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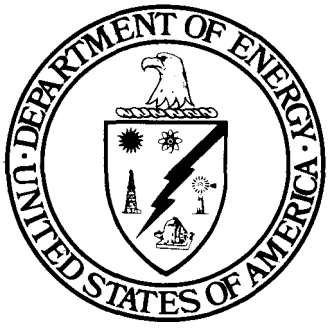
NATIONAL ENERGY PLAN II
MAY 1979

APPENDIX A:
WORLD OIL PRICES

U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR POLICY AND EVALUATION
OFFICE OF ANALYTICAL SERVICES
WASHINGTON, D.C. 20585



FOREWORD

The Second National Energy Plan (NEP-II) which President Carter forwarded to the Congress on May 7, 1979, is replete with forecasts of the Nation's energy future and the impacts of that future on the American way of life. The analyses which form the basis of those forecasts are extensive and highly detailed. The reflection of these analyses in the basic NEP-II document is necessarily brief, in order that the basic document be readable, and also so that the reader may maintain an appropriate perspective on the larger issues at hand.

The serious student of energy policy, however, will wish to examine some of the assumptions and analyses in greater detail. This appendix is addressed to that need. It is one of a series of three appendices which cover individual aspects of the energy problem.

The analysis reported here has employed complex models which require massive amounts of data. Where such models have been used, they are identified, and the reader may wish to examine further the detailed documentation of those models, which is separately referenced.

In preparing these analyses, heavy reliance has been placed on analytical techniques developed and employed by the Energy Information Administration (EIA). Indeed, in the interest of economy of analytical effort, much of the analysis reported here draws on work which EIA performed for the 1978 Annual Report of its Administrator to the Congress. Appendices to that report provide additional information on these analyses.

The reader should not be begiled by the complexity and detail of computer models, nor assume that they are "black boxes" from which truth will somehow emerge, or which will conceal bias. In fact, the use of computers is an orderly and explicit mechanism for performing large numbers of calculations. It is the insights into the behavior of energy markets and perceptions of the forces which will shape those markets in the future, which drive the results. Often, those insights and perceptions must rely heavily on judgement, since basic truths and detailed data are lacking. The world's and the Nation's energy future are far from deterministic. NEP-II attempts to deal explicitly with the uncertainties, by identifying the most important ones, and then using a range of estimates to bracket the range of responsible opinion.

In order that the reader may judge for herself or himself the reasonableness of the forecasts and estimates in NEP-II, the appendix in this volume describes in detail far greater than would be possible in the NEP-II report itself, the assumptions and methods of analysis used to generate the NEP-II results.

Copies of the original NEP-II and related appendices are available from the National Technical Information Service:

NTIS
Springfield, Virginia 22161

Titles		Order Number
NEP-II		DOE/TIC-10203
Appendix:	Environmental Trends and Impacts	DOE/TIC-10203 (APP)
Appendix A:	World Oil Prices	DOE/TIC-10203 (APPA)
Appendix B:	U.S. Energy Projections	DOE/TIC-10203 (APPB)
Appendix C:	Energy and the Economy	DOE/TIC-10203 (APPC)

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NOTE

The analyses reported in this appendix were performed in early 1979 and do not fully reflect the effects of the 1979 revolution in Iran and subsequent rapid increases in world oil prices. This appendix serves only to explain the basis for the projections reported in the Second National Energy Plan released in May 1979. The analyses in this appendix are out of date and do not represent current Department of Energy projections.

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A-I INTRODUCTION

In formulating the Second National Energy Plan, the U.S. Department of Energy recognized the immense uncertainty related to forecasting world oil prices--whether the forecast is for next year, a decade from now, or for the year 2020. Recognition of uncertainty, however, does not help government or private decision makers who must base today's energy decisions on some expectation about future world oil prices. Thus, the Second National Energy Plan (NEP-II), published in May 1979, provides a range of reasonable and internally consistent expectations about future world oil prices for use in performing domestic energy analysis.

This appendix reports the detailed assumptions and projections used to develop the NEP-II world oil price cases. By providing a well-documented analysis of world oil prices, DOE hopes to achieve two goals: first, to improve the state of knowledge about feasible world oil prices; and second, through careful documentation, to provide a good starting point for improved world oil price analysis in the future as we learn more about underlying assumptions.

This report consists of three major sections. The first section presents assumptions about potential world demand and production of oil, assuming constant real future world oil prices. Included is a discussion of alternative theories of OPEC behavior. The second section presents world oil price paths generated by mathematical models of world oil supply and demand. The models calculate oil prices that act through price elasticities to change the assumed "constant-price" oil demand and supply conditions to achieve a balanced oil market. The final section synthesizes the various model projections into the range of world oil price cases used in NEP-II and reports major conclusions resulting from the world oil price analysis.

A-II WORLD OIL DEMAND/SUPPLY ASSUMPTIONS

World oil prices depend on future world oil demand and supply.[1/2/] Key uncertainties that will affect future world oil demand include economic growth, total energy demand, non-oil energy consumption (including coal, nuclear, gas, solar, and other non-oil sources) and net oil imports from Communist countries. Uncertainty about oil supply stems both from uncertainty as to the political and economic environment affecting oil producer decisions and uncertainty about the world's oil resource base. Future world oil supply will depend primarily on the rate of development of known oil fields and the rate of discovery and development of new oil fields. The production potential of unconventional oil sources is an additional area of oil supply uncertainty. The following sections discuss each of the key uncertainties related to future world oil demand and supply. A final section summarizes a range in key assumptions and compares the range with several other studies.

2.1 WORLD OIL DEMAND

This section identifies a range in world oil demand that might occur if energy prices, including the price of oil, were to remain constant in real dollars in the future.[3/]

Later sections use this "potential" oil demand as an input to generate world oil price forecasts.

2.1.1 Total Energy Demand

A good starting point for forecasting oil demand is to study past behavior. Table 1 summarizes relevant historical energy information for the period 1960 to 1978.

1/ The term "world" in this analysis will denote the world excluding Communist Countries. These countries include the U.S.S.R., Eastern Europe, and the People's Republic of China.

2/ Oil is assumed to include natural gas liquids.

3/ In this analysis (which was performed prior to the June, 1979 meeting of OPEC), constant prices will mean a level approximately equal to $16 per barrel for crude oil delivered to the U.S. East coast.

TABLE 1

GROWTH IN WORLD GNP AND ENERGY CONSUMPTION[1/]
(%/yr)

	1960-1973	1973-1977	1976-1977
GNP	5.3	2.7	4.1
Total Energy Consumption	5.6	1.3	2.6
Non-Oil Energy Consumption	3.4	2.0	2.7
Oil Consumption[2/]	8.0	0.7	2.5

1/ World excluding Communist Countries.

2/ Includes Natural Gas Liquids.

A simple but effective way to forecast potential energy demand under constant prices is to forecast an expected rate of economic growth and assume a relationship between the rate of economic growth and rate of growth in energy demand. As Table 1 shows, during the period from 1960 to 1973, world energy and oil consumption grew faster than world Gross National Product (GNP).

Figure 1 shows the average world oil price over the period 1960 to 1978. From 1960 to 1973 the price of oil was low in absolute terms and declining in real dollars. The quadrupling of world oil prices in 1973-1974 drastically altered world energy consumption patterns. From 1973 to 1977 world GNP grew approximately 2.7 percent per year while world energy consumption grew more slowly at 1.3 percent per year. The relationship between growth in energy demand and growth in GNP thus declined from an historical value above 1 to a value closer to .5.

How long the effects of the government policies and changes in lifestyles that lead to this reduction will last is not yet known. If oil prices were to remain constant in the future, the adjustments caused by the 73-74 price rise could eventually diminish and, all other things remaining unchanged, world energy consumption could once again rise at the same rate as world GNP.

To deal with the uncertainties related to world GNP growth and energy consumption, we have constructed high, medium and low world energy consumption scenarios summarized in Table 2.

High potential energy demand would result from a combination of high world GNP growth of approximately 4.5 percent per year to 1990 and an energy to GNP growth ratio (E/GNP) under constant world oil prices of approximately .9. Medium potential energy demand occurs with a world GNP growth of approximately 4.0 percent per year to 1990 and an E/GNP ratio of .85. Finally, low energy demand results from low world GNP growth of approximately 3.5 percent per year to 1990 and E/GNP ratio of .8. The resulting range in potential world energy demand assuming constant world oil prices is about 130 to 150 million barrels of oil equivalent (MMBD) in 1990 (compared to about 93 MMBD consumed in 1978).[1/] Note that the E/GNP ratios discussed here are input assumptions under constant world oil prices. As prices rise in

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[1/] Oil equivalent is defined as 5.8 million Btu per barrel

