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Appendix I

OTA Background Perspective of Energy Forecasts

Summary

If U.S. energy consumption is allowed to grow at historic rates and if domestic production remains stagnant as it has since 1970, oil-producing nations may not be able to meet world demand in 1985. The gap between world supply and world demand could be as large as 20 percent, and even the threat of a shortage of this magnitude would lead industrial nations to start bidding up prices sharply in the 1980's." The resulting inflation and the impact of actual shortages would set the stage for recession in strong economies and collapse of weak economies.

Most published forecasts discount the possibility of 'such a crisis because of the assumptions about U.S. consumption and production that are built into their projections. They assume declining rates of growth of demand. They assume rapid expansion of U.S. coal and nuclear-energy production. They assume a reversal of historic declines in domestic production of oil and natural gas.

Based on these assumptions, most forecasters expect the United States to hold its imports to about 10 million barrels a day in 1985, which would keep world supply and demand in balance at close to current world prices. * To achieve this, Saudi Arabian production would increase by about 3 million barrels a day in 1985 to the 12.5 million barrels which the Saudis have said they are willing to produce that year, Other

industrial nations would require imports of about 25.3 million barrels a day, roughly equal to or slightly above the anticipated capacity of exporting countries outside of Saudi Arabia.

However, neither declining rates of demand growth or increasing rates of domestic production can be assumed with certainty. A prudent national energy policy must consider the possibility that such changes in historic patterns will not occur rapidly. Energy demand in the United States could grow at historic rates and domestic production could follow present trends. If that were to happen, world oil supply and demand will be thrown sharply out of balance before 1985.

Recent forecasts conclude that the volume of oil produced by the oil exporting nations outside of Saudi Arabia will roughly equal the oil import requirements of nations outside the United States of about 25.3 million barrels per day. If historic demand and supply trends continue, U.S. import requirements would reach about 16.2 million to 19.6 million barrels a day by 1985. If this were to be met along with the rest of the world's demand, a substantial increase in production by Saudi Arabia would be needed. The U.S. import estimate of 16.2 million barrels per day coupled with the expected demand by the rest of the world would require a Saudi production increase to about 16.6 million barrels per day. The high U.S. import estimate and the same non-U.S. demand would mean that Saudi Arabia would have to produce 20 million barrels per day, which is considered the most optimistic estimate of their maximum capacity.

*All projections in this paper assume current world prices

In view of the Saudi political situation, it is not realistic to expect production at either of these high levels. Some factions among Saudi leadership argue that the Nation's long-range interests lie in producing between 2 million and 6 million barrels a day. Current Saudi Arabia production is 9.2 million barrels a day.

Even if Saudi Arabia were willing to produce at the high levels, it would leave the Saudis no reserve capacity to use in moderating pressures among other Organization of Petroleum Exporting Countries (OPEC) nations for price increases.

1. Introduction

The purpose of this paper is to establish a framework on which to base analysis of the proposed National Energy Plan. It will show that this Nation faces the possibility of a substantial gap between demand and domestic supply which may be impossible to close with imported oil.

Two published projections and one draft projection of U.S. energy supply and demand through 1985 are examined. All of these projections make certain assumptions about society's response to higher energy prices, the rate of discovery of new oil, trends in the economy, the impact of environmental constraints such as strip mining regulation, and the rate at which new energy supplies can be introduced. They also estimate the effectiveness of laws that mandate more efficient automobiles and appliances. While these projections differ in detail, they all assume significant shifts from historical rates of growth of supply, demand, or both.

Obviously, if the assumptions are wrong, the forecasts are wrong. If the response to higher prices is weak, if existing conserva-

tion measures do not work as anticipated, or if the recent downward trend in energy supply cannot be reversed, U.S. imports could rise to levels that would threaten national security and economic stability. To illustrate how dramatically changes in assumptions can alter forecasts of the gap between U.S. energy demand and domestic supply, 1985 demand and domestic supply are calculated based on continuation of historical trends. It is intended only to estimate the gap that could occur between domestic supply and demand in order to demonstrate the magnitude and importance of the effort that is needed to bring the Nation's energy problem under control.

