5
2005																					
CASE A	8.6	6.0	14.6	28.0	11.2	2.3	56.1	7.1	6.0	13.1	4.7	5.0	1.4	24.2	12.6	6.0	18.6	--	5.0	1.7	25.3
CASE B	8.9	5.8	14.7	28.1	10.3	--	53.2	6.9	5.4	12.3	5.9	5.2	1.7	25.0	18.1	7.5	25.6	--	5.5	1.3	32.5
CASE C	8.2	5.6	13.8	27.9	9.3	-1.0	50.1	5.5	5.1	10.6	7.0	5.9	1.1	24.6	21.3	8.4	29.7	--	5.7	0.7	36.1
2010																					
CASE A	8.3	6.0	14.3	28.2	10.3	2.5	55.2	6.3	5.4	11.7	5.6	5.9	1.6	24.9	13.8	6.5	20.3	--	6.0	1.8	28.2
CASE B	8.8	6.3	15.1	28.0	9.7	--	52.8	5.5	5.2	10.7	7.0	6.2	1.8	25.7	21.6	8.8	30.4	--	6.8	1.5	38.7
CASE C	8.0	6.4	14.4	27.8	9.1	-1.0	50.2	4.1	5.0	9.1	8.6	7.5	1.1	26.3	25.1	10.1	35.2	--	7.0	0.8	43.1

TABLE 5-5 (continued): ENERGY SUPPLIED TO THE FREE WORLD UNDER ALTERNATIVE WORLD VIEWS

(Million Barrels per Day of Oil-Equivalent)

	NUCLEAR						RENEWABLES/OTHER						TOTAL PRIMARY						
	OECD						OECD						OECD						
YEAR	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS. 5/	TOTAL
ESTI.																			
1982	1.4	2.1	3.5	--	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	32.1	21.8	53.9	21.3	13.6	2.4	91.2
PROJ.																			
1985																			
CASE A	2.1	2.6	4.7	--	0.1	4.8	2.9	4.0	6.9	0.2	2.0	9.2	33.6	22.8	56.4	25.1	15.0	2.2	97.8
CASE B	2.2	2.6	4.8	--	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	34.0	22.5	56.5	24.8	15.0	1.6	97.9
CASE C	2.2	2.7	4.9	--	0.1	5.0	2.9	3.8	6.7	0.2	1.9	8.7	34.7	22.8	57.5	24.6	14.9	0.8	97.7
1990																			
CASE A	3.0	3.4	6.4	--	0.4	6.8	3.3	4.4	7.7	0.2	2.7	10.7	34.9	24.2	59.1	28.6	18.5	2.8	109.0
CASE B	3.1	3.4	6.5	--	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	36.4	24.0	60.4	28.2	18.2	1.0	108.0
CASE C	3.2	3.4	6.6	--	0.2	6.9	3.2	3.7	6.9	0.2	2.4	9.5	37.4	23.5	60.9	28.1	17.6	-0.3	106.2
1995																			
CASE A	3.1	4.0	7.1	0.1	0.5	7.8	3.9	5.0	8.9	0.2	4.2	13.3	35.0	26.3	61.3	30.3	22.3	3.8	117.7
CASE B	3.3	4.0	7.3	--	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	38.3	25.2	63.5	31.1	21.4	1.7	117.7
CASE C	3.3	3.8	7.1	--	0.4	7.6	4.1	4.2	8.3	0.2	3.3	11.8	39.4	24.1	63.5	31.6	20.2	--	115.4
2000																			
CASE A	3.6	4.8	8.4	0.3	0.9	9.6	4.5	5.9	10.4	0.3	5.0	15.6	36.1	28.7	64.8	31.9	25.7	4.8	127.2
CASE B	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	41.0	28.0	69.0	32.8	25.0	2.4	129.3
CASE C	3.6	4.4	8.0	--	0.7	8.8	4.8	5.0	9.8	0.2	3.9	13.9	42.4	26.9	69.3	33.9	23.3	0.4	126.9
2005																			
CASE A	4.3	5.5	9.8	0.6	1.6	11.9	5.0	6.6	11.6	0.3	5.3	17.2	37.5	30.0	67.5	33.6	28.1	5.5	134.8
CASE B	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	43.8	30.6	74.4	34.5	27.4	3.0	139.2
CASE C	4.0	5.0	9.0	0.1	1.1	10.1	6.0	5.9	11.9	0.2	4.3	16.3	45.0	30.0	75.0	35.2	26.2	0.8	137.2
2010																			
CASE A	5.4	6.3	11.7	0.9	2.2	14.8	5.7	7.3	13.0	0.3	6.0	19.3	39.4	31.5	70.9	35.1	30.4	5.9	142.4
CASE B	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	47.9	33.8	81.7	35.8	30.1	3.3	151.0
CASE C	4.3	5.7	10.0	0.3	1.3	11.6	7.6	6.8	14.4	0.3	4.7	19.5	49.1	34.0	83.1	37.0	29.6	0.9	150.7

1/ Supply from each region includes production, stock changes, and adjustments. The Case A scenario assumes high energy supply and conservation potential. The Case C scenario assumes low energy supply and conservation potential. Totals may not add due to independent rounding.

2/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil and natural gas liquids. Units are physical barrels.

3/ Includes coal production for synthetics.

4/ Includes about 0.5 MMBD of refinery gain and excludes U.S. territories which are included as part of the other OECD.

5/ Net exports from Centrally Planned Economies.

TABLE 5-6: NET ENERGY TRADE UNDER ALTERNATIVE WORLD VIEWS 1/

(Million Barrels per Day of Oil-Equivalent)

	NET OIL EXPORTS						NET GAS EXPORTS					
	OECD						OECD					
YEAR	U.S.	OTHER 2/	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES	U.S.	OTHER 2/	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES
ESTI.												
1982	-4.2	-12.3	-16.5	16.9	-2.0	1.5	-0.4	-0.6	-1.0	0.1	0.5	0.4
PROJ.												
1985												
CASE A	-6.2	-15.0	-21.2	20.1	-0.1	1.1	-0.5	-0.3	-0.8	0.1	0.5	0.3
CASE B	-6.1	-14.4	-20.4	19.8	-0.1	0.7	-0.5	-0.4	-0.9	--	0.5	0.4
CASE C	-5.7	-13.7	-19.4	19.4	-0.1	0.1	-0.5	-0.5	-1.0	0.2	0.4	0.4
1990												
CASE A	-6.4	-16.1	-22.5	21.7	-0.6	1.4	-0.9	-0.4	-1.3	0.1	0.8	0.4
CASE B	-5.9	-14.6	-20.5	21.1	-0.6	--	-0.9	-0.6	-1.5	0.2	0.8	0.5
CASE C	-5.3	-13.5	-18.8	20.6	-0.8	-1.0	-0.8	-0.7	-1.5	0.5	0.6	0.4
1995												
CASE A	-7.0	-16.1	-23.1	21.6	-0.3	1.7	-1.2	-0.6	-1.8	--	1.1	0.7
CASE B	-5.9	-14.2	-20.1	21.4	-1.3	--	-1.1	-1.1	-2.2	0.4	0.9	0.8
CASE C	-5.2	-12.9	-18.1	21.2	-2.0	-1.0	-1.2	-1.3	-2.5	1.0	0.9	0.6
2000												
CASE A	-6.8	-16.8	-23.6	21.3	0.3	2.0	-1.4	-1.0	-2.4	--	1.2	1.2
CASE B	-5.2	-13.5	-18.7	20.5	-1.8	--	-1.2	-1.6	-2.8	0.5	1.0	1.3
CASE C	-4.3	-12.5	-16.8	20.6	-2.9	-1.0	-1.6	-1.8	-3.4	1.3	1.2	0.8
2005												
CASE A	-6.7	-15.6	-22.3	21.0	-1.0	2.3	-1.5	-1.4	-2.9	0.1	1.4	1.4
CASE B	-4.8	-11.7	-16.5	20.2	-3.7	--	-1.3	-2.0	-3.3	0.6	1.0	1.7
CASE C	-3.7	-11.0	-14.7	19.8	-4.2	-1.0	-2.0	-2.1	-4.1	1.5	1.5	1.1
2010												
CASE A	-6.6	-14.1	-20.7	20.9	-2.6	2.5	-1.7	-1.6	-3.3	0.2	1.5	1.6
CASE B	-3.9	-10.6	-14.5	19.6	-5.1	--	-1.4	-2.2	-3.6	0.8	1.0	1.8
CASE C	-3.1	-9.6	-12.7	19.1	-5.4	-1.0	-2.4	-2.3	-4.7	1.8	1.8	1.1

TABLE 5-6 (continued): NET ENERGY TRADE UNDER ALTERNATIVE WORLD VIEWS

(Million Barrels Per Day of Oil-Equivalent)

	NET COAL EXPORTS						NET ENERGY TRADE					
	OECD						OECD					
YEAR	U.S.	OTHER 2/	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES	U.S.	OTHER 2/	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES
ESTI.												
1982	1.3	-1.8	-0.5	--	--	0.5	-3.3	-14.7	-18.0	17.0	-1.5	2.4
PROJ.												
1985												
CASE A	1.0	-1.6	-0.6	--	-0.1	0.8	-5.8	-16.9	-22.7	20.1	0.4	2.2
CASE B	1.3	-1.7	-0.4	--	-0.1	0.5	-5.3	-16.5	-21.8	19.8	0.3	1.6
CASE C	1.6	-1.8	-0.2	--	-0.1	0.3	-4.6	-16.0	-20.6	19.6	0.2	0.8
1990												
CASE A	0.8	-1.6	-0.8	--	-0.1	1.0	-6.6	-18.1	-24.7	21.8	0.1	2.8
CASE B	1.6	-1.9	-0.3	--	-0.2	0.6	-5.2	-17.0	-22.2	21.3	-0.1	1.0
CASE C	2.4	-2.3	0.1	--	-0.4	0.3	-3.8	-16.5	-20.3	21.0	-0.5	-0.3
1995												
CASE A	0.4	-1.5	-1.1	--	-0.3	1.4	-7.7	-18.2	-25.9	21.6	0.4	3.8
CASE B	2.1	-2.3	-0.2	--	-0.7	0.9	-4.9	-17.6	-22.5	21.8	-1.1	1.7
CASE C	3.4	-2.9	0.5	--	-0.9	0.4	-3.0	-17.2	-20.2	22.1	-2.0	--
2000												
CASE A	0.5	-1.6	-1.1	-0.1	-0.4	1.6	-7.7	-19.3	-27.0	21.2	0.9	4.8
CASE B	2.6	-2.8	-0.2	--	-0.9	1.1	-3.9	-17.9	-21.8	21.0	-1.7	2.4
CASE C	4.7	-3.9	0.8	--	-1.4	0.6	-1.2	-18.2	-19.3	21.9	-3.0	0.4
2005												
CASE A	0.7	-1.6	-0.9	-0.1	-0.6	1.7	-7.6	-18.6	-26.2	21.0	-0.3	5.5
CASE B	3.3	-3.2	0.1	-0.1	-1.3	1.3	-2.8	-16.9	-19.7	20.7	-4.0	3.0
CASE C	6.0	-4.6	1.4	-0.1	-2.0	0.7	0.3	-17.7	-17.4	21.3	-4.7	0.8
2010												
CASE A	1.0	-1.7	-0.7	-0.2	-0.9	1.8	-7.3	-17.4	-24.7	21.0	-2.2	5.9
CASE B	4.0	-3.5	0.5	-0.1	-1.8	1.5	-1.3	-16.2	-17.5	20.2	-6.0	3.3
CASE C	7.3	-5.0	2.3	-0.1	-2.9	0.8	1.7	-16.8	-15.1	20.7	-6.6	0.9

1/ The Case A scenario assumes high energy supply and conservation potential. The Case C scenario assumes low energy supply and conservation potential. Totals may not add due to independent rounding.

2/ Includes U.S. territories.

TABLE 5-7: LIQUIDS CONSUMED BY AND SUPPLIED TO THE FREE WORLD UNDER ALTERNATIVE WORLD VIEWS 1/
(Million Barrels per Day)

YEAR	LIQUIDS CONSUMED						LIQUIDS SUPPLIED									
							OIL PRODUCTION 2/ (Excludes Coal Liquids)									
	OECD						NON-OPEC									
	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL	U.S. 4/	NON-U.S. OECD 3/	REST OF FREE-WORLD	SUB-TOTAL	OPEC	TOTAL	COAL LIQUIDS	STOCK CHANGES AND OTHER ADJUST. 5/	NET CPE OIL EXPTS. 6/	TOTAL
ESTI.																
1982	15.3	18.6	33.9	2.9	8.7	45.4	10.2	5.3	6.7	22.2	19.8	42.8	--	1.1	1.5	45.4
PROJ.																
1985																
CASE A	15.9	20.2	36.1	3.4	8.2	47.7	10.2	5.6	8.1	23.9	23.5	47.4	0.1	-0.8	1.1	47.7
CASE B	16.0	19.7	35.7	3.4	8.3	47.3	10.2	5.6	8.1	23.9	23.2	47.1	0.1	-0.6	0.7	47.3
CASE C	15.9	19.3	35.2	3.4	8.3	46.9	10.2	5.6	8.1	23.9	22.8	46.7	0.1	--	0.1	46.9
1990																
CASE A	16.0	21.9	37.9	4.5	10.1	52.6	9.6	5.8	9.5	24.9	26.2	51.1	0.1	--	1.4	52.6
CASE B	15.8	20.2	36.0	4.6	10.0	50.6	9.9	5.6	9.3	24.8	25.7	50.5	0.1	--	--	50.6
CASE C	15.3	19.0	34.3	4.7	9.9	48.8	10.0	5.5	9.0	24.5	25.2	49.7	0.1	--	-1.0	48.8
1995																
CASE A	15.8	22.1	37.9	5.4	11.0	54.3	8.8	5.9	10.6	25.3	27.0	52.3	0.2	--	1.7	54.3
CASE B	15.1	19.7	34.8	5.9	11.3	52.1	9.2	5.5	9.9	24.6	27.3	51.9	0.1	--	--	52.1
CASE C	14.3	18.2	32.5	6.0	11.3	49.9	9.1	5.2	9.2	23.5	27.2	50.7	0.2	--	-1.0	49.9
2000																
CASE A	15.5	22.9	38.4	6.2	11.7	56.3	8.5	6.1	11.9	26.5	27.5	54.0	0.3	--	2.0	56.3
CASE B	14.3	19.3	33.6	7.2	12.8	53.5	9.0	5.7	10.8	25.6	27.7	53.3	0.3	--	--	53.5
CASE C	13.0	17.9	30.9	7.5	12.8	51.1	8.6	5.3	9.8	23.7	28.1	51.8	0.3	--	-1.0	51.1
2005																
CASE A	15.6	21.7	37.3	6.9	12.4	56.6	8.6	6.0	11.2	25.8	28.0	53.8	0.5	--	2.3	56.5
CASE B	13.9	17.8	31.7	8.0	14.2	53.8	8.9	5.8	10.4	25.1	28.1	53.2	0.6	--	--	53.8
CASE C	12.0	16.9	28.9	8.1	13.7	50.6	8.2	5.6	9.3	23.1	27.9	51.1	0.5	--	-1.0	50.6
2010																
CASE A	15.5	20.2	35.7	7.3	13.0	56.1	8.3	6.0	10.3	24.6	28.2	52.8	0.9	--	2.5	56.1
CASE B	13.4	17.3	30.7	8.4	15.1	54.1	8.8	6.3	9.7	24.8	28.0	52.8	1.3	--	--	54.1
CASE C	11.6	16.4	28.0	8.7	14.8	51.5	8.0	6.4	9.1	23.5	27.8	51.2	1.3	--	-1.0	51.5

1/ Totals may not add due to independent rounding.
2/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil and natural gas liquids.
3/ Includes U.S. Territories.
4/ Includes about 0.5 MMBD of refinery gain, see Table 3-10.
5/ Negative numbers indicate a reduction in supply, positive numbers an addition to supply. Adjustments are a balancing item and include unaccounted for private stock changes, losses, gains, miscellaneous blending components and unaccounted for supply.
6/ Net oil exports from Centrally Planned Economies.

TABLE 5-8: U.S. FUEL PRICE SUMMARY BY SECTOR UNDER ALTERNATIVE WORLD VIEWS 1/

(1982 Dollars per Million Btu)

YEAR	WORLD OIL PRICE 2/ (1982 $/Bbl)	RESOURCE PRICES: REFINER CRUDE COST	RESOURCE PRICES: WELLHEAD GAS PRICE	RESOURCE PRICES: MINEMOUTH COAL PRICE	RESIDENTIAL SECTOR: DISTILLATE	RESIDENTIAL SECTOR: LIQUID GASES	RESIDENTIAL SECTOR: NATURAL GAS	RESIDENTIAL SECTOR: ELECTRICITY	COMMERCIAL SECTOR: DISTILLATE	COMMERCIAL SECTOR: RESID FUEL OIL	COMMERCIAL SECTOR: LIQUID GASES	COMMERCIAL SECTOR: NATURAL GAS	COMMERCIAL SECTOR: ELECTRICITY	INDUSTRIAL SECTOR: DISTILLATE	INDUSTRIAL SECTOR: RESID. FUEL OIL	INDUSTRIAL SECTOR: LIQUID GASES	INDUSTRIAL SECTOR: NATURAL GAS	INDUSTRIAL SECTOR: COAL	INDUSTRIAL SECTOR: ELECTRICITY	TRANSPORTATION SECTOR: GASOLINE	TRANSPORTATION SECTOR: DIESEL 3/	TRANSPORTATION SECTOR: RESID. FUEL OIL	TRANSPORTATION SECTOR: JET FUEL
EST																							
1982	33.59	5.49	2.36	1.32	8.47	9.26	5.39	20.11	7.80	5.60	6.20	5.00	20.11	7.90	4.90	6.20	3.60	1.65	14.51	10.24	7.25	4.90	8.51
PROJ.																							
1985																							
CASE A	21.00	3.55	3.11	1.45	5.77	5.58	5.75	19.31	5.22	3.76	4.58	5.39	19.96	5.22	3.53	4.58	4.27	1.96	14.26	8.76	5.44	3.53	5.03
CASE B	25.90	4.39	3.18	1.47	6.75	6.42	5.83	19.65	6.14	4.55	5.46	5.47	20.32	6.11	4.30	5.46	4.35	1.97	14.51	9.69	6.46	4.30	6.14
CASE C	30.50	5.19	3.23	1.48	7.67	7.21	5.89	19.89	7.01	5.30	6.29	5.53	20.58	6.95	5.01	6.29	4.40	1.98	14.69	10.57	7.42	5.01	7.14
1990																							
CASE A	25.60	4.42	3.33	1.52	6.64	5.87	5.60	20.55	6.02	4.58	5.62	5.30	21.63	5.94	4.46	5.62	4.31	2.13	15.69	9.94	6.67	4.46	5.85
CASE B	31.90	5.49	3.90	1.55	7.89	6.94	6.22	21.13	7.20	5.59	6.74	5.91	22.24	7.07	5.43	6.74	4.91	2.16	16.13	11.13	7.97	5.43	7.21
CASE C	40.30	6.96	4.62	1.59	9.58	8.40	6.99	21.76	8.79	6.96	8.26	6.68	22.91	8.61	6.75	8.26	5.67	2.19	16.61	12.75	9.73	6.75	9.04
1995																							
CASE A	30.30	5.22	3.69	1.60	7.57	6.67	5.98	22.04	6.90	5.33	6.46	5.68	23.31	6.78	5.18	6.46	4.64	2.24	17.17	10.83	7.64	5.18	6.86
CASE B	46.50	8.02	4.80	1.64	10.81	9.46	7.19	23.76	9.95	7.96	9.36	6.88	25.13	9.73	7.71	9.36	5.83	2.28	18.52	13.82	11.01	7.71	10.38
CASE C	59.50	10.25	6.36	1.64	13.39	11.69	8.87	24.75	12.38	10.06	11.67	8.55	26.17	12.09	9.72	11.67	7.47	2.28	19.28	16.39	13.70	9.72	13.18
2000																							
CASE A	36.00	6.21	4.55	1.71	8.72	7.66	6.92	22.04	7.98	6.27	7.49	6.61	23.40	7.83	6.07	7.49	5.55	2.38	17.42	11.93	8.84	6.08	8.11
CASE B	57.40	9.90	6.75	1.76	12.99	11.34	9.28	24.07	12.00	9.73	11.31	8.97	25.56	11.72	9.40	11.31	7.87	2.43	19.03	16.00	13.27	9.40	12.74
CASE C	80.30	13.85	9.69	1.80	17.55	15.27	12.46	25.21	16.29	13.43	15.40	12.13	26.77	15.87	12.96	15.40	10.97	2.47	19.93	20.36	18.02	12.96	17.69
2005																							
CASE A	46.50	8.03	5.60	1.72	10.81	9.47	8.05	23.17	9.95	7.98	9.36	7.74	24.63	9.74	7.71	9.36	6.66	2.42	18.36	13.93	11.02	7.71	10.39
CASE B	72.20	12.46	8.83	1.79	15.94	13.88	11.53	24.98	14.78	12.13	13.96	11.21	26.55	14.41	11.71	13.96	10.06	2.50	19.79	18.82	16.35	11.71	15.95
CASE C	104.00	17.93	13.77	1.80	22.27	19.34	16.85	26.81	20.74	17.27	19.63	16.51	28.49	20.17	16.65	19.63	15.27	2.50	21.24	24.87	22.93	16.65	22.82
2010																							
CASE A	54.60	9.42	6.89	1.80	12.43	10.86	9.43	22.81	11.48	9.28	10.81	9.12	24.24	11.21	8.97	10.81	8.01	2.54	18.07	15.47	12.70	8.97	12.14
CASE B	83.60	14.41	10.02	1.89	18.20	15.83	12.82	24.67	16.91	13.97	15.98	12.49	26.22	16.47	13.47	15.98	11.32	2.63	19.54	20.98	18.70	13.47	18.40
CASE C	111.40	19.20	14.28	1.92	23.74	20.61	17.40	26.40	22.12	18.47	20.95	17.06	28.05	21.51	17.79	20.95	15.81	2.66	20.91	26.27	24.46	17.79	24.41

1/ Projected delivered prices are resource prices plus estimated markups for processing and distribution.
2/ U.S. average refiner acquisition cost of imported crude oil.
3/ Excludes taxes.

