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Annual Report to Congress

Volume Three: Forecasts

Summary

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Preface

This volume is an innovation, prompted by comments from outside reviewers, in the format used to report energy forecasts by the Energy Information Administration (EIA).

A symposium to review the forecasts presented in Volume 3 of EIA's 1979 *Annual Report to the Congress* was held under EIA auspices in August 1980 at the University of Maryland. At that symposium, a panel of distinguished experts from outside the government presented their views on Volume 3. Several reviewers remarked that the size and detailed character of the discussion in the volume made it relatively inaccessible to those who are not energy experts. They suggested that nonexperts would be better served by a more compact treatment limited to the major features of the forecast.

That is the objective of this volume. Volume 3 of the 1980 EIA *Annual Report*—like its predecessors—presents EIA forecasts in considerable detail and discusses at length many of their features. This volume—an overview of those forecasts—draws together both historical data and projections to provide an overall view of how energy consumption, supply, and prices are likely to evolve in the 1980's.

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Executive Summary

The change in the energy situation from the 1950's and 1960's to the 1970's and 1980's is enormous. From the end of World War II through the early 1970's, energy prices were relatively low and at times declining, while supplies of energy seemed abundant and secure. Real energy prices are now much higher than they were then. Further increases in energy prices are likely and some of the major sources of oil supply do not seem to be secure.

During the past few years, the United States economy and the economies of other developed nations have begun to adapt to an environment of higher energy prices. Perhaps the most visible change was a decrease in gasoline consumption during 1979 and 1980. There are also many other less dramatic, but no less important, ways in which energy production and consumption are responding to changes in energy prices.

This report describes how the changes now underway in patterns of energy production and consumption are likely to evolve over the next decade. The picture offered emerges from a contrast between historical data on energy supply, consumption, and prices and forecasts of these variables for 1990.

WHAT THIS REPORT DOES

The forecasts presented in this report are grounded on assumptions about present and future circumstances relevant to energy supply, consumption, and prices. Radical departures from these assumptions are possible. For example, the economy might grow at much faster rates than the forecasts assume; a major disruption in oil supplies could occur; some dramatic technological breakthrough could substantially increase energy supplies at relatively low cost. To the extent such events occur, the forecasts presented here will prove to be inaccurate. Hence, the forecasts should not be understood as statements about what *will* happen. They are a description—based on a reasonable assessment of what is now known—of a possible future, which is worth understanding even if the assumptions do not prove entirely accurate.

Five assumptions warrant particular mention:

1. Most of the forecasts reported are for the "midprice case," which assumes that the world price of crude oil increases over the next decade only slightly more rapidly than the overall inflation rate. This case does *not* assume any large, sudden increases in the world price of oil such as occurred in 1974 and 1979. It attempts only to describe the evolution of energy supply, consumption, and prices in the absence of major disruptions in oil supply.
2. The forecasts assume that Federal leasing policy will not constrain development of domestic supplies of coal, oil, and natural gas.
3. It is assumed that firms and households base their choices among alternative energy sources on comparative costs, and that conversions to coal warranted by prevailing relative costs will not be substantially delayed by uncertainties surrounding Government regulation, development of new technologies, or relative energy prices.
4. The economy is assumed to grow over the period 1980–90 at about the same rate it grew during the years 1973–79. Population is also assumed to grow at rates characteristic of recent years. This means activities that consume energy—industrial production, transportation, household heating, and many others—are assumed to continue to grow in the 1980's.
5. Existing energy statutes are assumed to remain in force through the end of the forecast period. In particular, the forecasts recognize the decontrol of oil prices and assume that decontrol of the wellhead price of natural gas will proceed on the schedule set down in the Natural Gas Policy Act of 1978.

In general terms, the forecasts assume that the energy markets over the next decade will operate in an economic context much like the one prevailing since the 1973–74 embargo.

WHAT WAS FOUND

The forecasts paint a picture of energy consumption and supply in 1990 broadly similar to the current one. The forecasts imply no dramatic changes in oil and gas supplies, nor do they point to large shifts toward new energy technologies, radical differences in lifestyles, or an end to U.S. dependence on imported oil. Nevertheless, the forecasts suggest that by 1990, the adaptation to higher energy prices already underway will result in important changes in the composition of energy supplies and patterns of energy consumption.

Energy Prices

In the midprice case, the average level of energy prices in the United States in 1990 is projected to be—after accounting for the effect of inflation—about 178 percent above its level in 1978. This projected increase reflects:

1. The assumed increase between 1978 and 1990 in the world oil *price* of 165 percent (after accounting for general inflation).
2. Increases in the *costs* of acquiring additional amounts of energy from domestic sources.

The last of these points is of pervasive importance. In the wake of the 1973–74 embargo, there was a fairly widespread concern that the world was quickly exhausting its supplies of energy, especially of oil. It now seems that these concerns were misstated and that the world is not facing physical exhaustion of energy supplies. What is true is that the world is—and has been for some time—running out of relatively cheap sources of energy.

Domestic Energy Production

Growth in energy consumption during the 1950's, 1960's, and early 1970's was largely supplied by oil and natural gas. Domestic production of coal declined during the first part of this period and was roughly constant from 1960 on.

The forecast suggests a reversal of these trends. First, domestic production of oil and natural gas is *not* forecast to increase in the 1980's. Second, it appears that increments in energy consumption will largely be supplied by an increase in coal and nuclear power. The amount of electricity generated by nuclear power is forecast to about triple by 1990, and coal production is projected to approximately double. These projected increases account for virtually all of the forecasted growth in domestic energy production.

The forecasts of oil and gas production reflect:

- Sharply *increased* exploratory drilling due to higher prices
- Continuing depletion of fields currently in production.

These two forces result in a forecast of slow decline in natural gas production, while forecasted oil production in 1990 remains virtually unchanged from its present level.

Domestic Energy Consumption

For decades prior to the 1973–74 oil embargo there was a persistent growth in energy consumption. *Rates* of increase in energy consumption declined as energy prices rose during the 1970's. The forecasts here show *levels* of energy consumption in the residential, commercial, and transportation sectors slightly *below* what they were in 1979. These projected *declines* in energy consumption do *not* reflect decreases in population, household income, or GNP or radical changes in lifestyle. Instead, they largely reflect increased efficiency in energy use. For example, average automobile fuel efficiency is projected to increase from 14.3 miles per gallon in 1978 to 22.2 miles per gallon in 1990. Similarly, energy consumption per square foot of building space in the residential and commercial sectors is projected to decrease by about 25 percent by 1990. Energy consumption in the industrial sector is projected to increase in the 1980's. But, as true of the other sectors of the economy, the industrial sector is projected to use energy much more efficiently.

Oil Imports

United States imports of oil in 1980 were less than they were in 1979. This marked the reversal of a 30-year trend toward higher imports. For the midprice case, oil imports in 1990 are forecast to be about 35 percent below their 1978 level. This projected decline reflects:

- Increased efficiency in energy use, resulting in a very slow growth in total energy consumption
- Increased supplies of coal and nuclear power
- Maintenance of domestic oil production.

While this projected decrease in oil imports is desirable, it does *not* imply that U.S. dependence on foreign oil is likely to be inconsequential. On the contrary, the forecast implies that in 1990 imported oil will still supply 12 percent of total U.S. energy consumption and that the cost of imported oil will amount to about 2.6 percent of gross national product.

CONCLUSIONS

The theme that runs through the forecasts presented in this report is adjustment to higher prices. By the early 1970's, relatively low and stable energy prices had been reflected in product designs, location patterns, consumption habits, manufacturing methods, and many other aspects of the economy and daily life. Although none of these can be easily or quickly changed, all have begun to respond to the higher energy prices that have prevailed since the 1973–74 oil embargo.

On balance, the differences between the postembargo 1970's and the projections for the 1980's can be explained by the maturation of the adjustment process initiated when the oil price sharply increased after the 1973–74 embargo. Decisions by utilities to convert from oil and gas or industry to produce a more fuel-efficient fleet of automobiles take time to make and even longer to implement. The basic decisions that will lead to a reemphasis upon coal consumption at the expense of oil and gas and the stimulus of enhanced conservation in consumption were started in the postembargo 1970's. If the trends in energy price increases (upon which these decisions were based) continue, the results of these decisions will take place in the 1980's.

Approximate Conversion Factors

One quadrillion British thermal units (Btu) is approximately equal to each of the following:

- 172 million barrels of crude oil
- 471 thousand barrels of crude oil per day for 1 year
- 8.7 billion gallons of gasoline
- 969 billion cubic feet of natural gas
- 293 billion kilowatt-hours of electrical consumption
- 44.4 million short tons of coal

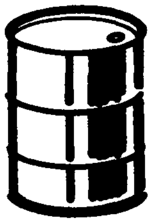
Quadrillion Btu is a measure used to describe different energy forms in common units so they can be compared. For example, 100 million barrels of crude oil can be converted to its quadrillion Btu heat equivalent by multiplying 100 million by the number of Btu in each barrel of crude oil (5.82 million) and then dividing by 1 quadrillion (i.e., 10^{15}). Thus, 100 million barrels of crude oil contain 582 trillion Btu, or about 0.6 quadrillion Btu, or about the same amount of energy as 27 million short tons of coal.

Total end-use energy consumption[1] in the United States in 1979 was about 62.5 quadrillion Btu, which is approximately 780 million Btu per day for each person in the country.

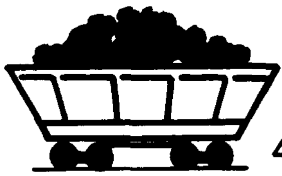
[1]End-use energy consumption is final consumption by the residential, commercial, transportation, and industrial sectors. It does not include losses incurred in conversion from one form of energy to another (e.g., coal to electricity).

Energy Measures

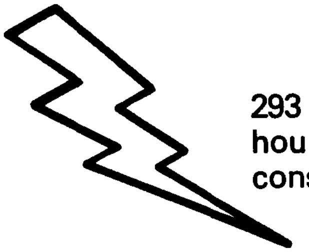
1 Quadrillion Btu is the same as:



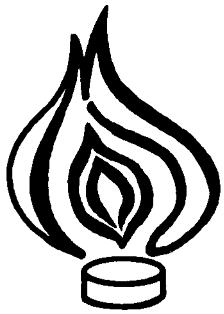
172 million barrels of oil.



44.4 million short tons of coal

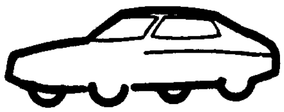


293 billion kilowatt hours of electrical consumption

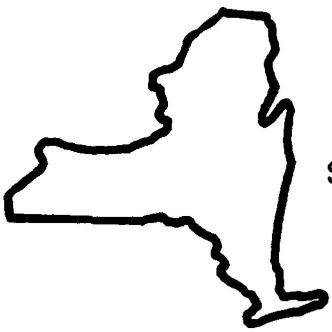


969 billion cubic feet of natural gas

1 Quadrillion Btu in 1980 is enough energy to:

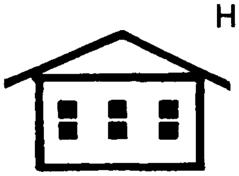


Fuel 12 million cars in the United States for 1 year.



Supply all of New York State's electrical needs for 3 years.

Heat 20 million well-insulated homes for 1 year.



1. Introduction

This report presents an overview of forecasts of domestic energy consumption, production, and prices for the year 1990. These results are selected from more detailed projections prepared and published in Volume 3 of the Energy Information Administration 1980 *Annual Report to Congress.* This report focuses specifically upon the 1980's and concentrates upon the similarities and differences in the domestic energy system, as forecast, compared to the national experience in the years immediately following the 1973–74 oil embargo. Interest in the 1980's stems not only from its immediacy in time, but also from its importance as a time in which certain adjustments to higher energy prices are expected to take place. Ultimately, the technology of energy production and use may change dramatically from its present state. However, new energy technologies will probably not play a major role in energy affairs until after 1990, perhaps well after. Yet higher and increasing energy prices will cause important adjustments in the 1980's.

In the postembargo 1970's, there was little choice beyond either paying higher energy prices or cutting back energy consumption. Even though the reality of higher energy prices has become firmly established, it took time, and will continue to take time, to identify and evaluate alternatives and adjustments to increasingly expensive energy. This is no less true for individuals planning their next automobile purchase than it is for a firm selecting a new boiler or an electric utility planning a new power station. During the 1980's the results of such planning and alternative-seeking are likely to emerge in substantial changes in patterns of energy production and consumption.

The projections presented here for the year 1990 turn on the *currently known* alternatives to how we now produce and consume energy, upon economic reasoning, and the perceived preferences of consumers and business decisionmakers. Of course, many factors not accounted for could make a tremendous difference to the pattern of energy production, consumption, and prices 10 years into the future. Unanticipated technological breakthroughs, an unexpected discovery of large reservoirs of oil resources, political upheaval, or economic calamity, among other possible events, could lead to dramatic changes in events as they would occur in 1990 compared to any projections presented here.

The forecasts presented do not attempt to account for all of this wide range of potentially important forces that could conceivably alter the energy situation. Instead, the projections are based on a particular set of assumptions that seems reasonable in light of what is currently known. For example, the rate of economic growth assumed for the 1980's is essentially that experienced in the postembargo 1970's and the rate of technological innovation is that which would be reasonably suggested by the recent past. The projections are thus "base cases" tailored for potential comparisons to other projections that do incorporate more radical assumptions. A particular consequence of this limitation concerns the assumptions about Government actions and policies. For these projections, current Government policies, and no others, are assumed. Certain variations of these assumptions are also considered here; others can be found in Volume 3.

One uncertainty is so crucial to the energy future that a number of cases were developed to represent a range of plausible possibilities. This is the uncertainty over the world price of imported oil. Projections were prepared for a case assuming that (roughly) today's price remains constant in real terms over the decade, and for two cases assuming successively higher rates of increase for import prices.

2. Background

Since the oil embargo of 1973, energy prices have increased faster than most other prices. Although there have been significant reductions in energy consumption due to the higher prices, total expenditures on energy have nevertheless increased. A larger proportion of the national income is now spent on energy and energy-related products than was spent in the decade before the embargo. These trends are expected to continue. Further, as the embargo and subsequent events have dramatized, energy supplies (or at least oil supplies) can be vulnerable to disruptions due to political factors.

It is these circumstances—higher energy prices, proportionately greater expenditure on energy, and the spectre of politically based disruptions in energy supplies—that constitute the "energy problem."

ENERGY TRENDS BEFORE THE EMBARGO

Energy prices were relatively stable compared to other prices during the 1950's and 1960's. This relative price stability was partly due to the development of oil resources in the Middle East. As domestic oil resources became increasingly expensive to find and extract, it became economically attractive to depend more and more upon foreign, particularly Middle Eastern, oil. After World War II, oil production in the Middle Eastern countries started to claim a significant percentage of total world production. During 1980, Saudi Arabia alone accounted for 20 percent of the total oil production outside the Communist-bloc countries, and it may well have an even larger proportion of reserves.[1] As a generality, Middle Eastern oil will remain economically competitive with any other sources of oil now known.[2] (See Figure 2.1.)

During the post-World War II period, the generally stable prices of oil and other sources of commercial energy combined with other broad trends to produce a continuing increase in U.S. energy consumption. One of the most pervasive forces behind this increase was the rapid and steady growth of prosperity. In 1950, the median household income in the United States (in 1979 dollars) was just over $8,000[3] per year, or only about 10 percent above what is in 1980 regarded as the poverty income level.[4] Most American families in 1950 did not regard themselves as living near poverty. Still, in terms of buying power, the average U.S. family in 1950 was comparatively poorer than its counterpart in the 1970's. This lower standard of living was particularly evident in ways that hold down energy consumption—higher urban residential densities, fewer automobiles per household, and less dependence upon major household appliances.

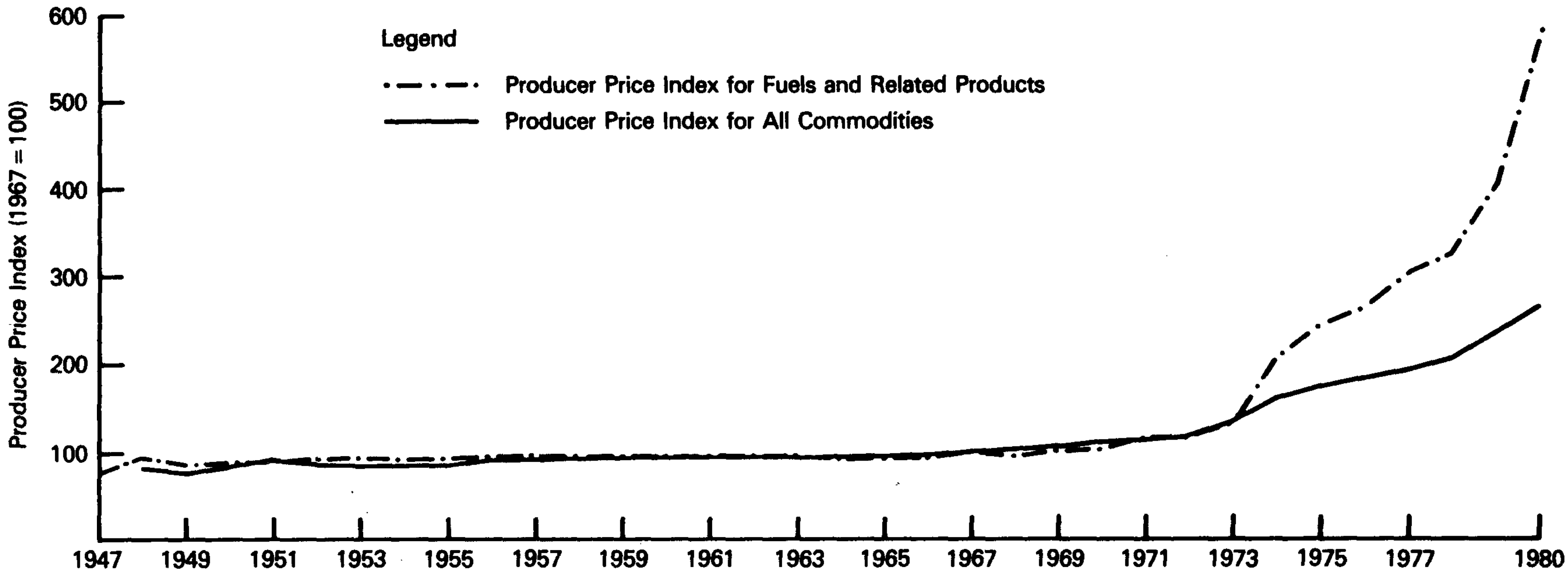
Another major trend of the 25 years following World War II was the population movement from rural areas and central cities to the suburbs. Suburban growth meant the growth of (energy-intensive) single family dwellings and, more importantly, lower residential densities. In turn, this meant more driving—to and from work and school, for shopping, recreation, and many other purposes. In 1960 the U.S. automobile stock is estimated to have been 57 million, or about one automobile per

[1]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 30, pp. 69–71.