Figure 1: Official Sales Price of Saudi Arabian Marker Crude Oil

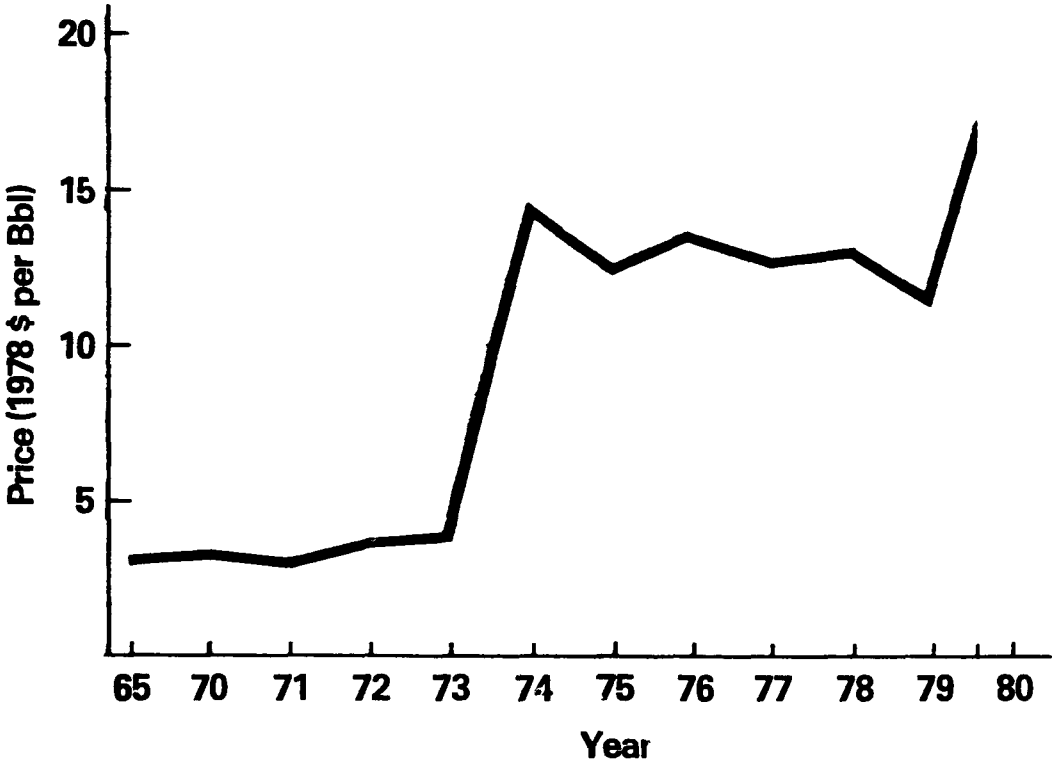


TABLE 2

RANGE IN POTENTIAL WORLD ENERGY DEMAND ASSUMING CONSTANT WORLD OIL PRICES[1/] 1978-1990

	High Energy Demand	Medium Energy Demand	Low Energy Demand
GNP Growth (%/yr)[2/]	4.5	4	3.5
Energy/GNP Growth Ratio	.9	.85	.8
Energy Demand Growth (%/yr)	4.0	3.4	2.8
Energy Demand (MMBD)			
1985	128	122	115
1990	152	142	132

1/ Excludes Communist countries. Assuming world oil prices as of January 1, 1979.

2/ Average Annual Percentage Increase.

real terms (as occurs in the actual projections), energy demand will fall and the E/GNP will be considerably below the constant price ratios of 0.8 to 0.9.

2.1.2 Non-Oil Energy Consumption

Non-oil energy consumption includes the consumption of all non-liquid forms of energy such as coal, gas, nuclear and most renewable energy sources. Non-oil energy consumption directly affects world oil demand through interfuel substitution--for a given total energy demand, the larger the amount of non-oil consumption, the smaller the resulting oil consumption. Non-oil energy consumption grew 3.4 percent per year from 1960 to 1973 and 2 percent per year from 1973 to 1977. We estimate that potential non-oil energy consumption under constant oil prices will increase to about 72 MMBD in 1990. Table 3 shows a likely range for consumption of different non-oil energy types for 1985 and 1990.

The large uncertainty in non-oil energy consumption stems from the economic, environmental and institutional uncertainties associated with projecting world totals for nuclear, coal and gas consumption. All of these fuels have considerable potential for replacing oil consumption by 1990. All, however, also have serious problems related to wide-spread use. Nuclear energy has safety, waste disposal and licensing and other regulatory problems. Coal and gas require development of a large international market. Coal suffers particularly from environmental problems associated with end-use. Gas, while a clean burning fuel, has serious problems associated with large-scale transportation in either liquified or natural forms. Because of the uncertainties pertaining to the use of nuclear, coal and gas, a range in non-oil energy consumption for 1985 and 1990 was derived. The range was determined by varying the mid-range estimate for non-oil energy consumption in 1990 by plus and minus 5 MMBD.

2.1.3 Net Oil Imports of Communist Countries

Net oil imports from Communist countries must be accounted for in estimating world oil demand as defined here. Analysis by the Central Intelligence Agency[1/] indicates that

1/ Central Intelligence Agency, The International Energy Situation: Outlook to 1985, April, 1977.

TABLE 3

RANGE IN NON-OIL WORLD ENERGY PRODUCTION
ASSUMING CONSTANT WORLD OIL PRICES 1/
(MMBD)

	1978	1985	1990
NATURAL GAS	17	15-21	15-24
COAL	17	23-25	26-30
NUCLEAR	2.8	6-10	11-14
RENEWABLES	7 2/	8-11	9-13

1/ Excludes Communist Countries.
2/ Water Power.

under assumptions of constant oil prices, Communist countries may become net importers of up to 2.5 MMBD of oil by 1985. Most other analyses estimate Communist oil exports will continue at the present level of approximately 1 MMBD. A range of 1 MMBD exports to 2.5 MMBD imports after 1985 seems to bracket the uncertainty with respect to Communist country net oil imports.

2.1.4 Adding the Oil Demand Uncertainties

Table 4 shows a combination of assumptions about world energy demand, non-oil energy consumption and Communist countries' net oil imports used to generate a range in potential world oil demand. World oil demand is assumed to grow between a high of 4 percent per year and a low of 2.5 percent per year between 1978 and 1990 under constant world oil prices. Potential world oil consumption would vary between 59 and 68 MMBD in 1985 and 66 and 80 MMBD in 1990. Table 5 compares four recent forecasts for 1990 which assume low or no increases in world oil prices. The NEP-II estimates are in general agreement with the other studies.

2.2 NON-OPEC CONVENTIONAL OIL PRODUCTION

This section describes the range of projections for non-OPEC conventional oil[1] production that might occur if future world oil prices were to remain constant. This analysis differentiates between OPEC and non-OPEC nations because different theories of oil producing and pricing behavior apply to each of these two producer groups. Later sections of this Appendix discuss OPEC behavior.

Of the non-OPEC nations, Mexico and the United States are of particular importance--Mexico because of its potentially large resource base and oil export potential, the U.S. because of its central role in this analysis. Table 6 shows data on conventional proved and probable oil reserves and remaining recoverable resources for the United States, the North Sea, Mexico, OPEC and other countries. OPEC nations have by far the most oil resources with 600 to 1000 billion barrels. Next is Mexico with from 50 to 300 billion barrels, followed by the U.S. with 110 to 190 billion barrels and the rest of the non-Communist world with 330 to 480 billion barrels.

Oil reserve and resource estimates are important since they place a constraint on conventional oil production. For example, we assume in this analysis that world oil production cannot exceed a "technical" limit determined by a reserve-to-production ratio of approximately 15 years, which declines to a minimum of 10 years as resources are depleted.[2] That is, oil production in a given year cannot exceed one fifteenth of estimated oil reserves. Currently, world oil reserves equal approximately 594 billion barrels and production is about 17 billion barrels per year yielding a reserve-to-production ratio of 35 years. If, for example, discoveries were not to increase as fast as production, the reserve-to-production ratio would decline and approach the "technical" limit.

1/ Conventional oil is defined here as crude oil which can be produced using primary and secondary recovery techniques and natural gas liquids. Refinery gain is not included in estimates of production volumes.

2/ A more complete discussion is given in Workshop on Alternative Energy Strategies, Energy: Global Prospects 1985-2000, McGraw-Hill, 1977, pp. 111-117.

TABLE 6

1978 WORLD CONVENTIONAL CRUDE OIL RESOURCES[1/]
(Billion Barrels)

Region	Proved & Probable Reserves[2/]	Potential Recoverable Resources[3/]
United States	40	110 to 190
North Sea	30	30 to 100
Mexico	30	50 to 300
OPEC	460	600 to 1000
Other Non-Communist Countries	40	330 to 480
TOTAL	600	1120 to 2070

1/ Excludes Communist countries.

2/ Oil recoverable through primary and secondary techniques. Includes known reserves plus expected extensions and revisions based on further exploration of known fields.

3/ Includes proved and probable reserves plus expected remaining discoveries of recoverable conventional oil.

Source: reserves--U.S. Central Intelligence Agency, International Energy Statistical Review, March 7, 1979, p. 4; resources--U.S. Department of Energy, International Affairs (January, 1979).

Non-OPEC oil production is defined here to include all non-OPEC countries excluding Communist countries. In 1978 the United States and Western Europe accounted for about 70 percent of non-OPEC world oil production of 18.9 MMBD. Given non-OPEC oil proved and probable reserves equal to 105 billion barrels, there is a current reserve-production ratio of about 19 years. In this analysis, we estimate non-OPEC oil production under constant real world oil prices to range from 22 to 28 MMBD in 1985 and 24 to 31 MMBD in 1990. Higher world oil prices could, of course, increase these amounts. Table 7 reports a range for assumed non-OPEC oil production by region under constant world oil prices.

TABLE 7

NON-OPEC OIL PRODUCTION POSSIBILITIES
ASSUMING CONSTANT WORLD OIL PRICES[1/]
(MMBD)

	1978	LOW SUPPLY 1985	LOW SUPPLY 1990	MEDIUM SUPPLY 1985	MEDIUM SUPPLY 1990	HIGH SUPPLY 1985	HIGH SUPPLY 1990
United States	10.3	10.0	10.2	10.5	10.5	10.6	11.0
Canada	1.6	1.5	1.4	1.7	1.6	1.9	1.9
North Sea	1.5	3.2	3.2	3.6	3.7	4.3	4.6
Other Developed Countries	0.7	0.7	0.7	0.9	1.0	1.1	1.1
Mexico	1.3	2.7	3.5	3.5	4.5	4.0	5.0
Other Less Developed Countries	3.5	4.9	5.5	5.6	6.5	6.6	8.0
Total	18.9	23	25	26	28	28	31

1/ Excludes Communist countries and includes natural gas liquids. Assuming world oil prices as of January 1, 1979.

Source: U.S. Department of Energy, International Affairs (January, 1979).

2.3 OPEC CONVENTIONAL OIL PRODUCTION

The OPEC countries have considerable flexibility in making oil production decisions. As the marginal supplier of world oil with large reserves and currently high reserve-to-production ratios, OPEC nations have considerable power to decide how much oil they will export. Any forecast of future world oil production and oil prices requires use of theories of OPEC behavior to estimate how much oil OPEC nations will make available in the future.