TABLE 5-9: PRIMARY ENERGY SUPPLIED TO THE U.S. ECONOMY UNDER ALTERNATIVE WORLD VIEWS
(QUADS)

YEAR	INDIGENOUS ENERGY PRODUCTION						NET IMPORTS[1/]					ADJUSTMENTS[2/]					PRIMARY ENERGY SUPPLIED TO U.S. ECONOMY
												STOCK WITHDRAWALS					
	OIL	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL	OIL	GAS	COAL	OTHER[3/]	TOTAL	OIL	GAS	COAL	OTHER[4/]	TOTAL	TOTAL
ESTI.																	
1982	20.6	17.8	18.4	3.0	6.2	66.0	9.0	0.9	-2.8	0.1	7.2	+0.3	-0.3	-0.6	+0.7	+0.1	73.3
PROJ.																	
1985																	
CASE A	19.4	19.0	20.0	4.4	6.3	69.1	13.1	1.1	-2.0	0.1	12.3	-1.0	--	--	--	-1.0	80.4
CASE B	19.5	18.9	21.3	4.6	6.2	70.5	12.8	1.2	-2.8	0.1	11.3	-0.6	--	--	--	-0.6	81.1
CASE C	19.6	18.8	22.0	4.8	6.2	71.3	12.0	1.2	-3.5	0.1	9.8	--	--	--	--	--	81.1
1990																	
CASE A	18.3	18.4	21.9	6.3	7.0	71.8	13.6	2.0	-1.8	0.1	13.9	--	--	--	--	--	85.8
CASE B	19.0	18.2	24.5	6.5	7.0	75.1	12.4	1.9	-3.3	0.1	11.1	--	--	--	--	--	86.2
CASE C	19.1	18.0	26.4	6.8	6.9	77.0	11.3	1.7	-5.0	0.1	8.1	--	--	--	--	--	85.2
1995																	
CASE A	16.8	17.5	22.9	6.6	8.4	72.1	14.7	2.5	-0.9	0.1	16.4	--	--	--	--	--	88.6
CASE B	17.7	17.2	28.7	6.9	8.6	79.1	12.4	2.4	-4.4	0.1	10.5	--	--	--	--	--	89.6
CASE C	17.3	16.3	32.2	7.1	8.7	81.6	11.0	2.5	-7.2	0.1	6.4	--	--	--	--	--	88.0
2000																	
CASE A	16.2	16.4	24.8	7.7	9.4	74.6	14.4	2.9	-1.1	0.1	16.3	--	--	--	--	--	90.9
CASE B	17.4	16.3	33.6	7.9	10.0	85.1	11.0	2.6	-5.4	0.1	8.3	--	--	--	--	--	93.4
CASE C	16.5	14.4	39.2	7.7	10.3	88.0	9.1	3.4	-10.0	0.1	2.6	--	--	--	--	--	90.6
2005																	
CASE A	16.5	15.0	26.6	9.2	10.5	77.9	14.2	3.3	-1.4	0.1	16.2	--	--	--	--	--	94.0
CASE B	17.2	14.5	38.5	9.2	11.6	91.0	10.2	2.7	-6.9	0.1	6.1	--	--	--	--	--	97.1
CASE C	15.8	11.7	45.1	8.4	12.6	93.7	7.8	4.3	-12.6	0.1	-0.4	--	--	--	--	--	93.2
2010																	
CASE A	16.0	13.3	29.2	11.4	12.0	81.9	14.1	3.6	-2.1	0.1	15.7	--	--	--	--	--	97.5
CASE B	17.0	11.6	45.7	12.0	13.5	99.9	8.2	3.0	-8.5	0.1	2.8	--	--	--	--	--	102.7
CASE C	15.4	8.6	53.3	9.2	16.0	102.4	6.6	5.1	-15.4	0.1	-3.6	--	--	--	--	--	98.9

1/ Including Strategic Petroleum Reserve.
2/ Negative numbers indicate a reduction in energy supplied and positive numbers indicate an increase in energy supplied to the economy.
3/ Includes small amounts of coal coke and electricity.
4/ A balancing item. Includes unaccounted for oil, gas and coal private stock changes, losses, gains, miscellaneous blending componets, unaccounted for supply and anthracite shipped overseas to U.S. Armed Forces.

TABLE 5-10: ENERGY CONSUMED BY THE U.S. ECONOMY UNDER ALTERNATIVE WORLD VIEWS

(QUADS)

YEAR	PRIMARY ENERGY CONSUMED BY U.S. ECONOMY							ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES	ENERGY USED BY FINAL CONSUMERS EXCLUDING INPUTS TO UTILITIES AND SYNTHETICS									
	OIL	GAS	COAL	NUCLEAR	RENEW-ABLE	NET ELEC-TRICITY IMPORTS	TOTAL	TOTAL	LIQUIDS	GASES	COAL SOLIDS	ELEC-TRICITY	RENEW-ABLE 1/	TOTAL	RESI-DENTIAL	COM-MERCIAL	INDUS-TRIAL	TRANS-PORTATION
ESTI																		
1982	30.4	18.1	15.5	3.0	6.1	0.1	73.3	-17.1	28.7	15.0	2.8	7.0	2.7	56.4	10.0	6.1	21.5	18.6
PROJ.																		
1985																		
CASE A	31.6	20.1	18.0	4.4	6.3	0.1	80.4	-19.7	29.1	17.2	3.3	8.1	3.0	60.7				
CASE B	31.7	20.1	18.4	4.6	6.2	0.1	81.1	-20.1	29.1	17.1	3.4	8.3	3.0	60.9				
CASE C	31.6	20.0	18.5	4.8	6.2	0.1	81.1	-20.3	29.1	17.0	3.4	8.3	3.0	60.8				
1990																		
CASE A	31.9	20.4	20.1	6.3	7.0	0.1	85.8	-21.9	29.9	17.9	3.7	9.0	3.4	64.0				
CASE B	31.4	20.1	21.2	6.5	7.0	0.1	86.2	-22.7	29.3	17.6	3.8	9.4	3.5	63.6				
CASE C	30.4	19.7	21.4	6.8	6.9	0.1	85.2	-22.9	28.3	17.1	3.9	9.4	3.4	62.3				
1995																		
CASE A	31.5	20.0	22.0	6.6	8.4	0.1	88.6	-23.2	30.0	17.9	3.9	9.6	3.9	65.4				
CASE B	30.1	19.6	24.3	6.9	8.6	0.1	89.6	-24.9	28.6	17.5	4.3	10.3	4.1	64.8		N/A		
CASE C	28.3	18.8	25.0	7.1	8.7	0.1	88.0	-25.1	26.8	16.8	4.7	10.4	4.3	62.9				
2000																		
CASE A	30.6	19.3	23.8	7.7	9.4	0.1	90.9	-25.1	29.6	17.5	4.0	10.3	4.4	65.8				
CASE B	28.3	18.9	28.2	7.9	10.0	0.1	93.4	-27.8	27.2	17.2	4.8	11.6	4.8	65.6				
CASE C	25.6	17.8	29.2	7.7	10.3	0.1	90.6	-27.9	24.4	16.1	5.4	11.7	5.1	62.7				
2005																		
CASE A	30.7	18.2	25.2	9.2	10.5	0.1	94.0	-27.0	30.1	16.7	4.1	11.1	5.0	67.0				
CASE B	27.4	17.2	31.6	9.2	11.6	0.1	97.1	-30.6	26.6	16.1	5.5	12.8	5.6	66.5				
CASE C	23.6	16.0	32.5	8.4	12.6	0.1	93.2	-30.9	22.6	14.9	5.8	13.1	5.9	62.3				
2010																		
CASE A	30.1	16.9	27.1	11.4	12.0	0.1	97.5	-29.3	30.2	15.9	4.4	11.9	5.8	68.2				
CASE B	25.2	14.6	37.3	12.0	13.5	0.1	102.7	-35.1	25.7	15.3	5.9	14.1	6.6	67.6				
CASE C	22.0	13.7	37.9	9.2	16.0	0.1	98.9	-35.2	22.0	14.2	6.2	14.5	6.8	63.6				

1/ Renewable central electric is included in electricity column.

TABLE 5-11: ENERGY TRANSFORMATION IN THE U.S. ECONOMY UNDER ALTERNATIVE WORLD VIEWS

(QUADS)

	ELECTRIC UTILITIES									SYNTHETIC FUELS								ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES
	ENERGY INPUT						ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES [2/]	NET ELECTRIC IMPORTS	SALES	ENERGY INPUT			TRANSFORMATION LOSSES	SALES				
										OIL	COAL			LIQUIDS	GASES			
YEAR	OIL [1/]	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL			TOTAL	FOR SYNTH. GAS	FOR SYNTH. GAS	FOR SYNTH. LIQUIDS	TOTAL		SNG	COAL GAS	TOTAL	TOTAL
ESTI.																		
1982	1.5	3.3	12.7	3.0	3.5	24.0	-17.1	0.1	7.0	0.2	--	--	--	--	0.2	--	0.2	-17.1
PROJ.																		
1985																		
CASE A	2.3	3.1	14.6	4.4	3.3	27.7	-19.7	0.1	8.1	0.2	--	--	--	--	0.2	--	0.2	-19.7
CASE B	2.3	3.2	15.0	4.6	3.2	28.3	-20.1	0.1	8.3	0.2	--	--	--	--	0.2	--	0.2	-20.1
CASE C	2.3	3.2	15.0	4.8	3.2	28.5	-20.3	0.1	8.3	0.2	--	--	--	--	0.2	--	0.2	-20.3
1990																		
CASE A	1.9	2.5	16.4	6.3	3.5	30.8	-21.9	0.1	9.0	0.1	--	--	--	--	0.1	--	0.1	-21.9
CASE B	2.0	2.6	17.3	6.5	3.5	31.9	-22.6	0.1	9.4	0.1	--	--	--	--	0.1	--	0.1	-22.7
CASE C	2.0	2.7	17.4	6.8	3.4	32.2	-22.9	0.1	9.4	0.1	--	--	--	--	0.1	--	0.1	-22.9
1995																		
CASE A	1.6	2.1	17.8	6.6	4.4	32.6	-23.1	0.1	9.6	--	--	0.2	-0.1	0.1	--	--	--	-23.2
CASE B	1.6	2.1	20.0	6.9	4.5	35.0	-24.8	0.1	10.3	--	--	0.1	-0.1	--	--	--	--	-24.9
CASE C	1.5	2.1	20.3	7.1	4.4	35.4	-25.1	0.1	10.4	--	--	--	--	--	--	--	--	-25.1
2000																		
CASE A	1.4	1.9	19.1	7.7	5.0	35.0	-24.8	0.1	10.3	--	0.1	0.6	-0.4	0.3	--	--	--	-25.1
CASE B	1.3	1.8	23.0	7.9	5.2	39.1	-27.6	0.1	11.6	--	0.1	0.3	-0.1	0.2	--	0.1	0.1	-27.8
CASE C	1.3	1.7	23.6	7.7	5.2	39.5	-27.8	0.1	11.7	--	0.1	0.1	-0.1	--	--	0.1	0.1	-27.9
2005																		
CASE A	1.2	1.7	19.8	9.2	5.6	37.5	-26.5	0.1	11.1	--	0.2	1.0	-0.5	0.6	--	0.1	0.1	-27.0
CASE B	1.2	1.6	24.7	9.2	6.1	42.7	-30.0	0.1	12.8	--	0.7	0.7	-0.6	0.4	--	0.4	0.4	-30.6
CASE C	1.1	1.5	25.9	8.4	6.7	43.6	-30.6	0.1	13.1	--	0.6	0.3	-0.3	0.2	--	0.4	0.4	-30.9
2010																		
CASE A	1.1	1.5	19.7	11.4	6.2	39.8	-28.0	0.1	11.9	--	0.7	2.3	-1.3	1.3	--	0.4	0.4	-29.3
CASE B	1.0	1.4	25.4	12.0	7.0	46.9	-32.9	0.1	14.1	--	3.4	2.5	-2.3	1.5	--	2.1	2.1	-35.1
CASE C	1.0	1.3	27.3	9.4	9.2	48.0	-33.5	0.1	14.6	--	2.6	1.7	-1.7	0.9	--	1.7	1.7	-35.2

1/ Includes petroleum coke.
2/ Includes utility own use and transmission losses.

CHAPTER 6: ALTERNATIVE RATES OF ECONOMIC GROWTH

The rate of economic growth is one of the most important and uncertain variables affecting future energy prices and the amount of energy which will be consumed, produced and traded. By reviewing the sensitivity of the projections to changes in free-world economic growth assumptions, a better understanding of how free-world energy conditions are affected by economic growth can be gained. Sensitivity analysis of this type does not however, help in answering questions regarding the impact of the U.S. economy on global energy markets. A review of the effects of changing the economic growth assumptions of the U.S. alone, consequently, is also provided. Since both types of sensitivity tests are reported in this chapter, the reader is cautioned to review results carefully, keeping in mind the distinction between results in which total free-world economic growth assumptions are varied (Section 6.1) and results in which only U.S. economic growth assumptions are varied (Section 6.2).

6.1 HIGH AND LOW FREE-WORLD ECONOMIC GROWTH

To test the energy impacts of changing the economic growth assumptions in all regions of the world, the reference case rates of economic growth for each region were gradually increased or decreased reaching a range of about plus and minus one half of one percent per year in the early 1990's. Since the change was made in the rate of economic growth, the range in the level of economic activity continued to increase for each region throughout the projection period (see Table 6-1). Changes in economic growth have considerable impact on world oil prices due to the effect of economic assumptions on the amount of energy consumed and supplied.

6.1.1 Effects of Economic Growth on World Oil Prices

There are many ways to evaluate the impacts of changes in economic growth on world energy conditions. In this analysis, we have chosen to account for the possible change in world oil prices that would result from a change in free-world economic growth (Table 6-1). We assume that world oil prices are primarily determined by OPEC production capacity utilization (see Chapters 2 and 4). Given an existing level of OPEC oil production capacity, a higher demand for OPEC oil translates into a higher world oil price than would otherwise be the case. An increase in free-world economic activity tends to increase total energy demand in general and oil demand in particular. A higher level of oil demand increases demand for OPEC oil--translating into higher world oil prices than would otherwise occur. Lower economic growth has the opposite effect and thus lowers world oil prices. Remember that in this analysis, we are not asking if higher or lower world oil prices would increase or decrease economic activity. Here we are trying to determine what impacts on energy conditions would result if free-world economic activity, for reasons unrelated to energy conditions, were higher or lower than the Scenario B amount. In reviewing the results of this section, therefore, the reader is cautioned to remember that both economic growth and world oil prices vary significantly between scenarios.

A review of Table 6-1 indicates that about a half a percent per year reduction in free-world economic growth could have a major impact on world oil prices because of lower demand for energy and oil. For example, the low free-world economic growth scenario has world oil prices of $66 per barrel in 2010 compared to a Scenario B result of $84 per barrel. Thus a reduction in economic growth rate from 3.1 percent per year for Scenario B to about 2.6 percent per year for the low case resulted in about a 20 percent reduction in the world oil price in 2010. This result indicates that if actual economic growth is significantly different than that which we assume, world oil prices could be considerably different as well.

6.1.2 Effects of Economic Growth on the Amount of Energy Consumed by the Free World

The amount of energy consumed by each region of the free world increases with higher economic activity. The increase would have been even greater except that higher economic growth results in higher energy prices which act to mitigate some of the increase in energy demand (Table 6-2). Energy demand in developing nations is reduced less by higher prices, since improvements in design efficiency stimulated by higher oil prices take much longer to become widely adapted by these economies. With higher prices and the technological advances associated with higher economic activity, the ratio of energy use per dollar of GDP actually falls faster for the free-world in general and for the OECD countries in particular when higher economic growth is assumed. By the year 2010, this ratio could be 3% lower than it is in the Scenario B case for the industrialized nations.

Petroleum consumption also shows interesting behavior (Table 6-2). In the short term, greater economic activity causes the amount of oil consumed throughout the free world to increase. As higher demand for OPEC oil drives up the oil price, the industrialized countries are able to use increasingly less petroleum as part of their energy inputs. Thus, because of higher oil prices, we see that the quantity of petroleum consumed by the OECD is actually lower under higher world economic activity by the end of this century. Again, however, partially because efficiency improvements take longer to be implemented by the developing nations, and also because the oil-exporting developing nations frequently subsidize their domestic petroleum prices, these countries consume more petroleum under higher economic growth throughout this scenario.

6.1.3 Effects of Economic Growth on the Amount of Energy Supplied to the Free World

In these simulations, much more energy is produced by the industrialized nations under higher economic growth (Table 6-3). Much of the initial increase is due to increased coal production to supply electric utilities with the necessary fuel to generate the additional electricity demanded. As energy prices rise, the return on investment increases, and domestic energy produced by the industrialized countries increases. The amount of energy produced by the developing nations also increases, partially to fill increased domestic demand and partially to satisfy demands for exports.

The quantity of petroleum produced in all regions of the free world consistently is higher under higher economic activity (Table 6-3). In the industrialized countries, where the amount produced varies with economic return, the increased oil prices resulting from greater economic activity stimulate increases in the amount of oil produced. The quantity of oil produced in the U.S. could be over 10% higher than the Scenario B value with higher economic growth. OPEC and the Rest of the Free World produce more primarily due to increased domestic oil consumption.

6.1.4 Effect of Economic Growth on Free-World Net Energy Trade

Under higher world economic activity, the U.S. becomes a net energy exporter by the year 2010 (Table 6-4). This is primarily due to an increase in the demand for U.S. coal by our trading partners. The other OECD nations become slightly more import dependent as world economic activity increases, since increased energy consumption cannot be totally offset by increases in The amount of domestic energy produced. The rise in oil prices, however, induces these nations to increasingly rely upon U.S. coal rather than OPEC oil. Energy exports from the CPE nations were kept constant at Scenario B values in this analysis.

TABLE 6-1: HIGH, SCENARIO B AND LOW FREE-WORLD ECONOMIC GROWTH ASSUMPTIONS

	GDP INDEX (1982=1.00)						
	OECD						RESULTANT WORLD OIL PRICE (1982 $/Barrel)
YEAR	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE-WORLD	TOTAL	
ESTI.							
1982	1.00	1.00	1.00	1.00	1.00	1.00	33.59
PROJ.							
1985							
LGDP	1.05	1.08	1.07	1.16	1.03	1.07	23.80
CASE B	1.12	1.10	1.11	1.16	1.04	1.10	25.90
HGDP	1.14	1.11	1.12	1.19	1.06	1.12	26.80
1990							
LGDP	1.24	1.23	1.24	1.51	1.24	1.25	27.80
CASE B	1.30	1.27	1.28	1.56	1.27	1.30	31.90
HGDP	1.34	1.32	1.33	1.63	1.31	1.34	36.20
1995							
LGDP	1.39	1.39	1.39	1.90	1.46	1.42	39.70
CASE B	1.48	1.46	1.47	2.02	1.54	1.51	46.50
HGDP	1.57	1.54	1.55	2.14	1.61	1.58	53.10
2000							
LGDP	1.52	1.54	1.53	2.31	1.68	1.58	48.20
CASE B	1.65	1.66	1.66	2.52	1.81	1.72	57.40
HGDP	1.78	1.79	1.78	2.73	1.95	1.84	68.80
2005							
LGDP	1.66	1.68	1.67	2.70	1.89	1.74	57.70
CASE B	1.85	1.86	1.86	3.01	2.09	1.94	72.20
HGDP	2.00	2.05	2.03	3.35	2.29	2.11	91.50
2010							
LGDP	1.82	1.82	1.82	3.06	2.09	1.90	65.60
CASE B	2.05	2.06	2.06	3.51	2.36	2.16	83.60
HGDP	2.27	2.32	2.30	4.01	2.66	2.41	102.40

TABLE 6-2: ENERGY CONSUMED BY THE FREE WORLD UNDER VARYING WORLD ECONOMIC ACTIVITY 1/
(Million Barrels per Day of Oil-Equivalent)

	LIQUIDS 2/ (Includes Coal Liquids)						GAS (Includes Synthetics)						COAL (Excludes Synthetic Feedstocks)						
	OECD						OECD						OECD						
YEAR	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC	REST OF FREE WORLD	TOTAL	COAL SYNTHETICS CONVERSION LOSS
EST.																			
1982	15.3	18.6	33.9	2.9	8.7	45.4	8.5	5.1	13.6	1.2	1.8	16.6	7.3	7.2	14.5	--	2.5	17.0	--
PROJ.																			
1985																			
LGDP	15.3	19.5	34.8	3.3	8.1	46.3	8.7	5.6	14.3	1.3	1.7	17.5	7.8	7.0	14.8	--	2.5	17.3	--
CASE B	16.0	19.7	35.7	3.4	8.2	47.3	9.5	5.7	15.1	1.4	1.8	18.4	8.7	7.1	15.8	--	2.6	18.4	--
HGDP	16.1	20.0	36.1	3.4	8.5	47.9	9.6	5.8	15.4	1.4	1.8	18.6	8.9	7.2	16.1	--	2.6	18.7	--
1990																			
LGDP	15.6	20.9	36.5	4.4	9.6	50.5	9.1	5.7	14.8	2.0	2.1	18.9	9.2	7.1	16.3	--	2.9	19.2	--
CASE B	15.8	20.2	36.0	4.6	10.0	50.6	9.5	5.9	15.4	2.1	2.2	19.8	10.0	7.4	17.4	--	3.1	20.6	--
HGDP	15.9	19.9	35.8	4.8	10.6	51.3	9.8	6.0	15.8	2.2	2.4	20.3	10.5	7.7	18.2	--	3.3	21.6	--
1995																			
LGDP	15.2	20.5	35.7	5.4	10.5	51.6	9.0	6.4	15.4	2.8	2.4	20.5	10.3	7.4	17.7	--	3.7	21.5	0.1
CASE B	15.1	19.7	34.8	5.9	11.3	52.1	9.3	6.5	15.8	3.1	2.8	21.6	11.4	7.9	19.3	--	4.1	23.5	0.1
HGDP	15.2	18.7	33.9	6.4	12.5	52.8	9.6	6.7	16.3	3.3	2.9	22.6	12.6	8.3	20.9	--	4.5	25.5	0.1
2000																			
LGDP	14.4	20.5	34.9	6.5	11.2	52.7	8.6	7.1	15.7	3.8	2.9	22.4	11.2	8.0	19.2	--	4.4	23.7	0.1
CASE B	14.3	19.3	33.6	7.2	12.7	53.5	9.0	7.3	16.3	4.2	3.3	23.8	13.1	9.0	22.1	--	5.1	27.3	0.2
HGDP	14.4	17.9	32.3	8.0	14.4	54.7	9.0	7.6	16.6	4.6	3.7	24.8	14.7	10.0	24.7	--	5.9	30.7	0.3
2005																			
LGDP	13.6	19.3	32.9	7.3	12.3	52.5	8.3	7.1	15.4	4.6	3.5	23.6	12.1	8.9	21.0	0.1	5.4	26.4	0.3
CASE B	13.9	17.8	31.7	8.0	14.1	53.8	8.3	7.4	15.7	5.3	4.2	25.2	14.3	10.5	24.8	0.1	6.6	31.4	0.4
HGDP	13.7	17.1	30.8	8.5	15.8	55.1	8.3	7.8	16.1	6.1	4.9	27.0	16.2	12.1	28.3	0.1	7.9	36.3	0.8
2010																			
LGDP	13.3	18.3	31.6	7.6	13.1	52.3	7.9	6.9	14.8	5.3	4.1	24.2	12.4	9.6	22.0	0.1	6.5	28.7	0.9
CASE B	13.4	17.3	30.7	8.4	15.1	54.1	7.9	7.4	15.3	6.3	5.2	26.7	14.8	11.7	26.5	0.1	8.4	35.0	1.4
HGDP	13.3	17.0	30.3	9.2	17.4	56.9	7.9	7.8	15.7	7.1	6.4	29.3	17.7	14.0	31.7	0.2	10.4	42.3	2.0

TABLE 6-2 (continued): ENERGY CONSUMED BY THE FREE WORLD UNDER VARYING WORLD ECONOMIC ACTIVITY
(Million Barrels per Day of Oil-Equivalent)

	NUCLEAR						RENEWABLES/OTHER						TOTAL PRIMARY					
	OECD				REST OF FREE WORLD		OECD				REST OF FREE WORLD		OECD				REST OF FREE WORLD	
YEAR	U.S.	OTHER 3/	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER 3/	SUB-TOTAL	OPEC		TOTAL
ESTI.																		
1982	1.4	2.1	3.5	--	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	35.4	36.8	72.2	4.3	14.8	91.2
PROJ.																		
1985																		
LGDP	1.9	2.6	4.5	--	0.1	4.5	2.9	3.9	6.8	0.2	2.0	9.0	36.7	38.6	75.3	4.9	14.4	94.6
CASE B	2.2	2.6	4.8	--	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	39.2	39.0	78.2	4.9	14.7	97.9
HGDP	2.2	2.7	4.9	--	0.1	5.0	2.9	3.9	6.8	0.2	2.0	9.0	39.7	39.5	89.2	5.0	15.0	99.2
1990																		
LGDP	2.8	3.2	6.0	--	0.3	6.3	3.3	4.0	7.3	0.2	2.6	10.1	40.0	41.0	81.0	6.6	17.5	105.0
CASE B	3.1	3.4	6.5	--	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	41.6	41.0	82.6	7.0	18.3	108.0
HGDP	3.2	3.5	6.7	--	0.4	7.2	3.3	4.0	7.3	0.2	2.6	10.2	42.7	41.3	84.0	7.3	19.2	110.6
1995																		
LGDP	3.1	3.7	6.8	0.1	0.4	7.3	3.8	4.5	8.3	0.2	3.8	12.2	41.3	42.6	83.9	8.5	20.8	113.3
CASE B	3.3	4.0	7.3	--	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	43.2	42.7	86.9	9.3	22.5	117.7
HGDP	3.6	4.2	7.9	--	0.7	8.6	4.2	4.7	8.9	0.2	3.8	12.8	45.3	42.6	87.9	10.0	24.5	122.4
2000																		
LGDP	3.4	4.3	7.7	0.1	0.7	8.5	4.3	5.3	9.6	0.2	4.4	14.2	42.1	45.2	87.3	10.7	23.8	121.7
CASE B	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	44.9	45.9	90.8	11.8	26.7	129.3
HGDP	3.8	5.2	9.0	0.1	1.3	10.3	5.1	5.8	10.9	0.2	4.4	15.5	47.1	46.5	93.6	13.0	29.7	136.4
2005																		
LGDP	4.1	4.8	8.9	0.2	1.1	10.2	4.8	5.8	10.6	0.3	4.8	15.7	43.1	46.0	89.1	12.4	27.1	128.7
CASE B	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	46.6	47.5	94.1	13.8	31.3	139.2
HGDP	4.4	6.2	10.6	0.2	2.0	12.8	5.8	6.8	12.6	0.3	4.8	17.8	49.0	50.1	99.1	15.2	35.6	149.9
2010																		
LGDP	5.2	5.4	10.6	0.3	1.4	12.3	5.5	6.5	12.0	0.3	5.3	17.6	44.9	46.8	91.7	13.7	30.5	135.9
CASE B	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	49.2	50.1	99.3	15.6	36.1	151.0
HGDP	5.9	7.5	13.4	0.6	2.6	16.7	6.8	8.1	14.9	0.3	5.5	20.7	53.3	54.6	107.9	17.5	42.5	167.9

1/ Totals may not add due to independent rounding.
2/ Also includes natural gas liquids. Units are physical barrels.
3/ Includes U.S. territories.