The projections by the Federal Energy Administration (in draft) * [1], the Department of Commerce [2], and EXXON Corporation [3], all conclude that U.S. oil imports will not reach a level that would throw world supply and demand for oil sharply out of balance by 1985 or 1990.

Two other forecasts were evaluated, but are not covered in detail in this paper. One is a Central Intelligence Agency forecast, published in April 1977 [4]. The CIA says its forecast "broadly resembles other official and private forecasts," but is less optimistic about the outlook than most published projections. The pessimism is based in part on a CIA conclusion that the Soviet Union will be a net importer of world oil by 1985, adding to the burden on exporters, and in part on a judgment that supplies from OPEC countries assumed by most other forecasts may not

* The projections in this paper attributed to FEA appear in the draft of the 1977 National Energy Outlook issued January 1977. These figures are subject to change as a result of changes in FEA's assumptions about the effect of various existing and future policies.

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be available. The possible Soviet import requirements are not considered in this paper. The principal consequence of including them "would be to decrease the likelihood of filling the U.S. domestic supply/demand gap calculated from a "historic trends" analysis.

Another forecast not covered is a report on a 1976 United Nations conference of geologists and economists, which reaches generally optimistic conclusions about world oil supply over a period of 40 to 50 years. The U.N. report focuses on new technologies and oil recovery in the period after 1985, while the time span of this paper is the period between now and the mid-1980's. This paper addresses the important question of production capability within the 1977-85 time frame and not long-term reserve estimates.

II. The Domestic Picture

The United States depends on oil and natural gas for 75 percent of its energy, but domestic production of both resources peaked early in this decade and oil imports have been rising steadily since then. Unless consumption patterns change, imports will continue to increase through 1985.

In 1970, the United States produced crude oil at an average rate of **9.6** million barrels a day [5]. In October 1976, the United States produced slightly more than 8 million barrels a day [6], Alaska fields on-shore will add 2 million barrels a day to domestic supplies when they are producing at capacity, but they will not stop the decline in domestic production. The National Petroleum Council expects primary and secondary production from known

reserves, excluding the north slope of Alaska, to drop to 3 million barrels a day by 1985 [7]. The difference between declining supply and increasing demand can be made up only with imports and with enhanced recovery techniques and new discoveries of domestic oil.

The United States will continue to rely on oil and natural gas for more than half of its energy at least through 1985 because large-scale new energy systems cannot be put online before then. Although domestic coal supplies are vast, coal production can, at best, probably only hold fossil-fuel contributions to total energy supplies constant through 1985.

The 1974-75 recession slowed the rate of growth in energy demand and, at one point, produced an absolute decline in demand [51]. But the Nation is recovering from the recession and adjusting to a four-fold increase in the cost of energy, and demand is rising again. The growth rate will probably be lower than it was before the 1973-74 oil embargo, but it is likely to remain strong enough to widen the gap between demand and domestic supply.

Growing reliance on imports to bridge the gap could have disastrous consequences for the economy and the pattern of life in the United States. As the president noted on April 18, oil imports cost \$3.7 billion 6 years ago and may cost \$45 billion this year. In addition to this massive outflow of capital, the United States remains vulnerable to cutoffs of supplies similar to the 1973-74 embargo. The "historic trends" analysis suggests that the most crippling consequence of rising imports may occur in the 1980's when the United States could not buy enough oil to meet demand at an acceptable price.

III. Standard Forecasts

As part of its analysis, OTA reviewed the assumptions in forecasts published by the Department of Commerce, EXXON Corp., and a draft forecast by the Federal Energy Administration.

The first three projections estimate demand in 1985 for the industrial, residential/commercial, and transportation sectors as well as supply of domestic and imported oil and natural gas, coal, nuclear, and other energy. These are shown in table 1-1. Table I-2 shows the annual growth rates for the three forecasts and their components.

Table I-1

DEMAND (in Quadrillion Btus)

Sector	1976 Actual	FEA	1985 DOC	EXXON
Res/Comm	27.40	31.6	30.2	34.3
Industrial	27.01	40.5	35.5	37.8
Transport	19.36	19.2	21.2	22.2
Total	73.77	91.3	86.9	94.3
Electric	21.37	31.4	32.6	32.5

(Note: Electricity, including conversion losses, has been distributed to the three end-use sectors.)