[2]For evidence of the costs of oil from various parts of the world, see M. A. Adelman, *The World Petroleum Market* (Baltimore: Johns Hopkins Press, 1972), Chapter 2 and Appendices to Chapter 2.

[3]Calculated from GNP deflator as reported by the U.S. Department of Commerce, Bureau of Economic Analysis; and income figures from Table 729, *Statistical Abstract of the United States, 1978,* U.S. Department of Commerce, Bureau of the Census.

[4]U.S. Department of Commerce, Bureau of the Census, *Current Population Reports, 1979,* Series P–23.



Source:
Derived from Data Resources, Inc. (DRI), U.S. economy model data bank.

Figure 2.1 Producer Price Indices for All Commodities and Fuels, 1947–80

household.[5] By 1976 there were 1.3 autos per household, and the total stock of automobiles had increased to 98 million.[6]

Stable energy prices were not the only—or even the dominant—factor behind the growth of suburbs and increased auto ownership. It can be said, however, that residential patterns and housing construction, travel patterns, the location of schools, hospitals, and stores developed in a period of stable energy prices. Had energy prices been higher during these decades, lifestyles and product designs probably would have been different in many respects relevant to energy consumption.

During the 1950's and 1960's energy use per unit of industrial output declined. However, total industrial energy consumption increased, and there was also a substitution by industry of oil and natural gas for coal. The era of industrial expansion in the United States that began in the 1870's and continued through the 1920's was largely fueled by coal, with oil and natural gas only accounting for relatively small shares. During the 1930's, however, the substitution of oil and natural gas for coal began on a substantial scale, and it continued at an accelerated pace during the 1950's and 1960's. By 1950, industry used about as much coal as it did oil and natural gas combined. By 1975, oil and gas supplied about three times more of industry's energy consumption than did coal.[7]

The trends in total energy consumption, patterns of fuel use, and energy prices during the 1950's and 1960's were not matters of general concern. It was during this period, however, that two aspects of the current energy problem made their appearance. First, in 1948 the United States became a net importer of oil, and U.S. oil imports subsequently grew steadily over the following decade. By 1958, U.S. oil imports had increased to nearly one-fifth of total U.S. oil supply.[8] Second, additions to U.S. petroleum reserves fell below production in 1955 for the first time during the postwar period.[9]

A key fact in understanding why the effects of the 1973–74 oil embargo were so severe is that throughout the 1960's and early 1970's the production rates from developed oil fields in the United States were generally below their capacities. Neither the disruption of Middle Eastern oil supplies during the Suez Canal crisis in 1956, nor the one during the 1967 Arab-Israeli war, had a significant economic impact on the United States. But by 1973, the reserve capacity of the U.S. petroleum industry had disappeared, and in 1972 imports were nearly 30 percent of U.S. oil supply.[10]

ENERGY TRENDS SINCE THE EMBARGO

The 1973–74 oil embargo put energy high on the agenda of significant national issues. Its position there was confirmed by the disruption of oil supplies caused by the Iranian Revolution in 1979. There is concern that the war between Iran and Iraq could lead to further disruptions.

To many, the prospect of sudden disruptions in oil supply is *the* energy problem. From this perspective, the dependence of the United States—and Europe, Japan, and most developing nations—on imported oil is fundamentally a problem of national security and international relations.

But whatever the future holds in terms of disruptions in oil supplies, the United States is now in the very long process of adapting to higher real energy prices. Figure 2.2 shows the average U.S. oil import price from 1970 through 1979. This price more than doubled during the 1973–74 embargo. In the following 4 years, the price increased only moderately, and, taking account of inflation, even declined slightly. But starting in late 1978, the world price of oil again began to increase sharply.

Apart from a recognition of the potential for politically based energy supply disruptions, the 1973 oil embargo coincided with a general recognition of the potential for increasing real energy prices. Such price increases were projected to stem

[5]U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1974,* Table No. 55.

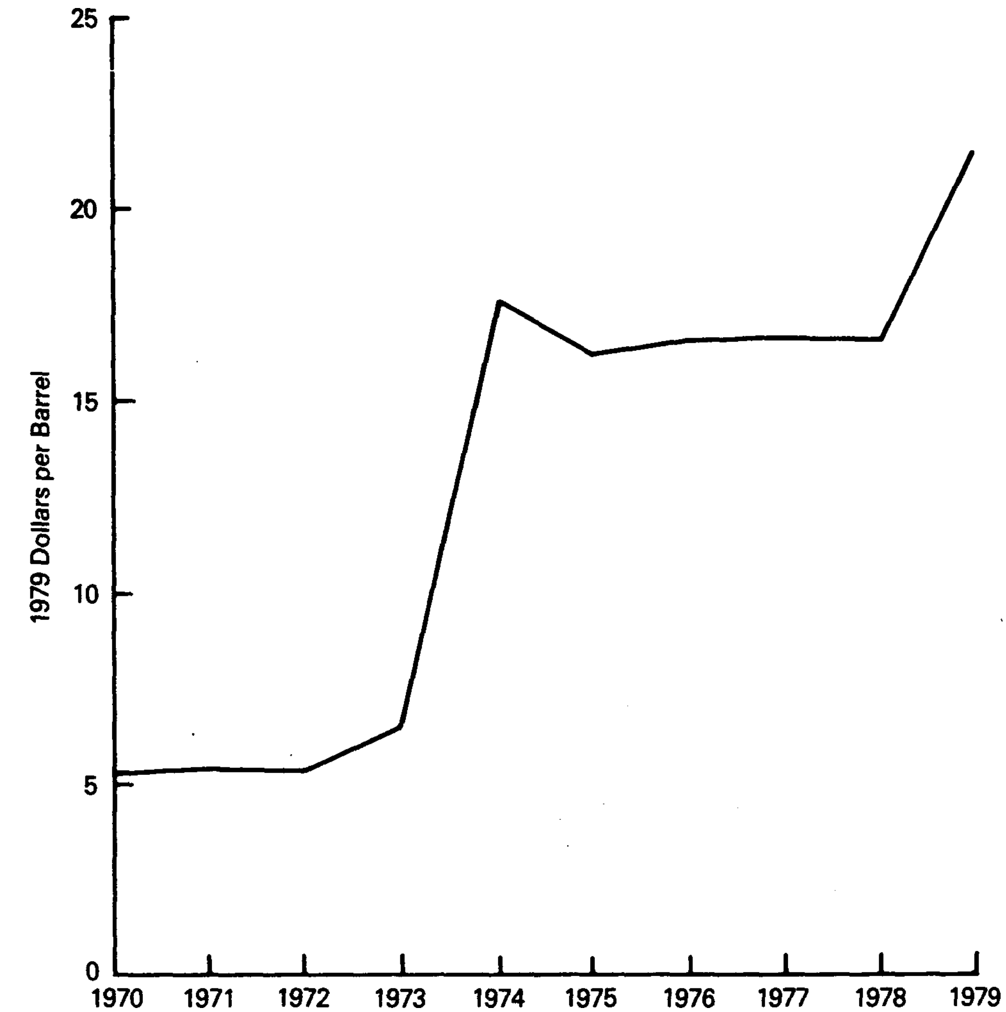
[6]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 24, p. 55; and U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1978,* Table 1101.

[7]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Tables 26, 39, and 46 for petroleum, natural gas, and coal consumption, respectively, pp. 59, 93, and 113.

[8]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 18, p. 43.

[9]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Tables 16 and 18, pp. 35 and 43.

[10]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 18, p. 43.



Sources:
Historical data from 1970 to 1978 from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1978, Volume 3,* Figure 2.6, page 28.

1979 oil price reported in U.S. Department of Energy, Energy Information Administration, *Short-Term Energy Outlook,* August, 1980, Table 1, page 4.

Figure 2.2 Annual Average World Oil Prices, 1970–79

from the depletion of oil resources and a growing dependence on more expensive forms of energy. It is worth emphasizing that the major problem calling for adjustment is higher energy prices, not energy shortages. The Nation is not running out of energy; it is running out of inexpensive energy.

Using conventional methods, for example, only about 32 percent of the oil in existing fields can be extracted on average. There are ways to increase recovery rates to perhaps 50 percent of the oil in the ground, but they are much more costly than conventional methods. Moreover, the costs of finding new oil fields tend to increase over time. There may be very large, as yet undiscovered, favorably located, shallow fields of oil, but this does not seem likely. Experience suggests that new fields will typically be smaller, deeper in the earth, in less favorable locations, and harder to find. All of these factors imply higher costs.

Higher energy prices have begun to induce changes in energy consumption. Perhaps the most dramatic of these was the decrease in gasoline consumption observed in 1979 and 1980. In 1978, U.S. gasoline consumption was 7.4 million barrels a day. Consumption during 1979, however, fell to about 7 million barrels a day, even though the total stock of U.S. automobiles had increased by about 2.5 percent.[11]

There are more forces at work in these changes—and others described in Chapter 4—than people simply conserving energy by turning down thermostats and driving less. As was noted above, for decades adaptations to low energy prices were designed into autos, appliances, houses, patterns of residential location, and many other facets of daily life. The higher energy prices experienced over the past few years, and concern over future real increases, are slowly encouraging these adaptations to be "designed out" in favor of those that use energy more efficiently.

GOVERNMENT ENERGY PROGRAMS

A variety of energy programs have been developed by the Government. Generally, energy programs can be placed in one of five categories:

1. *Conservation programs.* These include establishment of automobile fuel efficiency standards, building energy efficiency standards, appliance energy efficiency standards, and tax credits to promote home insulation. Also included are programs specifically designed to conserve oil and gas—especially the Powerplant and Industrial Fuel Use Act of 1978 (Public Law 95–620)—by requiring conversions from oil or natural gas to alternative fuels.
2. *Supply programs.* These include the Synthetic Fuels Corporation, focus on the development of new methods of oil recovery, promote the development of geothermal energy, and promote research and development of new energy technologies. Programs focusing upon supply have been implemented primarily through such measures as grants, subsidies, tax credits, loans, loan guarantees, and guaranteed purchases.
3. *Price controls.* These include controls on crude oil and petroleum products, allocations of crude oil among refiners, controls on natural gas prices, and interstate sales of electricity.
4. *Direct and indirect payments.* These are designed to cushion the effects of higher energy prices (particularly to low-income groups) and taxes on profits resulting from higher energy prices.
5. *Emergency programs.* These include the Strategic Petroleum Reserve and the standby gasoline rationing plan authorized by Congress in November 1979.

With some exceptions (especially control of natural gas prices and nuclear research and development programs), these programs were enacted after the 1973–74 oil embargo and constitute the core of what usually is referred to as "Federal energy programs." There are, however, several other longstanding categories of Federal actions directed specifically at different energy industries:

- Regulation of rates charged by oil and natural gas pipelines
- Regulation of nuclear safety, licensing of commercial reactors, production and control of nuclear fuel, and disposal of nuclear wastes
- Leasing of Federal lands for exploration and development of oil, natural gas, and coal
- Production of electricity by Federal power authorities.

In addition, there are a number of Federal programs that apply to industry generally, but which are particularly significant to one or more of the energy industries. Within this category, considerable attention has been paid to environmental regulation of air and water pollution and of hazardous wastes produced by electrical utilities, refineries, and, in some cases, oil and gas drilling operations. Also of significant importance are a variety of Federal tax code provisions, Federal regulation of inland and coastal waterways shipping rates, and recent actions by Congress to deregulate the railroads, which will in turn affect the price of delivered coal.

Finally, State severance taxes—especially on coal—are important, and retail prices of electricity and natural gas are, in most States, regulated by State public utility commissions. Furthermore, about 4 percent of the electricity generated in the United States is supplied by municipally owned utilities, and another 15 percent by Federal power authorities.[12]

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[11]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 25, p. 57.

[12]Standard and Poor's *Industrial Surveys, Utilities—Electric: Basic Analysis,* April 17, 1980, Section 2, p. U15.

BASE CASE ASSUMPTIONS

This report presents forecasts for a "base case" and, for comparison, additional forecasts that incorporate selected changes in the base case assumptions. All program types mentioned above are taken into account in the base case forecasts. The forecasts are also heavily influenced by several factors that fall almost completely outside domestic energy market boundaries. Of these, the most important are the world oil price and the growth in both industrial production and personal income over the forecast period.

To represent the uncertainty about future world oil prices, three cases that differ only in the assumptions about a "low," "middle," and "high" world oil price were developed. Figure 2.3 presents the world oil price, stated in 1979 dollars, used in making the forecasts. Prices for 1990, *stated in 1990 dollars,* would reflect inflation during this decade and consequently would be substantially higher than those shown in the table. The midprice case assumes an increase in the real world oil price of about 3 percent per year from 1980 to 1990. This is substantially below the average annual oil price growth rate of nearly 20 percent during the 1970's. The midprice case does not assume sudden increases in the world price, such as those of 1974 and 1979. Forecasts made for this case, then, provide an indication of how events are likely to unfold in the absence of a disruption in oil supplies.

The "high" and "low" paths for world oil prices are assumptions resting upon forecasts made for a number of cases that consider "high" and "low" world economic growth, non-OPEC supply, and OPEC capacity. The "high" price path also assumes:

- The Communist bloc becomes a net importer of oil, at a rate of 1 million barrels per day, by 1985.
- Supply disruptions of 2 million barrels per day for 1 year occur in both 1983 and 1988.

The real world oil price is essentially constant in the "low" price case; in the "high" world oil price case, it increases at an average rate of 4.5 percent between 1980 and 1990.

Table 2.1 reports historical data and projections of the GNP price deflator, inflation rate, real disposable income per capita, and manufacturing production used to make the forecasts. These are variations of projections (TRENDLONG2005) recently published by Data Resources Incorporated (DRI). In this forecast, real gross national product increases at a rate of 2.5 percent per year from 1980 to 1995 and reflects a continued increase in labor force participation. The population is assumed to grow at 1.8 percent annually, the same rate as between 1965 and 1978. The values of specific variables, of course, reflect interaction of the general economy and the energy sector and are described in more detail in Volume 3, the companion to this report.

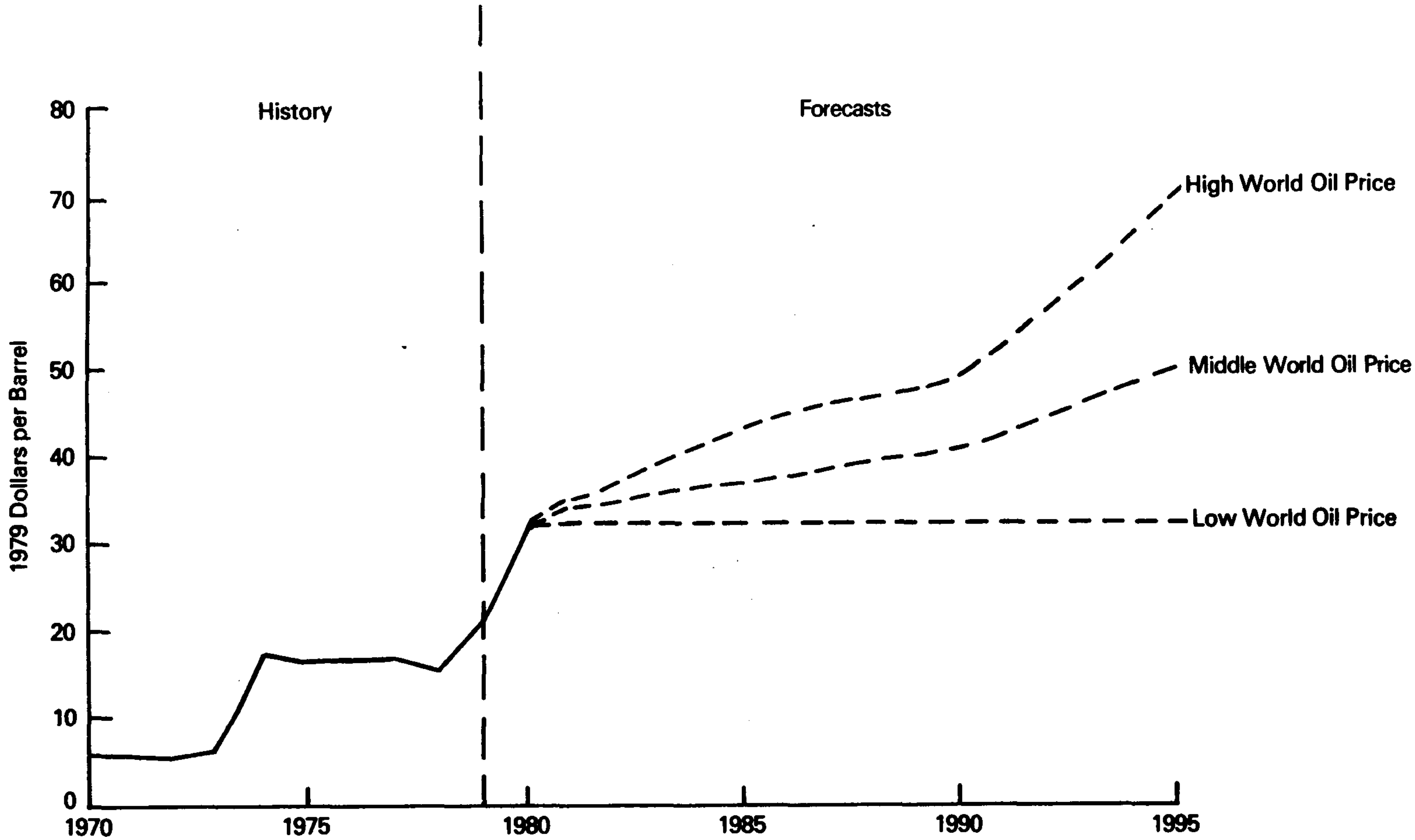
Table 2.1 Indices of Manufacturing Production, Real Disposable Per Capita Income, Implicit GNP Deflator, and Annual Inflation Rate: History, 1975–79, and Forecasts, 1980–90

Index of Year	Capita Manufacturing Production (1967 = 100)	Real Disposable Income per Implicit (thousand 1979 dollars)	GNP Deflator (1972 = 100)	Inflation Rate (percent)
1975	1.16	6.6	1.27	9.5
1976	1.30	6.8	1.34	5.2
1977	1.38	7.0	1.42	6.0
1978	1.47	7.3	1.52	7.3
1979	1.53	7.4	1.66	8.9
1980	1.44	7.3	1.81	9.4
1981	1.45	7.3	1.99	9.8
1982	1.59	7.5	2.17	9.2
1983	1.66	7.7	2.36	8.5
1984	1.70	7.9	2.55	8.2
1985	1.78	8.0	2.76	8.2
1986	1.90	8.2	2.96	7.3
1987	2.01	8.4	3.17	7.0
1988	2.09	8.5	3.39	7.0
1989	2.16	8.7	3.62	6.9
1990	2.24	8.8	3.87	6.9

Source: Historical data from Data Resources, Inc. (DRI), U.S. model data base; forecasts are derived by Energy Information Administration using DRI U.S. model.