TABLE 6-3: ENERGY SUPPLIED TO THE FREE WORLD UNDER VARYING WORLD ECONOMIC ACTIVITY 1/
(Million Barrels per Day of Oil-Equivalent)

	LIQUIDS 2/ (Excludes Coal Liquids)							GAS (Excludes Synthetics)							COAL 3/						
	OECD							OECD							OECD						
YEAR	U.S. 4/	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS 5/	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS 5/	TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC	REST OF FREE WORLD	NET CPE EXPTS 5/	TOTAL
EST.																					
1982	11.1	6.0	17.1	19.8	7.0	1.5	45.4	8.1	4.5	12.6	1.3	2.3	0.4	16.6	8.6	5.4	14.0	--	2.5	0.5	17.0
PROJ.																					
1985																					
LGDP	9.9	5.3	15.2	22.1	8.1	0.7	46.2	8.2	5.3	13.5	1.3	2.2	0.4	17.5	9.1	5.3	14.4	--	2.5	0.5	17.4
CASE B	9.9	5.3	15.2	23.2	8.1	0.7	47.3	8.9	5.3	14.2	1.4	2.3	0.4	18.4	10.0	5.4	15.4	--	2.5	0.5	18.5
HGDP	9.9	5.3	15.2	23.8	8.1	0.7	47.9	9.1	5.3	10.4	1.5	2.3	0.4	18.6	10.3	5.4	15.7	--	2.6	0.5	18.8
1990																					
LGDP	9.7	5.6	15.3	25.8	9.3	--	50.4	8.6	5.3	13.9	2.0	2.6	0.5	18.9	10.5	5.3	15.8	--	2.9	0.6	19.3
CASE B	9.9	5.6	15.5	25.7	9.3	--	50.5	8.6	5.4	14.0	2.3	3.0	0.5	19.8	11.5	5.5	17.0	--	3.0	0.6	20.7
HGDP	10.0	5.6	15.6	26.2	9.3	--	51.2	8.8	5.4	14.2	2.5	3.1	0.5	20.3	12.3	5.7	18.0	--	3.1	0.6	21.8
1995																					
LGDP	9.0	5.5	14.5	27.3	9.8	--	51.5	8.1	5.5	13.6	3.0	3.2	0.8	20.5	11.9	5.4	17.3	--	3.4	0.9	21.7
CASE B	9.2	5.5	14.7	27.3	9.9	--	51.9	8.1	5.5	13.6	3.5	3.7	0.8	21.6	13.5	5.6	19.1	--	3.6	0.9	23.7
HGDP	9.4	5.6	15.0	27.6	10.0	--	52.6	8.2	5.5	13.7	4.0	4.0	0.8	22.6	15.2	5.9	21.1	--	3.9	0.9	25.8
2000																					
LGDP	8.7	5.6	14.3	27.5	10.6	--	52.5	7.5	5.6	13.1	4.0	3.9	1.3	22.4	13.1	5.8	18.9	--	4.0	1.1	24.0
CASE B	9.0	5.7	14.7	27.7	10.8	--	53.2	7.7	5.7	13.4	4.8	4.3	1.3	23.8	15.9	6.4	22.3	--	4.5	1.1	27.8
HGDP	9.3	5.8	15.1	28.2	11.0	--	54.3	7.6	5.7	13.3	5.6	4.6	1.3	24.8	18.6	6.9	25.5	--	4.9	1.1	31.5
2005																					
LGDP	8.4	5.7	14.1	27.9	10.2	--	52.1	7.0	5.4	12.4	4.8	4.6	1.7	23.5	14.5	6.5	21.0	--	4.8	1.3	27.1
CASE B	8.9	5.8	14.7	28.1	10.3	--	53.2	6.9	5.4	12.3	5.9	5.2	1.7	25.0	18.1	7.5	25.6	--	5.5	1.3	32.5
HGDP	9.4	6.1	15.5	28.2	10.6	--	54.2	6.8	5.5	12.3	7.2	5.5	1.7	26.7	22.2	8.5	30.7	--	6.4	1.3	38.4
2010																					
LGDP	8.0	6.0	14.0	27.9	9.4	--	51.4	5.6	5.1	10.7	5.4	5.6	1.8	23.6	16.6	7.3	23.9	--	5.7	1.5	31.0
CASE B	8.8	6.3	15.1	28.0	9.7	--	52.8	5.5	5.2	10.7	7.0	6.2	1.8	25.7	21.6	8.8	30.4	--	6.8	1.5	38.7
HGDP	10.1	6.7	16.8	28.1	10.0	--	55.0	5.5	5.3	10.8	8.6	6.6	1.8	27.8	27.6	10.4	38.0	--	8.2	1.5	47.6

TABLE 6-3 (continued): ENERGY SUPPLIED TO THE FREE WORLD UNDER VARYING WORLD ECONOMIC ACTIVITY
(Million Barrels per Day of Oil-Equivalent)

YEAR	NUCLEAR						RENEWABLES/OTHER						TOTAL PRIMARY						
	OECD				REST OF FREE WORLD		OECD				REST OF FREE WORLD		OECD				REST OF FREE WORLD	NET CPE EXPTS. 5/	
	U.S.	OTHER	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC		TOTAL	U.S.	OTHER	SUB-TOTAL	OPEC			TOTAL
ESTI.																			
1982	1.4	2.1	3.5	--	0.1	3.6	2.9	3.8	6.7	0.2	1.7	8.6	32.1	21.8	53.9	21.3	13.6	2.4	91.2
PROJ.																			
1985																			
LGDP	1.9	2.6	4.5	--	0.1	4.5	2.9	3.9	6.8	0.2	2.0	9.0	32.4	22.7	55.1	23.7	14.8	1.6	94.6
CASE B	2.2	2.6	4.8	--	0.1	4.9	2.9	3.9	6.8	0.2	2.0	9.0	34.0	22.5	56.5	24.8	15.0	1.6	97.9
HGDP	2.2	2.7	4.9	--	0.1	5.0	2.9	3.9	6.8	0.2	2.0	9.0	34.7	22.9	57.6	25.5	15.1	1.6	99.2
1990																			
LGDP	2.8	3.2	6.0	--	0.3	6.3	3.3	4.0	7.3	0.2	2.6	10.1	34.8	23.5	58.3	28.1	17.6	1.0	105.0
CASE B	3.1	3.4	6.5	--	0.3	6.8	3.3	4.0	7.3	0.2	2.6	10.1	36.4	24.0	60.4	28.2	18.2	1.0	108.0
HGDP	3.2	3.5	6.7	--	0.4	7.2	3.3	4.0	7.3	0.2	2.6	10.2	37.6	24.4	62.0	28.9	18.6	1.0	110.6
1995																			
LGDP	3.1	3.7	6.8	0.1	0.4	7.3	3.8	4.5	8.3	0.2	3.8	12.2	36.0	24.6	60.6	30.5	20.4	1.7	113.3
CASE B	3.3	4.0	7.3	--	0.6	7.9	4.1	4.6	8.7	0.2	3.8	12.6	38.3	25.2	63.5	31.1	21.4	1.7	117.7
HGDP	3.6	4.2	7.9	--	0.7	8.6	4.2	4.7	8.9	0.2	3.8	12.8	40.7	25.8	66.5	31.9	22.2	1.7	122.4
2000																			
LGDP	3.4	4.3	7.7	0.1	0.7	8.5	4.3	5.3	9.6	0.2	4.4	14.2	37.1	26.6	63.7	31.9	23.6	2.4	121.7
CASE B	3.7	4.8	8.5	0.1	1.0	9.5	4.7	5.5	10.2	0.2	4.4	14.9	41.0	28.0	69.0	32.8	25.0	2.4	129.3
HGDP	3.8	5.2	9.0	0.1	1.3	10.3	5.1	5.8	10.9	0.2	4.4	15.5	44.3	29.4	73.7	34.1	26.2	2.4	136.4
2005																			
LGDP	4.1	4.8	8.9	0.2	1.1	10.2	4.8	5.8	10.6	0.3	4.8	15.7	38.8	28.2	67.0	33.1	25.5	3.0	128.7
CASE B	4.4	5.5	9.9	0.2	1.5	11.6	5.5	6.3	11.8	0.3	4.8	16.9	43.8	30.6	74.4	34.5	27.4	3.0	139.2
HGDP	4.4	6.2	10.6	0.2	2.0	12.8	5.8	6.8	12.6	0.3	4.8	17.8	48.7	33.1	81.8	35.9	29.2	3.0	149.9
2010																			
LGDP	5.2	5.4	10.6	0.3	1.4	12.3	5.5	6.5	12.0	0.3	5.3	17.6	40.9	30.3	71.2	34.0	27.4	3.3	135.9
CASE B	5.7	6.4	12.1	0.5	2.0	14.5	6.4	7.2	13.6	0.3	5.4	19.3	47.9	33.8	81.7	35.8	30.1	3.3	151.0
HGDP	5.9	7.5	13.4	0.6	2.6	16.7	6.8	8.1	14.9	0.3	5.5	20.7	55.9	38.0	93.9	37.7	33.0	3.3	167.9

1/ Supply from each region includes production, stock changes and adjustments. Totals may not add due to independent rounding.
2/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil and natural gas liquids. Units are physical barrels.
3/ Includes coal production for synthetics.
4/ Includes about 0.5 MMBD of refinery gain (see Table 3-10), and excludes U.S. territories which are included as part of the other OECD.
5/ Net exports from Centrally Planned Economies.

TABLE 6-4: NET ENERGY TRADE UNDER VARYING WORLD ECONOMIC ACTIVITY 1/
(Million Barrels per Day of Oil-Equivalent)

YEAR	NET OIL EXPORTS: OECD U.S.	NET OIL EXPORTS: OECD OTHER 2/	NET OIL EXPORTS: SUB-TOTAL	NET OIL EXPORTS: OPEC	NET OIL EXPORTS: REST OF FREE WORLD	NET OIL EXPORTS: CENTRALLY PLANNED ECONOMIES	NET GAS EXPORTS: OECD U.S.	NET GAS EXPORTS: OECD OTHER 2/	NET GAS EXPORTS: SUB-TOTAL	NET GAS EXPORTS: OPEC	NET GAS EXPORTS: REST OF FREE WORLD	NET GAS EXPORTS: CENTRALLY PLANNED ECONOMIES
ESTI.												
1982	-4.2	-12.3	-16.5	16.9	-2.0	1.5	-0.4	-0.6	-1.0	0.1	0.5	0.4
PROJ.												
1985												
LGDP	-5.4	-14.2	-19.7	18.8	--	0.7	-0.5	-0.3	-0.8	--	0.5	0.4
CASE B	-6.1	-14.4	-20.4	19.8	-0.1	0.7	-0.5	-0.4	-0.9	--	0.5	0.4
HGDP	-6.2	-14.6	-20.8	20.3	-0.2	0.7	-0.5	-0.5	-1.0	0.1	0.4	0.4
1990												
LGDP	-5.9	-15.3	-21.2	21.5	-0.3	--	-0.6	-0.4	-1.0	--	0.5	0.5
CASE B	-5.9	-14.6	-20.5	21.1	-0.6	--	-0.9	-0.6	-1.5	0.2	0.8	0.5
HGDP	-5.8	-14.3	-20.1	21.3	-1.2	--	-1.0	-0.6	-1.6	0.3	0.8	0.5
1995												
LGDP	-6.2	-15.0	-21.2	21.9	-0.7	--	-0.8	-0.9	-1.7	0.2	0.7	0.8
CASE B	-5.9	-14.2	-20.1	21.4	-1.3	--	-1.1	-1.1	-2.2	0.4	0.9	0.8
HGDP	-5.7	-13.1	-18.8	21.2	-2.4	--	-1.4	-1.2	-2.6	0.7	1.1	0.8
2000												
LGDP	-5.6	-14.9	-20.5	21.0	-0.5	--	-1.1	-1.5	-2.6	0.2	1.0	1.3
CASE B	-5.2	-13.5	-18.7	20.5	-1.8	--	-1.2	-1.6	-2.8	0.5	1.0	1.3
HGDP C	-4.9	-12.1	-17.0	20.2	-3.3	--	-1.4	-1.8	-3.2	0.9	1.0	1.3
2005												
LGDP	-5.1	-13.5	-18.6	20.6	-2.0	--	-1.3	-1.7	-3.0	0.2	1.1	1.7
CASE B	-4.8	-11.7	-16.5	20.2	-3.7	--	-1.3	-2.0	-3.3	0.6	1.0	1.7
HGDP	-3.8	-10.8	-14.6	19.7	-5.1	--	-1.1	-2.3	-3.4	1.1	0.5	1.7
2010												
LGDP	-4.9	-12.0	-16.9	20.3	-3.4	--	-1.7	-1.8	-3.5	0.2	1.5	1.8
CASE B	-3.9	-10.6	-14.5	19.6	-5.1	--	-1.4	-2.2	-3.6	0.8	1.0	1.8
HGDP	-2.1	-9.7	-11.8	18.9	-7.0	--	-0.9	-2.5	-3.4	1.4	0.2	1.8

TABLE 6-4 (continued): NET ENERGY TRADE UNDER VARYING WORLD ECONOMIC ACTIVITY
(Million Barrels Per Day of Oil-Equivalent)

	NET COAL EXPORTS						NET ENERGY TRADE					
	OECD						OECD					
YEAR	U.S.	OTHER[2/]	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES	U.S.	OTHER[2/]	SUB-TOTAL	OPEC	REST OF FREE WORLD	CENTRALLY PLANNED ECONOMIES
ESTI.												
1982	1.3	-1.8	-0.5	--	--	0.5	-3.3	-14.7	-18.0	17.0	-1.5	2.4
PROJ.												
1985												
LGDP	1.3	-1.7	-0.4	--	-0.1	0.5	-4.6	-16.2	-20.8	18.8	0.4	1.6
CASE B	1.3	-1.7	-0.4	--	-0.1	0.5	-5.3	-16.5	-21.8	19.8	0.3	1.6
HGDP	1.4	-1.8	-0.4	--	-0.1	0.5	-5.3	-16.8	-22.1	20.5	0.1	1.6
1990												
LGDP	1.3	-1.7	-0.4	--	-0.1	0.6	-5.2	-17.4	-22.6	21.5	0.1	1.0
CASE B	1.6	-1.9	-0.3	--	-0.2	0.6	-5.2	-17.0	-22.2	21.3	-0.1	1.0
HGDP	1.7	-2.0	0.3	--	-0.3	0.6	-5.1	-16.9	-22.0	21.6	-0.6	1.0
1995												
LGDP	1.6	-2.1	-0.5	--	-0.4	0.9	-5.4	-18.0	-23.4	22.0	-0.3	1.7
CASE B	2.1	-2.3	-0.2	--	-0.7	0.9	-4.9	-17.6	-22.5	21.8	-1.1	1.7
HGDP	2.5	-2.5	--	--	-0.9	0.9	-4.6	-16.8	-21.4	21.8	-2.2	1.7
2000												
LGDP	1.8	-2.3	-0.5	--	-0.6	1.1	-4.9	-18.6	-23.5	21.2	-0.1	2.4
CASE B	2.6	-2.8	-0.2	--	-0.9	1.1	-3.9	-17.9	-21.8	21.0	-1.7	2.4
HGDP	3.4	-3.2	0.2	--	-1.2	1.1	-2.8	-17.2	-20.0	21.1	-3.5	2.4
2005												
LGDP	2.1	-2.6	-0.5	-0.1	-0.8	1.3	-4.3	-17.8	-22.1	20.7	-1.7	3.0
CASE B	3.3	-3.2	0.1	-0.1	-1.3	1.3	-2.8	-16.9	-19.7	20.7	-4.0	3.0
HGDP	4.5	-3.9	0.6	-0.1	-1.8	1.3	-0.4	-17.0	-17.4	20.7	-6.4	3.0
2010												
LGDP	2.5	-2.7	-0.2	-0.1	-1.1	1.5	-4.0	-16.5	-20.5	20.3	-3.1	3.3
CASE B	4.0	-3.5	0.5	-0.1	-1.8	1.5	-1.3	-16.2	-17.5	20.2	-6.0	3.3
HGDP	5.7	-4.3	1.4	-0.2	-2.6	1.5	2.6	-16.6	-14.0	20.1	-9.5	3.3

1/ Totals may not add due to independent rounding.
2/ Includes U.S. territories.

6.2 HIGH AND LOW U.S. ECONOMIC GROWTH

Changes in U.S. conditions can have a significant impact on the global energy situation. Although it is unlikely that U.S. economic growth potential could be significantly higher or lower than the reference case assumption unless the same were true for at least some other regions of the free world, a scenario where only U.S. economic potential is changed allows us to study the impacts of economic growth on U.S. energy conditions without complications caused by changes in non-U.S. economic assumptions. In doing such analysis, U.S. average annual economic growth was ranged by almost a full percentage point. Changing only U.S. economic growth had a small impact on world energy prices. By affecting the amount of energy consumed by and supplied by the U.S. economy, changing the U.S. growth assumption altered U.S. energy import levels and thus affected world energy prices. It should be noted, that the feedback from changes in world energy prices caused a slight variation from achieved Scenario B GDP values for non-U.S. regions.

6.2.1 Effects of U.S. Economic Growth on Energy Prices

Since in this section only U.S. economic activity was altered, impacts on world oil prices were not large (see Table 6-5). The world oil price is only moderately affected by a shift in U.S. economic activity compared to a shift in free-world economic activity (see Table 6-1).

6.2.2 Effects of U.S. Economic Growth on the Amount of Energy Consumed Domestically

The amount of energy consumed domestically increases significantly under higher U.S. economic growth. Increases in energy used by final consumers account for slightly more than half of the increase in the quantity of total primary energy consumed; conversion losses associated principally with increased electricity generation account for the remainder of the increase.

Table 6-5: EFFECTS OF U.S. ECONOMIC ACTIVITY ON OIL PRICES[1/]

	INPUT ASSUMPTION			RESULTANT PRICE		
	U.S. GNP (Trillion 1982 $/Year)			WORLD OIL PRICE (1982 $/Barrel)		
YEAR	LOW	SCENARIO B	HIGH	LGNP	SCENARIO B	HGNP
1982	3.06	3.06	3.06	33.59	33.59	33.59
1985	3.21	3.44	3.48	24.70	25.90	26.20
1990	3.77	3.98	4.14	31.20	31.90	32.50
1995	4.22	4.53	4.83	45.70	46.50	47.50
2000	4.64	5.07	5.49	56.20	57.40	59.20
2005	5.03	5.67	6.19	68.90	72.30	74.50
2010	5.51	6.28	7.02	81.00	83.60	85.70

1/In these scenarios only U.S. GNP was varied--non-U.S. growth rates were left at Scenario B levels.

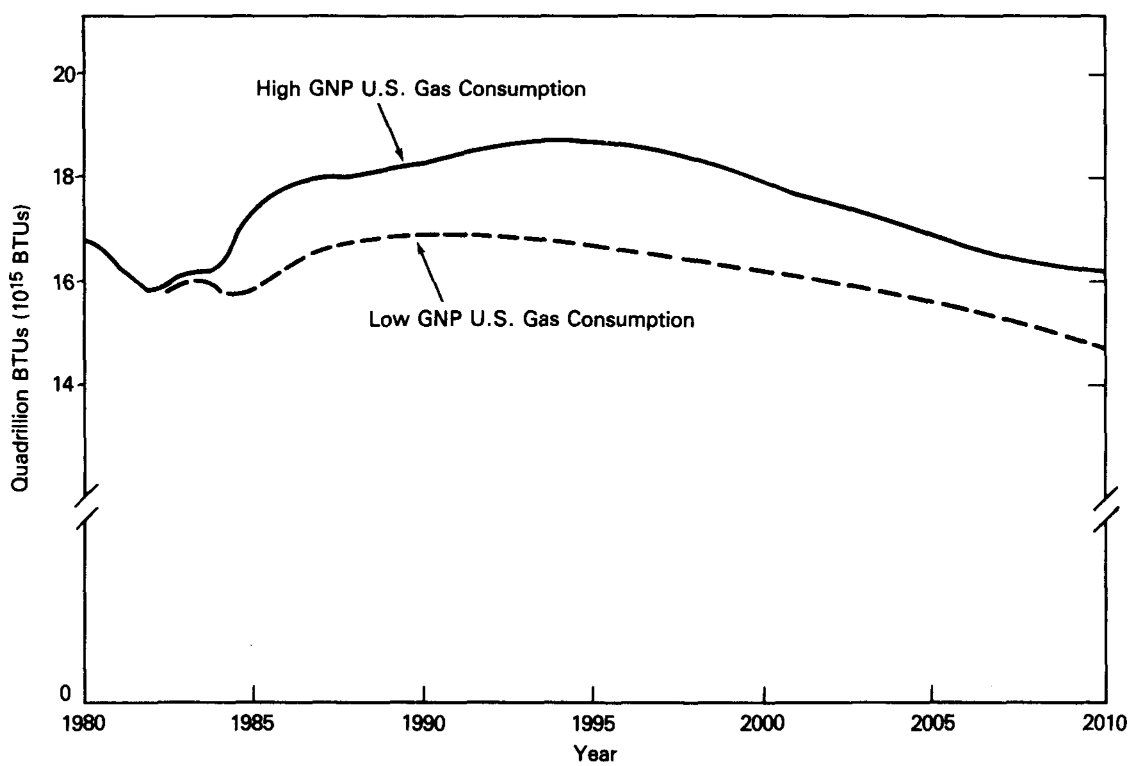
Higher economic growth significantly retards the gradual decline in liquids consumed which occurs in the Scenario B projections. Oil use still peaks in the early part of the next decade, as in the Scenario B case, and declines thereafter. Under the higher economic growth scenario, however, this peak is higher, and the subsequent decline in consumption is more gradual than under lower growth. The differential in consumption between the two cases grows by over 150% between 1990 and 2010.