DOMESTIC SUPPLY (in Quadrillion Btus)

Resource	1976 Actual	FEA	1985 DOC	EXXON
Oil and NGL	19.6	23.9	21.2	21.7
Natural Gas	19.2	16.9	17.4	15.2
Coal	13.7	21.6	18.7	20.0
Nuclear	2.0	7.2	7.9	7.5
Hydro and Other	3.1	4.3	4.7	4.0
Total	57.6	73.9	69.9	68.4

IMPORTS (in Quadrillion Btus)

Resource	1976 Actual	FEA	1985 DOC	EXXON
Oil	15.4	16.0	16.9	23.8
Natural Gas	1.0	2.0	1.4	3.4
Total	16.4	18.0	18.3	27.2
Grand Total	74.0	91.9	88.2	95.6

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Table I-2

Assumed Rates of Growth in Energy Demand

(in percents)

	1950-1976	FEA	1976-1985 DOC	EXXON
Total Energy.	3.0	2.4	2.0	2.8
Transportation	3.1	1.5	1.0	1.5
Residential/Commercial	4.0	1.6	1.1	2.5
Industry	2.3	4.5	3.1	3.8

A. Demand

Both the draft FEA and the Commerce forecasts assume rates of growth in energy demand that are about 20 to 30 percent below the rate between 1950 and 1976 [5]. The assumed rates of growth in transportation, housing, and commercial activities are about half the historic rate. Only the EXXON forecast assumes a growth rate about equal to the 1950-76 experience. (See table I-2.)

The Commerce and draft FEA projections assume better-insulated buildings, more efficient automobiles, more efficient electrical appliances, and a slower rate of new household formation. Both expect higher fuel prices and new taxes on inefficient equipment to speed up replacement of existing automobiles and appliances with more energy-efficient models.

All three forecasts assume that the growth rate for industry will be close to the preembargo rate because most "easy" conservation measures have been taken and further steps will require larger capital investments than the forecasters believe are likely.

B. Supply

All three forecasts assume that problems associated with development of new energy supplies will be overcome—capital will be available for development and conservation measures, air quality and mining safety problems encountered with the use of coal will be resolved, and nuclear powerplants will be built that satisfy environmental and safety concerns.

The supply forecasts assume increases in domestic energy resources of between 10 and 14 Quads by 1985. This rate of growth means reversing recent trends. Domestic energy production was virtually stagnant at about 59.5 Quads between 1970 and 1976, with an actual drop to 57.6 Quads in 1976.

Electricity: All three forecasts expect utilities to increase supplies of electricity by 4.5 to 4.8 percent a year, and to use about 35 percent of primary energy supplies by 1985, compared with 28 percent in 1976. The forecasts assume 7.5 Quads of nuclear power from new plants generating 92,000 Megawatts (MWe) of electricity at a 60-percent capacity factor and existing plants generating about 43,000 MWe, operating at 53 percent of capacity [8].

Oil: All three forecasts assume an increase in domestic oil production from the present 8 million barrels a day to between 10 million and 11.5 million barrels a day. The increases would come from Alaska production, extensive new discoveries—primarily on the outer Continental Shelf (OCS)—and increased secondary and tertiary recovery from existing reservoirs. The oil production forecasts assume removal of price controls on new and enhanced oil. The OCS projections assume resolution of both environmental and technical problems associated with offshore development and optimistic rates of discovery.

Natural gas: The forecasts assume a slowing of the rate of decline in natural gas supplies as a result of new discoveries, mostly on the OCS. The forecasts expect declines in natural gas production over the 9-year period of 11 to 15 percent and assume decontrol of new gas prices and a resolution of OCS problems.

Other: The forecasts also assume some expansion of hydroelectric capacity, generation of some geothermal electricity, and the use of a small amount of solar heat.

C. Assessment

Although it is possible that the new supplies of nuclear power and coal assumed in the three “standard” forecasts will be available in 1985, it is by no means certain. For example, meeting the implied nuclear power timetable would mean trebling existing rates of plant construction and resolving all safety, environmental, and financial problems that now inhibit the growth of nuclear capacity.