CONCLUDING COMMENT

Together, the economic assumptions outlined above sketch a picture that is similar to recent experience—relatively slow rates of growth in industrial production and family income, continued inflation, and high and increasing energy prices. The last of these is especially important to the forecasts presented below. Energy price increases during the past few years have had large effects on both energy production and consumption. The analysis presented in the following chapters describes how trends already visibly underway seem likely to develop through the 1980's.



Sources:
Historical data derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1978, Volume 3,* Figure 2.6, page 28, and *Short-Term Energy Outlook,* August 1980, Table 1, page 4.

Figure 2.3 World Oil Prices: Historical, 1970–79, and Forecasts, 1980–95

3. Domestic Energy Production

The United States is a major producer of energy. Although domestic oil production is currently below its 1970 peak, in 1978 the United States was second in oil production only to Saudi Arabia among non-Communist nations and was the largest among Western countries.[1] U.S. coal production is also larger than that of any other Western nation;[2] the United States produces nearly two-fifths of the world's marketed natural gas,[3] and it is also the world's largest producer of uranium.[4]

Nevertheless, neither the United States nor any other developed country has large energy reserves available at costs comparable to those before the early 1970's. The United States and other developed nations face the problem of adjusting both their energy consumption and supplies to an era of higher energy costs.

TRENDS IN DOMESTIC ENERGY PRODUCTION

As oil prices rise, and domestic oil supplies from conventional sources decline with the depletion of known fields, a sequence of adjustments along the following lines would be expected:

1. An increase in drilling activity, caused by higher prices raising the rewards for finding and developing the remaining U.S. oil deposits.
2. A shift toward the development of oil and gas sources that could not be economically exploited at lower prices.
3. An increased production of other domestic energy resources, particularly coal, as higher oil prices make them appear more attractive.
4. The emergence of some new energy technologies, such as solar, geothermal, biomass (e.g., wood, alcohol fuels, and methane from municipal wastes), and others that are not currently in large-scale production.

Most of these adjustments are already well underway.

The data for total U.S. energy production shown in Figure 3.1 reflect two major trends that have been roughly counterbalancing since 1970. First, production from conventional sources of oil and natural gas has declined as existing reserves have been depleted. Second, the quadrupling of the world oil price following the 1973–74 embargo and the further doubling of the world oil price in 1979 have helped to stimulate domestic energy production. Petroleum exploration, particularly in Alaska and the Outer Continental Shelf, has increased. There also are visible shifts to the production of relatively cheaper and more secure energy sources such as coal. Much effort has been directed toward the development of new extractive energy technologies and new methods of supplying energy.

Oil and Natural Gas

As seen in Figure 3.2, domestic production of oil and natural gas peaked in 1970 and 1973, respectively. Since then production has remained somewhat below the levels reached in those years. During this period oil and natural gas together accounted for roughly 60 percent of the U.S. total gross domestic energy supply.[5]

Table 3.1 presents data on domestic oil and gas production in 1978 and estimates of proved reserves and resources of oil and gas. "Conventional" and "unconventional" sources are distinguished in this table. Generally, oil resources that can be

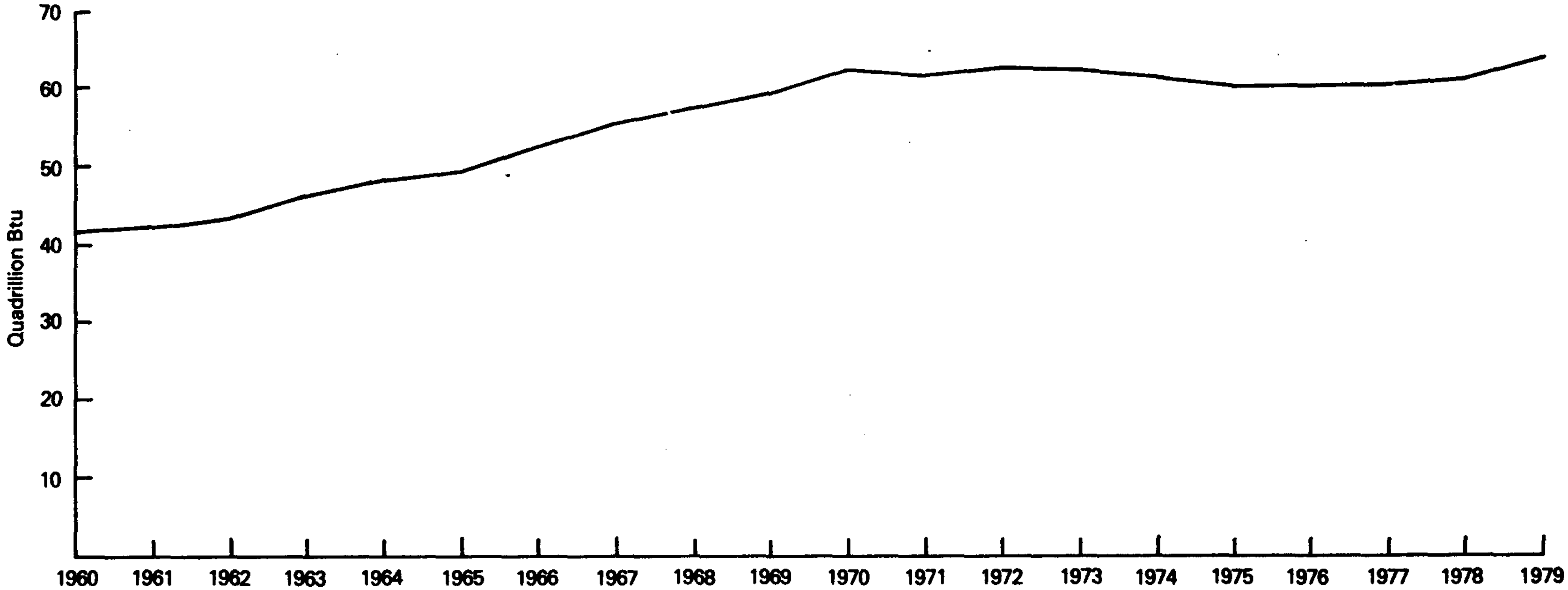
[1] U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 30, pp. 69–71.

[2] U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 53, p. 127.

[3] U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 41, pp. 97–99.

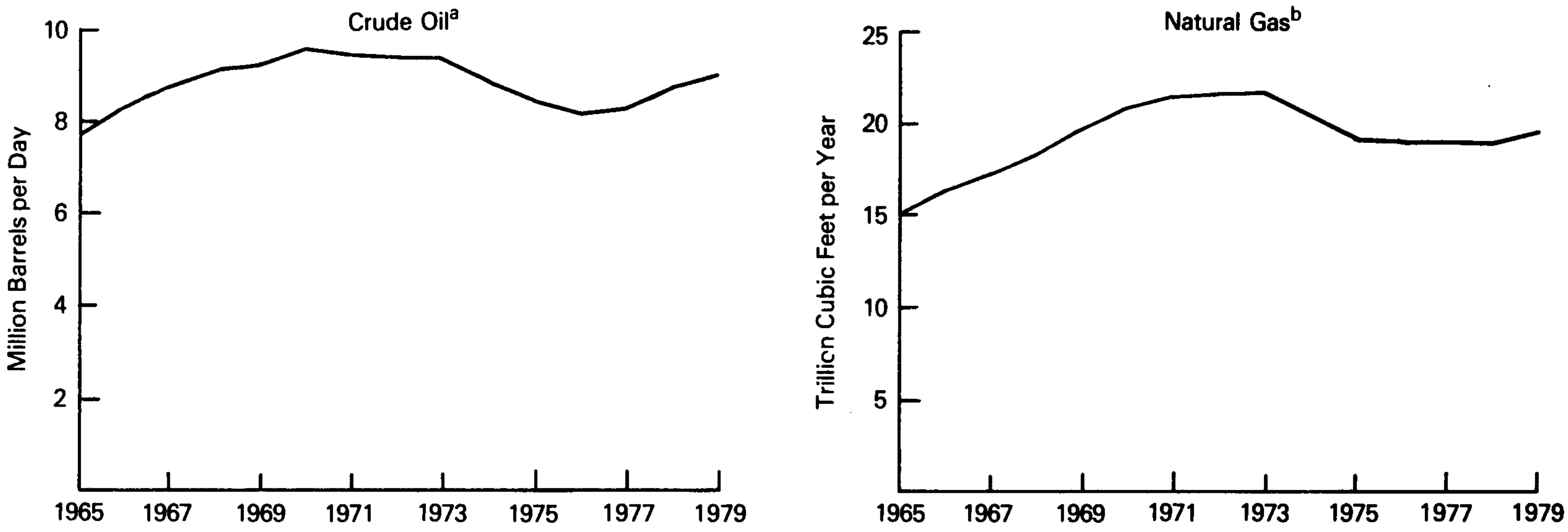
[4] Robert J. Wright and Robert K. Pitman, "Foreign Exploration and Uranium Supply," *Proceedings of the Uranium Industry Seminar,* U.S. Department of Energy, Publication Number GJO 108(79), October 1979, p. 121.

[5] U.S. Department of Energy, Energy Information Administration, *Annual Report to the Congress, 1979,* Volume 2, Table 1, p. 3.



Source:
U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 1, page 3;
Monthly Energy Review, December 1980, Executive Summary, page 2.

Figure 3.1 Gross Domestic Energy Production, 1960–79



[a]Includes lease condensate.

[b]Dry marketed natural gas.

Source:
U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Tables 2 and 18, pages 5 and 43; *Monthly Energy Review*, December 1980, pages 26 and 46.

Figure 3.2 Domestic Production of Crude Oil and Natural Gas, 1965–79

Table 3.1 Production of Oil and Gas in 1978, and Estimated Oil and Gas Proved Reserves and Resources
(Quadrillion Btu)

	1978 Domestic Production	Proved Reserves	Approximate Resources
Crude Oil			
Conventional and Enhanced Oil Recovery	[a]21	185	[b]500
Tar Sands	0	NA	190
Shales	0	NA	2,100
Natural Gas			
Conventional	19	204	[b]500
Tight Sands	0	NA	900
Devonian Shale	0	NA	200–2,000

[a]Includes natural gas liquids.
[b]Excludes proved reserves.
Sources: Production data found in U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 2, p. 5; proved reserves data found in Table 16, p. 35; resources for conventional crude oil and natural gas were derived from Table 11, p. 25; tight sands and Devonian shale resource estimates from National Petroleum Council, *Unconventional Gas Sources*, 1980.

recovered from subsurface reservoirs by drilling, and which require no special treatment in the ground or after production, are termed "conventional." "Unconventional" resources include reservoir accumulations that must be induced to flow by injection of chemicals or application of heat, gas trapped in tight formations and coal seams, and shale oil and tar sands that cannot be produced or refined using standard techniques. Proved reserves, on the other hand, are a measure of the amount of petroleum known to be producible at current prices.

Gross additions to crude oil reserves range from 1 to 3 million barrels in most years. (See Table 3.2.) However, with the exception of 1970 when large reserves in northern Alaska were first reported, annual production has exceeded additions to reserves in every year since 1967. Proved reserves have, therefore, been declining, and furthermore, the trend in additions to reserves has been downward.

These trends reflect both the availability of oil and gas resources, their costs, and the economies of the industries. Using an average oil field life of 15 years to provide a rough approximation, production from existing proved reserves in 1969 would be expected to have declined about two-thirds by 1979. However, domestic crude oil production in 1979 was only 8 percent less than in 1969.[6] This fact

Table 3.2 Gross Additions to Proved Crude Oil Reserves and Crude Oil Production, 1966–78
(Billion Barrels)

Year	Additions to Proved Reserves	Production
1966	3.0	3.0
1967	3.0	3.2
1968	2.5	3.3
1969	2.1	3.4
1970	12.7	3.5
1971	2.3	3.5
1972	1.6	3.5
1973	2.1	3.4
1974	2.0	3.2
1975	1.3	3.1
1976	1.1	3.0
1977	1 4	3.0
1978	2.2	3.2

Sources: 1967–77 data from American Petroleum Institute, *Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada as of December 31, 1977, Volume 32*, June 1978, p. 24; 1978 data calculated from U.S. Department of Energy, *U.S. Crude Oil and Natural Gas Reserves*, DOE/EIA–0216(78), Table 4, p. 15.

is explained by the continuing development of new reserves during the 1969–79 period.

Exploration activity has accelerated with increases in the prices of oil and gas. Figure 3.3 shows two measures of drilling activity over the 1949–78 period. Both the number of active rotary drilling rigs and the number of feet drilled declined during the 1960's and early 1970's, but they have since increased sharply over the past few years as crude oil prices have risen. In addition, the composition of drilling rigs has changed. Rigs capable of drilling deep wells (2 miles or more in depth) account for an increasing proportion of the drilling rig population, indicating an increased ability and willingness to search for high-cost, deeper deposits of oil.[7]

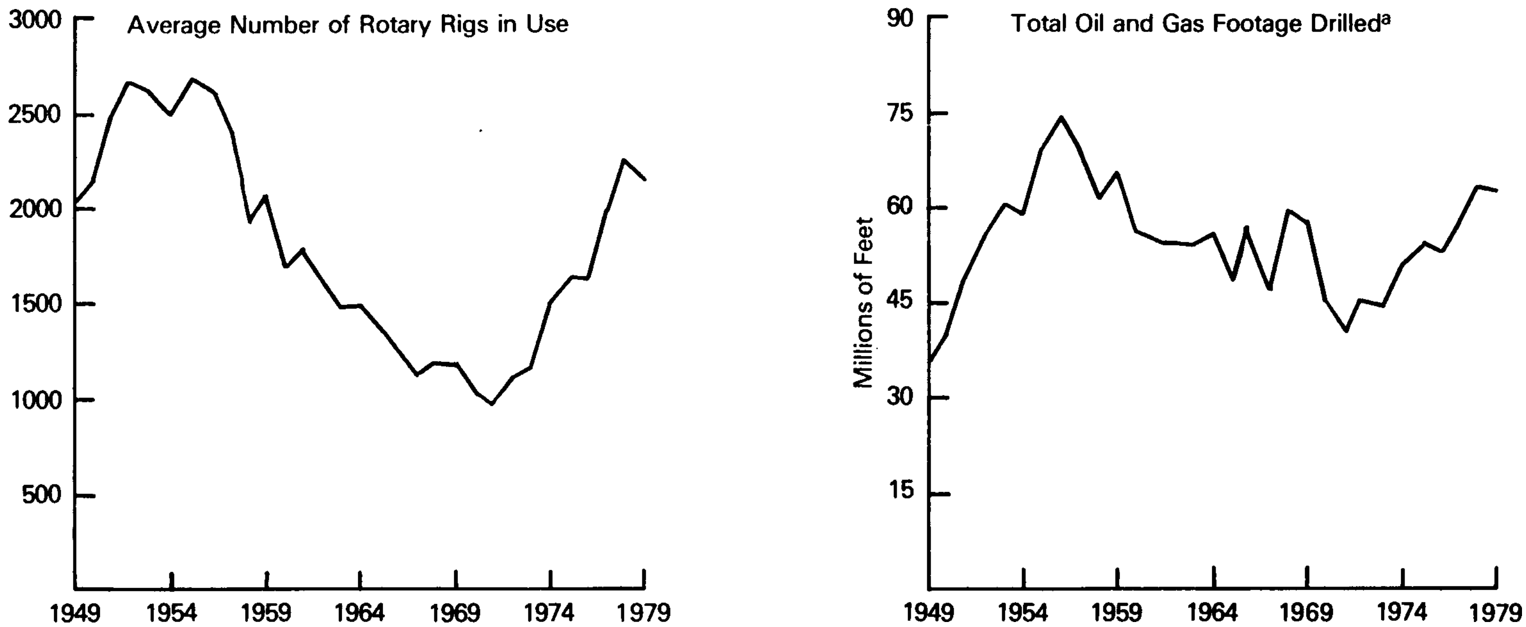
The average drilling costs for a well have risen by more than 160 percent (73 percent in real terms) since 1972.[8] More recent exploratory oil wells tend to be about 6,000 feet deep on average, or about 500 feet deeper than in the 1960's and over 1,000 feet deeper than in the 1950's.[9] The physical

[6]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 18, p. 43.

[7]For further discussion, see *The Oil and Gas Drilling Industry*, by Nancy Ody, U.S. Department of Energy, Energy Information Administration, Office of Energy Source Analysis, forthcoming.

[8]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 15, p. 33.

[9]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 13, p. 29.



[a]Includes dry holes.

Source:
U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Tables 12 and 13, pages 27 and 29; *Monthly Energy Review*, January 1981, page 52; and American Petroleum Institute; *Quarterly Review of Drilling Statistics for the United States*, March 1980, Table 2.

Figure 3.3 Average Number of Rotary Rigs in Use and Total Exploratory Oil and Gas Footage Drilled, 1949–79

The Natural Gas Policy Act of 1978

The Natural Gas Policy Act is an outgrowth of the problems encountered by the Federal Power Commission (FPC) in the regulation of the wellhead prices of natural gas. The Supreme Court, in a 1954 case, *Phillips Petroleum Co. versus Wisconsin* (347 U.S. 672), decided that the FPC was required to regulate the wellhead prices of natural gas sold in *interstate* markets. The FPC initially attempted to regulate the prices of individual producers using procedures similar to those used by State public utility commissions to regulate electricity rates. This proved to be unworkable because of the very large number of natural gas producers, and, in 1960, the FPC moved to "area price controls."

Under this system, a schedule of prices was established for all producers in a given area. Prices for the entire area, however, were still determined along the lines of rate-of-return regulation. By the early 1970's, the FPC essentially adopted a national price schedule for new interstate gas. Since sales of gas to *intrastate* pipelines were not subject to Federal regulation, a parallel *intrastate* market (with higher prices) developed and the proportion of new finds dedicated to the interstate market declined precipitously.

National wellhead price controls continued until the 1978 passage of the Natural Gas Policy Act (NGPA). The NGPA brought under price controls almost all gas production, rather than only gas produced for the interstate market. More generally, the NGPA moved away from controlling gas prices through rate-of-return regulation. Instead, the NGPA established a series of price tiers based on (1) the physical characteristics of the well, (2) proximity to other wells, (3) whether the gas was sold in the interstate market in November 1978, and (4) the date the well began production. The Act established a maximum price for gas in each tier. The NGPA also established a timetable, extending from 1979 into the 1990's, on which the prices of gas classified in many tiers would be decontrolled.

The Federal Energy Regulatory Agency (FERC, the successor to the FPC) is authorized by the NGPA to provide incentive or relief rates for the following types of gas:

1. Interstate gas from small producers.
2. Gas from geopressurized brine, coal seams, Devonian shale, or other high-risk/high-cost gas.
3. Gas not otherwise covered by the Act.