The amount of gas consumed is considerably higher under higher economic activity (Figure 6-1). The behavior in each scenario is however, similar: after declining in the early 1980's, the amount of gas consumed increases, peaks and then gradually declines for the remainder of the projection period. The decline occurs as gas becomes increasingly expensive and consumers switch to alternative means of obtaining their energy services.

6.2.3 Effects of U.S. Economic Growth on the Amount of Energy Produced Domestically

The amount of total U.S. energy produced domestically is moderately higher under higher U.S. economic growth than under lower growth assumptions (Table 6-7). Much of this increase is in response to the greater rate at which electricity is consumed as a result of the higher level of economic activity. This higher electricity consumption stimulates domestic coal, nuclear, and

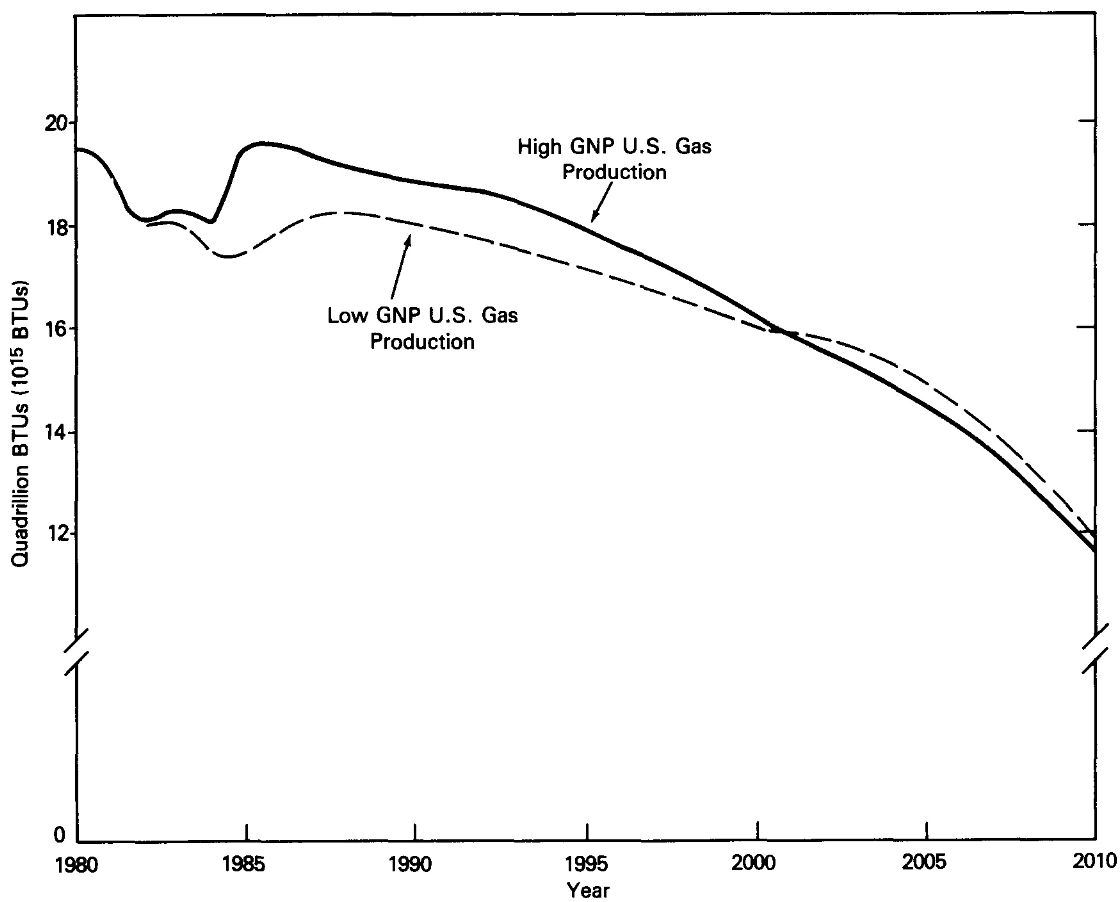
Figure 6-1
IMPACT OF HIGH AND LOW ECONOMIC GROWTH ON U.S. GAS CONSUMPTION



renewable production. Higher gas demand also stimulates domestic gas production in the near term. Gas reserves cannot, however, keep pace with the amount of gas produced, and by the late 1990's depletion of reserves causes the quantity of gas produced by conventional means to decline under both high and low economic growth. Beyond 2000, the amount of natural gas produced could be slightly lower under a higher U.S. economic growth. This is a result of greater quantities of gas having been produced in the 1985 to 2000 time frame (Figure 6-2).

The amount of domestic oil produced is rather insensitive to the rate of domestic economic growth. We assume that domestic producers will provide all the oil that is economical under a given oil price. The amount of oil produced varies with the return on investment, rather than with oil demand. Since Table 6-5 shows that varying U.S. economic growth (while holding non-U.S. growth unchanged) has only a moderate effect on world oil prices, we should not expect much impact of economic activity on the amount of domestic oil produced.

Figure 6-2
IMPACT OF HIGH AND LOW ECONOMIC GROWTH ON U.S. GAS PRODUCTION



6.2.4 Effects of U.S. Economic Growth on Domestic Energy Trade

We anticipate that economic activity will have a significant impact on U.S. energy trade. For example, the rapid growth in the amount of oil consumed caused by a vigorous economic recovery, accompanied by virtually no change in the amount of oil produced domestically, results in a much higher level of U.S. oil imports under higher economic growth. The differential in oil imports between the high and low cases grows by approximately three percent per year from 1985 on, caused in part by the increase in the differential between absolute levels of economic activity over time (Table 6-5).

Under high economic growth, U.S. gas imports approach 3.5 trillion cubic feet per year (Tcf) by 2000. If, under high economic growth, gas imports were limited for some reason to a level less than 3.5 Tcf, gas curtailments in the U.S. could result (since projected gas demand would exceed available supply). For example, under high economic growth, gas consumed by final consumers could be almost 1 Tcf lower if only 2 Tcf/year of imports were available. Under low economic growth assumptions, U.S. gas imports only approach 2 Tcf/year by 2010. Consequently, a 2 Tcf/year ceiling on U.S. gas imports would likely have little impact on the amount of gas consumed by the U.S. economy under low economic growth conditions.

Coal exports are not significantly affected by a variation in U.S. economic activity (leaving non-U.S. economic activity unchanged). The coal export market is more strongly influenced by the world oil market and overseas economic activity. Consequently, coal exports do not vary appreciably until the differential in oil imports becomes large enough to have an impact on the world oil price and thus affect international coal markets (see section 6.1.4 for a discussion of U.S. coal exports when non-U.S. economic growth is varied as well as U.S. economic growth).

TABLE 6-6: PRIMARY ENERGY SUPPLIED TO THE U.S. ECONOMY UNDER HIGH AND LOW U.S. ECONOMIC GROWTH ASSUMPTIONS-- LEAVING NON-U.S. ECONOMIC GROWTH AT SCENARIO B LEVELS

(QUADS)

	INDIGENOUS ENERGY PRODUCTION						NET IMPORTS[1/]					ADJUSTMENTS[2/]					PRIMARY ENERGY SUP-PLIED TO U.S. ECONOMY
												STOCK CHANGES					
YEAR	OIL	GAS	COAL	NUCLEAR	RENEW-ABLE	TOTAL	OIL	GAS	COAL	OTHER[3/]	TOTAL	OIL	GAS	COAL	OTHER[4/]	TOTAL	TOTAL
ESTI.																	
1982	20.6	17.8	18.4	3.0	6.2	66.0	9.0	0.9	-2.8	0.1	7.2	+0.3	-0.3	-0.6	+0.7	+0.1	73.3
PROJ.																	
1985																	
LGNP	19.5	17.4	19.4	4.0	6.1	66.5	11.4	1.1	-2.8	0.1	9.7	-0.6	--	--	--	-0.6	75.6
CASE B	19.5	18.9	21.3	4.6	6.2	70.5	12.8	1.2	-2.8	0.1	11.3	-0.6	--	--	--	-0.6	81.1
HGNP	19.5	19.1	21.6	4.7	6.2	71.1	13.1	1.2	-2.8	0.1	11.5	-0.6	--	--	--	-0.6	82.0
1990																	
LGNP	18.8	18.0	22.4	5.9	6.9	72.0	11.6	1.1	-3.2	0.1	9.6	--	--	--	--	--	81.6
CASE B	19.0	18.2	24.5	6.5	7.0	75.1	12.4	1.9	-3.3	0.1	11.1	--	--	--	--	--	86.2
HGNP	19.0	18.6	25.8	6.9	7.0	77.4	13.1	2.2	-3.3	0.1	12.1	--	--	--	--	--	89.5
1995																	
LGNP	17.6	17.1	26.1	6.4	8.1	75.3	11.5	1.5	-4.4	0.1	8.7	--	--	--	--	--	84.1
CASE B	17.7	17.2	28.7	6.9	8.6	79.1	12.4	2.4	-4.4	0.1	10.5	--	--	--	--	--	89.6
HGNP	17.7	17.7	31.5	7.7	8.9	83.4	13.5	3.1	-4.4	0.1	12.3	--	--	--	--	--	95.7
2000																	
LGNP	17.3	16.0	29.4	7.2	9.2	79.1	9.8	1.7	-5.3	0.1	6.2	--	--	--	--	--	85.4
CASE B	17.4	16.3	33.6	7.9	10.0	85.1	11.0	2.6	-5.4	0.1	8.3	--	--	--	--	--	93.4
HGNP	17.4	16.0	37.2	8.0	10.7	89.3	12.7	3.4	-5.5	0.1	10.8	--	--	--	--	--	100.1
2005																	
LGNP	17.0	14.9	33.6	8.5	10.2	84.2	7.8	1.7	-6.8	0.1	2.9	--	--	--	--	--	87.1
CASE B	17.2	14.5	38.5	9.2	11.6	91.0	10.2	2.7	-6.9	0.1	6.1	--	--	--	--	--	97.1
HGNP	17.3	14.4	43.7	9.4	12.2	96.9	11.8	3.4	-7.0	0.1	8.3	--	--	--	--	--	105.2
2010																	
LGNP	16.7	11.7	40.2	10.7	11.6	91.0	6.1	2.1	-8.3	0.1	--	--	--	--	--	--	91.0
CASE B	17.0	11.6	45.7	12.0	13.5	99.9	8.2	3.0	-8.5	0.1	2.8	--	--	--	--	--	102.7
HGNP	17.4	11.5	53.1	12.7	14.4	109.0	10.0	3.6	-8.5	0.1	5.2	--	--	--	--	--	114.2

1/ Including Strategic Petroleum Reserve.
2/ Negative numbers indicate a reduction in energy supplied and positive numbers indicate an increase in energy supplied to the economy.
3/ Includes small amounts of coal coke and electricity.
4/ A balancing item. Includes unaccounted for oil, gas and coal private stock changes, losses, gains, miscellaneous blending componets, unaccounted for supply and anthracite shipped overseas to U.S. Armed Forces.

TABLE 6-7: ENERGY CONSUMED BY THE U.S. ECONOMY UNDER HIGH AND LOW U.S. ECONOMIC GROWTH ASSUMPTIONS--
LEAVING NON-U.S. ECONOMIC GROWTH AT SCENARIO B LEVELS

(QUADS)

	PRIMARY ENERGY CONSUMED BY U.S. ECONOMY							ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES	ENERGY USED BY FINAL CONSUMERS EXCLUDING INPUTS TO UTILITIES AND SYNTHETICS									
YEAR	OIL	GAS	COAL	NUCLEAR	RENEWABLE	NET ELECTRICITY IMPORTS	TOTAL	TOTAL	LIQUIDS	GASES	COAL SOLIDS	ELECTRICITY	RENEWABLE 1/	TOTAL	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION
ESTI.																		
1982	30.4	18.1	15.5	3.0	6.1	0.1	73.3	-17.1	28.7	15.0	2.8	7.0	2.7	56.2	10.0	6.1	21.5	18.6
PROJ.																		
1985																		
LGNP	30.3	18.5	16.5	4.0	6.1	0.1	75.6	-18.2	28.0	15.8	3.1	7.5	2.9	57.3	10.2	6.5	23.3	17.4
CASE B	31.7	20.1	18.4	4.6	6.2	0.1	81.1	-20.1	29.1	17.1	3.4	8.3	3.0	60.9	10.9	7.0	25.0	18.1
HGNP	31.9	20.3	18.8	4.7	6.2	0.1	82.0	-20.5	29.3	17.3	3.5	8.4	3.0	61.5	11.1	7.2	25.1	18.2
1990																		
LGNP	30.4	19.1	19.2	5.9	6.9	0.1	81.6	-20.7	28.5	16.8	3.5	8.6	3.4	60.8	10.7	7.2	25.8	17.1
CASE B	31.4	20.1	21.2	6.5	7.0	0.1	86.2	-22.7	29.3	17.6	3.8	9.4	3.5	63.6	11.4	7.6	27.0	17.5
HGNP	32.1	20.8	22.5	6.9	7.0	0.1	89.5	-24.0	29.9	18.2	4.1	9.9	3.5	65.6	11.9	8.0	27.9	17.8
1995																		
LGNP	29.1	18.6	21.8	6.4	8.1	0.1	84.1	-22.7	27.7	16.5	3.9	9.4	4.0	61.4	10.8	7.0	26.6	17.0
CASE B	30.1	19.6	24.3	6.9	8.6	0.1	89.6	-24.9	28.6	17.5	4.3	10.3	4.1	64.8	11.5	7.7	28.1	17.4
HGNP	31.2	20.8	27.0	7.7	8.9	0.1	95.7	-27.4	29.5	18.5	4.6	11.4	4.3	68.2	12.3	8.0	29.9	18.0
2000																		
LGNP	27.1	17.7	24.0	7.2	9.2	0.1	85.4	-24.2	26.0	16.0	4.5	10.0	4.6	61.1	10.4	7.2	26.8	16.8
CASE B	28.3	18.9	28.2	7.9	10.0	0.1	93.4	-27.8	27.2	17.2	4.8	11.6	4.8	65.6	11.4	8.0	28.4	17.7
HGNP	30.1	19.4	31.8	8.0	10.7	0.1	100.1	-30.4	29.0	17.7	5.2	12.8	5.0	69.7	12.2	8.6	30.1	18.8
2005																		
LGNP	24.8	16.6	26.8	8.5	10.2	0.1	87.1	-26.5	24.1	15.4	4.9	11.0	5.2	60.6	10.1	7.5	26.7	16.4
CASE B	27.4	17.2	31.6	9.2	11.6	0.1	97.1	-30.6	26.6	16.1	5.5	12.8	5.6	66.5	11.1	8.3	29.2	18.0
HGNP	29.1	17.8	36.7	9.4	12.2	0.1	105.2	-33.9	28.4	16.7	5.9	14.3	5.9	71.3	11.9	9.0	31.1	19.3
2010																		
LGNP	22.8	13.8	31.9	10.7	11.6	0.1	91.0	-30.0	23.2	14.5	5.3	11.9	6.0	60.9	10.1	7.7	27.1	16.1
CASE B	25.2	14.6	37.3	12.0	13.5	0.1	102.7	-35.1	25.7	15.3	5.9	14.1	6.6	67.6	11.2	8.7	29.7	18.0
HGNP	27.4	15.1	44.6	12.7	14.4	0.1	114.2	-40.3	27.9	15.9	6.5	16.4	7.1	73.9	12.3	9.6	32.2	19.7

1/ Renewable central electric is included in electricity column.

TABLE 6-8: ENERGY TRANSFORMATION IN THE U.S. ECONOMY UNDER HIGH AND LOW U.S. ECONOMIC GROWTH ASSUMPTIONS--
LEAVING NON-U.S. ECONOMIC GROWTH AT SCENARIO B LEVELS

(QUADS)

	ELECTRIC UTILITIES									SYNTHETIC FUELS								ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES
	ENERGY INPUT						ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES[2]	NET ELECTRIC IMPORTS	SALES	ENERGY INPUT			TRANSFORMATION LOSSES	SALES				
										OIL	COAL			LIQUIDS	GASES			
										FOR SYNTH. GAS	FOR SYNTH. GAS	FOR SYNTH. LIQUIDS				COAL GAS		
YEAR	OIL[1]	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL	LOSSES	IMPORTS	TOTAL	GAS	GAS	LIQUIDS	TOTAL		SNG	GAS	TOTAL	TOTAL
ESTI.																		
1982	1.5	3.3	12.7	3.0	3.5	24.0	-17.1	0.1	7.0	0.2	--	--	--	--	0.2	--	0.2	-17.1
PROJ.																		
1985																		
LGNP	2.1	2.9	13.5	4.0	3.2	25.6	-18.2	0.1	7.5	0.2	--	--	--	--	0.2	--	0.2	-18.2
CASE B	2.3	3.2	15.0	4.6	3.2	28.3	-20.1	0.1	8.3	0.2	--	--	--	--	0.2	--	0.2	-20.1
HGNP	2.4	3.2	15.3	4.7	3.2	28.7	-20.5	0.1	8.4	0.2	--	--	--	--	0.2	--	0.2	-20.5
1990																		
LGNP	1.8	2.4	15.7	5.9	3.5	29.2	-20.7	0.1	8.6	0.1	--	--	--	--	0.1	--	0.1	-20.7
CASE B	2.0	2.6	17.3	6.5	3.5	31.9	-22.6	0.1	9.4	0.1	--	--	--	--	0.1	--	0.1	-22.7
HGNP	2.1	2.8	18.4	6.9	3.5	33.7	-23.9	0.1	9.9	0.1	--	--	--	--	0.1	--	0.1	-24.0
1995																		
LGNP	1.5	2.0	17.8	6.4	4.1	31.9	-22.6	0.1	9.4	--	--	0.1	-0.1	--	--	--	--	-22.7
CASE B	1.6	2.1	20.0	6.9	4.5	35.0	-24.8	0.1	10.3	--	--	0.1	-0.1	--	--	--	--	-24.9
HGNP	1.7	2.3	22.4	7.7	4.6	38.7	-27.3	0.1	11.4	--	--	0.1	-0.1	--	--	--	--	-27.4
2000																		
LGNP	1.3	1.7	19.2	7.2	4.6	34.0	-24.0	0.1	10.1	--	0.1	0.3	-0.1	0.2	--	--	--	-24.2
CASE B	1.3	1.8	23.0	7.9	5.2	39.1	-27.6	0.1	11.6	--	0.1	0.3	-0.1	0.2	--	0.1	0.1	-27.8
HGNP	1.3	1.8	26.2	8.0	5.6	42.9	-30.2	0.1	12.8	--	0.1	0.3	-0.1	0.2	--	0.1	0.1	-30.4
2005																		
LGNP	1.2	1.6	20.5	8.5	5.0	36.8	-25.9	0.1	11.0	--	0.6	0.7	-0.6	0.4	--	0.4	0.4	-26.5
CASE B	1.2	1.6	24.7	9.2	6.1	42.7	-30.0	0.1	12.8	--	0.7	0.7	-0.6	0.4	--	0.4	0.4	-30.6
HGNP	1.1	1.5	29.2	9.4	6.3	47.5	-33.3	0.1	14.3	--	0.8	0.8	-0.6	0.5	--	0.5	0.3	-33.9
2010																		
LGNP	1.0	1.4	20.7	10.7	5.7	39.6	-27.8	0.1	11.9	--	3.4	2.4	-2.2	1.5	--	2.1	2.1	-30.0
CASE B	1.0	1.4	25.4	12.0	7.0	46.9	-32.9	0.1	14.1	--	3.4	2.5	-2.3	1.5	--	2.1	2.1	-35.1
HGNP	1.1	1.4	31.7	12.7	7.4	54.2	-37.8	0.1	16.5	--	3.6	2.7	-2.5	1.6	--	2.2	2.2	-40.3

1/ Includes petroleum coke.
2/ Includes utility own use and transmission losses.

CHAPTER 7: COMPARING PROJECTIONS

The preceding chapters give an idea of the complexity and uncertainty involved in projecting future patterns of energy consumption, production and prices. It is not surprising that projections produced by different analysts and organizations can vary substantially. The comparison of energy projections and discussion of the limitations of projections presented in this chapter provide a context for evaluating the NEPP-1983 energy projections, and others.

7.1 COMPARISON OF ENERGY PROJECTIONS

This comparison section presents results from a variety of energy studies. Also included are discussions of differences and trends in energy projections.

7.1.1 Presentation of projections

Two comparisons of energy projections are presented here: a comparison of national energy policy plan projections and a comparison of recently published projections. The executive summary of this report discusses differences among past National Energy Policy Plan projections. This chapter includes the supporting data for that discussion. Tables 7-1 and 7-2 summarize important U.S. and world energy trends from:

- the second National Energy Plan, May 1979 (NEP-1979);
- the third National Energy Policy Plan, June 1981 (NEPP-1981); and
- the current National Energy Policy Plan (NEPP-1983).

The first National Energy Plan did not include comprehensive projections of world and U.S. energy conditions. Therefore, it is not included in the tables or discussion.

A comparison of recent projections is presented in Tables 7-3 to 7-11 at the end of this chapter. Tables 7-3 to 7-9 show U.S. comparisons, while Tables 7-10 and 7-11 show world energy comparisons, including an extensive comparison of recent world oil price projections. The energy projections presented here do not represent an exhaustive or systematic review of all available studies. This group is large enough, however, to be representative of the range of "reference", "most likely" or "business as usual" scenarios. Included in the sample are projections that are widely circulated and represent recurring efforts by the following groups:

- U.S. Government--the NEPP-1983 Scenario B projections and projections by the Energy Information Administration (EIA);

- Industry--four oil companies, the American Gas Association (AGA) and the Gas Research Institute (GRI);

- Consultants--Data Resources, Inc.(DRI), Wharton Econometrics and Applied Energy Services (AES); and

- Research Group--Institute for Energy Analysis, Oak Ridge Associated Universities (ORAU).

References for the studies can be found in Annex D of this report.

Various analytical techniques and approaches are represented in this sample. Most projections are now produced with mathematical models that are modified by expert judgment. Although the studies typically do not present methodology as carefully as they do numbers, a review of approaches shows the use of econometrics (DRI; GRI, which used DRI's model; Wharton; EIA), structure/process simulation (NEPP; AGA; AES), judgment and combinations of the above (e.g., ORAU) .

In reviewing the tables of projections please note that in order to use consistent units and definitions for the numbers being compared, it was necessary to adjust various projections. Because of the alterations, descrepancies may exist between the numbers as reported on the tables and as reported in the original studies.

7.1.2 Why Projections Differ

There are many reasons for the differences between projections. These reasons include differences in definitions, conversion factors, data sources, base years used in trend fitting, estimation techniques and core assumptions. Probably the most important differences stem from the core or fundamental assumptions used in determining future quantities and prices. These assumptions concern the variables involved and the ways they interrelate, and can vary widely. The choice of core assumptions significantly shapes the results of analysis.

Foremost among the core assumptions are those leading to the path of the world oil price. Oil is currently the leading energy source, comprising 43% of the total amount of energy consumed by the U.S. economy in 1982. Because oil is the marginal fuel or the only fuel for many uses, oil prices have an impact on all fuels. The level and speed of oil price changes relative to other fuel prices directly affect the depletion and discovery rates of oil reserves, investment in other energy sources, and fuel-switching by oil consumers. Models vary widely in their treatment of oil prices. In some cases the oil price is generated entirely within the model according to some pricing formula, and feedback effects from other variables such as economic activity and OPEC production capacity are considered. At the other extreme are models in which the oil price is a totally exogenous assumption.

Estimates of energy resources also affect projections. These estimates vary widely, especially for oil. A recent survey of 1975 to 1979 estimates of world oil resources includes figures ranging from 1240 to 5600 billion barrels of ultimately recoverable conventional oil. Recent estimates of U.S. oil resources range from 45 to 135 billion barrels.