Many theories of OPEC decision making are based on the belief that social and political, as well as economic, pressures influence OPEC oil capacity investment and pricing decisions. Because of the number of conflicting objectives, and the complexity of the calculations necessary to understand how present actions will affect future results, it is assumed that OPEC leaders set minimal standards of achievement for each of their objectives. In the economic literature this is often referred to as satisficing behavior.

The goals that individual nations within OPEC must satisfy are both domestic and international. Domestic goals concern, for example, internal economic and social development as well as efficient long-term development of oil fields. International goals concern, for example, Middle East negotiations and impacts of oil pricing decisions on world political stability.

There are a variety of reasons why OPEC nations may choose to limit expansion of oil production capacity, and thus induce higher world oil prices.

First, oil production in many OPEC countries (e.g., Iran, Algeria, Ecuador) is beginning to decline or will do so in the near future. Exploration in other OPEC countries has not occurred rapidly enough to increase production in the near-term sufficiently to offset the production declines in other OPEC nations.

Second, the OPEC nations with relatively high population and revenue needs for development generally are also the countries with the least possibility for dramatically expanding production. These "high absorber" countries will apply pressure for limited capacity expansion in those countries with more resources and push price increases as their only

way to raise revenues. If OPEC yields to pressure to raise prices, there is little reason to expand capacity in the longer term. Higher prices, other things remaining equal, will tend to reduce demand for OPEC oil.

Third, conservationist pressures exist: (1) engineering concerns over maximum recovery rates; (2) economic concerns over flaring of associated natural gas for lack of markets; and (3) religious/political concerns over "exploitation" of national oil wealth for the gain of Western countries, and consequent loss of national patrimony for future generations. This is a particular concern in those OPEC countries with large oil resources relative to their population (e.g., Saudia Arabia, Kuwait), although it has obviously been a factor in the recent turmoil in Iran. In addition, these "low absorber" countries must invest heavily in foreign financial instruments which have not shown particularly attractive returns. Internal investments in these low absorber countries are limited by a scarcity of production factors, primarily skilled and unskilled labor. Further, there is a fear that too rapid modernization threatens the social and political structure of the country, not to mention the power of elite regimes. Oil production cutbacks or reduced capacity expansion are highly visible ways of attempting to slow the rate of economic growth and cultural change. Expectation of increased value of oil makes oil in the ground a better investment than financial markets.

Fourth, the power to expand capacity rests primarily with the low absorber group. If the low absorbers continue to expand production, this would increase their international visibility and increase the likelihood of takeover by either internal or international forces.

Last, decisions by OPEC countries not to significantly increase productive capacity may be based on miscalculations of growth in world oil demand from incorrect assumptions of economic growth or optimistic estimates about the effectiveness of conservation programs in the industrial countries.

There are again a variety of factors that might result in OPEC deciding to expand capacity and keep oil prices low.

First, OPEC price increases are a factor in the higher inflation of the goods they import from Western countries. Inflation and dropping U.S. exchange rates reduce the attractiveness of the foreign investments of the OPEC countries. Low price increases mitigate these effects.

Second, OPEC low absorber countries have shown concern for the destabilizing affect of rapid increases in oil prices on Western economic systems, as well as on traditionally unstable political systems (e.g., Italy).

Third, OPEC has exhibited concern for the affect of price increases on the economic growth and welfare of the less developed countries.

Fourth, OPEC has shown concern for the international political good-will of the U.S. and other Western countries that would result in bargaining small oil price increases for military arms purchases, concessions in Middle-East peace negotiations, and trade agreements.

Fifth, OPEC countries could believe that unconventional oil production, other forms of energy substitutes or conservation measures are easily achievable and that prices must be kept low to insure the long-term profitability of remaining OPEC oil resources.

Last, expansion of capacity by low absorber countries, especially Saudi Arabia, gives them excess capacity and preserves these countries' status as the influential element in OPEC.

The demand for OPEC oil is to a large extent a "residual" of world oil demand and non-OPEC supply. Because of the wide variation in estimates of future world oil supply and demand, OPEC pricing and production expansion decisions are made also in an environment of tremendous uncertainty about the future market for OPEC oil. Uncertainty also comes from the unknown relationships among oil price increases, world economic growth, inflation, monetary exchange rates and other international political, social and economic factors. Thus, even assuming that OPEC has unambiguous objectives, uncertainty about future world events makes unclear how OPEC should go about achieving those objectives.

Given all the pressures and uncertainties influencing OPEC nations, OPEC's final pricing and capacity expansion

decisions are likely to result from a political process in which different interest groups within countries compete for their particular view. Rather than attempt to predict how the different pressures will balance and determine OPEC's final decisions, a range of outcomes --from high oil price cases in which OPEC does not expand production capacity, to low oil price cases in which OPEC expands capacity--are used as assumptions for the NEP-II world oil price analysis.

With OPEC's 1978 oil production of 29.6 MMBD and reserve-production ratio of 43 years, OPEC can "technically" sustain higher production levels. OPEC's sustainable capacity prior to the crisis in Iran equaled about 36 MMBD. Required infrastructure development, salt-water injection and gas separation facilities and other constraints prohibit a rapid increase in OPEC production capacity. In Iran, oil strikes and civil strife decreased Iranian production by about 6 MMBD at the height of the crisis. When the political situation settles in Iran, that government may not have the desire or the means to bring Iranian oil production up to the precrisis amount of about 6 MMBD. Depending upon Iran and other uncertainties, a range of sustainable OPEC oil production for 1985 is 32 to 41 MMBD and in 1990, 32 to 44 MMBD. This would require Saudi Arabian crude oil production in 1985 of approximately 8.8 to 12.5 MMBD and in 1990 of 8.8 to 14 MMBD. Beyond the 1990s, depletion of reserves will lead to a decreasing OPEC production capacity.

Political, social and/or economic factors could result in significantly lower OPEC capacity in 1985 and beyond. For example, given recent events in Iran, a 1985 OPEC capacity less than 30 MMBD is a possibility. Table 8 summarizes the uncertainties concerning future sustainable OPEC production capacity embodied in the NEP-II projections.

Table 8

OPEC OIL PRODUCTION POSSIBILITIES
(MMBD)

		LOW SUPPLY		MEDIUM SUPPLY		HIGH SUPPLY	
	1978	1985	1990	1985	1990	1985	1990
Saudi Arabia[1/]	8.3	8.8	8.8	10.5	12.5	12.5	14.0
Kuwait[1/]	2.1	2.3	2.3	2.3	2.5	3.3	3.5
U.A.E.	1.8	2.3	2.5	2.4	2.5	2.9	3
Qatar	0.5	0.5	0.4	0.5	0.4	0.6	0.5
Iraq	2.5	3.5	4.0	4.0	4.5	4.5	5.0
Libya	2.0	2.3	2.5	2.4	2.6	2.5	2.8
Algeria	1.0	1.2	1.0	1.2	1.1	1.4	1.2
Nigeria	1.9	2.2	2.0	2.3	2.2	2.5	2.5
Gabon	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Iran	5.2	3.5	3.5	4.5	4.5	5	5
Venezuela	2.2	2.1	1.7	2.2	2	2.3	2.3
Ecuador	0.2	0.2	0.2	0.3	0.2	0.3	0.3
Indonesia	1.6	1.5	1.4	1.7	1.6	1.9	1.9
Natural Gas Liquids (NGL)	.7	1.5	2	1.5	2	1.5	2
TOTAL	30.3	32.1	32.5	36	38.8	41.5	44.3

1/ Includes share of Neutral Zone production.

Source: U.S. Department of Energy, International Affairs (January, 1979).

2.4 UNCONVENTIONAL OIL PRODUCTION

Unconventional oil production is defined here to include liquid fuels from the following sources:

- oil which costs more than $25 per barrel to develop because of the field condition, field location or use of tertiary recovery techniques;
- heavy oils;
- tar sands;
- shale oil;
- coal liquids;
- oil from biomass.

Two major uncertainties will affect future world unconventional oil production: (1) the cost of unconventional sources; and (2) the "timing" of when facilities will be built and made operational.

2.4.1 Cost of Unconventional Oil

At current world oil prices, little unconventional oil production could occur. However, when oil prices rise in real terms, more and more unconventional oil resources will become profitable to produce. Indeed forecasting the future for unconventional oil production depends heavily on narrowing the uncertainty of its economic costs and environmental impact. It is likely that current estimates of unconventional oil costs will rise as pilot and demonstration plants are built. Only when commercial size facilities are operational will the true cost of these unconventional sources be known. For this analysis we assume that unconventional oil will be economic enough to support significant unconventional oil production at prices between $25 and $35 per barrel in 1978 dollars.

2.4.2 Timing of Production

Unconventional production can occur only after necessary extraction, processing and transport facilities have been

built. Investments in such facilities will not occur until world oil prices or expectations about future world oil prices reach a level sufficient to attract the "risk" capital necessary for development. If investors are cautious because of economic or environmental regulatory uncertainties, they may not commit large sums of money until the actual world oil price reaches a level high enough to "guarantee" a reasonable rate of return on investment in unconventional production facilities. After a decision to invest in production facilities, planning, construction and regulatory delays of five to ten years or longer could limit the actual amount of unconventional oil produced.

For example, enhanced oil techniques, such as chemical or heat injection, will take years to prove effectiveness and implement. Shale oil production may become embroiled in environmental litigation. Heavy oil, such as exists in the Venezuelan Orinoco region, will require lengthy investment in infrastructure.

The inability to produce sufficient unconventional oil to replace diminishing conventional oil could lead to a world oil price temporarily higher than the cost of unconventional oil. Depending upon government policies, the higher price could translate into a very high rate of return for investment in unconventional oil production facilities. This would cause more rapid investment and expansion of unconventional production capacity until the resulting higher production caused world oil prices to decline to a stable price equal to the cost of marginal oil supplies plus a reasonable profit.