Finally, the NGPA also made major changes in the method of establishing natural gas prices to industrial and residential consumers. The relevant parts of the NGPA are the "incremental pricing provisions." Under incremental pricing, a set of complex accounting rules pass directly to industrial consumers part of the costs associated with high-priced natural gas. Residential and other gas consumers pay less than they would if their price were based on the full average price of natural gas.

The amount passed directly to industrial consumers is limited by a ceiling price based on the cost of alternative fuels. Since the incremental pricing provisions apply only to interstate pipelines and their customers, industries (and residential consumers) in major gas-producing States may not be affected in the same manner as customers who obtain gas from the interstate pipeline system.

difficulty of adding new reserves is expected to continue to increase.

Costs and prices are also of key importance in the development of unconventional oil and gas resources. Cost increases for the development of conventional oil and gas reserves provide an incentive for developing other ways of obtaining these fuels—new recovery technologies and unconventional resources. One approach of growing interest during the past few years is the use of "enhanced oil recovery" (EOR) techniques, also known as "tertiary methods," which inject steam, gases, or chemicals into the reservoir to increase recovery.

Conventional production methods include:

- Natural flow from the reservoir and mechanical pumping (primary methods)
- Injection of natural gas or water to increase the flow rate (secondary methods).

Primary and secondary methods together result in the average recovery of about 32 percent of the reservoir. Accordingly, only about 32 percent of the total amount of oil in a reservoir is included in proved reserves. The remainder is left in the ground. Through the use of EOR techniques, recovery can be increased from 32 percent to perhaps as much as 50 percent of the oil in a deposit. EOR techniques are, however, much more costly than conventional methods and may present environmental problems.

By early 1980, there were about 266 enhanced oil recovery projects in the United States, or about 37 percent more than in 1978. These projects produce about 300,000 barrels of oil a day.[10] In brief, the picture presented here is one of relatively small production using EOR techniques, but one of rapid growth.

Another option is the development of shale deposits. Shale was used for oil production both in the United States and Scotland over a century ago. In 1850, some 53 companies produced small amounts of oil from shale,[11] and shortly after World War I, 26 firms built pilot plants for recovery of oil from shale.[12] Oil shale has not been exploited in more recent years largely because oil and gas could be obtained more cheaply from conventional domestic resources or from abroad. However, as world oil prices and the cost of developing conventional resources increase, development of this and other unconventional oil and gas resources becomes increasingly attractive.

Other Energy Sources

Higher prices for oil and gas indirectly affect production of other energy sources through two processes. First, high prices of oil and gas induce substitution of alternative energy sources for these fuels. Second, high prices of oil and natural gas have produced considerable public and private research and development work to develop new energy sources.

[10]*Oil and Gas Journal,* March 31, 1980, pp. 79–96.

[11]M. J. Gavin, "Oil Shale, An Historical, Technical, and Economic Study," U.S. Bureau of Mines, Bulletin 210, 1932.

[12]R.H. McKee, *Shale Oil,* (New York: Chemical Catalog Col, 1925), pp. 150–168.

The new energy technologies—solar, geothermal, biomass, fusion and others—have attracted much attention, perhaps because they seem to promise supplies of energy that are virtually unlimited and cheap, with no major environmental problems. These promises may be fulfilled, but they have not yet been realized. During the past decade, small amounts of commercial geothermal and solar power have been produced. Although both sources have grown rapidly, they still are a very small part of the domestic energy supply—much less than 1 percent.[13] For this reason, and because by 1990 these resources are projected to contribute less than 1 percent of domestic commercial supply, the focus that follows is on coal and nuclear power.

Coal and Nuclear Power

While production of oil and gas in the United States peaked in the early 1970's, nuclear power has increased greatly, and coal production generally has grown since 1973. (See Figure 3.4.)

As discussed in the next chapter, the growth in coal production reflects a demand shift induced by high oil and gas prices. For example, New England Power plans to convert at least six of its existing power generating units from oil to coal.[14] Oil consumption by electric utilities declined sharply in 1979, down to 3.3 quadrillion Btu from 3.8 in 1978.[15] Available coal resources do not impose a limit to this process. Proved U.S. coal reserves are estimated to be over 5,000 quadrillion Btu (or 440 billion tons), which is more than 60 times total U.S. energy consumption in 1978.[16]

Concerns regarding the development of coal production have centered on several issues:

- Environmental regulations and environmental costs of burning coal
- The adequacy of the railroad system to move large amounts of coal and the impact of railroad deregulation upon coal rates

[13]U.S. Department of Energy, Energy Information Administration, *Annual Report to the Congress, 1979,* Volume 2, Table 2, p. 5.

[14]*Electrical Week,* November 24, 1980, p. 5.

[15]U.S. Department of Energy, Energy Information Administration, *Preliminary Power Production, Fuel Consumption and Installed Capacity Data for 1979,* DOE/EIA-0049(79), May 1980, pp. 38–39.

[16]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Tables 3 and 52, pp. 7, 125. Resources are based upon estimates of coal reserve recoverability; about one-half of the overall U.S. reserve base is estimated to be recoverable.

The United States Synthetic Fuel Corporation

The Energy Security Act (Public Law 96–294) of 1980 created the United States Synthetic Fuel Corporation (USSFC). The chief goal of the USSFC is to increase synthetic fuel production to the equivalent of at least 500,000 barrels of crude oil per day by 1987 and to 2 million barrels per day by 1992, and thereby reduce United States dependence on imported oil. The USSFC is empowered to provide financial assistance to the private sector for commercial synthetic fuel projects in the following order of decreasing priority:

1. Purchase agreements, price guarantees, and loan guarantees, up to 75 percent of the project cost.
2. Loans up to 40 percent of initially estimated project costs unless such limits would prevent the financial viability of the proposed project, in which case up to 75 percent would be authorized.
3. A minority equity interest, under partnership law, in a joint venture where the Government could provide up to 75 percent of project costs for commercial modules prior to approval of the comprehensive strategy.

The USSFC is authorized to operate for 12 years and has been budgeted at $88 billion. The Corporation is initially authorized to spend $20 billion in fiscal year 1981; additional appropriations will be allocated by the Congress. Funding for the Corporation is to be distributed from a U.S. Treasury account known as the Energy Security Reserve. These funds will stem from windfall profits tax collections.

Before the Congress authorizes appropriations in excess of the initial $20 billion, the USSFC must submit to the Congress a comprehensive strategy for the achievement of the national synthetic fuel goals. This proposal must be submitted by 1984. Prior to submitting a comprehensive strategy, the USSFC is authorized to own unique facilities using new technologies for energy production. Under certain limited conditions, the Corporation may acquire control or purchase and lease synthetic fuel projects over a 5-year period. In addition, a maximum of two synthetic fuel projects may be constructed by the Corporation prior to enactment of the comprehensive strategy. Funding for these projects is limited to 10 percent of the Corporation's available appropriations and is subject to congressional approval.

- Access to potential mining land, particularly Federal lands, which contain about 34 percent of domestic coal reserves[17]
- Regulation of strip mining
- Social, economic, and ecological problems that might develop as a result of rapid development of coal lands in the Western States
- The levels of State severance taxes on coal, particularly in the Western States.

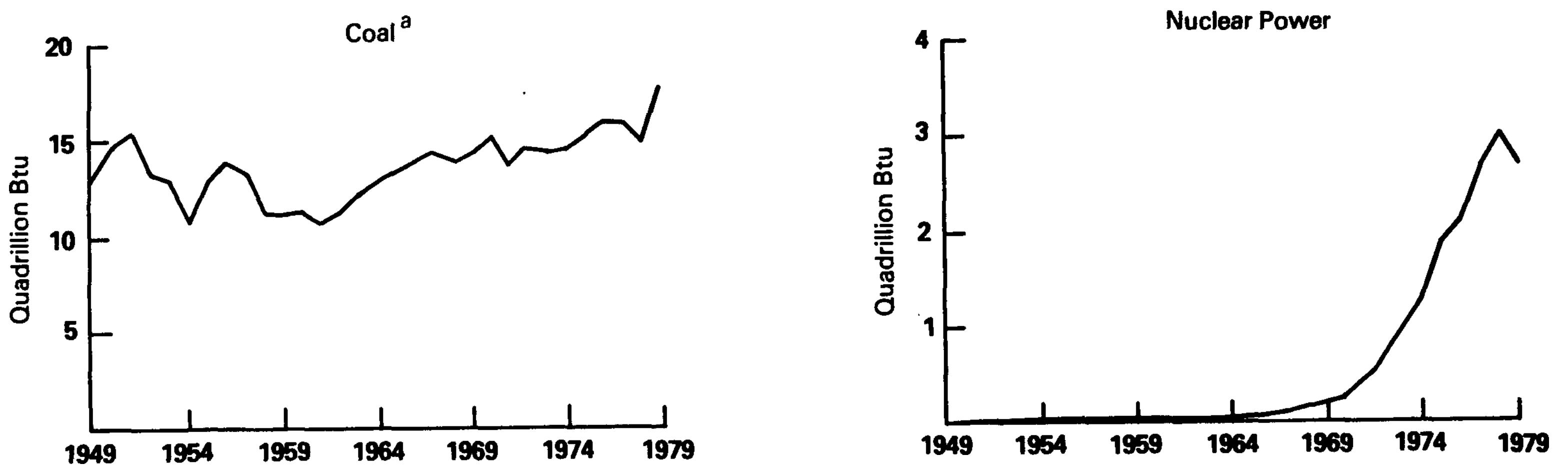
While not all of these topics are discussed here, they must be noted as major issues surrounding large-scale increases in coal production.

The growth in nuclear power, as shown in Figure 3.4, cannot be attributed to increases in oil prices because construction of nuclear plants operating during the late 1970's began before the 1973–74 oil embargo. Construction of the first U.S. commercial nuclear generating facilities began in 1956. By 1978, 71 commercial nuclear generating units[18] were supplying about 13 percent of the electricity generated in the United States. Nuclear plants accounted for 20 percent of the increase in U.S. commercial electrical generating capacity during 1970–78.[19]

[17]Edward Porter, *The Use of Federal Lands for Energy Development,* U.S. Department of Energy, Energy Information Administration, DOE/EIA–0201/8, March 1980, p. 10.

[18]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Tables 65, p. 155.

[19]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Tables 66, pp. 157.



[a]Bituminous, lignite, and anthracite.

Sources:
U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 2, page 5, and *Monthly Energy Review*, December 1980, Executive Summary, page 4.

Figure 3.4 Domestic Production of Coal and Nuclear Power, 1949–79

As in the case of coal, there are a number of public policy issues associated with nuclear power:

- Concern with the consequences of nuclear accidents and the adequacy of Nuclear Regulatory Commission regulations for reactor design and safety
- Safeguards on the transportation and handling of nuclear materials
- Disposal of nuclear waste
- Federal support for R&D on technologies for reprocessing spent fuel and the fast breeder reactor
- Long periods required to gain approval from various regulatory authorities for construction of new nuclear plants.

None of these issues is new, but they have become of intense concern since the accident at Three Mile Island in 1979.

FORECASTS OF DOMESTIC ENERGY SUPPLY

Table 3.3 presents the EIA middle world oil price forecast of U.S. energy production in 1990. While the forecasted growth in gross domestic energy supply is fairly rapid, this aspect taken alone is somewhat misleading. Gross energy production is computed by stating the amounts of various energy sources produced in terms of their Btu heat content. However, some of the gross supply is consumed during transformation into other forms of energy prior to final use (in particular, the transformation of coal and other fuels into electricity by electric utilities) or lost in transmission. The net energy consumption forecasts take account of these losses and, at the same time, include energy imports from abroad. As discussed in later chapters, forecasted net energy consumption increases much less rapidly than gross energy supply because an increased proportion of end-use consumption is satisfied by electricity.

Table 3.3 U.S. Gross Domestic Energy Production: 1978 and Midprice Case Forecast for 1990[a]
(Quadrillion Btu)

Source	1978	1990
Oil and Natural Gas Liquids[b]	20.4	20.2
Natural Gas[b]	19.8	17.0
Coal[b]	15.0	28.1
Nuclear Power[c]	3.0	8.0
Other[d]	3.0	3.6
Total	61.1	76.9

[a]Sum of components may not equal total due to independent rounding.

[b]1978 gas production includes both conventional and synthetic gas; historical oil is net of that used in production of synthetic gas; forecasts include production of both synthetic and conventional oil and gas. Coal is net of that used in production of synthetic oil and gas.

[c]Thermal value of input to electricity generated by nuclear power (11,000 Btu per kWh).

[d]Thermal value of input to electricity generated from hydroelectric (10,000 Btu per kWh), geothermal, and utility solar sources.

Source: Historical data derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1980, Volume 3*: Supplement.

In the domestic energy supply forecasts, oil and gas remain important fuels. However, other forms of energy, particularly coal, are projected to become increasingly important.

Production of coal in 1990 is forecast to be nearly twice that of 1978. Much of this increase represents expanded use of coal by electric utilities, which is forecast to increase 78 percent by 1990. This projected increase reflects, first, increases in the price of oil relative to coal and, second, the effects of the Powerplant and Industrial Fuel Use Act (FUA), which restricts the use of oil and gas by powerplants and other large boilers.

Production of nuclear power is also forecast to increase rapidly. Forecasted nuclear power production in 1990 is about 167 percent above its 1978 level.[20] The forecasted growth from other sources—hydroelectric power, geothermal, and utility solar—is much slower, but still results in 20 percent greater supply from these sources in 1990 compared to 1978. Hydroelectric power continues to remain the largest of these sources, although geothermal power is growing more rapidly. Some electricity is also produced from wood, wood waste, and solid waste, but the proportion from such sources compared to the total is small.

Domestic oil and gas production is not forecast to increase. Production of crude oil and natural gas liquids is forecast to be slightly lower in 1990 compared to 1978. Although natural gas output has been essentially constant since 1974, it is forecast to be 14 percent lower in 1990 than it was in 1978, due to the depletion of older producing areas.

[20]U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Tables 57 and 66, pp. 139 and 157.

Beneath the broad similarity between the forecasts in Table 3.3 and recent experience, there are a number of significant shifts in the location of production and among the resources from which domestic energy supplies are derived. These shifts are interesting in themselves and serve as important illustrations of shifting production patterns in response to changes in the relative costs of different energy sources.

The most dramatic of these changes is seen in the forecasted geographic pattern of coal production. Coal production levels in both the East and the West are projected to increase, but by much larger amounts in the West. In 1963, 96 percent of all coal produced in the United States was mined east of the Mississippi River.[21] By 1978 that proportion had declined to 73 percent,[22] and by 1990, western production is projected to amount to fully 44 percent of total U.S. production. The large forecasted expansion in western coal occurs because of cost differences. While most eastern coal production is projected to be extracted by underground methods, much western coal lies in thick seams relatively close to the surface on gentle slopes. These deposits are suitable for less expensive surface mining techniques.

Table 3.4 shows the composition of domestic production of crude oil in 1978 and the forecast for 1990. Immediately apparent is a sharp decline in projected production from the Lower-48 States by conventional production techniques. This decline results from the depletion of the oldest producing reserves. The loss of this traditional production is, however, largely offset by projected increases in production from Lower-48 offshore fields and northern Alaska, as well as from more intensive exploitation of older fields by using enhanced oil recovery techniques. By 1990, the production of oil from shale and tar sands is projected to appear in quantity. However, forecasted production of synthetic oil from coal in 1990 remains very small.

The composition of natural gas supply in Table 3.5 shows similar changes. Alaskan natural gas is projected to become important upon completion of the pipeline from Alaska to the Lower-48 States—this is assumed to occur by 1986. Lower-48 onshore gas production is forecast to decline, whereas offshore production, synthetic gas production, and production from unconventional sources become significant in 1990.

The forecasts reported here imply that by 1990 about 12 percent of domestic oil and gas will be produced by using unconventional techniques, or from unconventional resources through the use of enhanced recovery methods. This estimate serves to put the future role of unconventional resources into perspective. Currently, the amounts of oil and gas derived from unconventional sources is very small. But by 1990, it is forecast that production of oil and gas from unconventional resources will yield about the equivalent of nearly 1 million barrels of oil per day. This suggests that oil and gas production from unconventional resources will be an important component of future domestic supplies.

Table 3.4 Composition of U.S. Oil and Natural Gas Liquids Production: 1978 and Midprice Case Forecasts for 1990
(Percent)

Source	1978	1990
Conventional Oil Production		
Lower-48 States Onshore	60	49
Lower-48 States Offshore	11	11
North Alaska	11	17
Natural Gas Liquids	15	10
Enhanced Oil Recovery	3	11
Shale and Tar Sands	—	2
Synthetic Oil from Coal	—	—

— = Not applicable.
Note: Percentage distribution is volumetric and may deviate slightly from the distribution by heat content. Sum of components may not equal 100 percent due to independent rounding.
Source: Historical data derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1980, Volume 3:* Supplement.

Table 3.5 Composition of U.S. Natural Gas Production: 1978 and Midprice Case Forecasts for 1990
(Percent)

Source	1978	1990
Lower-48 States	99	81
North Alaska	—	6
Unconventional[a]	—	8
Synthetic Gas from Coal	—	6

[a]Includes production from tight sands and Devonian shale.
— = Not applicable.
Note: Sum of components may not equal 100 percent due to independent rounding.
Source: Historical data derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1980, Volume 3:* Supplement.

[21]U.S. Department of the Interior, Bureau of Mines, *Mineral Yearbook—Coal: Bituminous and Lignite,* by W. H. Young and J.J. Gallagher, 1965, pp. 16–17.

[22]Derived from U.S. Department of Energy, Energy Information Administration, Midterm Energy Forecasting System (MEFS), 1978 historical base case.

ALTERNATIVE SUPPLY ASSUMPTIONS

The assumptions underlying the forecasts presented above can be usefully grouped into three categories:

- Assumptions that indirectly lead to changes in energy production from various sources through changes in levels and composition of demand as caused by changes in relative energy prices
- Geological, technological, and economic factors that govern energy production costs
- Government policies and programs that directly affect energy supply.

Table 3.6 reports results obtained for different assumptions on some of the important topics within each of these categories.

The production of oil and natural gas in 1990 is forecast to be 10 percent higher and 3 percent lower, respectively, in the "high" world oil price case than in the "low." Since the real world oil price in 1990 for the high case is forecast to be

Policy on Leasing of Federal Coal Lands

Most land owned by the Federal Government is in the West, and it contains significant amounts of coal deposits. Estimates of coal on Federal lands vary, but some have placed such coal reserves as high as 75 percent of all the coal west of the Mississippi River, and 40 percent of the total U.S. coal.