The level and content of economic activity is another key assumption. Economic activity is positively correlated with the demand for fuel and approximated by measures of the gross national product (GNP). Economic growth is sometimes assumed to be affected by fuel prices via feedback effects. Many models, however, simply incorporate a given level of economic growth.

Closely related to the GNP assumption are assumptions concerning elasticities. Price and income elasticities of demand are measures of the change in resource consumption in response to price and income changes. Likewise, the price elasticity of supply is a measure of how the level of production of a resource increases or decreases as prices rise or fall. Estimates of elasticities can differ substantially--both in amount and method of incorporation into analysis.

Together, this set of assumptions usually provides the basis for the linkage between the supply of and the demand for energy resources, with the elasticity assumptions allowing for feedback effects between the GNP level and energy supply, demand and prices. Assumptions concerning a number of other variables impact on projections both directly and via their effects on the above assumptions. Among others, these include government policies and regulations, interest rates, technological innovation, climatic conditions, and people's preferences and expectations. Changes in any of the assumptions, or differences in these assumptions between analysts, will affect the projections being made, sometimes producing dramatically different estimates. It will be seen, however, that at a given point in time assumptions of different analysts are somewhat similar, so that the projections tend to "bunch" together.

7.1.3 Historical Trends in Energy Projections

After reviewing a number of past energy projections, two trends are apparent. First, projections of energy consumption, production and price, made in a given time period for a specified future period, are often "bunched" together. Second, the bunch or set of projections tends to follow recent trends in the variable being projected. Figures 7-1, 7-2, and 7-3 illustrate these points using projections of U.S. primary energy consumption for the years 1975, 1980, 1985, and 2000. The movement of the bunch of projections is due to changing information and theories, which are often conditioned by the zeitgeist, or cultural spirit of the time.

The figures show the differences in projections of U.S. primary energy consumption by year of publication. Projections published before 1964 are generally lower than later ones. This is mainly because both economic growth and the growth in energy consumption were not as dramatic in the periods preceeding the estimates. Projections made after 1965 reflected the higher growth rates in economic activity and energy consumption which occurred in the preceeding years. Studies made after 1967 began expressing serious concern about the implications of these growth rates, especially for the environment. According to a 1972 report prepared for the House Committee on Interior and Insular Affairs:

> The change in attitude most likely result[ed] from recent higher consumption forecasts, unexpected delays in the development of nuclear sources of energy, and a realization that growth trends in domestic exploration, discovery, and recovery of traditional fossil fuels have failed to keep pace with domestic energy consumption.

Because of concerns about projected energy demands, most of the attention focussed on the problem of sufficiency of supply. The relative availability of data on the production process, compared to the consumption process, facilitated this approach.

Before the 1973 Arab oil embargo, energy projection studies were "... based on assumptions of only gradual technological change, constant relative fuel prices, unrestricted fuel availabilities, no major changes in government policy, only moderate swings in the business cycle ...," and continued exponential growth in consumption (Committee on Interior and Insular Affairs, 1972). There was an impressive decrease in the energy/GNP ratio from 1920 to 1950, but because this ratio was fairly stable from 1950 to 1970, it was widely believed that energy demand had become tightly coupled to the rate of economic growth. Only severe economic dislocation was thought capable of slowing the growth in energy consumption.

The 1973 oil embargo and accompanying oil price increases resulted in the implementation of new energy policies, changes in economic activity, and a reduction in energy demand growth--which upset many of the basic assumptions underlying prior projections. By 1977, the potential for reduced energy consumption per dollar of real output was conventional wisdom. Today, the amount of demand flexibility remains unknown, especially under rapid price movements.

Post-Embargo projections reflect the interruption of the rate of consumption in the early 1970's. The projections for 1980 presumed a resumption of pre-Embargo consumption trends, since analysts did not anticipate the effects of the Iranian revolution. Confronted with the evident flexibility in consumption, energy analysts began to focus on the demand side. The effects of this focus can be seen in the revision of the estimates of consumption for 1985 and 2000. The projections of primary energy consumption in the U.S. for 1985 shown in Figure 7-2 have dropped by almost 50% in ten years--a striking rate of decline. The revisions are similar for U.S. oil consumption. A 1979 comparison of 43 projections for 1985 found that projections of oil consumption published before 1974 averaged about 27 MMBD, while projections published between 1974 and 1978 averaged about 21 MMBD. The current NEPP scenario B projections estimate about 16 MMBD (see Chapter 3). In the 1979 sample, projections for oil imports in 1985 averaged 15 MMBD before 1974 and 9 MMBD from 1974 to 1978, while the current NEPP projects 6.1 MMBD in Scenario B. Changes in assumptions of economic growth and energy prices are thought to account for much of the movement in these projections.

Projections for the year 2000 have dropped as dramatically as those for 1985. The 1972 report of the Committee on Interior and Insular Affairs surveyed 11 projections published between 1960 and 1971. The estimates of primary U.S. energy consumption ranged from 135 to 337 quads, with an average of 187 quads (There was only a slight upward trend in the later estimates). The average of the recent projections shown in Table 7-6 is about 94 quads. The evolution of these estimates in the past decade is shown in Figure 7-3.

7.2 LIMITATIONS TO ACCURACY IN PROJECTIONS

The purpose of making projections is to help in preparing for the future, in part by demonstrating the logical implications of making a specific set of assumptions. When evaluating and using projections, a number of considerations must be taken into account. These include problems with energy data, the assumptions made to simplify the process of making projections, and the uncertainty affecting much of the process--all of which limit the analyst's ablility to make accurate projections.

7.2.1 Problems With Energy Data

There are many problems with the collection, measurement and use of data. Although there is a tremendous amount of detailed energy data available (e.g., regulatory data), appropriate data for making energy projections are hard to obtain. An important reason is that it is not really known which data are most critical to understanding future energy conditions. Another constraint is cost: data are costly to collect and validate. Yet another problem is that data are often unavailable or untimely due to lags in collection and dissemination. Even if a data set is available, it may be incomplete due to gaps where, for instance, data have not been collected for a particular year.

Apart from problems of collection, correct measures are hard to attain. A direct measure of the variable in question may not be available, requiring the use of an indirect or partial measure. For example, end-use oil consumption is measured by sales not consumption, thus excluding losses, private stocks and non-energy uses. On the other hand, detailed information may be lost when heterogeneous data is aggregated--as when petroleum data masks the differences in the energy content of different types of oil or when average price data conceal important regional trends. Data may also be measured in units other than those the analyst needs for projections, necessitating time-consuming conversions which increase the likelihood of error.

A major concern in the use of data is the inability to assess its accuracy. Systematic under-reporting or misreporting may occur in the collection process, but validity checks on the data sources are usually impossible or infeasible. This is a problem with oil production data in OPEC countries. Another example is when surveys designed to collect data are not updated frequently, structural changes in an industry being studied can lead to systematic misreporting. Other errors come from the processing of data, phrasing of and differing interpretations given to survey questions, and inappropriate sampling methods leading to unrepresentative samples. The exact size of data errors is unknown and not readily estimable. The poorest data are those that concern end-use consumption, areas outside the OECD, and noncommercial fuels. Problems with data increase the uncertainty associated with understanding past conditions. Without complete information on past conditions, the process of projecting future trends is made difficult.

7.2.2 Simplifying Assumptions

Energy quantities and prices affect and are affected by the highly complex workings of the U.S. and world economies. As with all types of analysis, making projections requires analysts to reduce their representations of reality to manageable proportions. This is done by building models (i.e., theories) of social and physical interactions using simplifying assumptions, some of which are described below.

Analysts who work with mathematical models often express the relationships between factors using a variety of functional forms with which they are familiar, which are relatively easy to manipulate and which appear to represent adequately the behavior under study. These functional forms, often linear, log-linear, exponential or sigmoidal, approximate actual behavior and interrelationships of variables in the system. As approximations, they are limited by the range of prior experience; e.g., time-series data on oil prices has not proven to be a good predictor of future oil prices. As simplifications, they are limited by aggregation of non-identical factors and exclusion of other factors. In the former case, for example, production of oil and of natural gas liquids may be combined for ease of analysis or because of the lack of data. In the latter case, political, behavioral and environmental factors may be excluded.

Although simplifications are needed to improve understanding, they can be misleading--as when analysts assume reversibility of relationships, or attempt to specify time lags. An example of this problem is the assumption that oil consumption will respond in the opposite direction with the same magnitude when prices are rising as when prices are falling. But in fact, technological innovation stimulated by rising prices is not forgotten or discarded once prices fall. Consequently, representing oil consumption in terms of a constant oil price elasticity, as incorporated in many energy models, can produce misleading results.

7.4.3 Uncertainty, Judgment and Accuracy

The problems inherent in collecting and analyzing energy data stem from the attempt to stop and decompose a constantly changing reality. Since agreement on the causes of past events is not nearly complete, projecting into the future is certain to cause much debate. Because of the uncertainty in what is known about how socioeconomic systems adjust, judgment plays a significant role in shaping the results of analysis. The effects of judgments made by different analysts using different techniques, however, are often obscured.

Studies of past projections and forecasts (mainly economic ones) have found little difference in accuracy between judgmental and objective methods, causal and extrapolative methods, simple and complex methods, or institutional groups. The evidence is scant, but the above conclusions seem to apply to energy projections as well (e.g., see Figure 7-1).

Although methods or broad institutional groupings do not seem to affect accuracy, it appears that analysts and groups with different stakes or views do produce different results (see Figure 7-3). For instance, Amory Lovins' projections of energy consumption are consistently lower than all other estimates (Lovins himself characterizes his views as "beyond the pale"). The differences between projections are conditioned by choices in assumptions. This is most obvious in the results of the National Academy of Sciences' CONAES study, where the estimates of energy consumption differed by about a factor of two. The main potential bias in choosing assumptions is the failure to seek disconfirming evidence, which can limit the conclusions to preconceptions. The effects of choices in assumptions by different analysts and groups are not clear, however, because of the interactions among assumptions (e.g., cancellation effects) and the judgmental adjustments made to produce "reasonable" estimates.

7.3 CONCLUSIONS

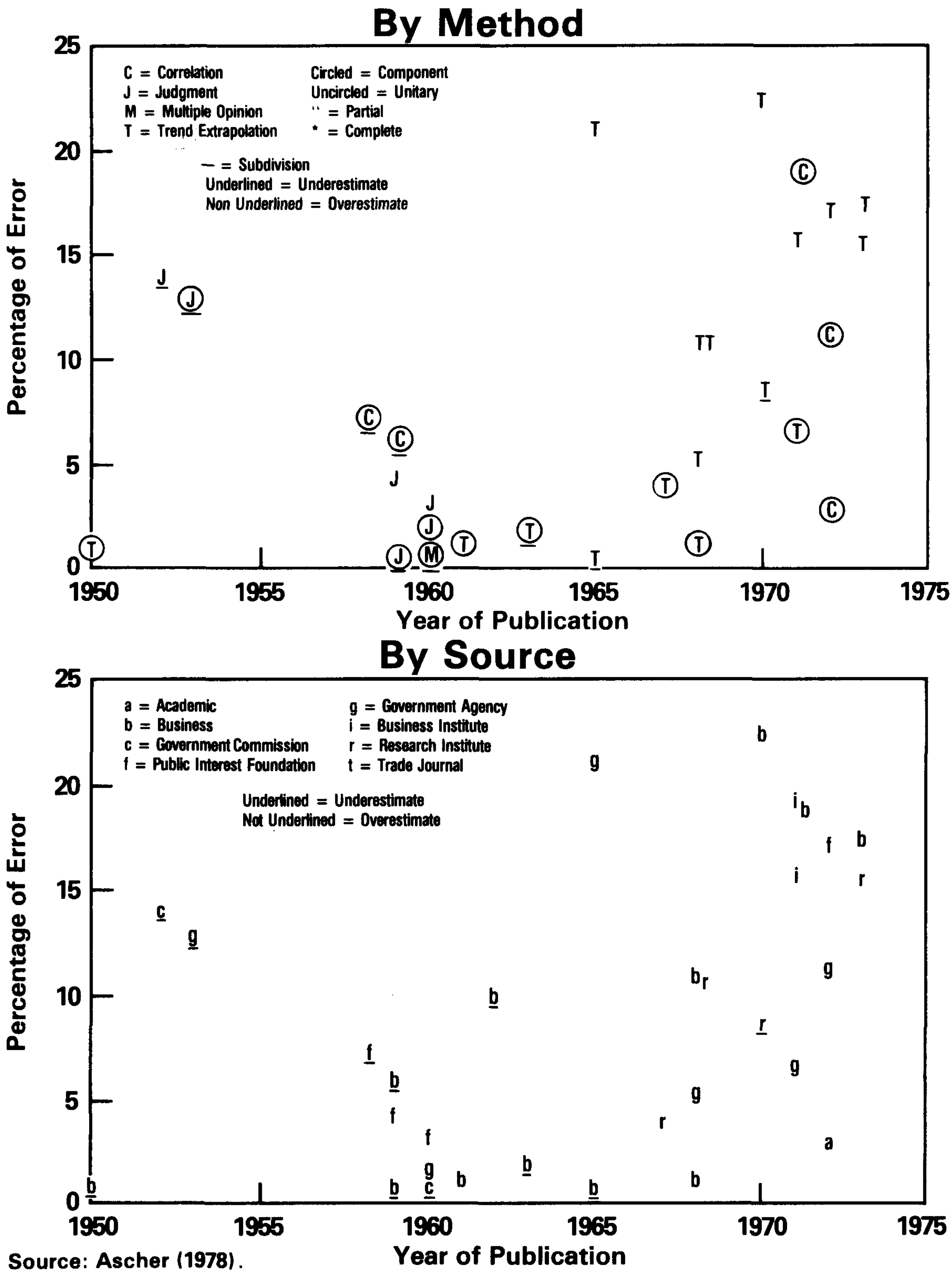
This chapter presented a discussion of the major assumptions, trends and limitations in energy projections, as well as detailed tables containing recent projections. The major assumptions concern resources or supply, levels of demand based on economic activity, energy prices, and a set of methods to balance supply, demand and prices. These and related assumptions significantly shape the results of the projections. For example, changing assumptions have caused projections of U.S. primary energy consumption to drop by about 50% in the last decade.

As the assumptions change through time, so do the projections. For any point in time though, the assumptions are similar, and thus the projections tend to "bunch" together. The similarity of assumptions is due to the concensus among experts as to what can reasonably occur in the future. This concensus seems to be conditioned primarily by recent information and events, since the bunch of projections follows the recent movements of the projected variable.

Major difficulties in making energy projections stem from problems with incomplete or inappropriate theories and data. Expert judgment is used to fill in gaps in theory and data, though often imperfectly. Despite problems and imperfections, projections help in preparing for the future by integrating knowledge, by showing the implications of making certain assumptions and by framing issues among competing points of view.

Figure 7-I

ERRORS OF 1975 U.S. PRIMARY ENERGY CONSUMPTION PROJECTIONS

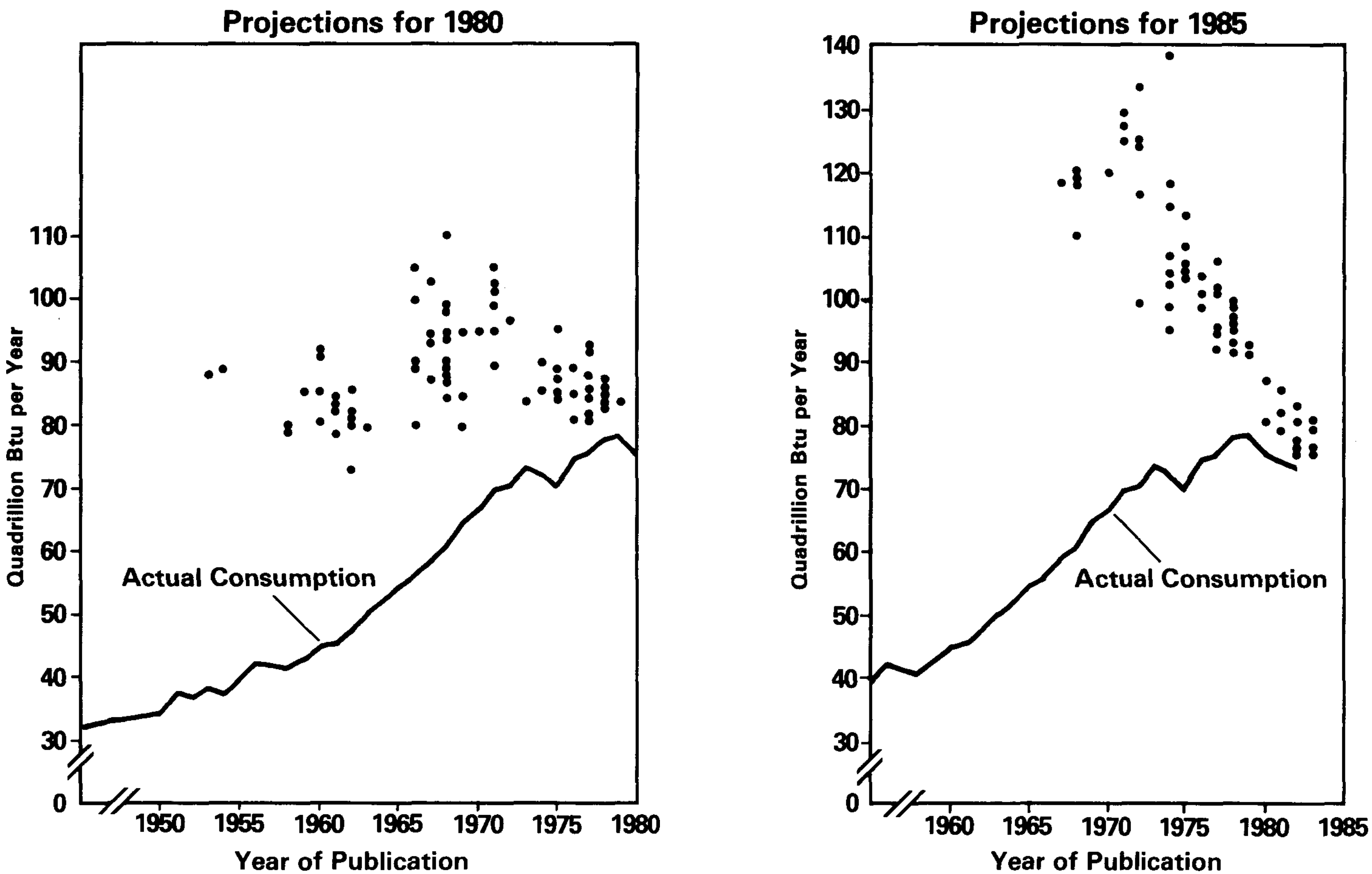


Source: Ascher (1978).

Figure 7-2

PROJECTIONS FOR U.S. PRIMARY ENERGY CONSUMPTION FOR 1980 AND 1985 VERSUS REAL PRIMARY ENERGY CONSUMPTION

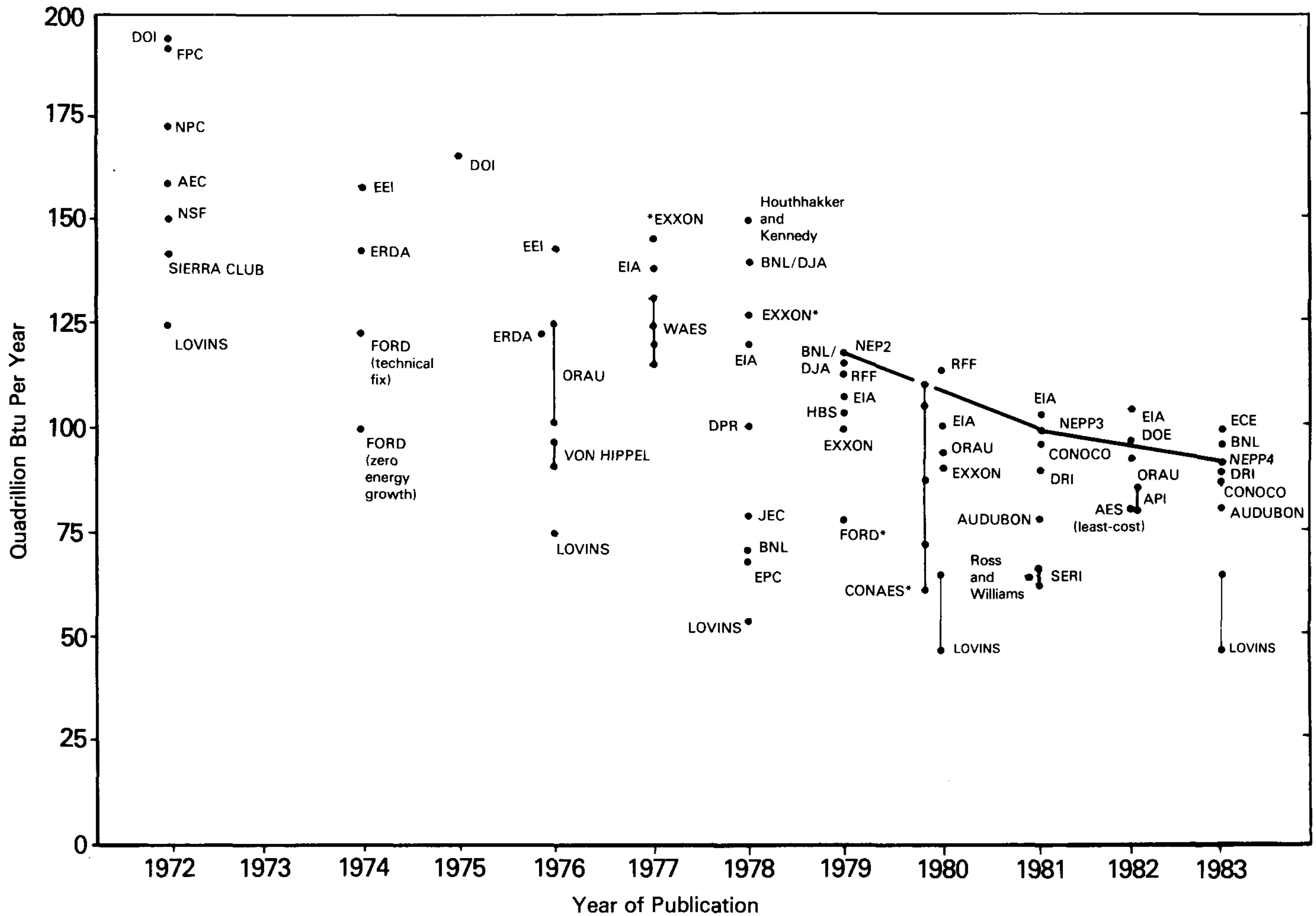
(Quadrillion Btu per Year)



Sources: Committee on Interior and Insular Affairs (1972); National Science Foundation (1972); Joint Economic Committee (1970); Committee on Science and Astronautics (1973); Committee on Energy and Natural Resources (1978); Ascher (1978); Energy Information Administration (1977-1982); Office of Policy, Department of Energy (1979-1983).

Figure 7-3

PROJECTIONS OF U.S. PRIMARY ENERGY CONSUMPTION FOR THE YEAR 2000



Sources: Oak Ridge Associated Universities(1982) and; Department of Interior(1972); National Petroleum Council(1972); Domestic Policy Review of Solar Energy, U.S. DOE(1978); Energy Information Administration(1979-1981); Office of Policy, U.S. DOE(1979-1983); Lovins(1981); American Petroleum Institute(1982); Audubon(1983); Beltramo and Manne(1983).

*Estimates derived from the study (a year 2000 number was not reported).