2.5 SUMMARY RANGE

Table 9 shows a summary range for estimates of key assumptions about potential world oil demand and production to 1990. If high demand estimates are used in conjunction with low production, considerable pressure exists to raise world oil prices because of excess demand. For example, the high oil demand for 1985 of 65 MMBD is 11 MMBD higher than the low production estimate of 54 MMBD. A physical shortage may not occur but oil prices would have to increase rapidly in order to reduce oil demand and induce additional production until achievement of a demand/supply balance.

Table 10 compares the NEP-II constant price world oil demand and supply assumptions with several other studies. The NEP-II assumptions are well within the range of uncertainty of the other studies.

Figure 2 summarizes the information of Table 9 graphically by plotting a range in potential oil demand growth compared with the range in potential production, both assuming constant prices. The period from the present to about 1995 is identified as a time when oil demand will approach world oil production capacity and the price of world oil will have to start to rise rapidly in real terms to insure a balance between demand and supply. The next section generates price trajectories which insure a balanced oil market given the range in constraints on world oil demand and supply identified here.

TABLE 9

SUMMARY RANGE IN POTENTIAL
WORLD OIL DEMAND AND PRODUCTION
ASSUMING CONSTANT WORLD OIL PRICES[1]
(MMBD)

		High Demand/ Low Supply		Low Demand/ High Supply	
	1978	1985	1990	1985	1990
Potential Oil Demand					
World[2]	49	68	80	59	66
Potential Oil Production					
Non-OPEC	19	22	24	28	31
OPEC	30	32	32	41	44
World[3]	49	54	56	69	75

1/ Assuming world oil prices as of January 1, 1979.

2/ Including Communist Countries' Net Oil Import Demand which was 1.5 MMBD of net oil exports in 1978.

3/ Excluding Communist Countries.

FREE WORLD OIL DEMAND AND PRODUCTION POTENTIAL (INCLUDES NATURAL GAS LIQUIDS)

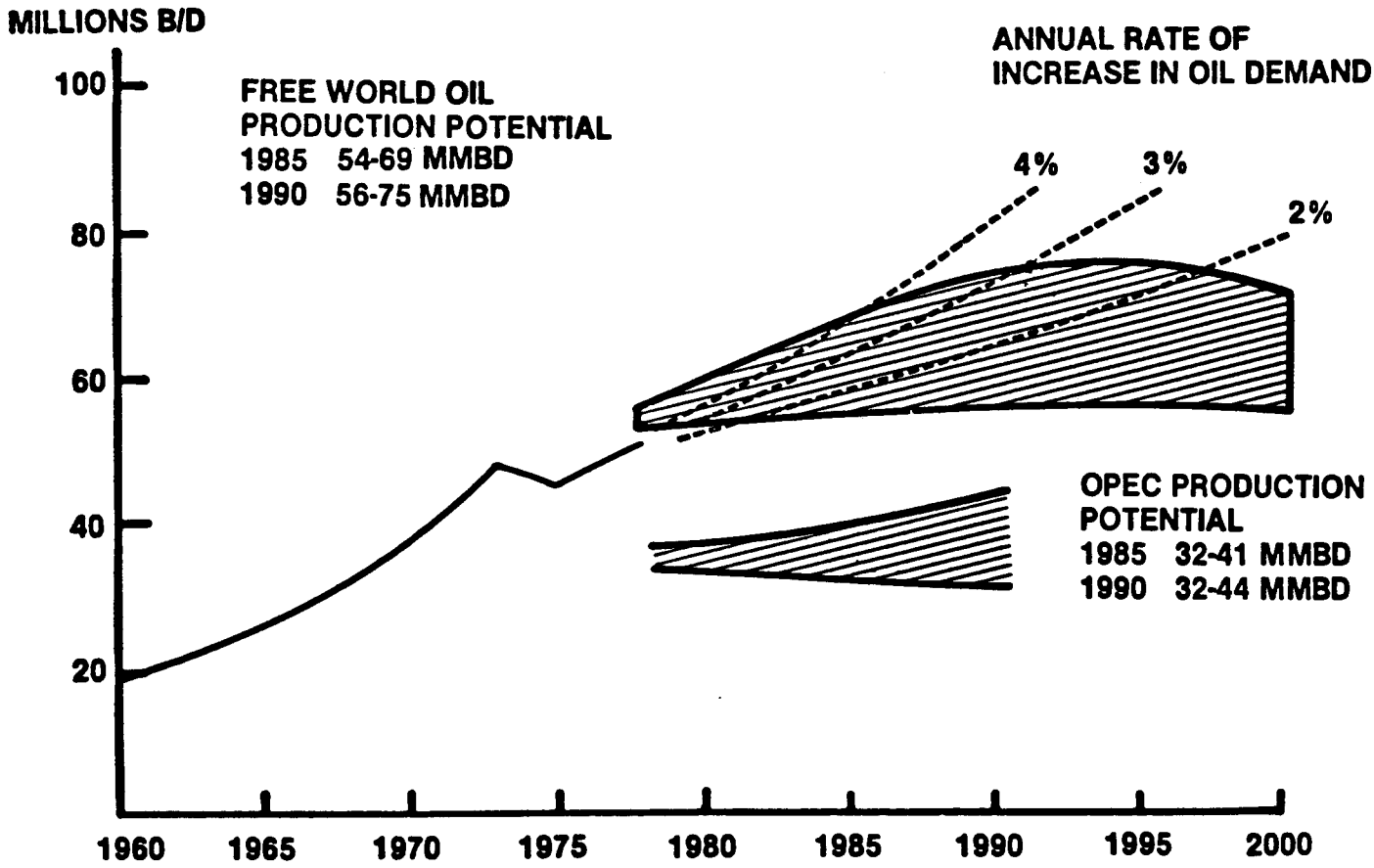


FIGURE 2: Projected Free World Oil Demand and Production Capacity Given Constant World Oil Prices

TABLE 10

COMPARISON OF NEP-II FORECASTS FOR OPEC OIL DEMAND IN 1990 WITH OTHER STUDIES ASSUMING CONSTANT WORLD OIL PRICES[1/]
(MMBD)

	EIA[2/]	EXXON[3/]	PIRF[4/]	WAES[5/]	NEP-II RANGE
World Oil Demand	70-77	62-82	64	63-71	66-80
Communist Net Oil Imports (Exports)	(1.3)-2.5	(1)	(.5)	NA	(1) to 2.5
Non-OPEC Production	35-36	27	28.5	21-25	24-31
Demand for OPEC Oil	34-40	34-54	35	42-47	34-58
Maximum OPEC Production	45	47	35+	40-45	32-44

1/ World excluding Communist Countries.

2/ DOE/EIA, Annual Report to Congress, 1978, Vol. III.

3/ Exxon, World Energy Outlook, 1978, pp. 33, 35.

4/ The Outlook for World Oil into the 21st Century, 1978, pp. 5-5, 6-3, 6-14 Case D.

5/ Workshop on Alternative Energy Strategies, Energy: Global Prospects 1985-2000, 1977, pp. 66, 133, 135, 138.

A-III WORLD OIL PRICE ANALYSIS

The Department of Energy has utilized a variety of mathematical models to integrate and portray the range of uncertainty in world oil demand and supply and to provide scenarios of future oil prices for use in NEP-II. The primary models used for NEP-II world oil price analysis were:

- The Oil Market Simulation Model (OMS) developed and operated by the Office of Integrative Analysis in the Energy Information Administration (EIA); and
- The World Oil Model (WOIL) developed and operated by the Office of Analytical Services for the Assistant Secretary for Policy and Evaluation.

These models complement each other. OMS focuses primarily on the 1985 to 1995 period, whereas WOIL is intended for operation to the year 2000 and beyond.

Development of the world oil price cases reported in NEP-II occurred over the period March 1978 to about March 1979. Because of the Iranian crisis and other events, the underlying assumptions used to operate the models changed during the year of analysis. Also, the price results reported here do not reflect the OPEC price increase made in June 1979. For reference, Table 11 presents the cost of imported oil in the U.S. from 1974 to 1979.

This section briefly describes the OMS and WOIL models and summarizes key results of more that 25 specific outputs from the models. The final world oil price cases reported in NEP-II result from an attempt to summarize the various model results and to represent the "best" estimate of what is likely to occur given information as of May, 1979.

TABLE 11

U.S. REFINER ACQUISITION COST OF IMPORTED OIL

	Actual Price ($/Bbl)	Deflated Price[1] (1979 $/Bbl)
1974	12.52	17.88
1975	13.93	18.15
1976	13.48	16.70
1977	14.53	17.04
1978	14.57[2]	15.87
1979	19.75[2]	19.75

[1] Converted to 1979 dollars assuming U.S. Department of Commerce GNP Implicit Price Deflator (DOE/EIA, Annual Report to Congress, Volume Two, 1978, p.175) for 1974-1978 and DRI Control Solution GNP deflator of 8.94 percent for 1978-1979.

[2] Estimated.

Source: DOE/EIA, Annual Report to Congress, Volume Two, 1978, p. 63; DOE/EIA, Monthly Energy Review, June, 1978, p. 78.

3.1 OIL MARKET SIMULATION MODEL

The Oil Market Simulation (OMS) Model was developed for the purpose of forecasting world oil supply, demand and oil prices. Operation of OMS in fact requires the iterative use of the following, more detailed macroeconomic and energy models:

- the Data Resources, Inc. (DRI) macroeconomic model of the U.S. economy,
- the Mid-Range Energy Forecasting System (MEFS) of the U.S. energy sector, and
- the International Energy Evaluation System (IEES) model of the non-U.S., world energy market.

Documentation of these models is available from the Office of Integrative Analysis, Energy Information Administration, U.S. Department of Energy.

3.1.1 Description of OMS

OMS provides oil demand and supply for seven regions: The United States, Canada, Japan, Europe, the LDC's (including all other developed countries), and OPEC. Two equations define the supply and demand paths for each region. Communist countries' net oil imports are represented as an additional oil demand.