The U.S. Department of the Interior, acting under the authority of several statutes, manages the leasing of Federal lands for development of resources contained on them. In 1971, the Secretary of the Interior announced a moratorium on coal leasing, and consequently, leases were not granted for about 2 years. In 1973, a new short-term leasing policy was announced. Under this policy there was a complete moratorium on the issuance of new prospecting permits, and new leases were issued only to maintain existing mines or to provide for production in the near future. Also, in 1973 a long-term plan to develop a new coal leasing system was announced. This plan was modified by the Federal Coal Leasing Amendments Act of 1976, which, among other things, largely abolished noncompetitive leasing from valid existing prospecting permits, strengthened diligence, i.e., development, requirements, established standards for consolidating leases into "logical" mining units, and limited lease holdings per person to 100,000 acres nationwide. Other legislation—the Federal Lands Policy and Management Act of 1976—provided the Bureau of Land Management, within the U.S. Department of the Interior, with a statutory framework for land use planning in conjunction with the disposal of Federal lands. In 1977, the Surface Mining Control and Reclamation Act established uniform minimum standards for regulating surface mining and reclamation activities, and a procedure for designating certain lands unsuitable for all or certain types of mining operations.

The new leasing policies require an environmental assessment and an Environmental Impact Statement before issuance of two types of leases. Applications pending for leases under existing prospecting permits will be issued. New leases also may be issued, but the procedures differ from previous policies in that the Secretary of the Interior determines the rate and order of lease offerings, and leases will entail rentals of at least $3 per acre annually and royalties of at least 12.5 percent for surface mining and 8.0 percent for deep mining. Once in operation, health, safety, and environmental regulations are enforced by the Bureau of Mines, the Office of Surface Mining, and the U.S. Geological Survey. The U.S. Department of the Interior has announced plans to resume leasing under this new program in 1981. The Department approved competitive sales of five Federal coal leases, and the sales were held in March 1980. These leases cover 3,392 acres in Alabama, North Dakota, Utah, and Wyoming; all of the applicants are companies operating near the lease areas. The rationale for these sales was a concern that Federal coal would be bypassed completely if it were not removed by private operators currently producing coal from mining operations adjacent to the deposits.

Table 3.6 Forecasted Domestic Gross Energy Production in 1990 under Alternative Assumptions
(Quadrillion Btu)

Fuel	Oil Price Assumption			Low Finding Rates	Coal Leasing Moratorium
	Low	Middle	High		
Oil[a]	19.2	20.2	21.1	17.7	20.2
Natural Gas[a]	17.2	17.0	16.8	15.8	17.0
Coal[a]	28.0	28.1	28.2	28.5	28.0
Nuclear[b]	8.0	8.0	8.0	8.0	8.0
Other[c]	3.6	3.6	3.6	3.6	3.6
Total	76.0	76.9	77.6	73.7	76.6

[a]Forecasts include production of both synthetic and conventional oil and gas; coal used in production of synthetic oil and gas is excluded.
[b]Thermal value input to electricity generated by nuclear power (11,000 Btu per kWh).
[c]Thermal value input to electricity generated by hydroelectric, geothermal, and utility solar power (10,000 Btu per kWh).
Note: Sum of components may not equal total due to independent rounding.

about 53 percent higher than the price in the low case, these production changes are not very large. The availability of Federal lands, which may contain approximately 32 percent of the undiscovered oil and gas in the United States, and long leadtimes needed for finding and developing new resources moderate the price responsiveness expected during 1980 to 1990. The effect of price on oil imports, however, is substantial. Forecasted oil imports in 1990 are approximately 38 percent lower in the high price case than in the low. This forecast reflects the projections of somewhat greater domestic oil production and lower energy consumption in the high price case.

The second case shown in Table 3.6 assumes lower "finding rates" for oil or gas. The finding rate is the ratio of the new annual additions to proved reserves of oil and gas to the number of exploratory drilling feet (including unsuccessful wells) required to discover those reserves. This provides a rough measure of the difficulty—or cost—of developing new oil and gas reserves. The amount of oil found will very likely decline as exploratory drilling proceeds because the most promising prospects will be drilled first, leaving the less attractive possibilities for development when real prices are higher. Recently reported finding rates indicate that 20 barrels of oil, on average, are found for every foot of exploratory well drilled.[23] This level is high relative to the experience of prior years. The forecasts reported in the preceding section are based on data including those recent finding rates. In the case considered in Table 3.6, however, initial finding rates were reduced to 1978 levels and, therefore, do not reflect recent increases. The result of the lower assumed finding rate for oil is to reduce forecasted oil production in 1990 by 12 percent. Forecasted natural gas production in 1990 declines by 7 percent.

A final case in Table 3.6 concerns Federal coal leasing policies. About 75 percent of western coal deposits, projected to produce 50 percent of total coal production in 1990, are on Federal lands. Although Federal lands are important sources of oil, gas, and coal production, the enormous increase in western coal production is a fundamental feature of the forecasts. The basic forecast assumes that western lands will be available for development as needed. However, Federal leasing in general, and leasing of western coal lands in particular, has had a long and complex history. Effectively, a moratorium on leasing existed from 1973 to 1979. The case shown in Table 3.6 assumes that this moratorium is maintained through 1990.

The effect of this assumption on the forecast of total coal production is not large. But as shown in Table 3.7, the assumed moratorium does result in a large decrease of forecasted coal production in the West and an almost equally large increase in the East.

CONCLUSIONS

The alternative cases that have been discussed do not essentially alter the picture presented in the

Table 3.7 Regional Distribution of Coal Production under Alternative Federal Leasing Policy Assumptions: 1978 and Midprice Case Forecasts for 1990
(Percent of Total Domestic Coal Production)

Assumption	1978		1990	
	East	West	East	West
Midprice Case	72.5	27.5	55.8	44.2
Leasing Moratorium	—	—	60.1	39.9

— = Not applicable.
Source: Historical data from U.S. Department of Energy, Energy Information Administration, Midterm Energy Forecasting System (MEFS), historical base case.

[23]Derived from Table 3.1 of this chapter, the American Petroleum Institute and *Quarterly Review of Drilling Statistics;* statistic equals reserve additions divided by total exploratory footage.

midprice case forecast for 1990, which can be summarized as follows:

- Declining production of crude oil and natural gas from conventional resources, with production increasingly coming from northern Alaska rather than from the Lower-48 States
- Substantial growth in oil and gas production from unconventional resources, resulting in total oil production declining only slightly from its 1978 production level, but natural gas production declining significantly
- Very large increases in production of coal and nuclear power
- Slow growth in energy supply after accounting for conversion losses and imports.

4. Changes in Energy Use

This chapter discusses how energy use has changed in recent years, why these changes have occurred, and what the future trends in energy use may be. Higher real energy prices and Federal conservation programs have already led to reductions in average energy consumption. The energy consumption forecasts indicate that higher real energy prices and conservation programs will lead to even greater future reductions in energy intensity by each sector of the economy.

TRENDS IN ENERGY CONSUMPTION BEFORE AND AFTER THE EMBARGO

By the early 1970's, patterns of energy use reflecting both relatively low prices and plentiful supplies had been woven into the fabric of nearly every aspect of the U.S. economy. The design of productive equipment and other capital goods, residential and commercial location patterns, individual travel habits, and many other aspects of everyday life reflected relatively low and stable energy prices.

Between 1950 and 1972, real gross national product (GNP) grew at an average annual rate of 3.6 percent, while total energy consumption grew 3.5 percent annually.[1] The result was a slight decline in the energy intensity of the economy, from 38.1 thousand Btu per dollar of real GNP (in 1979 dollars) in 1950 to 37.0 thousand Btu per dollar of real GNP in 1972.[2] The major source of decreasing energy intensity was in the industrial sector, where changing product mix and technological changes reduced energy use per dollar of output. Consumption of energy in transportation did not grow as fast as GNP between 1950 and 1972. In contrast, the use of energy in the household and commercial sectors grew somewhat more rapidly than real GNP.[3]

With the 1973–74 embargo, the United States began adapting to an economy and lifestyle corresponding to much higher real energy costs. Some important elements of this process can be accomplished quickly, while others require more time. Some important shortrun and longrun aspects of this adaptation process are listed below in order of increasing time required:

1. Immediate changes in individual behavior, such as turning back thermostats in winter, combining travel trips, or turning off lights.
2. Substitution of domestic fuels for imported oil.
3. Retrofitting of existing capital stock either to improve energy efficiency or to enable conversion to other fuels.
4. Replacement of older, energy-inefficient equipment and structures by new, more energy-efficient, capital stock.
5. Development of new energy-using technologies and new energy sources.
6. Substitution of advanced communication techniques for individual travel and new housing patterns which require less individual automobile travel.

The United States is currently about 6 years into the era of higher energy costs. During these years, there have been substantial adjustments of the first four types listed. Although further changes will continue in the future, the importance of the adjustments already made are evident in the fact that total energy consumption increased by less than 1 percent per year between 1973 and 1979.[4]

Compared to the 1949–72 period, the growth in energy use fell dramatically after 1973, and the

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[1]Calculated from data base of the Data Resources, Inc. (DRI) Econometric Model of the U.S. Economy.

[2]Calculated from data base of the Data Resources, Inc. (DRI) Econometric Model of the U.S. Economy, and U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 3, p. 7.

[3]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 4, p. 9.

[4]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 3, p. 7.

energy intensity of the economy decreased from 36.5 thousand Btu per dollar of real GNP (1979 dollars) in 1973 to 32.9 thousand Btu per dollar of real GNP in 1979. (See Table 4.1.) All sectors contributed to the decreased growth in energy consumption after 1973. Industrial consumption decreased by more than 1 percent per year, and residential and commercial consumption remained near 1973 levels through 1979. Transportation energy use and energy lost in generating and transmitting electricity continued to grow between 1973 and 1978, after a brief decline in 1974. However, the growth rates of these two uses were much lower than their pre-1973 rates, and in 1979 the level of energy consumption in the transportation sector actually *decreased* from the 1978 level in response to large gasoline price increases.

FORECASTS BY SECTORS

Table 4.2 and Figure 4.1 present forecasts of energy consumption as well as historical consumption data. Domestic energy consumption is projected to be only 11.2 percent greater in 1990 than in 1978. Furthermore, modest decreases in *total* consumption are forecast for three sectors—residential, commercial, and transportation. Energy consumption by the industrial sector is forecast to be larger in 1990 than it was in 1978, but energy use per unit of industrial output is forecast to decline substantially. Electricity generating and transmission losses are projected to grow, reflecting the forecasted growth in electricity demand.

The very slow rate of growth in forecasted total energy consumption, relative to the rate of economic growth, and the decline in some sectors,

Table 4.1 Average Annual Growth Rates of Sectoral Energy Consumption Before and After the Embargo
(Percent per Year)

Source	1949–72	1973–79
Energy Use		
Residential/Commercial	4.3	0.1
Transportation	3.3	1.1
Industrial	2.7	–0.9
Total Net	3.4	0.1
Electricity Generating and Transmission Losses	5.6	3.4
Total Gross	3.7	0.7
Real Gross National Product	3.9	2.5

Sources: Energy use derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Tables 4 and 5, pp. 9 and 11. GNP from U.S. Department of Commerce, *Survey of Current Business*, selected issues.

Table 4.2 U.S. Energy Consumption: Historical Data and Midprice Case Forecasts for 1990
(Quadrillion Btu)

Year	Residential/ Commercial	Industrial	Transportation	Electricity Generation and Transmission Losses
1965	14.0	19.1	12.8	7.9
1973	18.8	24.0	18.9	14.0
1978	18.8	23.2	20.9	16.8
1990	18.3	26.9	18.6	23.0

Source: Historical data were derived from U.S. Department of Energy, Energy Information Administration, *State Energy Data Report: Statistical Tables and Technical Documentation, 1960 through 1978*, April 1980, DOE/EIA–0214 (78).

represent a continuation of trends already in progress. Nonetheless, they are extremely important because increased efficiency in energy use and shifts in fuel use patterns are involved in adaptation to higher energy prices.

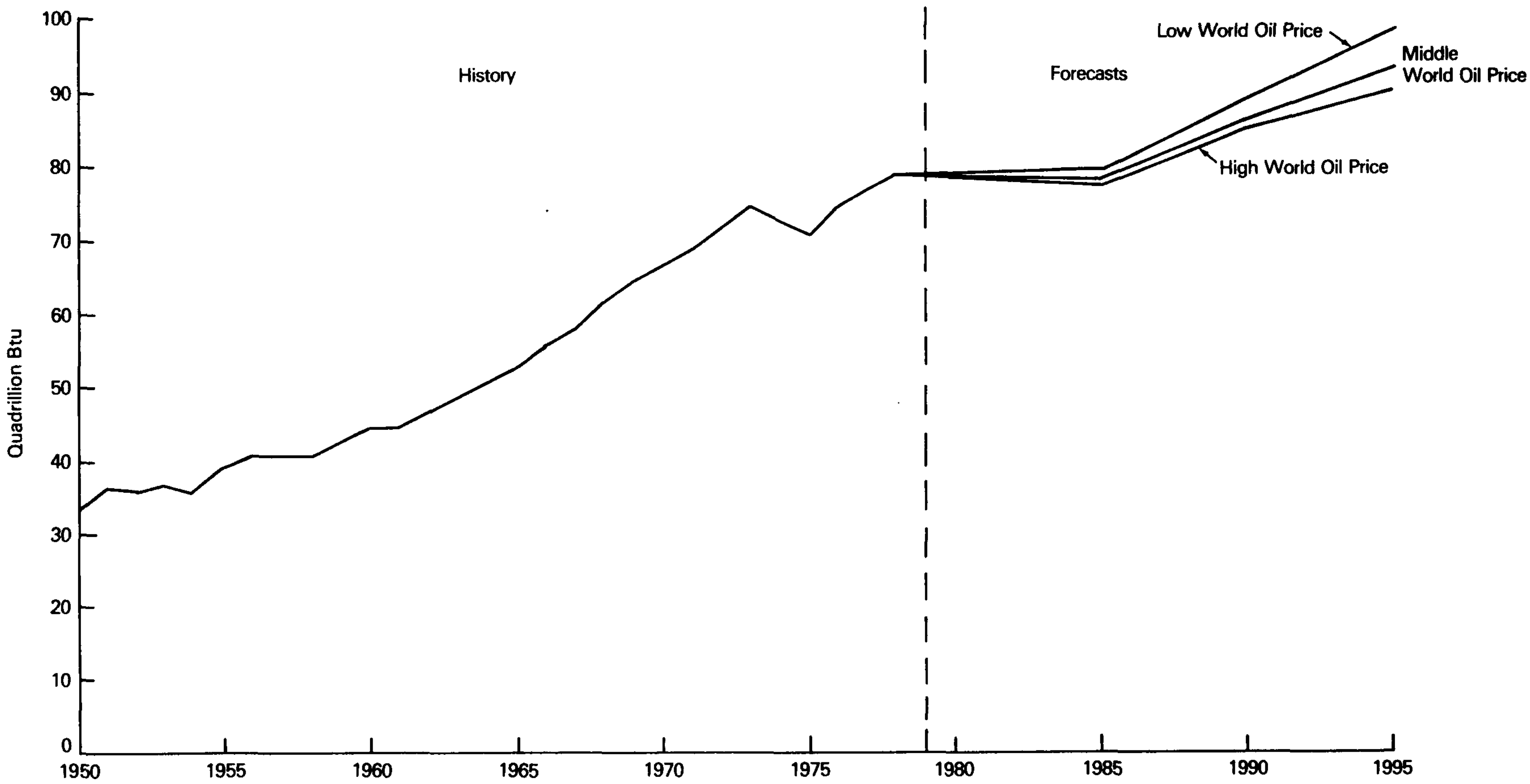
Transportation Sector

Data and forecasts of several factors that affect gasoline consumption, and of gasoline consumption itself, are presented in Table 4.3. Automobile ownership is projected to continue increasing during the 1980's, although at a slower rate than it did during the 1970's. This factor alone, however, would only result in a slower rate of increase in gasoline consumption. The decrease in gasoline use stems from the forecasts of substantial increases in expected fuel efficiency. Between 1978 and 1990, projected gasoline prices increase 7 percent annually. Annual vehicle miles traveled per automobile are projected to decline by about 3 percent over the period, and the fleet efficiency is forecast to increase from about 14 miles per gallon to over 22 miles per gallon.

Energy consumption by modes of transportation other than automobile is more directly related to general business activity and less responsive to changes in fuel prices. Thus, while projected gasoline consumption per capita falls by over 3 percent annually between 1978 and 1990, *total* transportation energy use per capita is forecast to decrease less than 2 percent annually.

Residential Sector

Residential energy consumption is forecast to remain roughly constant through 1990 despite



Sources:
Historical data from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2,* Table 4, page 9, and *Monthly Energy Review,* December 1980, Executive Summary, page 2.

Figure 4.1 Trends in U.S. Energy Consumption: Historical, 1950–79, and Forecasts, 1980–95

Table 4.3 Gasoline Consumption and Factors Influencing Gasoline Consumption: Historical Data and Midprice Forecast for 1990

Year	Automobiles per Capita	Average Fleet Miles per Gallon	Miles Traveled per Car (thousands)	Gasoline Price (1979 cents per gallon)	Automobile Gasoline Consumption (billion gallons)
1960	0.35	14.3	9.45	72.5	41.2
1973	0.51	13.3	9.77	61.1	78.0
1978	0.56	14.3	9.81	70.5	83.6
1990	0.59	22.3	9.50	158.5	57.7

Sources: Historical data were derived from Federal Highway Administration statistics, and Department of Energy, Energy Information Administration, *State Energy Data Report: Statistical Tables and Technical Documentation, 1960 through 1978*, April 1980, p. 18.

growing population and rising income levels. As a result, the energy intensity of the residential sector is projected to decrease. This decreased intensity is illustrated in Table 4.4, which shows that residential energy use per household is projected to decline by about 25 percent between 1978 and 1990. In contrast, between 1960 and 1973 energy use per household increased by nearly 14 percent.

The projected decreases in residential energy intensity result from several factors:

- Higher average energy prices, projected to grow at about 5 percent annually, in the residential sector
- Economic impacts of conservation and renewable resource programs
- The approach to market saturation of several types of appliances
- Increases in the efficiency of energy using equipment and better housing insulation
- Slight increase in the number of households living in multifamily dwellings, which are substantially more energy efficient than single-family dwellings.

Table 4.4 Residential Energy Intensity and Prices: Historical Data and Midprice Case Forecast for 1990

Year	Net Energy Consumed per Thousand Households (million Btu)	Average Residential Energy Price (1979 dollars per million Btu)
1960	140	4.02
1973	160	3.85
1978	150	5.19
1990	110	9.43

Sources: Historical data were derived from U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, and Department of Energy, Energy Information Administration, *State Energy Data Report: Statistical Tables and Technical Documentation, 1960 through 1978*, April 1980, p. 15.