TABLE 7-1: COMPARISON OF NEPP U.S. PROJECTIONS1/
(Quadrillion Btu)

	1990			2000		
	NEP-1979 2/ Base Case	NEPP-1981 3/ Midrange	NEPP-1983 Scenario B	NEP-1979 2/ Base Case	NEPP-1981 3/ Midrange	NEPP-1983 Scenario B
WORLD OIL PRICE (1982 $/Barrel)	29	55	32	41	74	57
U.S. GNP GROWTH (Percent per Year from 1980)	3.2	2.8	2.7	3.0	2.5	2.6
DOMESTIC PRODUCTION	83	78	75.1	103	100	85.1
Oil and NGL	22	18	19.0	21	20	17.4
Natural Gas	18	18.5	18.2	18	18	16.3
Coal	27	27	24.5	38	42	33.6
Nuclear	9.4	7.6	6.5	16	10.6	7.9
Hydro/Geothermal	3.6	3.6	3.4	4.3	4.3	4.1
Renewables (Other)	2.9	2.8	3.6	5.3	5.4	5.9
NET IMPORTS (Exports)						
Oil	19	10	12.4	18	3	11
Gas	2.3	2	1.9	2.0	2	2.6
Coal	(2.1)	(3.5)	(3.3)	(2.4)	(5.9)	(5.4)
TOTAL CONSUMPTION	101	87	86.2	119	100	93.4

1/ Definitions of categories are consistent with others in this document; totals may not add due to rounding.
2/ "Appendix B: U.S. Energy Projections," National Energy Plan II, May 1979, p. 83.
3/ "Energy Projections to the Year 2000," July 1981, supplement to National Energy Policy Plan 1981 (NEPP-III), pp. 1-9.

TABLE 7-2: COMPARISON OF NEPP FREE-WORLD PROJECTIONS1/
(Million Barrels Per Day Oil Equivalent)

	1985			1990			2000		
	NEP-1979 Base Case	NEPP-1981 Midrange	NEPP-1983 Scenario B	NEP-1979 Base Case	NEPP-1981 Midrange	NEPP-1983 Scenario B	NEP-1979 Base Case	NEPP-1981 Midrange	NEPP-1983 Scenario B
World Oil Price $57.00 (1982 $/barrel)	25	47	26	29	55	32	41	74	57
World Economic Growth (%/year from 1980)		3.7	2.2		3.3	3.0		3.0	2.8
LIQUIDS CONSUMPTION (Includes Coal Liquids)									
U.S.2/	19	15.9	16.0	19	14.4	15.8	19	12.3	14.3
Other OECD		19.7	19.7		17.0	20.2		16.4	19.3
OECD Subtotal3/		35.6	35.7		31.4	36.0		28.7	33.6
OPEC		3.6	3.4		4.9	4.6		7.3	7.2
Rest of the Free World	___	8.9	8.3	___	10.5	10.0	___	11.5	12.8
TOTAL OIL CONSUMPTION	53.0	48.0	47.4	60	46.9	50.6	70	47.4	53.5
OIL PRODUCTION4/ (Excludes Coal Liquids									
U.S.2/	10.5	9.6	10.2	10.7	9.4	9.9	10.1	10.0	9.0
Other OECD		4.9	5.6		5.2	5.6		4.8	5.7
Rest of Non-OPEC	___	7.9	8.1	___	8.2	9.3	___	6.9	10.8
Subtotal3/	26.0	22.4	23.9	29.0	22.8	24.8	31.0	21.7	25.6
OPEC	27.0	26.0	23.2	30.0	24.8	25.7	37.0	25.0	27.7
COAL LIQUIDS	0.2	0.1	0.1	0.2	0.4	0.1	1.3	1.7	0.3
Subtotal Liquids Production	53	48.5	47.2	60	47.9	50.6	70	48.4	53.5
STOCK DRAWDOWN		--	(0.6)		--	--		--	--
CPE NET OIL EXPORTS5/	0	(0.5)	0.7	0	(1.0)	0	0	(1.0)	0
TOTAL LIQUIDS SUPPLY	53	48.0	47.4	60	46.9	50.6	70	47.4	53.5

1/ Totals may not add due to rounding. Parentheses indicate negative numbers.
2/ Includes about 0.5 MMBD of refinery gain.
3/ Includes U.S. territories.
4/ Includes natural gas liquids, shale oil, heavy oil, tar sands, enhanced oil recovery and liquids from biomass.
5/ CPE--Centrally Planned Economies.

TABLE 7-3: ECONOMIC GROWTH ASSUMPTIONS OF RECENT PROJECTIONS[1/]
(Percent Per Year)

Organization	Date Published	1980-1990	1981-1990	1982-1990	1990-2000
NEPP-1983 Scenario B	7/83	2.6	2.7	3.3	2.4
Energy Information Administration (EIA; Case A)	4/83	2.5	2.6	3.1	-
Oil Company A	11/82	-	2.7	-	2.8
Oil Company B	2/83	1.9	-	-	2.1
Oil Company C	6/83	3.0	-	-	2.5
Oil Company D	2/83	-	2.6	-	2.3
American Gas Association (AGA)	2/83	-	-	3.1[2/]	2.7[2/]
Gas Research Institute (GRI)	10/82	-	2.8	-	2.4
Data Resources, Inc. (DRI)	4/83	2.6	2.7	3.2	2.5
Applied Energy Services (AES; business-as-usual case)	10/82	2.6[3/]	-	-	2.6[3/]
Institute for Energy Analysis, Oak Ridge Associated Universities (ORAU)	11/82	3.3	-	-	2.5
Wharton Econometric Forecasting Associates	4/83	-	-	2.5	-

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ AGA used selected aspects of Wharton's December 1982 forecast.
3/ Represents growth from 1980 to 2000.

TABLE 7-4: RECENT PROJECTIONS OF U.S. FUEL PRICES BY SECTOR[a]
(1982 Dollars per Million Btu)

YEAR	WORLD OIL PRICE 2/ (1982$ /Bbl)	RESOURCE PRICES: REFINER CRUDE COST	RESOURCE PRICES: WELLHEAD GAS PRICE	RESOURCE PRICES: MINE-MOUTH COAL PRICE	DELIVERED PRICES — RESIDENTIAL SECTOR: DISTILLATE	RESIDENTIAL: LIQUID GASES	RESIDENTIAL: NATURAL GAS	RESIDENTIAL: ELECTRICITY	COMMERCIAL SECTOR: DISTILLATE	COMMERCIAL: RESID FUEL OIL	COMMERCIAL: LIQUID GASES	COMMERCIAL: NATURAL GAS	COMMERCIAL: ELECTRICITY	INDUSTRIAL SECTOR: DISTILLATE	INDUSTRIAL: RESID FUEL OIL	INDUSTRIAL: LIQUID GASES	INDUSTRIAL: NATURAL GAS	INDUSTRIAL: COAL	INDUSTRIAL: ELECTRICITY	TRANSPORTATION SECTOR: GASOLINE	TRANSPORTATION: DIESEL 3/	TRANSPORTATION: RESID FUEL OIL	TRANSPORTATION: JET FUEL
1990																							
NEPP-1983 Scenario B	31.90	5.49	3.90	1.55	7.89	6.94	6.22	21.36	7.20	5.59	6.74	5.91	22.24	7.07	5.43	6.74	4.91	2.16	16.13	11.13	7.97	5.43	7.21
EIA	37.00	6.38	5.00	-	9.02	8.49	8.53	18.36	8.54	7.06	8.51	8.48	18.74	8.43	6.67	8.18	7.23	2.33	15.35	11.41	8.95[b]	5.74	9.34
AGA	37.00	5.94	3.18	1.47[f]	c	c	c	c	d	8.13[d]	-	5.82	21.52	7.43	5.21	-	5.06	2.34	17.11	-	-	-	-
GRI	39.00	7.09	4.24[e]	1.61[f]	-	-	6.97	21.05	-	-	-	6.57	21.40	8.09[g]	6.09[g]	-	5.79	1.83[h]	17.47	10.36	-	-	8.66
DRI	35.62	6.09	4.25[e]	2.12[i]	-	-	6.34	21.16	-	-	-	5.96	20.78	7.65[g]	5.12[g]	-	5.40	-	16.98	11.34	-	-	8.25[j]
AES (BAU)	41.00	7.07	6.28	-	9.88[j]	k	8.57[k]	19.72	9.03[d]	d	k	8.19[k]	19.78	9.24	6.65	k	7.43[k]	2.37	14.17	12.91	9.72[b]	-	10.12
WHARTON	35.00	6.02	5.27	1.88	12.74	-	9.27	28.10	-	-	-	-	-	-	-		-	-	-	-	-	-	-
2000																							
NEPP-1983 Scenario B	57.40	9.90	6.75	1.76	12.99	11.34	9.28	24.07	12.00	9.73	11.31	8.97	25.56	11.72	9.40	11.31	7.87	2.43	19.03	16.00	13.27	9.40	12.74
AGA	45.00	7.18	3.84	2.00[f]	c	c	c	c	d	9.61[d]	-	7.25	28.05	8.82	6.31	-	6.12	3.20	23.72	-	-	-	-
GRI	47.00	8.72	6.80[e]	1.86[f]	-	-	8.98	21.19	-	-	-	8.55	21.25	9.86[g]	8.04[g]	-	7.89	3.64[h]	18.89	12.77	-	-	10.53
DRI	51.16	8.80	6.43[e]	2.57[i]	-	-	8.69	21.45	-	-	-	8.11	21.25	10.70[g]	7.14[g]	-	7.57	-	18.59	14.79	-	-	11.54
AES (BAU)	60.00	10.34	7.51	-	13.17[j]	k	9.80[k]	20.88	11.93[d]	d	k	9.43[k]	20.99	12.53	8.55	k	8.55[k]	2.71	15.19	16.80	13.01[b]	-	13.56

a Discrepancies may exist because of rounding, conversion and/or classification differences.
b Represents distillate for this sector.
c Residential and commercial sectors are combined.
d Distillate and residual are combined; for, AGA represents a mix of 80:20 of distillate to residual.
e Represents "average acquisition."
f Represents average of high and low sulfur coal prices.
g Represents prices for all sectors combined.
h Represents high sulfur coal ("large industrial"); low sulfur coal ("small industrial") is 2.59 for 1990 and 5.11 for 2000.
i Represents "contract average."
j Includes kerosene.
k Liquid gases and natural gas are combined.

TABLE 7-5: RECENT PROJECTIONS OF PRIMARY ENERGY SUPPLIED TO THE U.S. ECONOMY1/
(Quadrillion Btu)

YEAR	INDIGENOUS ENERGY PRODUCTION2/						NET IMPORTS					PRIMARY ENERGY SUPPLIED TO U.S. ECONOMY
	OIL	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL	OIL	GAS	COAL	OTHER	TOTAL	TOTAL
1990												
NEPP-1983 Scenario B	19.0	18.2	24.5	6.5	7.0	75.1	12.4	1.9	-3.3	0.1	11.1	86.2
EIA	19.3	16.4	23.9	6.3	4.4	70.3	15.1	1.2	-3.8	0.4	12.9	82.9
OIL CO. A	20.1	18.8	23.5	7.1	5.0	74.5	11.1	1.4	-3.6	--	8.9	83.4
OIL CO. B	17.1	16.8	23.4	5.1	6.4	68.8	15.7	2.0	-3.5	--	14.2	83.0
OIL CO. C	17.1	19.2	--	6.5	5.6	--	10.6	1.7	--	--	--	84.3
OIL CO. D	19.6	17.8	25.3	6.5	3.7	72.9	10.2	1.0	-3.4	--	7.8	80.7
AGA	--	19.7	--	--	--	--	--	1.8	--	--	--	82.9
GRI	20.2	16.8	26.0	6.3	4.5	73.8	9.3	2.4	-3.8	--	7.9	81.7
DRI	20.0	15.0	23.6	6.8	4.2	69.6	13.0	2.8	-3.6	--	12.2	81.5
WHARTON	18.9	18.2	26.0	6.0	3.9	72.9	14.5	1.8	-3.6	-.2	12.4	85.2
2000												
NEPP-1983 Scenario B	17.4	16.3	33.6	7.9	10.0	85.1	11.0	2.6	-5.4	0.1	8.3	93.4
OIL CO. A	17.5	18.5	30.8	8.5	8.9	84.2	14.5	2.3	-3.9	--	12.9	97.1
OIL CO. B	12.7	16.2	30.9	7.2	8.5	75.5	19.3	1.6	-5.5	--	16.4	91.9
OIL CO. C	16.2	20.7	36.6	7.0	9.0	89.5	14.6	(0.5)	-4.8	--	9.3	98.8
OIL CO. D	18.8	--	33.8	8.0	4.6	--	11.2	--	-5.1	--	--	87.9
AGA	--	20.5	--	--	--	--	--	2.9	--	--	--	95.8
GRI	20.6	15.0	39.0	7.4	6.4	88.4	11.1	2.6	-5.7	--	8.0	96.4
DRI	18.4	14.6	34.6	7.5	5.2	80.3	14.9	3.1	-5.2	--	12.8	93.3

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Stock changes, if indicated, are included under production.

TABLE 7-6: RECENT PROJECTIONS OF ENERGY CONSUMED BY THE U.S. ECONOMY[1]
(Quadrillion Btu)

DATE RELEASED	PROJECTION YEAR	PRIMARY ENERGY CONSUMED BY U.S. ECONOMY: OIL	GAS	COAL	NUCLEAR	RENEW-ABLE	TOTAL	ENERGY TRANS-FORMATION AND DISTRIBUTION LOSSES: TOTAL	ENERGY USED BY FINAL CONSUMERS EXCLUDING INPUTS TO UTILITIES AND SYNTHETICS: LIQUIDS	GASES	COAL SOLIDS	ELEC-TRICITY	RENEW-ABLE	TOTAL	RESI-DENTIAL	COM-MERCIAL	INDUS-TRIAL	TRANS-POR-TATION
	1990																	
6/83	NEPP-1983 Scenario B	31.4	20.1	21.2	6.5	7.0	86.2	-22.7	29.3	17.6	3.8	9.4	3.5	63.6	11.4	7.6	27.0	17.5
5/83	EIA	34.3	17.6	20.1	6.3	4.8	82.9	-22.6	30.3	15.2	3.8	9.6	1.4	60.1	10.5	6.9	26.0	16.9
11/82	OIL CO. A	31.2	20.2	19.9	7.1	5.0	83.4	-20.6	30.0	17.6	4.3	9.9	1.0	62.8	18.3[2]	--	26.1	18.4
2/83	OIL CO. B	32.8	18.8	19.9	5.1	6.4	83.0	--	--	--	--	--	--	--	--	--	--	--
6/83	OIL CO. C	30.0	20.8	20.9	6.6	6.0	84.3	-20.9	--	--	--	--	--	63.4	18.0[2]	--	26.6	19.0
2/83	OIL CO. D	29.8	18.8	21.9	6.5	3.7	80.7	--	28.8	16.6	4.9	9.1	--	59.3	16.0[2]	--	24.8	18.5
2/83	AGA	34.2	21.5	20.1	3.7	3.4	82.9	-20.2	31.7	19.0	4.0	8.0	--	62.7	18.9[2]	--	23.2	20.6
10/82	GRI	29.5	19.2	22.2	6.3	4.5	81.7	-22.9	28.5	16.2	4.8	8.9	0.4	58.8	15.0[2]	--	26.9	16.9
4/83	DRI	33.0	17.8	19.8	6.8	4.2	81.5	-22.7	31.0	14.7	4.2	9.2	--	58.8	9.3	6.4	23.6	19.5
11/82	AES(BAU)	29.3	19.7	22.2	6.2	5.1	82.5	-20.7	28.4	16.9	6.4	8.5	1.6	61.8	10.6	4.8	28.8	17.6
11/82	ORAU	33.7	23.2	22.2	5.5	4.2	88.8	-22.4	31.6	20.1	5.4	9.3	--	66.4	9.9	6.4	30.2	20.0
4/83	WHARTON	33.0	20.0	22.4	6.0	3.8	85.2	--	--	--	--	--	--	--	--	--	--	--
	2000																	
6/83	NEPP-1983 Scenario B	28.3	18.9	28.2	7.9	10.0	93.4	-27.8	27.2	17.2	4.8	11.6	4.8	65.6	11.4	8.0	28.4	17.7
11/82	OIL CO. A	32.0	20.8	26.9	8.5	8.9	97.1	-25.0	31.5	19.7	5.5	12.1	3.3	72.1	20.5[2]	--	32.8	18.8
2/83	OIL CO. B	33.0	17.8	25.4	7.2	8.5	91.9	--	--	--	--	--	--	--	--	--	--	--
6/83	OIL CO. C	30.7	19.4	29.6	7.1	8.3	95.1	-25.5	--	--	--	--	--	69.6	19.6[2]	--	31.2	18.8
2/83	OIL CO. D	30.0	16.6	28.7	8.0	4.6	87.9	--	29.5	15.6	6.4	10.8	--	62.8	16.4[2]	--	27.6	18.7
2/83	AGA	36.7	23.4	28.8	3.2	3.7	95.8	-25.5	34.8	20.9	4.8	9.9	--	70.4	21.4[2]	--	26.6	22.4
10/82	GRI	31.7	17.6	33.3	7.4	6.4	96.4	-29.2	31.0	16.3	6.9	11.4	1.6	67.2	16.5[2]	--	31.9	18.8
4/83	DRI	33.3	17.7	28.7	7.5	5.2	92.3	-27.9	31.4	15.5	5.9	11.4	0.2	64.4	9.3	7.9	26.9	20.3
11/82	AES(BAU)	28.1	18.7	28.8	8.4	5.6	89.6	-23.9	27.9	17.1	9.4	9.7	1.6	65.7	11.3	5.0	31.2	18.2
11/82	ORAU	34.7	21.2	26.4	7.4	4.6	94.3	-25.4	33.2	18.7	6.4	10.6	--	68.9	8.9	5.9	35.2	18.8

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Represents residential and commercial.

TABLE 7-7: RECENT PROJECTIONS OF U.S. ENERGY CONSUMPTION BY END-USE SECTOR[1/]
(Quadrillion Btu)

	RESIDENTIAL AND COMMERCIAL						TRANSPORTATION			INDUSTRIAL								
										FEEDSTOCKS (Non-Energy)			INDUSTRIAL TOTAL (Non-Energy and Energy)					
SOURCE	LIQUIDS	GASES	SOLIDS	ELEC-TRICITY	RENEW-ABLE	TOTAL	LIQUIDS	OTHER	TOTAL	OIL	GAS	COAL	OIL	GAS	COAL	ELEC-TRICITY	RENEW-ABLE	TOTAL
1990																		
NEPP-1983 Scenario B	3.2	8.4	0.2	5.8	1.5	19.1	16.7	0.8	17.5	3.7	0.9	0.1	9.4	8.5	3.6	3.5	2.0	27.0
EIA	3.4	6.8	0.2	5.8	1.2	17.4	16.9	--	16.9	5.1	0.5	--	10.3	8.3	3.6	3.8	0.2	26.0
OIL CO. A	4.4	8.1	0.2	5.6	--	18.3	18.2	0.6	18.8	3.6	--	--	7.8	8.9	4.1	4.3	1.0	26.1
OIL CO. C	3.5	7.9	0.1	5.3	1.2	18.0	17.8	1.2	19.0	5.7	--	0.1	8.6	9.1	4.3	3.5	1.1	26.6
OIL CO. D	2.6	7.8	0.2	5.5	--	16.0	17.8	0.7	18.5	--	--	--	8.4	8.0	4.7	3.6	--	24.8
AGA	4.7	8.9	0.2	5.0	--	18.9	19.8	0.8	20.6	3.8	2.5	1.7	7.1	9.3	3.8	3.0	--	23.2
GRI	2.1	7.4	0.2	5.2	0.1	15.0	16.4	0.5	16.9	4.9	0.7	--	10.0	8.3	4.6	3.7	0.3	26.9
DRI	2.4	7.3	0.2	5.8	--	15.7	19.0	0.5	19.5	4.1	0.7	--	9.3	6.9	4.0	3.4	--	23.6
AES (BAU)	3.1	6.7	0.1	5.1	0.4	15.4	17.0	0.6	17.6	4.3	2.6	2.2	8.4	9.5	6.3	3.4	1.2	28.8
ORAU	2.5	7.6	0.1	6.1	--	16.3	19.4	0.7	20.0	4.2	0.9	--	9.8	11.9	5.3	3.3	--	30.2
2000																		
NEPP-1983 Scenario B	2.2	8.0	0.2	6.8	2.2	19.4	16.8	0.9	17.7	4.3	1.2	0.1	8.2	8.6	4.6	4.7	2.4	28.4
OIL CO. A	4.0	9.4	0.2	6.7	0.3	20.5	18.2	0.6	18.8	5.5	--	--	9.4	9.7	5.3	5.5	3.0	32.8
OIL CO. D	2.0	8.0	0.3	6.2	--	16.4	18.1	0.6	18.7	--	--	--	9.8	7.1	6.1	4.6	--	27.8
AGA	4.6	10.2	0.1	6.5	--	21.4	21.8	0.6	22.4	4.3	2.5	1.8	8.4	10.1	4.7	3.4	--	26.6
GRI	1.6	7.6	0.3	6.5	0.5	16.5	17.8	1.0	18.8	6.2	0.9	--	11.6	7.9	6.6	4.7	1.1	31.9
DRI	1.9	7.8	0.3	7.1	0.3	17.4	19.8	0.5	20.3	5.0	0.8	--	9.7	7.2	5.6	4.3	0.1	26.9
AES (BAU)	2.7	7.3	0.1	5.8	0.4	16.3	17.7	0.5	18.2	4.8	3.3	2.3	7.5	9.3	9.3	3.9	1.2	31.2
ORAU	1.7	6.4	0.1	6.8	--	14.8	18.2	0.7	18.8	5.9	1.2	--	13.4	11.7	6.3	3.8	--	35.2
OIL CO. C	3.2	7.4	0.1	6.4	2.5	19.6	17.6	1.2	18.8	6.8	--	0.1	9.9	9.7	5.9	4.2	1.5	31.2

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.

TABLE 7-8: RECENT PROJECTIONS OF ELECTRICITY INPUTS AND SALES[1]
(Quadrillion Btu)

	ELECTRIC UTILITIES								
	ENERGY INPUT						ENERGY TRANSFORMATION AND DISTRIBUTION LOSSES	NET ELECTRIC IMPORTS	SALES
YEAR	OIL	GAS	COAL	NUCLEAR	RENEWABLE	TOTAL			TOTAL
1990									
NEPP-1983 Scenario B	2.0	2.6	17.3	6.5	3.5	31.9	-22.6	0.1	9.4
EIA	4.0	2.4	16.3	6.3	3.2	32.2	-22.6	0.4	10.0
OIL CO. A	0.3	2.5	16.2	7.1	--	--	-20.5	--	9.9
OIL CO. D	1.0	2.4	16.5	6.5	3.6[2]	30.0	-20.9	--	9.1
AGA	2.5	2.6	15.9	3.7	3.4	28.1	-20.1	--	8.0
GRI	0.8	3.5	16.9	6.3	3.8	31.3	-22.0	0.4	8.9
DRI	2.2	3.0	15.5	6.8	4.1	31.6	-22.4	--	9.2
AES	0.9	2.8	15.8	6.2	3.5	29.2	-20.7	--	8.5
WHARTON	1.8	2.6	18.3	6.0	3.8	32.5	--	--	--
ORAU	2.1	3.1	16.8	5.5	4.2[2]	31.7	-22.4	--	9.3
2000									
NEPP-1983 Scenario B	1.3	1.8	23.0	7.9	5.9	39.1	-27.6	0.1	11.6
OIL CO. A	0.2	1.0	22.6	8.5	--	--	-24.4	--	12.1
OIL CO. D	0.5	1.3	21.6	8.1	4.5[2]	36.0	-25.2	--	10.8
AGA	2.0	2.5	23.2	3.2	3.7	34.6	-24.7	--	9.9
GRI	0.5	2.1	25.5	7.4	4.2	39.7	-27.5	0.8	11.4
DRI	1.8	2.1	22.8	7.5	4.9	39.1	-27.6	--	11.5
AGS	0.5	1.8	18.9	8.4	4.0	33.6	-23.9	--	9.7
ORAU	1.5	2.5	20.0	7.4	4.7[2]	36.1	-25.5	--	10.6

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Includes net imports.