World oil demand is determined by the rate of economic growth and the price of world oil, while non-OPEC supplies are determined strictly by the price of oil. Non-OPEC supplies are added to the assumed level of OPEC production to derive total world oil supply. Then, given the desired demand and available supplies, the market clearing price is calculated.

In order to understand the operation of the model, it is instructive to follow the adjustment mechanism when supplies and demands are not in equilibrium. When demand exeeds supply, consumers bid up the price of oil. The movement to higher prices causes three adjustments to take place simultaneously. These are:

- o A decrease in the rate of growth of real GNP due to economic feedback from higher oil prices;

- o A decrease in the quantity of oil demanded caused in part by an increase in the demand for alternative energy forms and the decrease in energy demand from lower GNP growth; and

- o An increase in the supply of non-OPEC oil in response to increasing oil prices.

Final equilibrium is reached when supply equals demand. These adjustments do not occur instantaneously. For example, as oil prices increase, energy saving capital adjustments are implemented and new wells and other advanced production techniques are introduced. The OMS model thus represents dynamic behavior by having the magnitude of the demand and supply elasticities vary over time.

To develop oil price forecasts, the OMS model is first simulated using a range of world economic growth rates and OPEC production capacities. The OMS model produces a range of preliminary oil prices which balance oil supply and demand. It is then necessary to use the detailed models to determine the set of elasticities that describe the response of economic growth to these higher prices, and the response of international energy supply and demand to both these higher prices and economic growth.

The OMS model is then recalibrated with the new elasticities and again simulated to project future oil prices. The resultant oil prices are the minimum prices necessary to insure balanced energy supply and demand, given the response elasticities and forecasted OPEC production capacity.

3.1.2 Price Analysis Using OMS

EIA is mandated to provide Congress each year with an independent forecast of energy supply, demand and prices. EIA has used OMS to develop a set of world oil price cases as part of its Annual Report to Congress. The EIA price cases were used as an input to selection of the final NEP-II price cases.

The results of the EIA independent price analysis are summarized in Table 12. The analysis indicates that in the high price case B, an initial real-price rise occurs in 1982 with world oil prices reaching about $23 per barrel by 1985 and $25 per barrel by 1990 (in 1979 dollars). The mid range estimate, Case C shows that prices do not rise until 1985 and that prices in 1990 equal about $20 per barrel in 1979 dollars. Finally, the low price case D has prices essentially constant at $16 per barrel until after 1990.

TABLE 12

WORLD OIL PRICE FORECASTS USING THE OMS MODEL[1/]
(1979 dollars/barrel)[2/]

	1985	1990	1995
High Price Cases			
Scenario B	23	25	34
Lowest OPEC Capacity[3/]	18	28	37
Medium Price Cases			
Scenario C	16	20	25
18 percent decrease in OPEC production[3/]	21	21	29
Low Price Cases			
Scenario D	16	16	18
Increase Communist Imports[3/]	16	21	26

1/ Average price of crude oil delivered to the U.S. East Coast.

2/ 1979 dollars computed as 1.074 times 1978 dollars.

3/ Sensitivity tests based upon Scenario C assumptions.

3.2 WORLD OIL MODEL

The World Oil Model (WOIL) is a simulation model that provides alternative world oil supply and demand scenarios as well as world oil prices to 2020. Documentation of WOIL is available from the Office of Analytical Services within Policy and Evaluation. The following sections describe the structure of WOIL and present high, medium and low world oil price scenarios.

3.2.1 Description of WOIL

The model is disaggregated into the following regions: the United States, OPEC, Mexico, and the rest of the world excluding Communist countries. Communist countries are included only by way of their net oil import demand. With the exception of the U.S. sector, WOIL is highly aggregated, distinguishing only between oil and non-oil energy production.

The United States is represented in WOIL by the FOSSIL2 national energy model. FOSSIL2 provides a detailed representation of solar, nuclear, oil, gas and coal production and consumption for the U.S. through 2020. FOSSIL2 takes world oil prices as an input and generates, among other things, U.S. oil import demand. WOIL takes U.S. oil import demand as an input in generating world oil prices. Running FOSSIL2 as a sector within WOIL closes a feedback relationship and allows direct testing of how U.S. energy policies may affect future world oil prices.

OPEC is represented as a single entity, rather than by individual countries. Total OPEC capacity can be exogenously set or can be endogenously determined by forecasting demand requirements. In either case, production is limited by technical considerations related to oil reserves and resources. OPEC pricing rules are endogenous and designed to maintain a desired average production capacity utilization for OPEC.

Mexico will become a major world oil producer by the turn of the century. For this reason, Mexican oil production is treated as a separate input assumption to WOIL. Mexican oil production is an exogenous projection to 2020, assuming constant future world oil prices. WOIL then adjusts this base line estimate to reflect the impact of higher or lower

oil prices. WOIL also insures that Mexican production remains below maximum production limits dictated by remaining oil resources.

Communist countries are represented in WOIL only by net oil imports, which are exogenous to 2020. WOIL uses Communist countries' oil demand as an input in calculating world oil demand. WOIL reduces Communist oil imports if world oil prices exceed specified limits.

All non-Communist countries, not a part of the U.S., OPEC, or Mexico, are aggregated as Rest of the World (ROW) countries in WOIL. ROW Gross National Product is exogenous as are non-oil energy and conventional oil production. Quantities must be specified for these factors through 2020 assuming that world oil prices remain constant in real dollars. WOIL then increases or decreases these base line estimates depending on whether world oil prices rise or fall. As world oil prices increase over time, for example, both ROW non-oil and conventional oil energy production increase compared to the base case amount.

In WOIL, unconventional oil is defined to include heavy oil, tar sands, shale oil, coal liquids, oil from biomass and tertiary recovery of conventional oil. Unconventional oil production occurs in WOIL either as U.S. production (i.e., as part of the FOSSIL2 model) or as aggregate production from any country outside the U.S.

Unconventional oil production capacity outside the U.S. is defined by the physical capital required to mine, transport, process and refine the unconventional oil. WOIL includes explicit delays between a decision to invest in unconventional oil production and when production actually occurs.

Investment in unconventional oil production capacity is controlled by two factors in WOIL:

- demand for unconventional oil;
- forecasted world oil price compared to the expected average cost of unconventional oil.

In WOIL, unconventional oil production is assumed to compete with OPEC conventional oil production in the world oil market. Here the phrase "world oil market" is defined as total

demand for OPEC and unconventional oil. A review of Figure 3 will show that total demand for OPEC and unconventional oil is equal to non-U.S., Free World oil demand plus U.S. imports minus Mexican and Rest of the World conventional oil production.

If the forecasted world oil price is much less than the expected cost of unconventional oil, the desired market share of unconventional oil producers is zero, since no profit can be made by selling unconventional oil. If, on the other hand, the forecasted price is equal to or greater than the expected cost of unconventional oil, then the desired market share of unconventional oil producers approaches 100 percent. However, the ability of the unconventional oil producers to actually penetrate OPEC's oil market is limited in WOIL as long as OPEC has production capacity. This is because OPEC can always lower world oil prices to increase use of its production capacity.

To simulate the behavior of the energy market described above, WOIL contains behavioral rules of the key decisions. For example, the yearly amount of investment in unconventional oil production capacity must be determined.

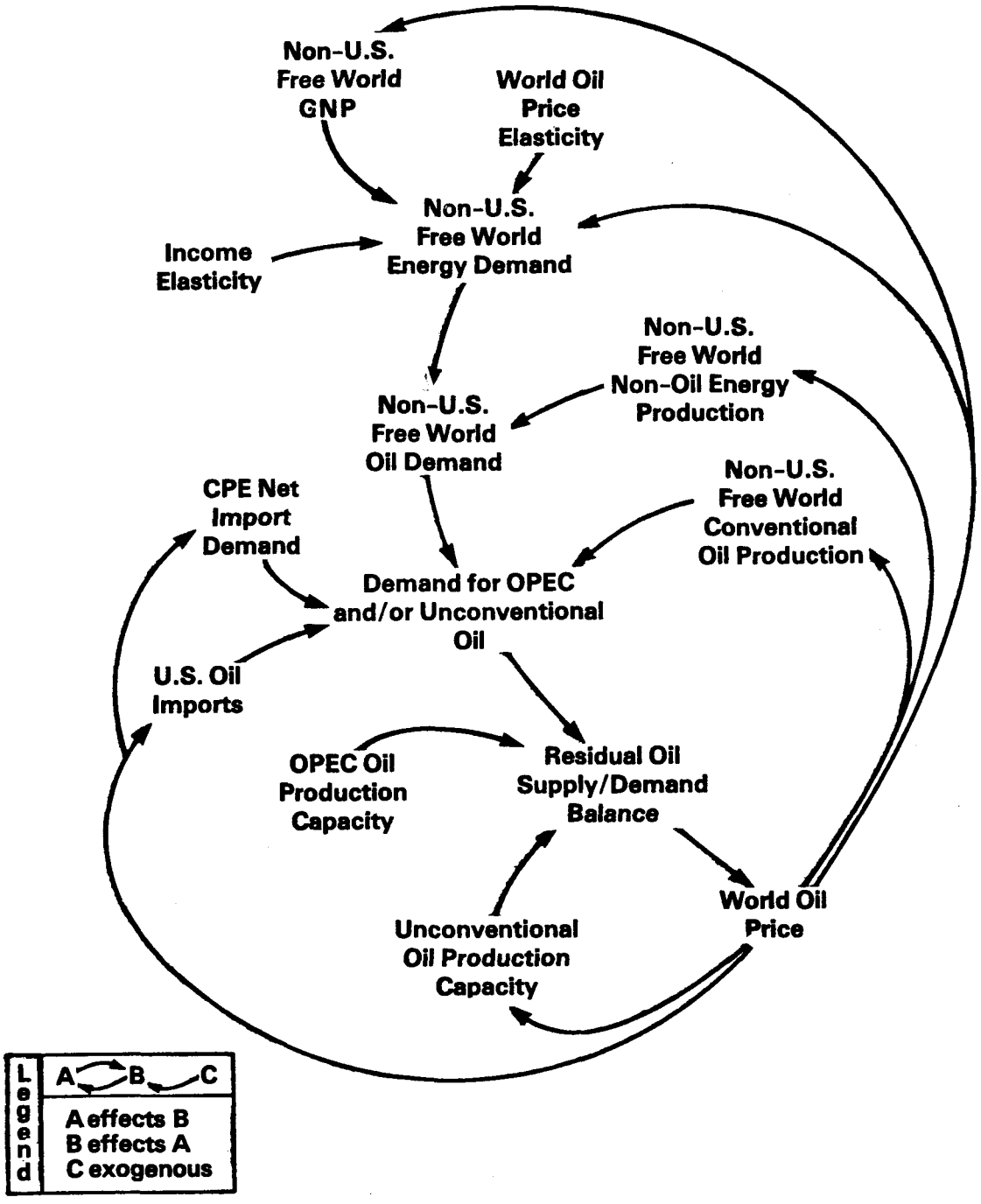
Another behavioral rule is the decision to raise or lower oil prices. World oil prices are set in WOIL by OPEC based on current and forecasted demand and supply for OPEC oil. In either case, the pricing decision depends on the fraction of OPEC capacity utilized. As actual or forecasted capacity utilization exceeds specified limits there is an increase in price to slow demand growth. If the capacity utilization decreases below the same limits, there is a decrease in price to encourage demand.