The most important of these factors are the direct effects of higher energy prices and the indirect effects of higher prices reflected in increases in the energy efficiency of appliances. Results reported in the Energy Information Administration 1980 *Annual Report to Congress*, Volume 3, imply that these two factors, in comparison to projections of use with constant prices and no conservation policies, explain about 70 percent of the difference in residential energy use. Most of the remaining 30 percent is attributed to renewable resource and conservation programs.

Commercial Sector

One useful indicator of commercial sector energy intensity is energy consumed per dollar of real GNP. On this basis, 1990 commercial sector energy intensity is forecast to be a little less than one-fourth its 1978 level. Since buildings use the most energy in the commercial sector, another useful indicator of energy intensity is energy use per square foot of commercial floor space. This measure is projected to decrease by 25 percent between 1978 and 1990. Both commercial energy intensity indicators increased slightly between 1960 and 1973. (See Table 4.5.)

The reductions in commercial sector energy intensity since 1973 and the projected further decreases by 1990 result from increased energy prices and Government conservation programs. Few Government conservation programs came into effect before 1978, so most of the reduction in energy use between 1973 and 1978 must be attributed to higher prices. When compared to projections made assuming constant real prices and no conservation programs, results reported in Volume 3 of the *Annual Report* imply that higher prices account for about 68 percent of the projected difference in the energy used in the commercial

Table 4.5 Commercial Energy Intensity and Price: Historical Data and Midprice Case Forecast for 1990

Year	Net Energy Consumed per Square Foot of Floorspace (million Btu)	Net Energy Consumed per Dollar of GNP (trillion Btu)	Average Commercial Energy Price (1979 dollars per million Btu)
1960	0.281	3.7	4.25
1973	0.283	3.8	3.77
1978	0.251	3.3	5.48
1990	0.189	2.4	9.52

Sources: Historical data were derived from U.S. Department of Commerce, *Survey of Current Business*, and Department of Energy, Energy Information Administration, *State Energy Data Report: Statistical Tables and Technical Documentation, 1960 through 1978*, April 1980, p. 16.

sector. Conservation programs and renewable resources account for the remainder.

Industrial Sector

Industrial energy use, which decreased after the oil embargo, is projected to grow modestly from 1978 to 1990. Unlike in the other sectors, the energy intensity of industrial production decreased during the preembargo period from about 50 thousand Btu per dollar of real value-added in manufacturing (1979 dollars) in 1960 to 37 in 1973. (See Table 4.6.) This decrease, which can be attributed to changing industrial product mix and technological improvements, was accelerated by increasing energy prices after the embargo. In the forecast, the energy intensity of industrial production continues to decline, but at a slower pace. The more dramatic response by industry to energy prices in 1973–78, while important, is of a one-time (housekeeping) nature (e.g., better boiler maintenance, insulation of steamlines). Further improvements will come more slowly as capital stocks of equipment are gradually replaced by more modern and energy-efficient equipment. Between 1978 and 1990, energy intensity is projected to decline from 32.5 to 24.6 thousand Btu per dollar of real manufacturing value-added. This decrease of 2.3 percent per year compares to the preembargo (1960–73) decline of 2.2 percent per year and the 1973–78 decline of 2.6 percent annually.

Table 4.6 Industrial Energy Intensity, Historical Data and Midprice Case Forecast for 1990

Year	Net Energy per Dollar of GNP (thousand Btu per dollar)	Net Energy per Dollar of Manufacturing Value-Added (thousand Btu per dollar)	Average Industrial Energy Price (1979 dollars per million Btu)
1960	13.0	49.6	1.64
1973	11.7	37.0	1.73
1978	10.0	32.5	2.98
1990	8.3	24.6	5.92

Sources: Historical data were derived from U.S. Department of Commerce, Census Bureau, *Annual Survey of Manufacturers* and *Survey of Current Business*, and U.S. Department of Energy, Energy Information Administration, *State Energy Data Report: Statistical Tables and Technical Documentation, 1960 through 1978*, April 1980, p. 17.

COMPOSITION OF ENERGY DEMAND

The forecasts presented above are focused upon total energy consumption by various sectors. Also of interest are changes in the composition of energy sources used.

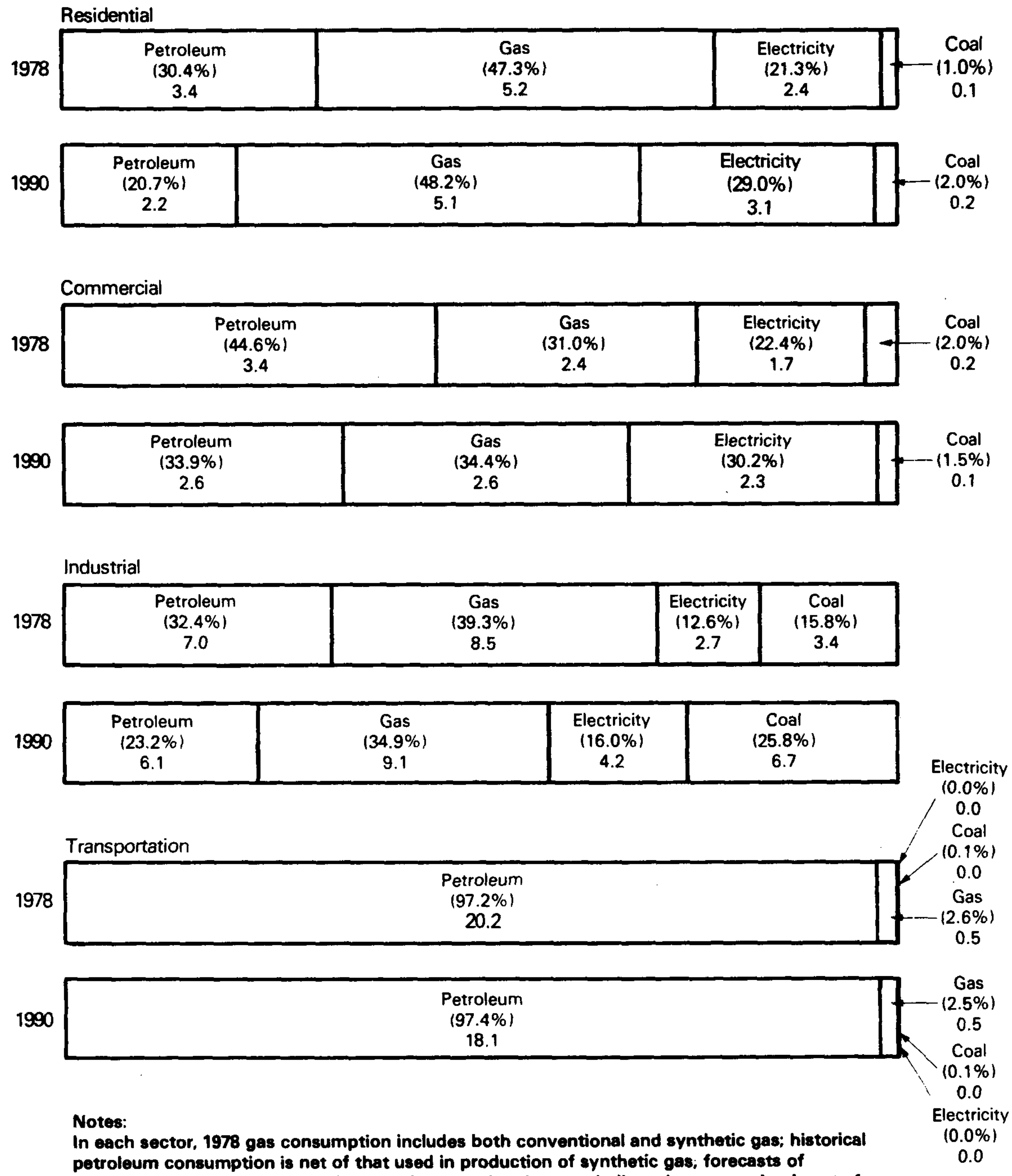
Figure 4.2 compares the composition of energy demand in 1978 with that forecast for 1990 for the transportation, residential, commercial, and industrial sectors. Two large shifts are evident in this figure:

- Increased use of electricity in all sectors except transportation
- Increased use of coal in the industrial sector.

Both features of the forecast are part of a single trend of decreased use of oil and increased coal use.

In addition to its environmental problems, there are several characteristics of coal that make it less desirable than alternative fuels such as oil and natural gas. These include the difficulties of transporting and handling, dealing with impurities, and a history of periodic labor-related supply interruptions. Coupled with the reasonably low prices of oil and natural gas, such factors discouraged the use of coal in most sectors during the preembargo period. Between 1949 and 1972 total coal use grew only at an average annual rate of 0.4 percent.

Underlying this seemingly stable consumption, however, were dramatic reductions in coal used by all sectors except electric utilities. During this period, coal essentially disappeared in the residential, commercial, and transportation sectors, decreasing from nearly 40 percent of total coal use in 1949 to little more than 1 percent by 1972. Industrial coal use also decreased dramatically



Notes:
In each sector, 1978 gas consumption includes both conventional and synthetic gas; historical petroleum consumption is net of that used in production of synthetic gas; forecasts of consumption include both synthetic and conventional gas and oil; coal consumption is net of that used in production of synthetic oil and gas.

Sum of components may not equal total due to independent rounding.

Source:
Historical data derived from U.S. Department of Energy, Energy Information Administration, Midterm Energy Forecasting System (MEFS), historical base case.

Figure 4.2 Composition of Net Energy Consumption by Sector: 1978 Historical Data and Base Case 1990 Forecasts (Quadrillion Btu)

from 44 percent of coal consumption in 1949, to 30 percent in 1972, and still further to 21 percent by 1979. In contrast, by 1979 utilities burned about 80 percent of total coal consumed, compared to less than 20 percent in 1949.[5]

After the oil embargo, coal prices increased at about one-half the rate of other fuel prices.[6] Between 1973 and 1978, the low price of coal relative to other industrial fuels had little effect on industrial fuel choice. However, this price advantage is projected to increase and to become a dominant factor in the choice of fuels for large industrial boilers and for electricity generation. The use of coal is forecast to increase over 5 percent per year between 1978 and 1990, with coal primarily replacing petroleum consumption. Coal is not, however, expected to regain a significant share of the residential, commercial, or transportation markets. The projected increases are in the industrial and utility sectors.

An indirect means of switching to more coal use is through increased use of electricity. During most of the post-World War II period, electricity was the fastest growing end-use form of energy in all sectors except transportation. Prices for electricity during the next decade are forecast to grow less rapidly than those for prices of most alternative end-use energy forms; correspondingly electricity is projected to claim a larger share of energy consumed in the residential, commercial, and industrial sectors.

The effect on oil demand of the projected increase in electricity consumption is enhanced by the growing use of coal and nuclear power as fuels for electricity generation. Electric utility fuel use patterns changed substantially between 1965 and 1978 as indicated in Table 4.7. In 1978, coal, while still the primary energy source, supplied 44 percent of electric utility fuel needs as compared to 53 percent in 1965. Coal's share had been declining in favor of oil and natural gas for some years. However, with the threat of sudden oil supply disruptions and higher future oil and gas prices, coal was again replacing their use by 1978. In addition, the Powerplant and Industrial Fuel Use Act (FUA) limits oil and natural gas use by all existing powerplants and prohibits construction of new oil- and gas-fired baseload plants. Following the accident at Three Mile Island in Harrisburg, Pennsylvania, virtually all expansion of nuclear powerplants was halted. However, completion of nuclear plants under construction will lead to large increases in the amount of electricity derived from nuclear power.

Table 4.7 Utility Fuel Use, Historical Data, and Base Case Forecasts for 1990
(Percent)

Fuel	1960	1965	1970	1978	1990
Coal	52	53	44	44	56
Oil	6	6	13	16	6
Natural Gas	22	22	25	14	2
Other[a]	20	19	18	26	36
Total	100	100	100	100	100
Total (quadrillion Btu)	8.1	11.0	16.3	23.3	32.6

[a]Hydroelectric, geothermal, nuclear, and utility solar.
Sources: Historical data derived from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Tables 2, 39, 46, and 63, pp. 5, 93, 113, and 151.

SENSITIVITY OF FORECASTS TO ALTERNATIVE ASSUMPTIONS

Table 4.8 reports forecasts of domestic consumption for the base case and several alternative assumptions. The cases reported include the major determinants of energy demand—the rate of real GNP growth and the level of world oil prices—and one alternative set of Government policies directed to conservation.

As described in Chapter 2, the midprice case assumes a macroeconomic forecast that implies an annual average growth of real GNP over the period 1978–90 of about 2.5 percent per year. This is about the average growth rate in GNP over the period 1973–78. The high and low macroeconomic forecasts, on the other hand, imply average growth rates of about 2.9 percent and 2.1 percent, respectively.

The differences in forecast consumption between the low and the high macroeconomic cases is pronounced. In the high case, forecasted consumption in the transportation sector is about 15 percent larger in 1990 than in the low case. The increase in forecasted consumption in the other sectors is smaller but still significant. Overall, forecasted total domestic energy consumption in 1990 in the high case is approximately 9 percent above the low case.

[5]Calculated from U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, Table 46, p. 113.

[6]U.S. Department of Energy, Energy Information Administration, state energy price data in Demand Analysis System.

Powerplant and Industrial Fuel Use Act of 1978

The Powerplant and Industrial Fuel Use Act (Public Law 95–620) was designed to reduce petroleum and natural gas consumption by electric utilities and large industrial boilers and to encourage greater use of coal and alternative fuels such as shale oil, uranium, renewable energy sources, byproducts of industrial operations, and synthetic oil and gas.

The Act applies to all new electric powerplants and large industrial boilers and affects existing powerplants and large industrial boilers capable of consuming coal or other alternate fuel. It prohibits these plants from consuming oil or natural gas as a primary fuel source unless an exemption is granted. Permanent or temporary exemptions are granted if the cost of using coal or alternative fuels "substantially exceeds" the cost of consuming imported oil or if environmental restrictions prevent the use of coal or an alternative fuel. Permanent exemptions also may be granted to peakload powerplants or facilities using a mixture of oil or gas and coal or alternative fuels. Cogeneration facilities that cannot use coal, facilities used only for emergency purposes, and certain other facilities also qualify for permanent exemptions.

Temporary exemptions are granted to plants which by the end of the exemption period will be retired, switch to synthetic fuel, or switch to an innovative technology for burning coal. The Secretary of Energy is authorized to grant a temporary exemption to any powerplant if he or she determines the exemption to be in the public interest. Although temporary exemptions usually may not exceed 5 years, temporary exemptions—either based upon a future use of synthetic fuels or resulting from a lack of adequate coal or alternative fuel supplies—may extend beyond 5 years but no longer than 10.

The FUA also contains provisions designed to limit the use of natural gas in existing electric powerplants. Natural gas cannot be used as a primary energy source in existing electric powerplants after January 1990 unless the utility submits a plan for reducing its natural gas consumption by 1990 to 20 percent of its natural gas consumption in 1976. In any year prior to 1990, a powerplant may not consume a greater proportion of natural gas than its average in the period 1974–76.

Table 4.8 Forecasted Domestic End-Use Energy Consumption in 1990 Under Alternative Assumptions
(Quadrillion Btu)

Sector	Midprice Case	Growth in GNP: Low	Growth in GNP: High	World Oil Price Assumption: Low	World Oil Price Assumption: High	High Conservation
Residential	10.7	10.5	10.8	10.8	10.6	10.1
Commercial	7.6	7.3	7.9	7.7	7.5	6.9
Transportation	18.6	17.2	19.8	19.9	17.7	17.7
Industrial	26.2	24.9	27.0	26.7	25.7	26.1
Total	63.1	60.7	66.2	65.1	61.5	60.8

The second set of cases reported in Table 4.8 uses the low and high world oil price paths instead of the middle path. However, more is involved than simply a change in the world oil price path assumption. The macroeconomic forecast was modified to reflect the likely consequences for overall economic activity of different levels of world oil prices. The low and high world oil price cases include both the direct effects of the differing oil prices and the indirect consequences of these.

The effects of the low and high world oil price cases on domestic energy production forecasts were discussed in Chapter 3. These effects appeared as forecasted higher coal production and lower oil imports in the high world oil price case. Some explanation of these effects appears in Table

4.8. In the transportation sector, forecasted consumption is considerably lower in the high oil price case and is largely responsible for the forecasted drop in oil imports. In other sectors, forecasted energy consumption also is slightly lower in the high world oil price case.

The "high conservation" case was constructed by assuming that:

- Current automobile and light-duty truck mileage standards would be extended from 1985 to 1995 and increased over time
- Diesel automobiles would capture an increased share of the automobile market (35 percent of new car sales by 1990 instead of the midprice assumption of 20 percent)
- Efficiency improvements in the other transportation modes would increase roughly twice as fast as in the base case
- Residential and commercial buildings and appliances would become 20 percent more energy efficient than in the base case.

Under these assumptions, forecasted energy consumption in the residential sector in 1990 is about 7 percent lower than in the midprice case, while forecasted transportation energy use declines by nearly 5 percent.

CONCLUSIONS

The forecasts suggest that the energy consumption trends that began with the 1973–74 oil embargo will continue in the 1980's. Specifically, the forecasts show:

- A reduction in the intensity of energy use
- A substitution of coal for oil and gas as a primary source of energy.

Government programs play a role in these trends, but the dominant factor seems to be the response to the general postembargo increases in energy prices relative to other prices and to the increase of oil and gas prices relative to coal. As a generality, these responses to energy price changes can be explained by the economics of energy use—the choice of energy versus competing commodities on the one hand and the choices among alternative energy sources on the other—and the role prices play in economic decisionmaking. These projected trends, resulting from energy price changes, are especially distinct since they began with the price increases related to the 1973–74 oil embargo and are clear reversals of trends underway in the 1960's and early 1970's.

5. Household Energy Expenditures, Inflation, and GNP

Higher energy prices influence general economic conditions as well as the specific markets for energy products. The economic impacts of energy price increases are measured by changes in the overall level of prices, reduced economic activity (compared to GNP levels which would occur without energy price increases), and increases in energy expenditures by consumers. The ultimate magnitudes of these impacts depend upon the ways in which the economic system responds to the adjustment process in individual markets discussed in the preceding chapters.

The initial magnitude of economy-wide reactions to increases in energy price increases can be somewhat greater than the longrun effects. This is because adjustments to the higher energy prices often take many years, and sudden increases can be disruptive. Under such circumstances, compensatory Government monetary and fiscal policies may be attempted. Such policies will, in turn, affect economic performance, especially employment and inflation.

The first two sections of this chapter describe the implications of the forecasts (presented in earlier chapters) for household energy expenditures, the inflation rate, and GNP. The final section discusses the closely related issue of the effects of oil price decontrol.

HOUSEHOLD EXPENDITURES ON ENERGY

Prices paid by residential users for energy increased substantially during the 7 years since the 1973–74 oil embargo. For example, the average price of gasoline (in 1979 dollars) was about 61 cents per gallon in 1973; by late 1980, the price had nearly doubled. The average residential price of electricity increased by almost the same rate, and the increases in the average prices of home heating oil, natural gas, and bottled gas were even larger.