TABLE 7-9: RECENT PROJECTIONS OF U.S. LIQUIDS AND GAS SUPPLY[1/]

SOURCE AND YEAR	OIL (MMBD)									GAS (TCF)						
	CONVEN-TIONAL	SHALE	NGL	SUB-TOTAL	SYNTHETICS	OTHER[2/]	TOTAL PRO-DUCTION	NET IMPORTS	TOTAL SUPPLY	CONVEN-TIONAL	UNCON-VENTIONAL	SUB-TOTAL	SYNTHETICS	TOTAL PRO-DUCTION	IMPORTS	TOTAL SUPPLY
1990																
NEPP-1983 Scenario B	8.0	--	1.4	9.4	--	0.5	9.9	5.9	15.8	17.8	0.1	17.9	0.1	18.0	1.8	19.8
EIA	8.2	0.3	1.3	9.8	--	0.3	10.0	7.1	17.0	--	--	--	--	16.4	1.2	17.6
OIL CO. A	8.0	0.1	1.4	9.5	0.1	0.7	10.3	5.6	15.9	17.3	0.7	18.0	0.3	18.3	1.4	19.7
OIL CO. B	7.0	--	1.0	8.0	--	0.5	8.6	6.8	15.4	--	--	--	--	16.5	--	19.2
OIL CO. C	8.1[2/]	0.1	1.4	9.6	--	0.4	10.0	5.0	15.0	18.6	--	18.6	0.2	18.8	1.7	20.5
OIL CO. D	8.0	--	1.5	--	--	0.6	10.1	4.8	14.9	--	--	18.2	0.3	18.5	0.9	19.4
AGA	--	--	--	--	--	--	--	--	16.1	--	--	18.9	1.2[3/]	20.2	1.8	21.9
GRI	8.4	0.2	1.2	9.8	--	--	9.8	4.4	14.2	15.9	0.9	16.8	0.5	17.3	2.4	19.7
DRI	8.5	--	1.3	9.8	--	0.5	10.3	6.2	16.5	--	--	15.3	0.3	15.6	2.4	17.9
WHARTON	7.7	--	1.4	9.1	0.3	0.5	9.9	5.7	15.6	--	--	17.7	0.1	17.8	1.8	19.6
2000																
NEPP-1983 Scenario B	7.5	0.1	1.0	8.5	0.1	0.5	9.0	5.2	14.3	14.3	1.6	16.0	0.1	16.1	2.6	18.6
OIL CO. A	6.3	0.5	1.0	7.8	0.2	0.8	8.8	7.2	16.0	14.3	3.0	17.3	0.7	18.0	2.3	20.3
OIL CO. B	5.2	--	0.7	5.9	0.1	0.5	6.5	9.1	15.6	--	--	--	--	15.9	--	18.1
OIL CO. C	6.7[2/]	0.2	1.2	8.1	0.1	0.4	8.6	6.8	15.4	15.7	0.6	16.3	0.3	16.6	2.6	19.2
OIL CO. D	7.5	--	1.3	--	0.3	0.6	9.7	5.3	15.0	--	--	15.4	0.4	15.8	1.5	17.3
AGA	--	--	--	--	--	--	--	--	17.4	--	--	16.7	4.2[3/]	20.9	3.0	23.9
GRI	8.1	0.7	0.7	9.5	0.4	--	9.9	5.3	15.2	12.8	2.2	15.0	0.8	15.8	2.6	18.4
DRI	7.9	0.2	0.9	9.0	0.1	0.5	9.6	7.0	16.6	--	--	14.9	0.4	15.3	2.6	17.9

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Includes tar sands, processing gain and/or stock change.
3/ Includes unspecified amounts of flue and stack gas.

TABLE 7-10: RECENT PROJECTIONS OF OPEC OIL PRODUCTION, FREE-WORLD OIL CONSUMPTION AND FREE-WORLD ENERGY CONSUMPTION[1/]

PUBLICATION DATE	SOURCE	OPEC OIL PRODUCTION (MMBD)			FREE-WORLD OIL CONSUMPTION (MMBD)			FREE-WORLD ENERGY CONSUMPTION (QUADS)			
		1990	2000	2010	1990	2000	2010	1980	1990	2000	2010
6/83	NEPP-1983, Scenario B	25.7	27.7	28	50.6	53.5	54.1	201	228	274	319
5/83	EIA	27.2	--	--	52.8	--	--	200	229	--	--
12/82	BRITISH GOVERNMENT	29-35	27-34	26-36	48.5-68	45.5-68	43-77	198	191-267	210-379	--
2/83	OIL CO. B	25.7	29.6	--	49.8	53.7	--	--	227	267	--
6/83	OIL CO. C	20.7	26.7	--	49.1	54.9	--	200	38	276	--
2/83	OIL CO. D	23.3	28.3	--	49.2	54.7	--	--	235	286	--
4/83	DRI	25.7	--	--	52.6	--	--	--	--	--	--
12/82	CAMBRIDGE ENERGY RES. GROUP (U.K.)[2/]	25	26	26	49	52	50	208	236	281	318
9/82	INT'L ATOMIC ENERGY AGENCY (High)[2/]	--	--	--	--	--	--	244	361	523	--
9/82	INT'L ATOMIC ENERGY AGENCY (Low)[2/]	--	--	--	--	--	--	244	37	451	--
6/82	STANDARD (Indiana)[2/]	23	26	--	48	53	--	205	245	299	--
--	IPE (Choucri, MIT)[2/]	30	37	--	55	67	--	--	--	--	--
12/82	I. SOHN (NYU)[2/]	33	42	--	55	74	--	200	268	350	--
1982	R. STOBAUGH (Low Supply)[2/]	25	23	--	--	--	--	--	--	--	--
7/82	WORLD BANK[2/]	28	34	--	48	53	--	199	246	323	--
1/83	3RT (Manne and Preckel, Stanford)[2/]	23	25	--	48	60	--	--	--	--	--

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Derived from Beltramo and Manne (1983).

TABLE 7-11: RECENT PROJECTIONS OF WORLD OIL PRICES[1/]
(1982 Dollars per Barrel)

SOURCE	PUBLICATION DATE	1990	2000	2010
NEPP-1983, SCENARIO A-B-C	4/83	26-32-40	36-57-80	55-84-110
EIA, ANNUAL ENERGY OUTLOOK[2/]	4/83	28-37-48	42-59-85	--
BRITISH GOVERNMENT[3/]	12/82	--	35-75	--
INTERNATIONAL ENERGY AGENCY[4/]	10/82	--	32-52	--
CHASE[5/]	3/83	34	42	--
DRI[6/]	3/83	36	51	--
WHARTON[7/]	4/83	35	--	--
ENERGY MODELING FORUM (EMF 6)[8/]	2/82	39-69	45-97	75-138
AGA[9/]	2/83	37	45	--
GRI[10/]	10/82	39	47	--
INTERNATIONAL ENERGY WORKSHOP[11/]				
BROOKHAVEN	--	30	70	105
ECONOMIC COUNCIL OF CANADA	9/82	43	--	--
CAMBRIDGE ENERGY RES. GROUP (U.K.)	12/82	35	63	85
CENTRAL RES. INST. OF ELEC. POWER (Japan)	1982	43	58	78
U.N. ECONOMIC COMMISSION FOR EUROPE	12/82	36	--	--
ETA-MACRO (A. Manne, Stanford)	11/82	46	61	--
ENERGY STUDY CENTRE (Netherlands)	1/83	53	64	--
EAST-WEST CENTER	1982	50	71	--
INST. ENERGY ECONOMICS (Japan)	12/82	31	--	--
ISRAEL ENERGY MODELING FORUM	6/82	53	71	95
INST. FUTURE TECHNOLOGY (Japan)	--	47	53	56
INT'L INST. APPLIED SYSTEMS ANALYSIS (IIASA)	1981	54	54	54
ELECTRIC POWER RESEARCH INSTITUTE	11/82	53	75	--
MINISTRY OF ENERGY (New Zealand)	8/82	54	74	78
OAK RIDGE ASSOC. UNIVERSITIES (IEA)	8/82	--	39	46
PAKISTAN ATOMIC ENERGY COMMISSION	12/82	43	48	48
SOLAR ENERGY RESEARCH INSTITUTE	1981	--	39	--
S. EMIL (University of Manitoba)	--	41	51	59
R. STOBAUGH (Low Supply)	1982	60	94	--
J. PARIKH (IIASA; Govt. of India)	1982	51	63	78
TRACTIONEL, SCENARIO 1, 2, 4 (Belgium)	7/82	31-42-53	--	--
WORLD BANK	7/82	45	55	--
3RT (Manne and Preckel, Stanford)	1/83	36	58	--

1/ Discrepancies may occur because of rounding, conversion and/or classification differences.
2/ Energy Information Administration, Annual Energy Outlook, 1983.
3/ "Oil Prices in the Long-Term," a study by an interdepartmental group of officials, London, December 1982.
4/ World Energy Outlook, OECD/IEA, Paris, 1982.
5/ Chase Econometrics, U.S. Macroeconomic Long-Term Forecasts, First Quarter 1983.
6/ Data Resources, Inc., Energy Review, Spring 1983.
7/ Wharton Econometric Forecasting Associates, Wharton Long-Term Forecast, April 1983.
8/ Energy Modeling Forum, World Oil Summary Report, February 1982.
9/ American Gas Association, "TERA Analysis," February 8, 1983.
10/ Gas Research Institute, "1982 GRI Baseline Projection of U.S. Energy Supply and Demand, 1981-2000," October 1982.
11/ Projections from "International Energy Workshop, 1983, Preliminary Poll Responses: A Summary;" Mark Beltramo and Alan S. Manne, Stanford University, February 1983. NOTE: These projections were derived from indexed values.

ANNEXES

CONTENTS

ANNEX A

CONVERSION FACTORS[1/]

OIL

1 Quad = 0.4724 MMBD of Domestic Oil (= 172.4 MMBOE)
= 0.4697 MMBD of Imported Oil (= 171.4 MMBOE)
= 0.6988 MMBD of Natural Gas Liquids
= 0.5240 MMBD of Residential Use Oil
= 0.5240 MMBD of Commercial Use Oil
= 0.4970 MMBD of Industrial Use Oil
= 0.5050 MMBD of Transportation Use Oil
= 0.4770 MMBD of Utility Use Oil
= 0.4130 MMBD of Asphalt
= 0.5220 MMBD of Gasoline
= 0.5030 MMBD of Jet Fuel
= 0.4700 MMBD of Diesel Fuel

GAS

1 Quad = 0.9804 TCF of Natural Gas

COAL

1 Quad = 46.95 MMT of Utility Use Coal
= 44.4 MMT of Synthetic Fuel Use Coal
= 41.7 MMT of Direct Use Coal
= 37.9 MMT of Exported Coal

ELECTRICITY

1 Quad = 93.98 BKWH from Nuclear Energy
= 96.59 BKWH from Non-Nuclear Energy (Average)
= 293 BKWH of Electricity Used As Heat or Imported

1/ Units:
MMBD = Million Barrels Per Day (For One Year)
TCF = Trillion Cubic Feet
MMT = Million Short (2000 lb) Tons
BKWH = Billion Kilowatt Hours
MMBOE = Million Barrels of Oil Equivalent
QUAD = Quadrillion Btu (10^{15} Btu)

ANNEX B

CRITIQUE OF NEPP-1983 PROJECTIONS

During the development of the NEPP-1983 energy projections, we had a series of discussions with both government and non-government energy analysts and officials regarding the material presented in the main body of this report. Informal meetings were held with private sector individuals and groups including university professors, trade organizations, energy consultants, and energy companies. We also conducted a formal review of this report within the Administration. As a consequence of the review process, many helpful comments and suggestions have been identified and incorporated into the main text of this report. This annex provides a summary of additional comments and suggestions that, either for lack of time or other considerations, were not incorporated into the main report. Most of the comments are presented verbatim as provided from reviewers. To aid the reader, the comments are organized into the following categories:

General

International (including world oil prices)

U.S. Energy Prices

U.S. Energy Consumption

U.S. Energy Production

U.S. Energy Transformation (Electricity and Synthetic Fuels Production)

In reviewing this annex readers are cautioned to remember that critiques, by their nature, result in predominantly negative comments--i.e. most reviewers do not bother to comment on the points with which they agree. For example, one reviewer may feel that nuclear projections are too low but that the wind energy projections are about right, while another reviewer may conclude that the wind projections are too high and the nuclear numbers are about right. It is likely that a summary of such critiques would result in comments that both wind and nuclear projections are unreasonable. Thus, critiques often do not result in a balanced view of the validity of a study, and to the contrary, can serve perhaps disproportionately to undermine the usefulness of the study (which may help to explain why so few studies contain self-directed critiques). On the other hand, critiques can be very helpful in pointing out major areas of uncertainty and issues needing further study, in addition to providing the reader more information with which to interpret the content of the document.

With these caveats in mind, the following review comments are offered.

B.1 GENERAL

- In using models and projections, it is most important to develop an understanding of why the projection may be incorrect and the implications of the projection being incorrect rather than focusing entirely on developing predictions of future conditions.

- The NEPP-1983 analysis was based upon the use of one energy model, WOIL, used under a variety of input assumptions to generate different scenarios. If the analysis were based on the use of several very different models, operated over a range of assumptions, a much wider band of uncertainty related to projected world and U.S. energy conditions is likely to have emerged.

- The forecasts here for the United States are very similar to those in the long-term chapter of EIA's Annual Report to Congress: 1980. As in the U.S., the world rate of growth (outside OPEC) is assumed to be 2 percent per year in real terms. Given the rate of population growth in recent U.N. forecasts (and given the lack of evidence that a major "demographic transition" is taking place), this means zero or negative growth in GNP per capita in much of the world. Lower economic growth and a shorter time-horizon seem to explain why the projections here are far more optimistic about energy markets than is the Forrester/Meadows model which we have reviewed elsewhere. ("The Role of Energy in the Global System," a working paper submitted for the Office of Technology Assessment critique of global models-OTA-R-165-is available in its entirety from the Longer-Term Information Division of EIA.)

- Throughout this report (as in many EIA reports), energy is measured in Btu's. Electricification is often associated with a decline in Btu's, because a Btu of electricity is worth more than a Btu of gas in applications where electricity is now used. Using cost-weighted indices of total energy use, we sometimes find an increase in energy use where Btu's show a decrease. In the industrial sector, half the dollars for energy went to electricity in 1979, even though the Btu's for electricity are a small fraction.

- There is a large jump in U.S. economic growth and U.S. primary energy consumption in the period 1982 to 1985, representing a strong economic recovery. Growth rates then stabilize over the long term, and the report claims that the net effect of business cycles can be adequately represented by a smooth path that shows the underlying trend. Sensitivity to high and low growth cases are also shown. However, to show the current business cycle with such a large departure from the smooth path seems inconsistent with the argument presented. There may be those who would question whether this is an artificial device to achieve some predetermined result. A sensitivity analysis should be done to show the effects of having this jump in the early years. This is different from the low GNP growth case which reduces growth over the entire time horizon.

- Another problem with trying to model highly cyclical behavior with a relatively straight curve is that aspects of marketplace behavior may be ignored. For example, companies would probably be willing to take on extremely expensive capital projects more readily in a stable, relatively predictable economy than in one characterized by large fluctuations. In the latter case companies might delay until they were confident of the underlying trend, and thus new capacity (synfuels, electric plants, etc.) would be added more slowly than in a more stable economy.

- The assumption in all scenarios of passage of the Administration Natural Gas Consumer Regulatory Reform Legislation is somewhat inappropriate. It would have been better to assume a continuation of the Natural Gas Policy Act in Scenario B and then test how Scenario B changes, given implementation of new gas legislation. Also, assuming no change in environmental laws is probably incorrect.

- Despite the enormous uncertainty surrounding results, extension of the projections to 2010 rather than 2000 is helpful to evaluate the potential for various emerging technologies over the long-term. Efforts to make long-term projections should continue.

- While we may disagree on a few individual numbers, the NEPP-1983 energy projections are the most comprehensive, internally consistent and complete set that we have reviewed to date. The straightforward presentation of the data, discussion of units and conversion factors and textual content are very useful.

B.2 INTERNATIONAL

- Many analysts suggest that the world oil price resulting from Scenario B is reasonable to 1990 but that prices rise unrealistically rapidly from 1990 to 2000 (i.e. 6.2 percent per year real). Also, the price resulting from Scenario A is too high in the 2000 to 2010 time frame to represent a truly "low" world oil price case.

- The report understates the potential for future oil supply disruptions with attendent oil price increases much higher than any projected in the NEPP-1983 world oil price scenarios.

- The more world oil prices decline in the near-term, the more likely prices will increase rapidly later. This implies that the low price associated with Scenario A, which is low throughout the 1980 to 2010 projection period, is not very likely, just as the price associated with Scenario C, which is always high, is unlikely. Actual price paths are likely to swing between those of Scenarios A and C.

- Several non-government analysts supported the view expressed in NEPP-1983 that future world oil supply, demand and price patterns will likely be cyclical in reality but that the use of smooth trends for planning purposes is necessary and useful.

- A critical aspect of world oil market conditions is the amount of "production cushion" (e.g. excess OPEC production capacity). The world needs a certain amount of production cushion (e.g. 5-6 MMBD) for stability in the world oil market. If the Iran/Iraq war continues, world economic growth could stimulate oil consumption and reduce the cushion to an undesirably low level by 1987-1990. This point should be emphasized in NEPP-1983.

- In developing the world oil price survey, the question should be posed so that the response for prices in a later year (e.g. 2010) is dependent upon the path of prices in earlier years.

- The NEPP-1983 projection of total free-world energy consumption, and coal consumption in particular, is considerably lower than several alternative projections.

- There are several reasons to suspect that the growth of nuclear power outside the U.S., particularly in OPEC and the rest of the Third World, might be much greater than is projected here. Given that we have not seen (nor seen cited here) a serious industry-style market study of nuclear penetration in the Third World through 2010, we suspect that extending recent U.S. experience to the entire world very much understates the possibilities. First, as shown in the Bariloche (Latin American) world projections, many Third World nations expect to resume economic growth, and place heavy reliance on nuclear power as a way to avoid limits to growth. Some nations like Mexico have even talked about breeder reactors. Second, many Third World nations (e.g., Iraq, Libya, Iran) may place a political premium in favor of using nuclear power, rather than against. Third, descriptions of the United States as the "Saudi Arabia" of coal may encourage some nations to rely less on coal. To the extent that political decision makers anticipate the long-term future (embody "foresight"), this trend may be reinforced. Finally, the potential for growth in renewables in the Third World may be less than assumed here; while there are no tables here showing which renewables are expected to grow, it seems relevant that many environmentalists believe that even the present use of firewood in the Third World may be nonsustainable. In summary, there is an uncertain but real possibility that nuclear materials may start moving around outside the United States on a scale much larger than we now are planning for.

- The Centrally Planned Economies net energy trade in NEPP-1983 implies a significant decline in hard currency earnings from energy exports by 1990. How would such a drop in hard currency earnings be handled by the CPE's, especially in the U.S.S.R.? This hard currency aspect of CPE trade should be evaluated.

B.3 U.S. ENERGY PRICES

- Between 1980 and 2010, Scenario B, NEPP-1983 refiner crude costs are projected to increase by 157 percent in real terms (1982 dollars) while well-head gas prices increase by 430 percent and coal increases by only 48 percent. This seems surprising. If oil and gas increase by 157 and 430 percent, respectively, the demand for coal should substantially increase. While the supply of coal is high, it is still likely that mine owners would want to increase their profits and miners would demand wage increases leading to higher coal prices than projected.

B.4 U.S. ENERGY CONSUMPTION

- It would be helpful to provide more detail on energy demand by sector. Rather than only providing aggregate fuel totals by residential, commercial, industrial, and transportation sectors, some information on particular types of energy usage (e.g. space conditioning in the residential sector) would be useful.

- In performing energy demand analysis as much attention should be devoted to analyzing demographic patterns (e.g. family size and regional migration patterns), as is now given to evaluating economic growth patterns.

- Total U.S. energy consumption in 1985 seems unreasonably high, as does electricity consumption. The high electricity consumption results in a, perhaps, too high consumption of oil and gas by utilities in 1985.

- According to the discussion in Chapter 1 of NEPP-1983, the electric power market is expected to be the first to recover from the current recession and to be the energy source of choice in the industrial, commercial, and residential sectors. The text in Chapter 1 claims that although electricity is costly (due to power generation and transmission inefficiencies), its end-use efficiency is quite high, thereby making electricity competitive with oil and gas. This scenario tends to ignore improvements that are being made in the combustion efficiency of oil and gas burners. The pulsed combustor for gas is one example. NEPP-1983 also seems to put great stock in the future wide use of the electric heat pump, seemingly ignoring the fact that in cold climates, the heat pump loses efficiency.

- Based on a statistical study of data from 1958-1979 (plus supplementary data through 1981), it now appears that higher energy prices have very little effect in encouraging substitution away from energy in specific industries; in other words, the elasticity has been overstated, due to a reliance on technological (rather than empirical) models, due to the use of sophisticated econometric specifications which do not fit post-embargo data, and due to the use of Federal Reserve Board data on output which overstated output growth in crucial industries such as the chemical industry. The post-embargo "conservation" in industry seems to be largely a product mix effect; energy price shocks were followed by recessions and high real interest rates, which in turn cut consumption disproportionately in energy-using industries and also increased imports in those industries. Energy use in industry is dominated by the steel, aluminum, chemical (plastics), and stone/clay/glass industries, all of which depend heavily on sales of automobiles, construction and capital equipment. A return to economic growth and low interest rates would probably cause a rebound in these areas. As you point out, electricity (unlike coal) can pick up a lot of the demand for other fuels used as energy. These conclusions are discussed in the documentation of the PURHAPS industrial model, Volume III, EIA.

- In addition to substitution based on price, energy use could rise or fall as the result of general technical progress. Most econometric studies show that technical progress tends to increase the relative share of energy as a cost in manufacturing; by using more energy, labor and other inputs are reduced. In data through 1979, we find this effect in all industries but the chemical industry, where the trend was towards conservation. Since 1974, there is preliminary evidence that all of these trends have slowed (especially in chemicals), but the reason is not known and further analysis is needed; technical progress in general may have slowed, or there may be a change in attitudes towards energy. An implication of all this is that the effect of energy prices on the economy may be far larger than current models tend to show, both in terms of price-induced recession and lower rates of growth (at a given savings rate). (The importance of price elasticities in determining these effects are described in Survey of the Research into Energy-Economy Interactions, DOE/HCP/I6346-01, 1979.) The actual observed declines in growth since 1973 may provide an indication of how large these impacts may be, in proportion to a given real increase (not percentage increase) in the world energy bill.

- EIA residential experts see lowered thermostats, not efficiency, as the main cause of conservation in this sector in recent years. Some industry experts argue that new gas heaters may go up from 85 percent efficiency to 95 percent efficiency over time, but it depends on installation whether even this much gain will be real. Better installation is a real possibility, technically, but recent trends suggest that the marketplace will take a very long time catching up with the possibilities. New houses are better insulated than those built twenty years ago, but the housing stock is turning over extremely slowly and even new homes are probably far less insulated than those in Sweden, for example. Incentives on builders and builder-buyer communication may be limiting progress here. Electric heat pumps are good, but they don't really operate at a full 300 percent efficiency (efficiency is reduced most when it is cold outside, when most of the heating is needed); typically, they lead to marginal net improvement in displacing other fuels, or to large percentage improvement in displacing resistance heaters in warmer climates.

- NEPP-1983 projected gasoline consumption seems to be too low based on what appear to be optimistic assumptions about achieved road miles per gallon for the 1990 and beyond time frame. Also, the 1982 value of 16.9 road MPG for passenger vehicles seems too high. Finally, although passenger road MPG increases substantially from 1990 to 2010, total road MPG only increases slightly implying a, perhaps, too rapid increase in truck use.