WOIL simulates how decisions would be made given all of these behavioral assumptions and information about market conditions. Since information on events in future time periods is not available to influence preceeding decisions, WOIL uses forecasting methods to generate expectations about the future. The forecasting methods rely primarily on extrapolating trends generated during model simulations.

A world oil price simulation occurs in the following sequence:

- User specifies initial conditions for a starting year (e.g., 1976);

Figure 3: WOIL Model Causal Structure



- o User specifies input assumptions (e.g., world GNP growth, Mexican, and Rest of the World non-oil and conventional oil production through 2020, under constant oil prices);

- o As shown in Figure 3, WOIL calculates total Rest of the World energy demand by using GNP and world oil price elasticities. Next, Rest of the World non-oil energy production is subtracted to yield total Rest of the World oil demand. WOIL then adds Communist countries' net oil imports and U.S. imports (from FOSSIL2) and subtracts Mexican and Rest of the World conventional oil production to yield a net demand for OPEC and/or unconventional oil production;

- o The relationship of estimated OPEC demand to OPEC production capacity leads to pressure to either raise or lower prices in the next period and also to invest in capacity if desired;

- o The new prices act through demand and supply elasticities to determine a new set of conditions for world oil demand, U.S. imports, Mexican production, etc. which in turn generate a new set of pressures to either raise or lower prices in the next period;

- o WOIL iterates through time generating year-by-year values for all internal variables.

3.2.2 Price Analysis Using WOIL

3.2.2.1 High Oil Prices

The high price scenario is projected assuming a pessimistic outlook for world oil supply and demand (i.e., high oil demand and low supply) and an OPEC behavior leading to constrained capacity expansion. Major assumptions, assuming constant oil prices, for this case through 1985 are those summarized in Tables 2 through 8.

The results of the high price assumptions are presented in Figure 4 (a-b) and Table 13. Figure 4 (a) indicates projections of conventional oil production for the U.S. Mexico, OPEC, and the rest of the Free World, as well as

Figure 4

WOIL Model High Price Case

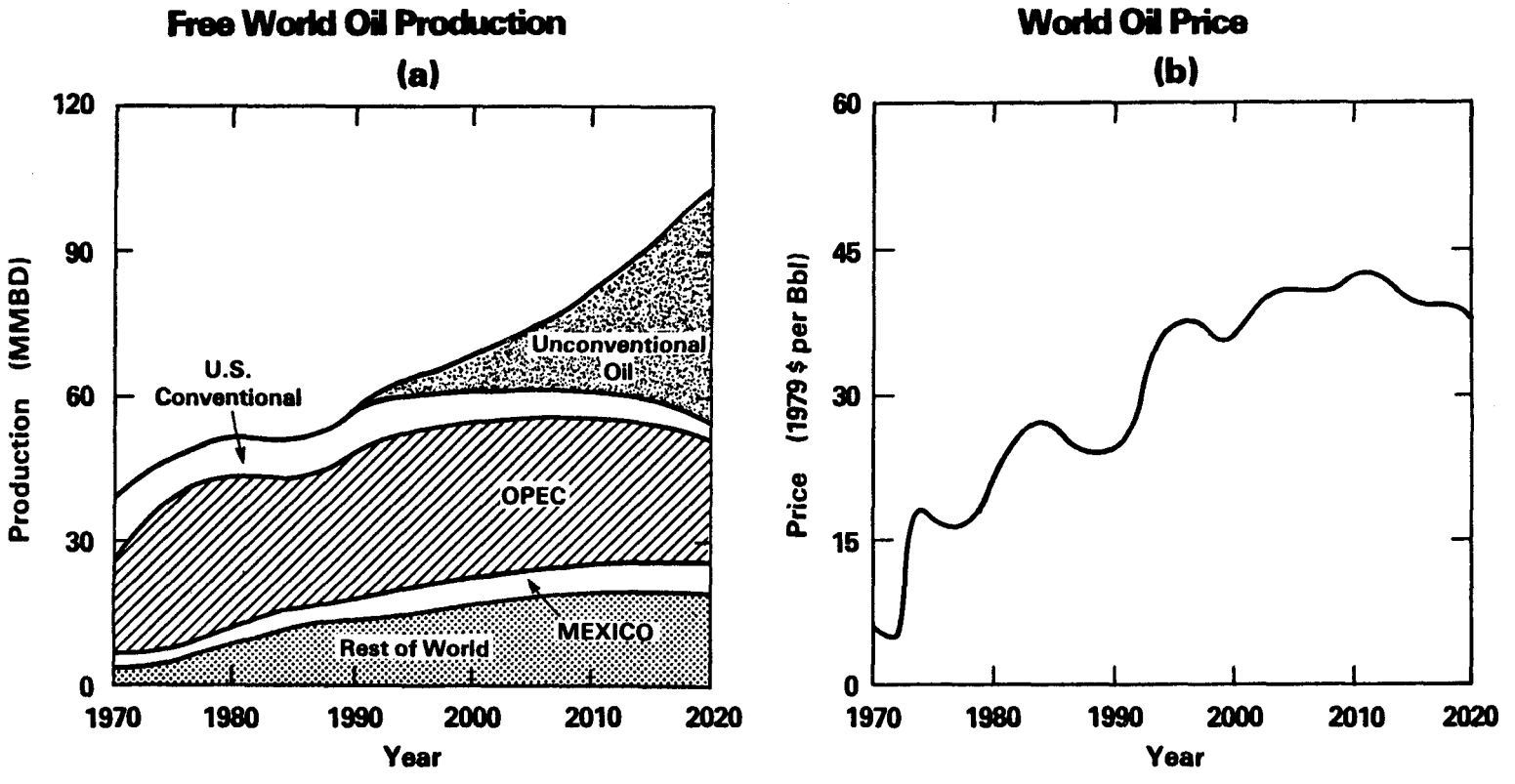


TABLE 13
HIGH PRICE CASE WORLD FUEL BALANCES
USING THE WOIL MODEL
(MMBD)

	1976	1985	1990	1995	2000	2020
Total Energy Demand	88.6	110	130	152	177	332
Non-Oil Demand	40.6	58	73	89	110	229
U.S.	19.2	24	30	35	40	72
Rest of World	21.4	33	43	55	70	158
Oil Demand[1/]	46.3	52	58	62	67	103
U.S.	17.0	18	19	18	18	20
Rest of World	31.0	33	39	44	49	83
Communist Countries Net Imports (Exports)	(1.7)	0	0	0	0	0
Non-OPEC Conventional Oil Production	16.7	23	26	27	28	27
U.S.	9.9	10	9.7	8.8	7.9	3.0
Mexico	0.9	2.8	3.9	5	6	4
Rest of World	5.5	10	12	13	14	20
OPEC Conventional Oil Production	30.8	28	31	31	32	27
Unconventional Oil Production[2/]	0	0.3	1.2	4.6	7.0	49
U.S.	0	0.2	1.2	2.5	3.7	9.9
Rest of World	0	0.1	0	2.2	3.4	39
World Oil Price[3/] (1979 $/Bbl)	16.70	26.00	24.25	37.50	36.00	37.00

1/ Including Communist Countries' net oil import demand.
2/ Enhanced oil recovery, shale oil, heavy oil, tar sands and coal liquids.
3/ U.S. refiner acquisition cost of imported oil.

unconventional oil production outside OPEC and Mexico. Figure 4 (b) presents the resulting world oil prices.

To summarize, the Iranian crisis causes oil price increases in 1979 which rise to around $26 per barrel (in constant 1979 dollars) in the mid 1980's. This increase causes a decline in demand for OPEC oil during the period.

Thus, OPEC must decrease prices to around $24 per barrel in 1990. The fall in oil prices causes OPEC excess capacity to again disappear by the mid 1990's and prices again rise to around $40 per barrel in 2000. This price increase is aided by OPEC's unwillingness to expand capacity. The price increase causes an elimination of the Communist countries' demand for oil imports. In addition, this price makes unconventional oil production profitable and production of such oil begins to increase in the 1990's. By 2000, production of unconventional oil, shown in Figure 4 (a), is 7 MMBD and by 2020 production of 49 MMBD is reached. Thus the oil price begins to stabilize around $38/barrel.

3.2.2.2 Medium Oil Prices

The medium oil price scenario assumed a set of assumptions that would lead to an intermediate demand for, and supply of, OPEC oil. Tables 2 through 8 also summarize these assumptions.

Figure 5 and Table 14 present the results for this scenario. The price increase that is caused by the Iranian crisis again can not be sustained because of the widening excess OPEC capacity. By 1985, the increase in capacity leads to a drop in the price of OPEC oil.