The 1990 forecast reported in Table 5.1 shows further increases in residential energy prices. These increases are largely explained by the forecast of higher world oil prices. In the midprice case, the real price of oil by 1990 is assumed to be 30 percent higher than the average price of oil in 1980, and in the high case 56 percent higher.

Energy price increases of the the 1970's and the forecast for 1990 are reflected in the historical data and projections of household expenditures reported in Table 5.2.[1] Between 1975 and 1979, median direct expenditures on energy by households in the United States increased from about $1,400 to $1,600 (in 1979 dollars). By 1990, direct expenditures for energy by the median household are forecast to increase to about $1,800.

[1]All household expenditure estimates, including both historical and projected, presented in the following pages are derived from the data base and/or simulation of EIA's MATH/CHRDS model (Micro Analytic Transfer to Households/Comprehensive Human Resource Data System). The model's data base includes historical sample data from both 1975 and 1979. Projections for 1990 are obtained from a model simulation in which projected income, energy prices, and energy consumption within the model are constrained to agree with MEFS assumptions and projections for the middle world oil price scenario developed for this report.

Table 5.1 Average Residential Energy Prices: Historical Data and Midprice Forecast for 1990
(1979 Dollars)

Energy Source	1975	1979	1990
Gasoline (dollars per gallon)	0.74	0.89	1.58
Electricity (dollars per thousand kilowatt hours)	41.76	43.40	57.94
Natural Gas (dollars per thousand cubic feet)	2.27	3.16	5.74
Fuel Oil (dollars per gallon)	0.51	0.73	1.20
Bottled Gas[a] (dollars per gallon)	0.32	0.50	0.83
Weighted Average (dollars per million Btu)	NA	NA	9.43

[a]Price of bottled gas is assumed to follow the price of fuel oil.
NA = Not available.
Sources: *State Energy Fuel Prices by Major Economic Sector from 1960 through 1977: Preliminary Report and Documentation*, July 1979, DOE/EIA–0190.

Table 5.2 Median Household Energy Expenditures: Historical Data and Midprice Forecasts for 1990

(Thousand 1979 Dollars)

Income Category	1975	1979	1990
Median Household			
Expenditures	1.4	1.6	1.8
Disposable Income (percent of)	10.2	10.6	11.8
Above Poverty Income Level			
Expenditures	1.5	1.7	1.9
Disposable Income (percent of)	9.7	10.0	10.9
Poverty Income Level[a]			
Expenditures	0.6	1.0	1.0
Disposable Income (percent of)	19.8	30.4	31.5

[a]Poverty status is defined in terms of money income in 1979 dollars for families and individuals rather than households. A poverty index is used based on an "economy" food plan, designed by the U.S. Department of Agriculture for "emergency or temporary use when funds are low." A family is classified as poor if its total money income is less than approximately three times the cost of the "economy" food plan. See U.S. Bureau of the Census, *Public Use Samples of Basic Records from the 1970 Census Description and Technical Documentation,* (Washington, D.C., 1972), p. 22.

Source: The data for 1975 and 1979 are estimates derived from U.S. Department of Energy, Energy Information Administration, MATH/CHRDS model historical data base.

Two points about these comparisons should be noted. First, the historical data and the forecasts reflect adjustments in consumption patterns made in response to both higher energy prices and Government programs. Second, the historical data and the forecasts only take into account direct expenditures on energy products themselves, such as gasoline, home heating oil, and electricity. They do not include the indirect effects of energy costs on other prices, nor do they include any transfers to households of windfall profit tax collections.

The forecast of energy expenditures by households with incomes below the poverty level requires an additional comment. In 1975, poverty households spent about 20 percent of their income on energy. By 1979, they spent 30 percent, and by 1990 the forecasts imply they will spend even more on energy—about 32 percent of their disposable income.

Historical data on household energy expenditures by region, and forecasts of these expenditures in 1990, are presented in Table 5.3. In 1979, median household energy expenditures were highest in the New York/New Jersey area and lowest in the West, where average household energy expenditures were more than 25 percent below those of New York/New Jersey. These same patterns continue in the forecasts. It is forecast that median household energy expenditures in

Table 5.3 Median Household Energy Expenditures by Regions: Historical Data and Midprice Case Forecast for 1990

(Thousand 1979 Dollars)

Region	1975	1979	1990
Median, United States	1.4	1.6	1.8
New England	1.6	1.9	2.2
New York/New Jersey	1.5	1.9	2.1
Mid-Atlantic	1.4	1.6	1.9
South Atlantic	1.2	1.4	1.6
Midwest	1.5	1.7	1.8
Southwest	1.2	1.4	1.7
Central	1.4	1.6	1.7
North Central	1.3	1.5	1.6
West	1.2	1.4	1.5
Northwest	1.3	1.5	1.5

Note: Excludes households having zero use of a particular fuel.

Source: Historical data were derived from U.S. Department of Energy, Energy Information Administration, MATH/CHRDS model, historical data base.

northeastern regions in 1990 will still be the largest and those in western regions the lowest.

The median household energy expenditures presented here hide a great deal of variation. Differences in climate and the availability of different energy sources are reflected in the regional expenditure estimates discussed above. Expenditures on energy also vary (1) between central cities and suburbs, (2) between urban and rural areas, (3) with family size and age, (4) with type of employment, (5) with availability of mass transit, and (6) with other factors. Large variations in energy expenditures are the rule rather than the exception.

IMPLICATION FOR INFLATION

Increases in the world price of oil often have been blamed for the rapid inflation experienced by the United States during the past 8 years. These increases were, in fact, *part* of the explanation for these high inflation rates, but there seems to be substantial agreement that they were not the dominant factor.

The forecasts reported in Table 5.4 provide an indication of the possible effects on inflation; real GNP; and disposable income of the high, medium, and low paths for the world price oil. These forecasts do *not* assume any sudden increases in the world price of oil such as occurred in 1974 and in 1979. It is also important to note they assume the Federal Government does not respond to differences in the world price of oil by making major changes in monetary policy or changes in

Table 5.4 Measures of Energy Market/Economic Performance

Performance Measure	1973	1978	1990 High World Oil Price	1990 Mid World Oil Price	1990 Low World Oil Price
Real GNP (billion 1979 dollars)	2,044	2,314	3,076	3,130	3,171
Consumer Price Index (1967 = 1.00)	1.33	1.96	5.52	5.35	5.15
Energy End-Use Costs Index (billion 1979 dollars per quadrillion Btu)	0.79	1.84	5.69	5.11	4.41
Net Energy Consumed (quadrillion Btu)	6.5	61.3	62.4	63.8	65.9
Energy Expenditure (billion 1979 dollars)	48.6	112.8	355.1	325.9	290.5
Energy Expenditures as a Percentage of GNP	2.4	4.9	11.5	10.4	9.2

Sources: Real GNP and CPI were derived from Data Resources, Inc. (DRI) U.S. economy model simulations reflecting impacts of the energy projections in the three world oil price scenarios and from the historical data base for that model. Simulations were based on DRI forecast TRENDLONG2005 and do not reflect BEA revisions of National Income Account series issued in December 1980.

Projected and 1978 energy prices and net consumption were derived from MEFS projections for the three world oil price scenarios and the MEFS historical data base; 1973 net consumption was derived from the EIA *Annual Report to Congress, 1979, Volume 2;* and the 1973 energy price was calculated from *State Energy Fuel Prices by Major Economic Sector, 1960 through 1977: Preliminary Report and Documentation,* July 1979, 320C–DOE/EIA–0190, using quantity weights from *State Energy Data Report, Statistical Tables and Documentation, 1960 through 1978,* April 1980, DOE/EIA–C21478.

Energy expenditures are the products of average energy prices and net consumption levels.

policy on taxation and spending. For this reason, the forecast should be understood as a description of a problem and not an inevitable outcome.

Rapid inflation is the outstanding feature of the forecast in Table 5.4. The base case forecast implies an annual average rate of increase of 8 percent in the Consumer Price Index (CPI). While this is somewhat less than the rate of increase in the CPI during 1980, an annual average rate of 8 percent compounded over a decade leads to the nearly 250 percent increase (over its 1978 level) in the CPI shown in Table 5.4.

Cast against this background, the differences between the forecasts are fairly small, although the 1990 world price of oil used in the high price case is about one and one-half times that of the low price case. This very large difference shows up clearly in the forecasts of energy producers' prices.[2] The effect on the much broader CPI is (as would be expected) much smaller, but the forecasted 1990 CPI in the "high price" case is about 7 percent above that for the low case.

These features of the forecast are only evidence of how *much* higher oil prices can affect the inflation rate. As such, they do not address the equally important—and very complex—question of *how* oil prices affect inflation and economic growth.

Several links between energy prices to the overall inflation rates are familiar:

- Energy prices contribute directly to both the consumer and producer price indices
- By adding to costs of production, increases in energy prices tend to result in increases in the price of many nonenergy goods and services
- By contributing to increases in the Consumer Price Index, energy prices create pressures for wage increases.

While all of these mechanisms are important, viewed alone they convey the misleading impression that there is an automatic link between energy prices and inflation.

One fundamentally important point is reflected in the forecasts in Table 5.4 for real GNP, net energy consumption, and expenditures on energy. Compared to the low price case, in the high price forecast energy expenditures are about $65 billion *higher,* while less energy is consumed and real GNP is about $95 billion *lower.* Thus, in the high price case, it is forecast that the United States would consume less energy and less of other goods and services and in that respect clearly would be worse off economically.

This feature of the forecast does not simply reflect the "inflationary impacts" of higher oil prices. Higher world oil prices mean that the

[2]This index is computed by calculating producer's cost for domestic energy imports minus exports and dividing this total by end-use energy consumption. The index thus measures the value of the flow of extracted domestic energy supply prior to refining, conversion, and distribution plus net imports.

United States must exchange more of its goods and services for any given amount of oil imports. As a result, adjustments away from oil imports and towards domestic energy sources and increased efficiency in energy use can be expected. But—*as compared to a situation of freely available oil supplies at lower prices*—these adjustments are costly. The additional costs are reflected in greater expenditures on energy and lower GNP.

From this perspective, higher energy prices are the effect rather than the cause of underlying technological, geological, and economic conditions. There is, however, another perspective in which sudden increases in world oil prices create an economic problem.

In the face of large increases in petroleum prices, both residential consumers and industrial firms tend to reduce oil consumption somewhat. But because typically these cuts are proportionately less than the increase in price, expenditures on oil increase. This, in turn, creates pressures for reductions in expenditures on other items. For consumers, this usually means postponement of purchases of consumer durables such as automobiles and appliances, while industrial firms may cut back on investment expenditures.

Large increases in world oil prices would also lead to offsetting increases in expenditures to the extent that:

- Dollars paid for oil imports are respent in the United States
- Higher prices and profits stimulate increased investment by energy producers
- Increased tax collections from producers' profits lead to increased Government spending or a smaller Government deficit.

However, these increases are likely to come more slowly than the reductions in expenditures on other goods and services by households and industry. A sharp increase in the world oil price could then lead to a reduction in net spending on nonenergy goods and services which, if substantial, would be recessionary.

On a technical plane, this prospect implies that an increase in oil prices (or energy prices generally) does not *necessarily* result in an increase in the inflation rate. If the recessionary forces induced by the increase in oil prices are strong enough, the rate of inflation could be constant or even decline as other prices fell (or rose less rapidly) in response to the collapse of demand for various nonenergy goods and services.

The actual results of past jumps in energy prices, however, have differed from this recessionary scenario significantly, at least in degree, because of the stimulative effect of the Government's policy responses, particularly the response of monetary policy. To contain the potential recessionary impacts of oil price increases, monetary policy has typically allowed increases in cash and bank credit sufficient to partly offset the negative impact of rising energy prices on consumption and investment demand for nonenergy goods. By seeking to avoid major recessionary impacts on output and employment through these policies, however, the Government also tends to "ratify" the inflationary impetus given to the general level of prices by rising energy costs.

The conclusion of these comments is that a sharp increase in world oil prices does not necessarily lead to a correspondingly sharp increase in the inflation rate. The extent to which rapid inflation would result will depend heavily on the policies, particularly the monetary policies, adopted by the Government.

EFFECTS OF DECONTROL AND THE WINDFALL PROFIT TAX

Focusing on the adverse consequences for inflation and employment of higher oil prices leads directly to the question of whether overall economic performance was helped or hurt by the imposition of oil price controls which were removed in January 1981. An analysis of this question appears in a study recently released by EIA entitled, *Energy Programs/Energy Markets.*[3] A brief summary of that analysis follows.

Controls on domestic crude oil prices, and the allocation of crude oil among domestic refiners, were imposed in substantially their present form in 1973. The authority for this action was the Emergency Petroleum Allocation Act (Public Law 93–159). In 1975, the Congress passed the Energy Policy and Conservation Act (EPCA) (Public Law 94–163), which required that crude oil price controls and the related allocation program be terminated as of September 30, 1981. The EPCA also gave the President the authority to institute a phased program of decontrol under which the controlled prices were gradually increased to the levels of market prices. In July 1979, President

[3]U.S. Department of Energy, Energy Information Administration, *Energy Programs/Energy Markets—Overview*, July 1980, DOE/EIA-0201/16.

Carter exercised this option and instituted a phased decontrol program. In January 1981, President Reagan removed the controls completely.

At about the same time the phased decontrol program was announced, President Carter recommended to the Congress a number of energy programs. One of these, closely related to decontrol of oil prices, was the Crude Oil Windfall Profits Tax Act (Public Law 96-223) enacted in 1980.

Accordingly, the analysis in *Energy Programs/Energy Markets* considered two cases:

- A "current programs" case which assumed that the windfall profits tax would remain in place and that oil price and allocation controls would lapse at the end of September 1981
- A "continued controls" case which assumed that the windfall profits tax was never imposed, but that oil price and allocation controls would remain in place indefinitely.

For each case, forecasts of energy consumption and prices in 1990 were made. In the "continued controls" case, forecasted total net domestic energy consumption in 1990 is 2.5 percent *higher,* and forecasted domestic oil production in 1990 is nearly 14 percent *lower* than in the "current programs" case. Moreover, the combined effect of the higher forecasted energy consumption and lower forecasted oil production dramatically pushes up oil imports. In the "continued controls" case, the forecast for oil imports in 1990 is 42 percent higher than in the "current programs" case.

The macroeconomic implications of these two energy forecasts were investigated with a model of the U.S. economy that includes representations of supply responses by several broad sectors.[4] Results of the simulations for real GNP and personal consumption expenditures are presented in Table 5.5.

These forecasts suggest that—rather than improving the macroeconomic outlook—price controls on oil, continued over a period of years, tend to depress total output and consumption levels. In particular, forecasted real GNP in 1990 is nearly $40 billion lower in the "continued controls" case than it is for the "current programs" case. Likewise, forecasted real personal consumption expenditures are nearly $47 billion lower in the "continued controls" case. The overall inflation rate, as measured by the implicit deflator for personal consumption expenditures (not shown in the table), was even found to be very slightly lower in the "current programs"case—7.4 percent over 1980-90—as compared with 7.6 percent in the continued controls case.

Table 5.5 Real Gross National Product and Real Personal Consumption Expenditures: 1980-90 Forecast for the Current Programs and Continued Oil Controls Cases

(Billion 1979 Dollars)

Year	Real Gross National Product		Real Personal Consumption Expenditures	
	Current Programs Case	Continued Controls Case	Current Programs Case	Continued Controls Case
1980	2,340.0	2,334.5	1,496.2	1,491.9
1981	2,418.8	2,410.5	1,545.3	1,538.0
1982	2,519.3	2,508.2	1,608.1	1,597.7
1983	2,585.2	2,571.3	1,653.9	1,639.9
1984	2,643.3	2,626.8	1,693.7	1,676.3
1985	2,739.5	2,720.8	1,750.7	1,729.4
1986	2,854.8	2,832.1	1,813.8	1,788.5
1987	2,959.7	2,934.1	1,883.7	1,853.8
1988	3,024.3	2,994.5	1,936.1	1,901.0
1989	3,085.7	3,051.3	1,985.1	1,944.4
1990	3,173.0	3,133.6	2,037.3	1,990.5

Source: Data were derived from U.S. Department of Energy, Energy Information Agency, *Energy Programs/Energy Markets—Overview,* July 1980, DOE/EIA-0201/16, Table 5.3, page 50.

These results reflect a basic economic principle regarding the role prices play in guiding the decisions of producers and consumers. Oil price controls, when they are binding, keep market prices below the level that accurately communicates the cost of consuming imported oil. It can be argued that in the near term, price controls are nevertheless a proper means of dampening the potentially disruptive impacts of sudden price increases. Whatever the truth of this argument, the analysis shows that if the controls are indefinitely imposed, the longrun economic consequences are adverse.

Some mechanisms behind these longrun results are straightforward, and all of them in the final analysis trace back to the dramatically higher level of oil imports which occurs under domestic oil price controls. Because of higher oil imports, 1990 oil import payments in the "continued controls" case exceed those in the decontrol case by $31.2 billion. Similar, but smaller, differences in the oil import bills are also forecast for earlier years.

In the forecasts, these extra oil imports are assumed to be paid for by an increase in real

[4]This model, the nine-sector Dynamic General Equilibrium Model (DGEM), was developed by Dale Jorgensen Associates and provided under contract to the U.S. Department of Energy for its use.

exports by the United States. The distortion of prices away from actual costs, caused by oil price controls, is the key to explaining how exchange of real exports for the increased oil imports hurts the economy. When oil is imported, it is used in ways that contribute to total economic output, and the trade of exports for oil imports is not inherently a bad exchange. However, the full cost of imported oil under controls is not reflected in average crude oil prices paid by refiners because imported oil is averaged in with cheaper domestic crude oil. Consequently, under controls, oil is perceived as being worth considerably less than its true cost as an import. This disparity between prices perceived by domestic users and the true cost to the economy as a whole results in oil being used inefficiently. As a result of these inefficiencies, U.S. GNP is actually lowered, and the inflation rate slightly increased.

Two circumstances might temporarily lead to a divergence between events as they could develop and those projected. In one, there may be lags between the expenditure for oil imports and the consequent demand for domestically produced commodities as exports. As a result, the economic consequences of importing oil would be delayed, but not avoided. In the other, the purchasing power, created by the expenditure for oil imports, might not reemerge as a demand for currently produced export goods; instead, purchasing power may be traded for stocks or bonds issued by domestic enterprises, real properties, or government securities.

To the extent this occurs, the adverse economic impacts revealed by the analysis would again be delayed. This is because the value of stocks or debt instruments, or real property, represents a future flow of earnings to the holder. As a result, if the domestic economic system pays for oil imports with claims against future income, current imports might be paid for by an even greater value of future exports, since claims would usually reflect positive real rates of return to foreigners. If future income is properly discounted in the marketplace, such a delay is not necessarily a better (or worse) bargain for the national economy. Thus, analysis of decontrol—which assumes that oil imports are immediately paid for by exports—although a special case, nevertheless still reflects the basic economic impacts of continued price controls. More generally, even in cases where respending of petroleum money is delayed, events might alter the timing of the effects but not their basic character.