- New fleet mileage started to flatten out after reaching 22 MPG, and it will be many years before the fleet average reaches that point. After the next big psychological shock with world oil supply, if one occurs, the new car MPG will probably start rising again. There are some experimental vehicles which can do much better. The 50 percent cited efficiency is not with a conventional powerplant; this would seem impossible, given that the thermodynamics keep us from getting above 32 percent even in large coal-fired electric plants, at very high operating temperatures and pressures. It is with electric or hybrid vehicles, such as methanol/electric or gasoline/electric (and also in hypothetical vehicles never tested on the road). The research in this area has progressed reasonably well, and there are indications of possible breakthroughs. If the U.S. automobile industry can convert to robotic manufacturing methods, which allow rapid reprogramming, it is possible that new hybrid vehicle designs could penetrate the market very rapidly, when the research and oil prices reach the critical point. Also hybrid vehicles offer a combination of high range and lower energy costs (electricity) in commuter driving. From the viewpoint of national security, they offer a quick response to any oil supply problems.

B.5 U.S. ENERGY PRODUCTION

B.5.1 Oil and Gas

- The NEPP-1983 conventional lower-48 oil and gas reserve additions are considerably higher than estimates supplied by two major oil companies. On the other hand, NEPP-1983 estimates of enhanced oil recovery and unconventional gas production are lower than those of the same two oil companies.

- The Enhanced Oil Recovery (EOR) projections, which are noted to include thermal recovery, fall in the low end of the range projected by Department of Energy sponsored studies. That range is approximately 2 to 5 quads by 2000, depending on oil prices and the state of technology. Not all of these studies run to 2010, but those that do also show production within this range. These studies were carried out at oil prices similar to or less than the NEPP-1983 Scenario B price projections. Assumptions about EOR technology advancements and other mitigating factors, such as environmental constraints or failure to achieve the full technical potential, should be discussed in order to facilitate a proper comparison with other studies of EOR production and potential.

- Our analysis of natural resource costs, based on U.S. Geological Survey estimates of undiscovered recoverable reserves and on engineering cost data, suggest that the Scenario B world oil price track may not be competitive with domestic production in the later years. Liquid fuels from domestic sources should be available at lower prices than those shown, more in line with the Scenario A price track, so that the level of imports projected by NEPP-1983 beyond 2000 could not be sustained.

- Prior long-term models (e.g. LEAP), added in "Hotelling rent" (scarcity value) to the price of oil and gas. We understand that WOIL does not embody producer foresight, and cannot calculate Hotelling rent directly. In our internal studies, we found that Hotelling rent added on the order of 40 percent to U.S. oil prices towards the end of the forecast horizon, when scarcity becomes an issue in the minds of producers.

- NEPP-1983 seems to assume completion of the Alaskan natural gas pipeline by 1990--a somewhat unlikely outcome.

- The unconventional gas projections are considerably lower than those recently developed by the National Petroleum Council. Their study is generally considered the most complete done on the subject to date. The study's projected production in 2000 from tight sands ranges from 4 to 8 quads, depending on price and development scenario. This does not include their optimistic scenario which achieves 16 quads in 2000, but which they admit would be difficult to obtain. Only one case, that corresponding to the high end of the range, is extended beyond 2000, and it projects over 11 quads in 2010. The prices assumed range up to $6.34/mcf in 1982 dollars ($5.00/mcf in 1979 dollars) which is slightly lower than the NEPP-1983 Scenario B well-head gas price in 2000 and considerably below the Scenario B price of $10.28/mcf in 2010. We are aware that a number of industry projections of unconventional gas contributions are less sanguine than most analyses of the technological potential would suggest and believe a discussion along these lines would be fruitful. Within this context it may be necessary to reexamine the relative contributions of coal gasification and unconventional gas in the projections.

B.5.2 <u>Nuclear</u>

- NEPP-1983 does not analytically address Administration policy for enhancing the outlook for nuclear power. If "current policy" is limited to that which has been implemented, the EIA nuclear projections which are used provide a fairly realistic estimate of nuclear power growth through the year 2000. However, the NEPP-1983 projections should depart from the "currently implemented policy" viewpoint used by EIA, and assume that currently proposed policies are implemented and are successful.

- Even at a modest electric growth rate of about 3.0% per annum, the need for new baseload generating capacity will grow rapidly in the next 20 years. We estimate that from 1996 through 2000 alone, there will be a need for about 120 GWe of new baseload coal and nuclear capacity based on system expansion and retirement of older coal and nuclear plants. We believe it is imprudent to assume that all of this demand will be met with new coal plants. We would agree that projections of installed nuclear capacity prior to 1995 cannot significantly exceed projections based on plants already in the pipeline, but in the following period, a rebirth of the nuclear market is highly feasible. The large market potential for new capacity, combined with licensing reform and the shorter lead times that will bring, could significantly increase the post-1995 nuclear contribution. We believe that nuclear could capture at least a third of the 1995-2000 market as opposed to the 10-15% in recent EIA analyses.

- NEPP-1983 understates the potential role of the Liquid Metal Fast Breeder Reactor based on current planning within the Department of Energy. In view of the fact that DOE nuclear policy has the Clinch River Breeder Reactor (CRBR) scheduled for operation in 1989 and a large-scale prototype breeder (LSPB) planned for operation about 1996, with commercial breeders following shortly thereafter, NEPP-1983 should reflect 0.1 quad in year 2000 and 0.2 quad in 2010 for breeders.

- The report states that the supply of coal is enough to last through the middle of the next century. That may be right, although changes in the rate of growth could change the point of sharp price rises plus or minus a decade or two. (For a quick approximation, one can take the 200 quads total free world energy consumption cited, apply the growth rate, and compare with coal reserves.) Oak Ridge Associated Universities, in Carbon Dioxide Review-1982, presents an independent estimate that 4 trillion tons of carbon are tied up in coal on earth. Until a few years ago, 8 trillion tons of coal was the standard estimate (for discovered plus undiscovered); over 2/3 of this was in the Soviet Union. (See p. 99, H.S. Cole et al, Models of Doom: A Critique of the Limits to Growth.) A 50% recovery rate is typical for present coals, though much of this 8 trillion is less accessible. Tons of coal are a very poor measure, however, because low-Btu coal can weigh a lot without having much energy; recent additions to world coal estimates involve a lot of lignite which was previously considered useless. The high Btu coals now in use are almost entirely made up of carbon (either as free carbon or in long-chain hydrocarbons); thus the Oak Ridge estimate of coal carbon in tons, reduced for recovery loss, may be a better guide to the energy value of the resource than are estimates of coal in tons.

B.5.3 Renewables

- The projection of 1.5 quads of wind electric energy in 2010 appears to be optimistic compared to the projections for other emerging technologies. This would require nearly 60 GWe of capacity if one uses the efficiency and capacity factors assumed for wind electric systems by EIA in last year's Annual Report to Congress. Such an estimate implies a high degree of technical and market success, as well as very little regional or siting limitations on its deployment.

- Most of the industrial wood use cited is actually black liquor; see DOE/EIA-0341 for estimates of U.S. wood consumption. Since this is not a purchased fuel, but a recycled byproduct of a production process, we treat it as an efficiency improvement in the process of making paper. In theory, all the wood used by the paper and lumber industries might be counted as a nonenergy use of a fuel; however, data do not exist to support such an approach in empirical models. OTA has sometimes estimated the biomass potential as being as much as 12 quads or so, but the environmental implications of their scenario may be very serious. In New Roots for Agriculture, by Wes Jackson for the Friends of the Earth, it is suggested that existing biomass exploitation is dangerously high already. The OTA scenario involves doubling theoretical forest yields by replacing all the available forests with fast growing conifers; the long-term implications for species diversity, soil fertility and resistance to disease are all problematical.

- Last year, the Quality Assurance Division of EIA checked with New England Electric, TVA, the California utilities, Carl York of Lawrence Berkeley Laboratories, and others, to ask about their experience in marketing residential solar systems. All of their sources (industry and nonindustry) indicated that the real-world cost of buying and installing reliable active solar systems is about three times the engineering estimates which go into virtually all the models. In other words, the cost escalation factor is similar to what it was with synfuels. Unreliable systems, which freeze up and break within a year (except in Florida) or do not work in the first place, cost less. At this point, it is not clear whether EIA would project active solar penetration at all. Passive solar is economical, but faces the problems cited with residential conservation. Two years ago, photovoltaics showed a serious likelihood of surpassing the DOE performance plans; however, EIA has not had a chance to review the program since the budget was cut. (Unfortunately, many of the numbers in the popular models come from primary sources much more than two years old.)

- The forecasts in Table 3-13 are so reasonable looking that it is easy to overlook our gross uncertainty about the speed at which these technologies may penetrate. This speed, in turn, will be affected by policy in many ways. The relative contribution of different renewables, especially, is uncertain. One hears different stories about wind technology costs, although the potential U.S. output is said to be 2-3 quads. The potential of photovoltaics and solar thermal is often said to be very site-constrained, to a maximum of about 6 percent. (See the EIA Annual Report to Congress 1978.) Since photovoltaics can be mass produced, like calculators, one might expect a more rapid penetration when the technology reaches the critical point; also, one might expect less of a site constraint in other countries, where land is cheaper and energy more expensive. Even in the United States, the output potential is technically very large; the site problem is related to costs and prices. We have also reviewed the DOE and NASA work on solar power satellites and the associated critiques (see Role of Energy in the Global System); and concluded that despite the uncertainties there is a very serious chance that the technology might compete with nuclear power in terms of both scale of output and price, particularly in other countries; less land is required per kilowatt than with terrestrial countries; and there is far less damage (if any) to vegetation.

B.6 U.S. ENERGY TRANSFORMATION (ELECTRICITY AND SYNTHETIC FUELS PRODUCTION)

B.6.1 Electricity

- One important omission in the NEPP-1983 projections and text is a discussion of electric generating efficiencies. An analysis of the energy inputs and electric outputs presented in Table 3-6 reveals that NEPP-1983 used an overall generating and transmission efficiency of 28.8 percent for 1980 and projects an efficiency of only 29.9 percent for 2010. This very small increase in efficiency is surprising, given the large increase in projected new capacity, particularly fossil-fueled. It should also be remembered that a large percentage of existing capacity (1980) will be retired and replaced or upgraded. There is no discussion whatsoever on the effects of the addition of advanced technology power plants or new, more efficient pollution control units.

- NEPP-1983 assumes net U.S. electricity imports will remain constant to the year 2010 at the current level; yet, discussions with Canada indicate a potential for a significant increase in Canadian electricity sales to the U.S. over the long term.

B.6.2 Synthetic Fuels

- The reader should be warned that forecasts of the penetration of new technologies are likely to be extremely unreliable (as they have been in the past). Cost is certainly not the only factor; potential scale of output, speed of scale-up, consumer acceptance, social overhead, capital, costs and political regulations are all important, and all typically unquantified. Even cost is commonly overstated or understated by a factor of three, by well-informed scientists, before a technology reaches the marketplace.

- Ed Merrow of the RAND Corporation has written a draft report (to be R-2571-ORNL) for EIA on synfuels costs and prospects. Based on a statistical methodology, it is now possible to project these costs scientifically, and avoid the tripling and retripling of cost estimates which occurred in the past. While his cost estimates are similar to those cited in NEPP-1983, the delay in getting synfuels plants up in useful quantities needs to be considered as well. If it takes 10 years to get up an inefficient pioneer plant, 10 more years to get the bugs out and to fully crank up the supplier industries (which would be heavily strained by a massive synfuels program), and 15 years to build up a significant number of new plants, the lags can add up. From the viewpoint of national security, this technology does not seem likely to offer a quick reaction to sudden oil price changes.

- It would appear that the rapid increase in world oil prices between 1990 and 1995 (NEPP-1983, Scenario B) will provide the incentive to bring synthetic fuels on line by 2000. As this capacity is built up after the turn of the century it appears that the rate of oil price increase will decline. More detailed analysis of the impact of the world oil price path on synthetic fuel production is needed, however, before one can draw that conclusion with a degree of confidence.

- Assuming it all comes from coal, 1.5 quads of high Btu synthetic gas in 2010 is the equivalent of some 50 plants on the scale of Northern Great Plains in its present configuration. While this is plausible by itself, one should explore the potential constraints if all the synthetic plants visualized were to hit the construction line at the same time.

- We see no mention of tar sands as a source of synthetic liquids. Although it is a limited resource, tar sands should be one of the lower cost alternatives for liquids fuel supply around the turn of the century and it is reasonable to expect some 20-50,000 bbl/day of oil from that source in this timeframe. [Editor's note--Tar sands are included as part of shale oil production.]

- The projected rapid build up of synthetic fuel production between the year 2000 and 2010, especially oil from shale where production rises from 0.2 quads in 2000 to 3.1 quads (1.5 million bbl/day) in 2010, needs to be discussed in depth. To attain the projected production level in 2010, the equivalent of thirty 50,000 bbl/day oil shale conversion facilities would be required. Earlier analysis of potential constraints to building up shale oil production to a million bbl/day over an eight year period (1982-1990) identified several institutional, environmental and social/economic constraints as critical. These include:

--Availability of land

--Permitting procedures

--Major Pipeline capacity

--Design and construction services

--Equipment availability

--Compliance with environmental regulations

--Adequacy of existing water supply systems

--Adequacy of community facilities and services

Many of these "critical" constraints can be overcome with advance planning, of course, but some of them may remain critical. In addition, some discussion is needed of whether the environment in oil shale areas can support anticipated levels of oil shale production. Some say there is an environmental "congestion" cap at about 500-600,000 bbl/day. Others say it is nearer 1-1.2 million bbl/day. The projected level of shale oil production in 2010 exceeds these levels substantially.

B.7 CONCLUSIONS

The comments provided in this annex have highlighted many important issues related to making long-term energy projections. We plan to review and carefully evaluate these comments so that we can incorporate suggestions into the next set of energy projections that we develop.

ANNEX C

WORLD OIL PRICE SURVEY

The world oil price projections which accompany a National Energy Policy Plan are always of great interest and concern--both within and outside of government. In the development of the NEPP-1983 projections, we expended considerable effort in choosing appropriate assumptions and rigorously operating energy models to develop a credible range of world oil price scenarios. Models and model-generated results, however, are only one source of information about future energy conditions.

To provide further information, we conducted a judgmental world oil price survey. Survey respondents included government analysts and officials, and private sector individuals who work in associations, universities, companies, or research groups. All of those participating in the survey either develop world oil price projections as part of their normal work or use world oil price projections developed by others in making important energy-related decisions. The individuals asked to participate in the survey were choosen in an attempt to provide a balanced representation of the wide diversity of views on future world oil prices. We sent survey questionnaires to 54 individuals and received responses from 35 individuals in time for inclusion in this report.

Table C-1 shows the responses we received for world oil price probabilities in the years 1990, 2000 and 2010. Figure C-1 is a copy of the questionnaire sent to respondents. The following are some insights from the world oil price survey results:

- A statistical analysis indicates that, on average, respondents to our survey believe that oil prices resulting from Scenario B are reasonable in 1990, that in 2000 prices between the Scenarios A and B results are more likely, and that the prices associated with Scenario A (lowest case) are most likely in 2010.

- A midrange world oil price can be defined as a price where the probability of either being higher or lower is about equal (that is, 50 percent). Using this criterion, the experts survey indicates that the $32 price of Scenario B is a good midrange in 1990, since the total probability of being low (sum of regions I and II) equals an average of 49 percent. In the years 2000 and 2010, midrange values fall somewhere between the prices resulting from Scenario A (low case) and Scenario B--in 2000 about half-way between A and B or about $46 per barrel and in 2010 about one third of the way from Scenario A to Scenario B, or about $65 per barrel.

- Another way to interpret the results of the survey is to calculate the number of respondents who were more than 50 percent sure that the world oil price would be less than the Scenario B result. For the year 1990, of the 35 respondents, 15 (about 40 percent) gave a more than 50 percent probability of prices being below the Scenario B result of $32 per barrel. For 2000, 26 or about 75 percent of the respondents were more than 50 percent sure that prices would be below Scenario B. Finally, for 2010, all but 5 respondents (i.e. 85 percent) were more than 50 percent sure that world oil prices would be less than its Scenario B value of $84 per barrel.

- Beyond 1990, respondents indicated a significantly greater probability that the world oil price will be lower than the lowest case (Scenario A) than the probability that prices will be higher than the highest case (Scenario C). For example, in 2010 the average response indicates a 36 percent likelihood of world oil prices being lower than $55 per barrel, but only a 7 percent probability of prices being higher than $110 per barrel. This indicates that the upper range of NEPP-1983 world oil prices in 2000 and 2010 is higher than the judgmental opinion of those participating in this survey.

- A review of the lowest and highest responses shows that on average the range for each response varies between a low of about 1 percent probability and a high of about 65 percent. This indicates a very wide range of individual opinions about future world oil prices. For example, some respondents were 100 percent sure that prices in 2010 would be below $55 per barrel, while other respondents were 100 percent sure that prices in 2010 would be above $55 per barrel.

TABLE C-1: WORLD OIL PRICE SURVEY RESULTS[1/]
(Probabilities in Percent)

Respondent	1990				2000				2010			
	Below $26	$26 to $32	$32 to $40	Above $40	Below $36	$36 to $57	$57 to $80	Above $80	Below $55	$55 to $84	$84 to $110	Above $110
1	15	30	50	5	35	60	5	0	60	35	5	0
2	40	30	20	10	50	30	15	5	50	30	15	5
3	5	20	70	5	15	70	10	5	25	65	7	3
4	30	20	20	30	35	40	20	5	45	35	15	5
5	20	20	30	30	20	30	30	20	40	45	10	5
6	0	20	70	10	10	80	10	0	60	30	10	0
7	10	20	50	20	10	40	40	10	20	60	10	10
8	15	25	35	25	10	60	15	15	30	45	20	5
9	10	15	70	5	85	10	3	2	90	8	2	0
10	10	20	60	10	5	60	30	5	0	50	30	20
11	20	40	20	20	45	40	10	5	60	30	5	5
12	20	25	30	25	25	35	30	10	40	35	20	5
13	20	40	25	15	35	45	15	5	--	--	--	--
14	30	40	20	10	40	40	15	5	55	35	8	2
15	20	30	40	10	20	50	20	10	20	30	30	20
16	20	45	25	10	10	50	35	5	15	50	30	5
17	25	55	15	5	30	60	9	1	35	50	14	1
18	15	35	35	15	20	50	20	10	35	40	20	5
19	0	30	50	20	20	50	30	0	40	50	10	0
20	35	30	20	15	60	30	10	0	90	10	--	--
21	20	50	20	10	10	75	10	5	60	25	10	5
22	5	50	40	5	20	60	20	0	30	50	20	0
23	10	50	30	10	15	35	35	15	20	30	30	20
24	10	40	30	20	30	30	30	10	--	--	--	--
25	25	60	14	1	25	50	20	5	25	50	20	5
26	15	50	30	5	10	40	35	15	20	35	30	20
27	2	30	45	23	5	60	25	10	10	60	20	10
28	5	30	60	5	5	60	30	5	10	70	18	2
29	5	30	60	5	5	60	30	5	5	60	30	5
30	10	50	30	10	20	50	25	5	30	60	8	2
31	5	10	10	75	10	30	40	20	10	40	30	20
32	30	40	15	5	30	60	7	3	20	55	20	5
33	0	10	30	60	0	20	50	30	0	25	50	25
34	10	40	25	25	35	35	15	15	50	20	20	10
35	55	25	15	5	95	5	0	0	100	0	0	0
Average	16%	33%	35%	16%	26%	46%	21%	7%	36%	40%	17%	7%
Lowest	0%	10%	10%	1%	0%	5%	0%	0%	0%	0%	0%	0%
Highest	55%	60%	70%	75%	95%	80%	50%	30%	100%	70%	50%	25%
Standard Deviation[2/]	12.3	13.0	17.5	15.3	21.4	17.1	12.0	6.8	25.5	16.8	11.1	7.3

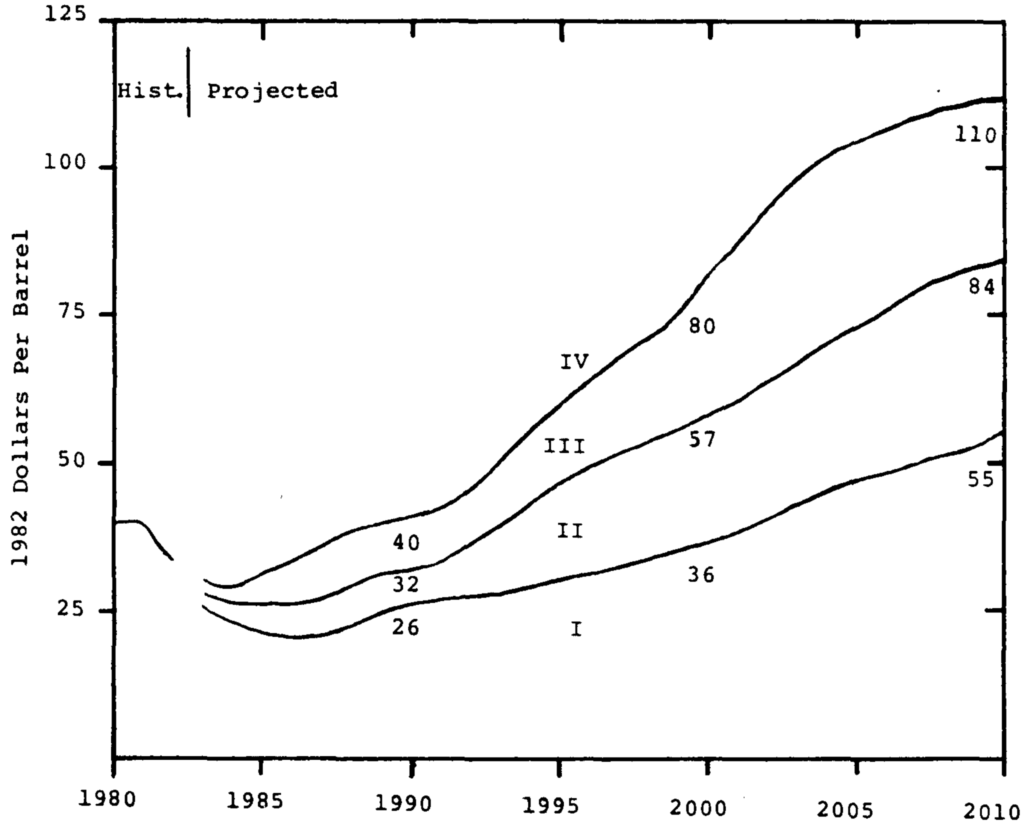
1/ World oil prices are average U.S. refiners acquisition cost measured in 1982 dollars per barrel.

2/ Standard deviation--a statistical measure of the dispersion of results. The larger the standard deviation, the greater the amount of dispersion.

FIGURE C-1: WORLD OIL PRICE1/ SURVEY

Optional Information

Name ______________________________ Date ______________________________
Organization ______________________ In doing energy analysis do you
Address ___________________________ use a mathetical model?
City ______________ State ____ Zip ______ Yes _____ No ____



1/ U.S. refiner acquisition cost of crude oil imports.

Using your judgment and accounting for potential unexpected events which could cause either higher or lower prices, please estimate the probability that prices will fall in the illustrated ranges.

Region	1990 Range (1982$/bbl)	1990 Probability (%)	2000 Range (1982$/bbl)	2000 Probability (%)	2010 Range (1982$/bbl)	2010 Probability (%)
I	below 26	____	below 36	____	below 55	____
II	26-32	____	36-57	____	55-84	____
III	32-40	____	57-80	____	84-110	____
IV	above 40	____	above 80	____	above 110	____
		100		100		100

ANNEX D

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