This rise and slow decline in price is repeated twice through the 1990's and early 2000's resulting in a price of around $30 per barrel by 2005. Around this price unconventional oil production is profitable and world unconventional production increases from 4 MMBD in 2000 to 20 MMBD in 2020.

3.2.2.3 Low Oil Prices

The low oil price scenario assumes an optimistic outcome for world oil supply and demand with an OPEC behavior

Figure 5

WOIL Model Medium Price Case

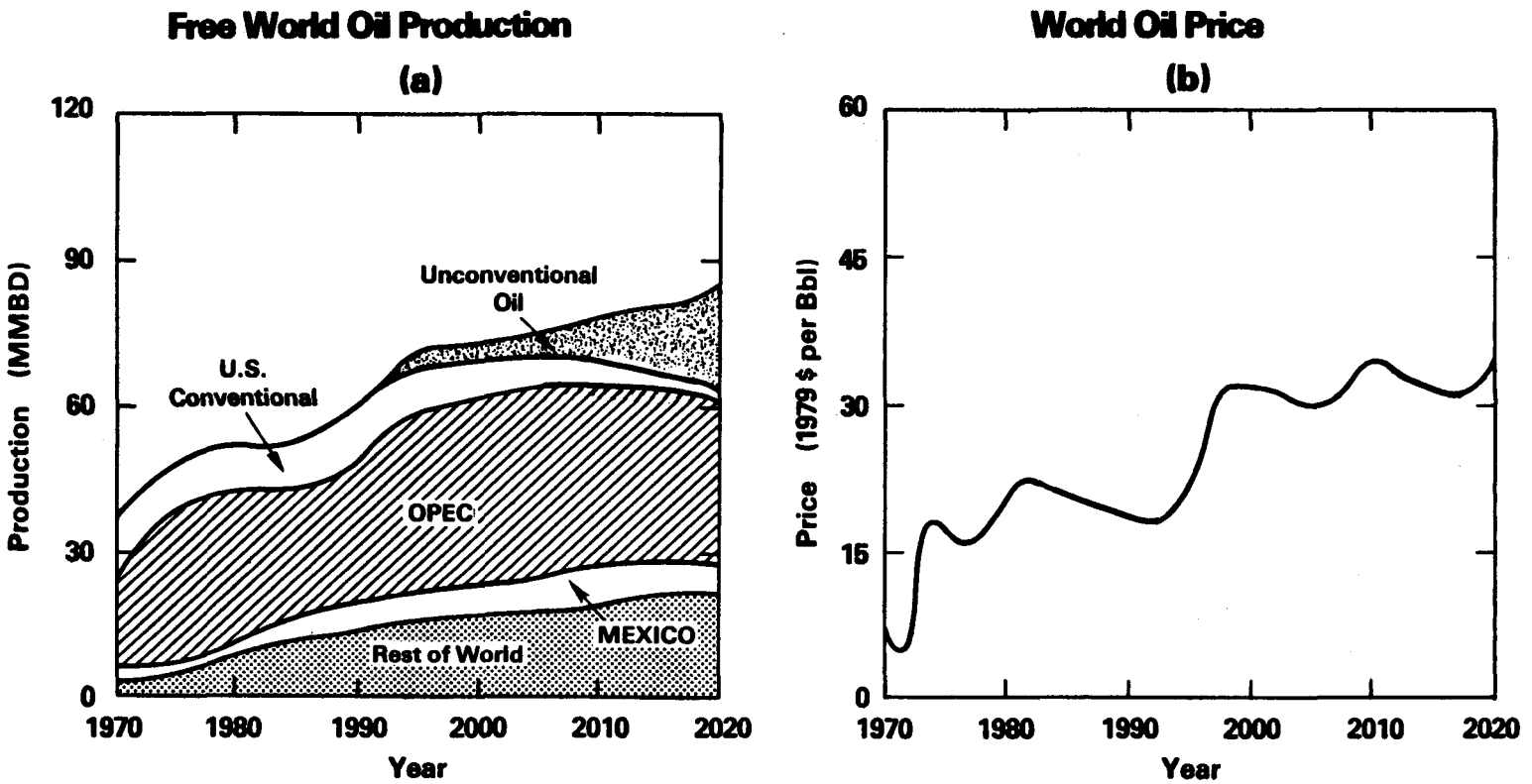


TABLE 14

MEDIUM PRICE CASE WORLD FUEL BALANCES
USING THE WOIL MODEL
(MMBD)

	1976	1985	1990	1995	2000	2020
Total Energy Demand	88.6	111	131	157	175	296
Non-Oil Demand	40.6	58	71	86	104	213
U.S.	19.2	24	28	32	37	58
Rest of World	21.4	34	43	54	68	155
Oil Demand[1/]	46.3	53	60	71	70	83
U.S.	17.0	19	20	21	20	22
Rest of World	31.0	34	40	50	50	61
Communist Countries Net Imports (Exports)	(1.7)	0	0	0	0	0
Non-OPEC Conventional Oil Production	16.7	26	28	29	29	29
U.S.	9.9	10	9.7	8.7	7.7	2.9
Mexico	0.9	3.6	4.8	5.3	6.2	5
Rest of World	5.5	12	14	15	15	21
OPEC Conventional Oil Production	30.8	27	30	40	37	35
Unconventional Oil Production[2/]	0	0.2	1.0	2.0	3.8	20
U.S.	0	0.2	1.0	2.0	2.6	4.7
Rest of World	0	0	0	0	1.3	15
World Oil Price (1979 $/Bbl)[3/]	16.70	20.75	18.75	21.50	31.75	34.25

1/ Including Communist Countries' net oil import demand.
2/ Enhanced oil recovery, shale oil, heavy oil, tar sands and liquids.
3/ U.S. refiner acquisition cost of imported oil.

leading to capacity expansion. Tables 2 through 8 summarize the major assumptions.

Figure 6 (a-b) and Table 15 present the results of these assumptions. The price of oil begins to increase starting in 1979 to about $20 per barrel in 1980 due to the Iranian situation and remains relatively stable with a slight decrease into the 1990's. This is because OPEC's capacity expansion, coupled with the initial price increase and lower world economic growth, decreases world demand for oil and substantially delays any tightening in world oil markets.

By 2010, prices are very near the unconventional oil price. Thus unconventional oil production as shown in Figure 5 (a), reaches about 2 and 4 MMBD in 2010 and 2020, respectively. As a result of the increase in the world's total oil production capacity, prices stabilize around 27 dollars per barrel, the assumed price of unconventional oil.

3.2.2.4 Sensitivity Tests

To test the sensitivity of WOIL results to changes in basic assumptions and to indicate the dynamic effect of such changes, a series of sensitivity tests were conducted. The tests were not meant to be comprehensive. They are indicative results of selected major changes.

Table 16 presents the test results, while Table 17 presents the assummptions for these tests.

The effect of a decrease in OPEC oil production in the current year generally is to increase prices in the short term and decrease them in the long term. For example, in the medium price test, the decrease in OPEC oil production increases energy prices in the near term. However, the higher prices discourage oil consumption and increase the life of world oil resources. This increase in resource life allows greater oil production in the long term, thus softening the need for higher energy prices by 2000.

The effect of higher OPEC or non-OPEC production or changes in economic growth rate generally have the opposite effect. This can be best seen in the high price test.

Increasing or decreasing the price elasticity of oil consumption has the anticipated effect throughout the time

Figure 6

WOIL Model Low Price Case

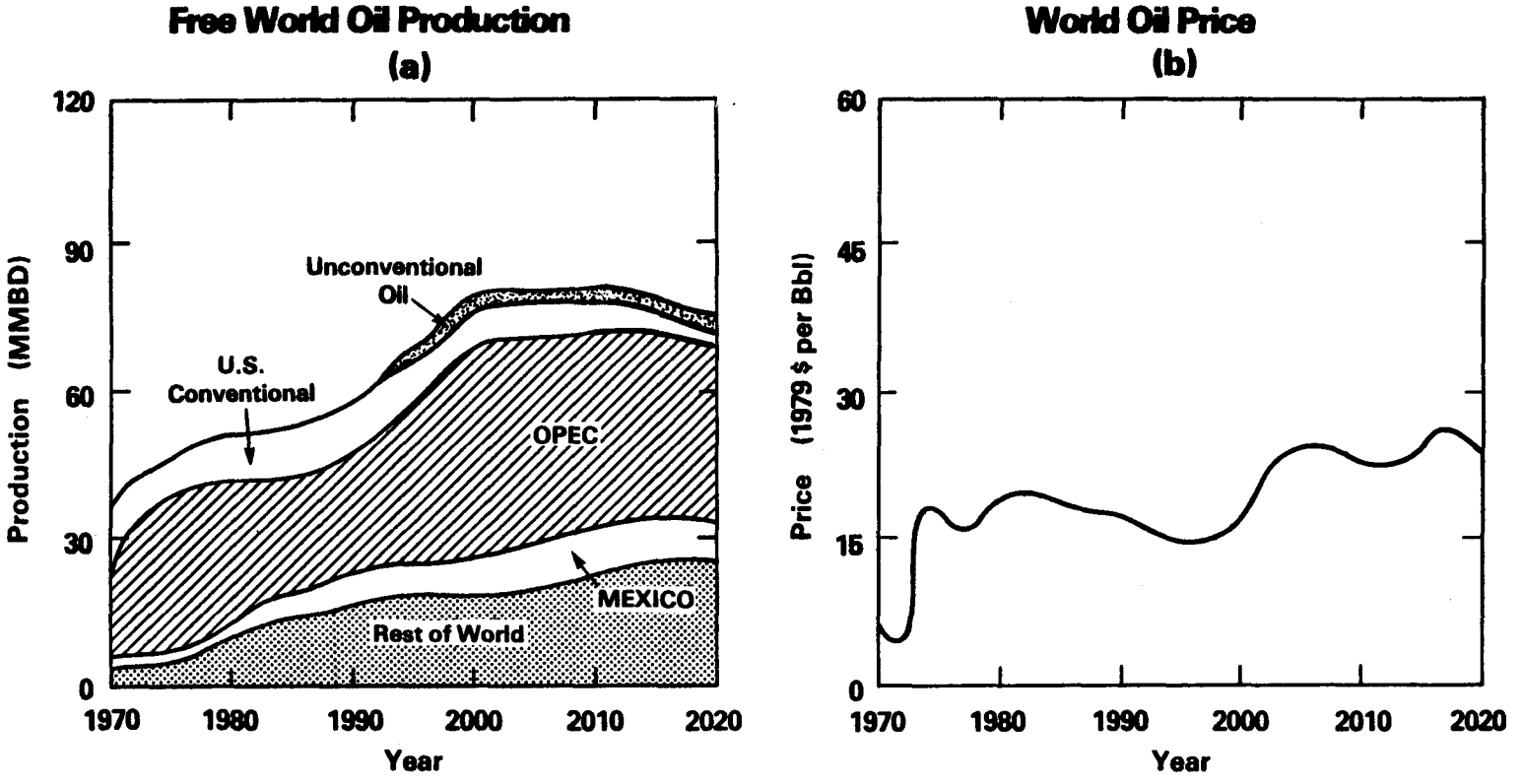


TABLE 15

LOW PRICE CASE WORLD FUEL BALANCES
USING THE WOIL MODEL
(MMBD)