CONCLUDING COMMENT

The material presented in this chapter touches on three themes that have had a major role in discussions of energy policy:

- The distribution of gains and losses caused by higher energy prices
- The bearing of energy prices on the shortrun management of inflation and unemployment
- The longrun consequences of using energy price controls as a tool of overall economic management.

These points describe the major facets of the energy problem viewed from the perspective of overall economic management. They do not suggest the proper strategy to deal with these problems—an issue which has been and remains highly controversial.

6. Oil Imports and Disruptions in Oil Supplies

Oil imports were not regarded as a problem as long as oil prices were relatively low and sources of supply were secure. They came to be a problem during the 1960's and 1970's as imports supplied an increasing proportion of the U.S. oil supply and, especially, when the experience of the 1973–74 embargo and subsequent events (the Iranian revolution and Iran–Iraq war) called the security of supply into question. Beyond this, the ties among the Western countries make the possibility of supply disruption a major international problem.

THE ROLE OF PETROLEUM IMPORTS IN NATIONAL ENERGY SUPPLY

In 1978, approximately 50 percent of the energy consumed in the United States came from petroleum. Of this amount, 42 percent was imported either as crude oil or finished petroleum products. Thus, 21 percent of gross domestic energy consumption was supplied by imported petroleum. This proportion is up from 17 percent in 1973 and from less than 10 percent in the middle 1960's.

This trend is not projected to continue, however. Indeed, the level of imports has already begun to fall. The various adjustments due to increasing energy prices projected over the next decade for domestic energy consumption and production work to reduce significantly imported petroleum's share of total domestic consumption. The share of imported petroleum in total consumption in 1990 has been forecasted for three world oil price paths. This share ranges from 10 to 15 percent depending on the world oil price assumption considered. (See Table 6.1.)

As a point of reference for describing the effects of past and projected future increases in the world price of oil, a "very low" world oil price case was analyzed. For this case, it was assumed that the world oil price of crude remained at its 1979 price of approximately $20 per barrel in 1990. This lower price was found to retard the substitution of coal and other energy sources for oil and to provide little stimulus for increased domestic oil production. Compared to any of the other three cases, the "very low" price case leads to projections of higher oil consumption, lower domestic oil production, and hence substantially higher import levels—two to three times the level of imports projected for the three other price paths.

For example, in the "very low" price case of $20 per barrel, 3.6 million barrels per day *more* oil imports are projected for 1990 compared to the import level projected under the assumption of $32 per barrel (the "low" world oil price case). Of these

Table 6.1 U.S. Domestic Production and Consumption of Oil and Oil Imports, 1978 and Forecasts for 1990
(Million Barrels per Day)

				1990 World Oil Price			
Source	1973	1978	1980	High (49.00)	Mid (41.00)	Low (32.00)	Very Low (20.00)
Domestic Consumption	17.3	18.9	17.0	14.9	15.6	16.6	18.6
Domestic Production	11.3	10.9	10.8	10.6	10.2	9.7	8.1
Net Imports	6.1	8.0	6.2	4.3	5.4	6.9	10.5
Imports as a Percent of Oil Consumption	35	42	36	29	35	42	56
Imports as a Percent of (Gross) Energy Consumption	17	21	17	10	12	15	24

Sources: U.S. Department of Energy, Energy Information Administration, *Annual Report to Congress, 1979, Volume 2*, p. 43, Table 18, and *Monthly Energy Review*, February 1981, DOE/EIA–0035 (80/11).

additional imports, about 70 percent resulted from increased consumption of oil within the industrial and electric power sectors, combined with the decline in domestic production. At the $20-per-barrel price, the conversions from oil to coal and other sources in these two sectors are not projected to take place to the same degree as projected for any of the higher world oil prices. But a strong economic incentive to bear the many costs of switching from oil use to alternative sources of energy by utilities and industry is provided if oil prices rise to $32 per barrel (as they already have). About 80 percent of the reduction in consumption by utilities and industry between the $20 oil price projections and the $49 projections occurs in the $32 projections.

Factors other than oil prices also can influence the future level of imports. In Table 6.2, projected imports for 1990 are given for the alternative assumptions about oil and gas finding rates discussed in Chapter 3 and the alternative assumptions (discussed in Chapter 4) on alternative rates of growth in real GNP. Forecasted 1990 oil production in the case that assumes lower finding rates for oil and gas is about 12 percent lower than in the midprice case. Virtually all of this is reflected in higher oil imports. Hence, forecasted 1990 oil imports in the low finding rate case are 22 percent higher than in the midprice case. The forecasted average growth rates for the "high" growth, "mid," and "low" growth macroeconomic forecasts are 2.9, 2.5, and 2.1, respectively. These compare with an actual average annual growth rate during the period 1970–79 of 3.2 percent. The difference in forecasted oil imports for these cases is substantial. Compared to the midprice case, imports in 1990 are forecast to be 0.9 million barrels per day higher in the "high" GNP growth rate case, and 1.1 million barrels per day lower in the "low" GNP growth rate case. Looking back at Table 6.1, these differences are of the same order as those for the "high" and "low" world oil price paths.

All cases considered here—except the constant $20 per barrel case—differ from the 1950–77 experience in that U.S. oil imports are forecast to decline. However, imports are not forecast to decline to an inconsequential level. In the midprice case forecast, oil imports still account for over 35 percent of total U.S. oil supply (the same as 1973) and about 12 percent of total U.S. energy consumption (as opposed to 17 percent in 1973). The picture for 1990 presented by these forecasts, in short, is one of declining but still substantial use of imported oil.

ECONOMIC ASPECTS OF VULNERABILITY TO SUPPLY DISRUPTIONS

This section is a discussion of the extent to which U.S. economic vulnerability to oil supply disruptions is reduced by reductions in U.S. oil imports. In many respects, U.S. vulnerability to supply disruptions is lessened as oil imports decrease. There are other respects, however, in which U.S. economic vulnerability to supply disruptions is *not* closely related to the level of U.S. oil imports.

The immediate impact of a disruption in oil supplies would be curtailment of shipments of

Table 6.2 Forecasted Domestic Crude Oil and Natural Gas Liquids Consumption, Production, and Imports, 1990, for Alternative Assumptions[a]
(Million Barrels per Day)

Source	Mid-price Case	Low Finding Rates for Oil & Natural Gas	Coal Leasing Moratorium	Growth in GNP		High Conservation
				High	Low	
Domestic Consumption of Crude Oil and Natural Gas Liquids	15.6	15.6	15.6	16.5	14.4	14.7
Domestic Production[b] of Crude Oil and Natural Gas Liquids	10.2	9.0	10.2	10.2	10.1	10.1
United States Oil Imports[c]	5.4	6.6	5.5	6.3	4.3	4.6

[a]All cases shown use the midprice assumption on the path of the world price of oil.
[b]Domestic production includes refinery gains and losses.
[c]The difference between imports and the residual of domestic demand and supply is due to independent rounding.

crude oil from abroad to U.S. refiners. These reductions might be partially offset by increased production from areas not affected by the disruption. They also could be reduced by drawdowns of private inventories and withdrawals from the Strategic Petroleum Reserve. The net effect might be little or no reduction in supply. For example, as of this writing, the reductions in production due to the war between Iran and Iraq have had relatively small effects on world oil prices because of the high level of oil stocks and high levels of production in other countries.

Nevertheless, disruptions of supply that were sufficiently large or prolonged would show up in reductions in oil available to U.S. refiners. This would lead to reduced shipments of petroleum products to utilities, wholesale and retail distributors, and final users, and, in the absence of Government intervention, to sharp increases in petroleum product prices.

Disruptions of supply relationships and price increases would prompt attempts to conserve oil use, substitute other fuels for oil, and cause reductions in economic activity, all of which would be costly. The magnitude of the economic costs would depend on the size of the disruption but could be extreme. Given that imported oil supplies are in the neighborhood of one-fifth of *total* U.S. energy consumption, a total cutoff of imported oil would have effects so far reaching that they cannot be briefly characterized.

To the extent U.S. oil imports decline, a disruption of world oil supply of any given magnitude will have a smaller immediate impact on the U.S. refinery and petroleum distribution system. This is important because (apart from price increases) sudden disruptions of supply relationships cause costly and painful problems. The ability of the United States to insulate itself from the world petroleum market may also be greater to the extent U.S. oil imports are lower.

There are other ways in which the economic vulnerability of the United States to disruptions in oil supply is *not* closely related to U.S. oil imports. The most important of these can be categorized as the effects of supply disruption on oil prices; effects on trade and the international monetary system; and international agreements relevant to supply disruptions.

Since price effects were discussed in Chapter 5, they need be mentioned only briefly here. There are two underlying points that should be kept in mind. First, disruptions in supply not offset by increases in production in unaffected areas and withdrawals from inventory result in higher world oil prices. Second, in the absence of price controls, U.S. oil prices will increase to come into equilibrium with world oil prices. Because of this, the price effects of a supply disruption depend not just on the level of U.S. oil imports but on total U.S. oil consumption. Moreover, to the extent that prices of other energy sources rise, total expenditures on these fuels are also relevant. As was discussed in Chapter 5, the increased prices of oil (and perhaps other energy sources) reflect the increased scarcity of energy implicit in a disruption of oil supply. The U.S. is economically less well off as a direct result of this greater scarcity. Increases in the prices of oil and other energy sources also can create recessionary pressures.

These comments have focused on the strictly domestic aspects of disruptions in oil supplies. However, disruption of supply to any one country will affect all countries and, because of economic and legal links between the United States and other countries, the international implications of disruptions in oil supplies are at least as important as the strictly domestic aspects.

The Strategic Petroleum Reserve

In December 1975, legislation was enacted to establish a Strategic Petroleum Reserve (SPR) of up to 1 billion barrels: enough oil to replace imports from the Persian Gulf for 1 year.

The development of the Government-owned oil reserve is scheduled to achieve a total storage level of 750 million barrels of oil by 1989 in a secure and reliable system capable of crude oil withdrawal of up to 4.5 million barrels per day. Intermediate goals include the completion of facility development and storage of 248 million barrels by the end of 1982. The average daily drawdown capability will be approximately 1.7 million barrels per day.

Middle Eastern oil accounted for about 42 percent of the oil produced outside the Communist-bloc countries in 1978. Since virtually all oil produced in the United States, Western Europe, and Japan is consumed domestically, this figure understates the dependence of these nations on Middle East countries for oil imports. (See Table 6.3.)

The economies of Western Europe, Japan, and most developing nations are even more dependent

Table 6.3 Petroleum Production and Consumption by Region, for Non-Communist Countries, 1978 and 1979
(Million Barrels per Day)

Region	1978 Production[a]	1978 Consumption	1979 Production[a]	1979 Consumption
OPEC[b]	30.5	2.5	31.5	2.5
Persian Gulf	21.0	1.6	21.3	NA
Non-Persian-Gulf Arab States	3.3	0.2	3.4	NA
Other OPEC	6.2	0.7	6.8	NA
Major Industrial Countries	14.7	38.6	15.4	38.7
United States	10.8	18.8	10.7	18.5
Other[c]	3.9	19.8	4.7	20.2
Other Non-Communist[d]	4.6	9.8	5.0	10.9
Total, Non-Communist World[e]	49.8	50.9	51.9	52.1

[a]Production includes crude oil, natural gas liquids, and 0.5 million barrels per day in U.S. refinery gains.
[b]Persian Gulf countries include Iran, Iraq, Kuwait, Saudi Arabia, Qatar, and United Arab Emirates. Non-Persian-Gulf Arab States include Algeria and Libya. Other Organization of Petroleum Exporting Countries (OPEC) include Ecuador, Gabon, Indonesia, Nigeria, and Venezuela.
[c]Includes Australia, New Zealand, Canada, Japan, Western Europe, and U.S. territories.
[d]Residual free world production and consumption.
[e]Consumption differs from production due to stock changes and net exports from Communist countries.
NA = Not available.
Sources: U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review*, and *1979 International Energy Annual*; and Central Intelligence Agency, *International Energy Statistical Review*.

The International Energy Agency Emergency Oil Allocation Program

The goal of the International Energy Agency (IEA) emergency program is to attain "... common energy self-sufficiency in oil supplies." To meet this goal, the agreement calls for "each participating country to maintain emergency reserves sufficient to sustain consumption for at least 90 days, with no net imports." This commitment may be met through stockpiling, fuel switching capacity, or standby production capabilities. The agreement also calls on members to develop a program for reducing demand in times of emergencies.

The heart of the IEA is, however, a system for allocating available oil supplies among participating countries in the event of a supply disruption. Each country is given a supply right equal to its "permissible consumption"; that is, normal consumption adjusted for mandated demand restraints, minus its obligatory reduction in inventories. A country whose supply right exceeds its domestic production and net imports during an emergency will have a right to receive the difference as additional net imports from other members. Conversely, a country with permissible consumption less than its sum of production and net imports will be obligated to share this difference among the other IEA members. The emergency program is implemented only in the event of a shortfall in supply of at least 7 percent of average daily base period consumption levels.

on imported oil than the United States. Adverse effects of a disruption on their economies would reduce their purchase of U.S. goods and (via reduced exports) result in increased U.S. unemployment. The same can be said of the developing nations. Furthermore, many of the developing nations have borrowed heavily to meet the large oil price increases of the past 7 years. A major oil supply disruption would drastically reduce the abilities of these countries to service their debt and, hence, could put great pressures on the international monetary system.

Finally, the United States and 15 other nations joined together to form the International Energy Agency (IEA) in 1974. The IEA—now comprising 21 member countries—is designed to allocate oil supplies among members during supply disruptions as fairly and equitably as possible and to foster cooperative research efforts. More generally, the IEA would provide a forum for international cooperation on a variety of problems that would arise from a major oil supply disruption.

CONCLUSION

The forecasts presented here suggest that over the next 10 years U.S. oil imports will decline. Even under very optimistic assumptions, however, it appears that imported oil will still be a major component of both U.S. oil supply and total energy consumption in 1990. The implications of this forecast for potential disruptions of oil supply do not lend themselves to summary. The only general point that can be made is that the forecast decline in U.S. oil imports will not eliminate U.S. vulnerability to supply disruptions.

7. Summary

Since the 1973–74 embargo, the United States has been in a period of adjustment to higher and rising energy prices. The forecasts for 1990 generally show a continuation of trends in energy production, consumption, prices, and overall economic activity that became apparent after the 1973–74 oil embargo.

Table 7.1 presents the forecasts of energy production and consumption for 1990 (midprice case) and historical data for 1973 and 1978. Also given are the average annual growth rates for the various components of the table for 1973–78 and 1978–90. Comparison of these growth rates is one means of highlighting the similarities and differences between the postembargo 1970's and projections for the 1980's. For example, real GNP and gross energy supply are both projected to continue to grow in the 1980's at about the same rates they did in the 1970's. Energy prices are also projected to continue to increase, but at a somewhat reduced rate.

These are important similarities, but there are also important differences. Domestically produced energy is projected to increase almost 2 percent per year compared to a decline for the 5 years after the embargo. The energy source responsible for this increase is coal. In 1990, coal production is projected to be almost double that of 1978. Oil and gas production are projected to continue to decline, but at reduced rates while other sources continue to grow. Electricity generated from nuclear power is projected to grow rapidly, but at a reduced rate

Table 7.1 Summary of U.S. Energy Production and Consumption 1978 and Base Case Forecast for 1990
(Quadrillion Btu)

			Midprice Case	Average Annual Percent Growth Rate	
	1973	1978	1990	1973–78	1978–90
Domestic Energy Production					
Oil	22.1	20.4	20.2	–1.6	–0.1
Gas	22.2	19.8	17.0	–2.3	–1.3
Coal	14.4	15.0	28.1	+0.8	+5.4
Other	3.8	6.0	11.6	+9.6	+5.6
Gross Domestic Energy Production	62.4	61.2	76.9	–0.4	+1.9
Oil Imports	13.0	17.1	11.1	+5.6	–3.5
Gas Imports	1.0	0.9	1.0	–2.1	+0.9
Coal Imports	–1.4	–1.1	–2.7	–4.7	+7.8
Net Imports	12.6	16.9	9.4	+6.0	–4.8
Gross Energy Supply	70.0	78.1	86.3	0.8	+0.8
Losses	–14.1	–16.6	–23.2	3.3	+2.8
Losses as a Percent of Gross Energy Supply	19	21	27	+2.0	+2.1
Net Available Energy[a]	61.5	61.2	63.8	–0.1	+0.3
Domestic Energy Consumption					
Residential	11.1	10.7	10.7	–0.7	0.0
Commercial	7.7	7.6	7.6	–0.1	0.0
Transportation	18.7	20.7	18.6	+2.1	–0.9
Industrial	24.0	26.2	26.9	+1.8	+0.2
Total Energy Consumption	61.5	61.2	63.8	–0.1	+0.3
Price of Imported Oil (1979 dollars per barrel)	6.50	15.50	41.00	+19.0	+8.4
Energy Price Index (billion 1979 dollars per quadrillion Btu)	0.79	1.84	5.11	+18.4	+8.9
Real GNP (billion 1979 dollars)	2,044	2,314	3,130	+2.5	+2.5

[a]After conversion and distribution losses.

compared to the postembargo 1970's. The growth in coal consumption is primarily due to conversion to coal from oil and gas by electric utilities and industry. The economic incentive for such conversion is fairly large for any of the world oil price assumptions studied. Compared to a "very low" world oil price of $20 per barrel, 80 percent of the conversions—which are projected to take place for imported oil at $49 per barrel—are also projected to take place at $32 per barrel.

Domestic supply is projected to increase more rapidly in the 1980's than is total consumption. As a result, imports are projected to decline. However, although imports are projected to be lower, they will continue to be significant. As a result, import supply disruptions could still have very large economic impacts.

Although continued growth in total energy consumption is projected, the mix of sectoral consumption is projected to change. In particular, consumption by the residential, commercial, and transportation sectors are all projected to remain constant or decline through the 1980's while industrial consumption alone will grow. In contrast, in the 5 years following the embargo, industrial consumption actually declined while consumption in transportation continued to grow.

On balance, the differences between the postembargo 1970's and the projections for the 1980's can be explained by the maturation of the adjustment process initiated when the oil price increases of the 1973–74 embargo were accepted and taken to forewarn of future price increases. Decisions to bear the costs of converting from oil and gas by utilities and industry or to produce a more fuel efficient fleet of automobiles take time to make and even longer to implement. The basic decisions that will lead to these results had their start in the postembargo 1970's. If the trends in energy price increases upon which these decisions were based continue, then the results of the decisionmaking will take place in the 1980's. It is the details of this adjustment process that are presented by the projections for this decade.

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