	1976	1985	1990	1995	2000	2020
Total Energy Demand	88.6	111	128	151	178	271
Non-Oil Demand	40.6	57	70	83	99	196
U.S.	19.2	24	27	30	32	45
Rest of World	21.4	34	43	54	67	151
Oil Demand[1/]	46.3	53	58	68	79	75
U.S.	17.0	19	20	21	23	24
Rest of World	31.0	34	38	47	56	51
Communist Countries Net Imports (Exports)	(1.7)	(1)	(1)	(1)	(1)	(1)
Non-OPEC Conventional Oil Production	16.7	29	33	33	34	39
U.S.	9.9	10	9.7	8.6	7.7	2.9
Mexico	0.9	4.1	5.3	6.2	6.9	7.7
Rest of World	5.5	14	17	18	18	24
OPEC Conventional Oil Production	30.8	23	24	32	43	36
Unconventional Oil Production[2/]	0	0.2	1.8	1.8	2.1	3.7
U.S.	0	0.2	1.0	1.8	2.1	1.4
Rest of World	0	0	0	0	0	2.3
World Oil Price (1979 $/Bbl)[3/]	16.70	18.50	16.50	15.00	16.75	24.50

1/ Including Communist Countries' net oil import demand.
2/ Enhanced oil recovery, shale oil, heavy oil, tar sands and liquids.
3/ U.S. refiner acquisition cost of imported oil.

TABLE 16

WOIL Model Sensitivity Test Results[1/]
(1979 $/Bbl)

Test	1985	1990	1995	2000	2020
Medium Price Case					
Base	20.75	18.75	21.50	31.75	34.25
1. Low OPEC Oil Production	22.00	21.00	31.00	29.50	31.75
2. High Non-OPEC Oil Production[2/]	19.75	18.00	18.25	32.25	31.75
3. High Elasticity of Oil Demand	20.00	18.00	18.00	29.00	29.00
4. Low Elasticity of Oil Demand	26.00	29.75	39.00	47.25	33.75
High Price Case					
Base	26.00	24.25	37.50	36.00	37.00
1. Low OPEC Oil Production	28.25	27.00	35.75	38.50	38.25
2. High OPEC oil Production	19.50	18.50	33.00	40.25	50.25
3. High Non-OPEC Oil Production[2/]	21.00	19.50	35.50	40.00	42.00
4. Low Economic Growth	23.50	21.50	24.00	28.75	31.50
Low Price Case					
Base	18.50	16.50	15.00	16.75	24.00
1. Low OPEC Oil Production	20.00	18.00	18.00	25.25	25.25
2. Low Non-OPEC Oil Production[2/]	19.25	17.50	16.00	23.50	26.00
3. High Economic Growth	18.50	16.75	18.00	33.75	42.25

1/ Sensitivity test assumptions are listed in Table 17.

2/ Excluding U.S. production.

TABLE 17

WOIL Model Sensitivity Test Assumptions

Low OPEC Oil Production	Reduction of potential OPEC oil production assumed in base high price case by 2 MMBD in 1985 and 4 MMBD by 1990 and thereafter.
High OPEC Oil Production	Potential OPEC oil production assumption of base low price case.
High non-OPEC Oil Production	Potential non-U.S., non-OPEC oil production assumption of base low price case.
Low Economic Growth	Economic growth assumption of base low price case.
High Economic Growth	Economic growth assumption of base high price case.
High Price Elasticity of Oil Demand	Increase price elasticity of non-U.S., non-OPEC, non-Mexico energy demand (RW) from -.35 to -.5. Increase of price elasticity of RW non-oil production from .1 to .3.
Low Price Elasticity or Oil Demand	Decrease price elasticity of RW energy demand from -.35 to -.1. Decrease price elasticity of RW non-oil production from .1 to 0.

period. That is the higher the elasticity, the lower the oil price. In particular, the low elasticity test in the medium price case causes prices to climb appreciably above the unconventional oil price (i.e., about $30 per barrel) before declining as unconventional oil production begins.

3.3 SUMMARY RANGE OF PRICE FORECASTS

Table 18 summarizes the world oil price forecasts for 1985, 1990 and 2000 from the various OMS and WOIL results.

TABLE 18

SUMMARY RANGE OF WORLD OIL PRICE FORECASTS
FROM OMS AND WOIL
(1979 dollars per barrel)

	1985	1990	2000	2020
High Price Cases				
OMS	18-23	25-28	NA	NA
WOIL	20-28	19-27	29-40	32-50
Medium Price Cases				
OMS	16-21	20-21	NA	NA
WOIL	20-26	18-30	29-47	29-34
Low Price Cases				
OMS	16	16-21	NA	NA
WOIL	19-20	16-18	17-34	25-42

A-IV CONCLUSIONS

4.1 FINAL ASSUMPTIONS

4.1.1 High Oil Prices

High world oil prices must prevail if relatively high oil demand occurs coupled with low world oil production. The following summarizes the key assumptions leading to high prices:

- high underlying economic growth of 4.5 percent per year or higher through 1990 (but decreasing thereafter);
- by 1985 Communist countries revert from exporters of 1 MMBD to presenting a net oil import demand of 2.5 MMBD;
- low oil production is realized from non-OPEC sources which total 22 and 24 MMBD in 1985 and 1990, respectively;
- OPEC decides to limit production to 32 MMBD in 1985 and 1990 and 33 MMBD thereafter;
- a price of around $38 per barrel for unconventional oil (1979 dollars).

4.1.2 Low Oil Prices

Low oil prices, on the other hand, may occur if relatively low demand for oil is combined with high world oil supply. The following summarizes the key assumptions leading to low prices:

- low economic growth of 3.5 percent per year or lower through 1990 and decreasing thereafter;
- Communist countries continue to export oil up to 1 MMBD;

- o higher oil production is realized from non-OPEC sources which reach 28 MMBD in 1985 and 31 MMBD in 1990, peaking and declining thereafter;
- o OPEC is willing to expand production as needed up to 44 MMBD;
- o a price of around $27 per barrel for unconventional oil (1979 dollars).

4.2 FINAL PRICE CASES

It is not possible to give any quantitative probabilities for the occurence of each set of assumptions. Any permutation of assumptions could occur. For example, OPEC is obviously faced with a difficult choice in deciding whether to expand or limit investment in production capacity. Not only are there good and bad impacts regardless of what decision is made, but the impacts have different, and often opposite, significance for different OPEC countries.

Table 19 summarizes input assumptions and Table 20 presents final world oil price estimates for use in development of the Second National Energy Plan. The estimates presented are not taken from any one scenario in any one model. Rather, they are the result of a judgmental analysis of the output from the models.

World oil prices could vary between $16 and $25 per barrel in 1985, $17 and $30 per barrel in 1990 and $21 to $38 per barrel by 2000. Beyond 2000, prices could exceed the cost of unconventional oil depending upon unconventional oil production constraints.

Prices could reach the 1985 levels either by rising abruptly in 1979/80 and remaining constant or falling slightly in real terms, or by rising more smoothly over the 5 year period. Recent spot market prices and other evidence of instability in the world oil market indicate the likelihood of more abrupt price increases in the near term.

TABLE 19

ASSUMPTIONS USED TO DETERMINE WORLD OIL PRICE PATHS

Assumptions	Cases[1/] High Demand/ Low Supply	Mid-Demand/ Mid-Supply	Low Demand/ High Supply
Free World Oil Demand (Percent Increase per Year) 1980-90 Average	4.0	3.4	2.5
OPEC Production Potential (MMBD) 1985	32	36	41[2/]
1990	32	39	44[2/]
Supply Available from Countries Outside OPEC (MMBD) 1985	22	25	28
1990	24	27	31
Net Oil Imports of Communist Economies (MMBD) 1985	+2.5	0	-1
Price for Unconventional Substitutes (1979 dollars per barrel)	38	32	27
CORRESPONDING PRICE CASE	HIGH PRICES	MEDIUM PRICES	LOW PRICES

1/ The supply and demand assumptions used here presume that world oil prices will be held constant. The price analysis then uses these assumptions as a starting point to generate oil price trajectories that change oil demand and supply to bring about a balanced oil market. All supply estimates include natural gas liquids.

2/ These supply assumptions give the technical limits on maximum OPEC capacity, which in the low price case would not be reached due to the low growth in world demand.

TABLE 20

WORLD OIL PRICE PROJECTIONS[1/]
(1979 $/Bbl)

	1985	1990	2000	2010	2020
High Prices	25	30	38-42	38-48	38-50
Medium Prices	20	23	32	32-37	32-35
Low Prices	16	17	21	24-30	24-30

1/ U.S. refiner acquisition cost of imported oil.

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