Cutting demand in transportation, housing, and commercial activities to the levels assumed in the FEA and Commerce forecasts will require significant changes in attitudes and habits. Many economists insist that low rates of growth in energy demand cannot sustain the level of economic growth the Nation needs to reduce unemployment [91]. But limitations on supply, both foreign and domestic, may drive growth rates to even lower levels than those forecast.

IV. The “Historic Trends” Analysis

With relatively modest changes in the assumptions of the “standard forecasts,” the gap between U.S. demand and domestic supply widens by 1985 to about 33 quads (1 6.5 million barrels per day oil equivalent), more than double 1976 levels. This shortfall in domestic supply would occur if present rates of demand growth do not change and if aggregate domestic energy production does not increase faster than historic trends indicate it will.

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A. OTA Assumptions

The following analysis suggests that the United States may be forced to choose between strong policies to lower the rate of growth in energy demand during the next decade and a severe shrinkage of the

economy with its attendant rising unemployment by the end of that period. Projecting historic trends in U.S. energy use and production gives the following situation [5,101 :

Table I-3

DEMAND (in Quadrillion Btus)

Sector	1976	Historic Trends 1985	FEA*	1985 DOC*	EXXON*
Res/Comm	27.4	39.0	31.6	30.2	34.3
Industrial	27.0	33.1	40.5	35.5	37.8
Transportation	19.4	25.5	19.2	21.2	22.2
Total	73.8	97.6	91.3	86.9	94.3

DOMESTIC SUPPLY (in Quadrillion Btus)

Resource	1976	Historic Trends 1985	FEA	1985 DOC	EXXON
Oil and NGL	19.6	20.3	23.9	21.2	21.7
Natural Gas	19.2	14.4	16.9	17.4	15.2
Coal	13.7	18.8	21.6	18.7	20.0
Nuclear.	2.0	6.8	7.2	7.9	7.5
Other ,	3.1	4.3	4.3	4.7	4.0
Total	57.6	64.6	73.9	69.9	68.4

IMPORTS (in Quadrillion Btus)

Resource	1976	Historic Trends 1985	FEA	1985 DOC	EXXON
Oil	15.4	32.5	16.0	16.9	23.8
Natural Gas	1.0	0.5	2.0	1.4	3.4
Total	16.4	33.0	18.0	18.3	27.2
Grand Total	74.0	97.6	91.9	88.2	95.6

*refer to Table 1-1.

In this forecast, the average rate of growth in demand from 1950 to 1976 is assumed to continue to 1985. * This rate, 3 percent, was chosen because it covers a period during which higher-than-normal growth rates of the 1960's are balanced by slower growth and, in some cases, absolute declines in demand, following the 1973-74 embargo. The analysis assumes that the 3 percent figure will reflect recent changes in the economy, such as a slowdown in new household formations, recent energy price increases, and the efficiencies in transportation and appliances mandated by the Energy Policy and Conservation Act of 1975 [21].

The estimate that domestic production of oil and natural gas liquids will be about 10 million barrels a day in 1985 is based on continuation of the 1970-76 rate of decline in domestic production, offset by production of 2 million barrels a day of Alaska crude [51]. This implies that the decline in production from existing reservoirs would be great enough that enhanced recovery and new discoveries cannot make up the difference.

The natural gas production estimate is also based on the continuation of its present rate of decline (since 1974). The resulting production in 1985 is about 14.1 trillion

● The period of 1950-76 was chosen to establish the historic trend in order to minimize the effects of shorter term fluctuations such as the high 1960-73 growth rate of 4.0 percent and the decline occurring from 1973 to 1975. The 1960-73 period was one in which the decline in real energy prices was greatest and the substitution of natural gas and petroleum for coal was at its peak. During that period the annual energy growth rate was slightly higher than the GNP growth rate. For the 1950-59 period the energy growth rate was 3.1 percent per year compared to a 3.9 percent per year GNP growth rate. Since real energy prices have risen to levels higher than in 1950, it is very unlikely that the 1960-73 growth rate can be duplicated. It is of interest to note that a continuation of the 4.0 percent growth rate would lead to a demand figure of 105 Quads by 1985 which would leave a gap of 20 million to 22.5 million barrels per day.

cubic feet (Tcf). This is slightly higher than the 13.8 Tcf which is projected by the Federal Power Commission [11]. (The FPC projection is based on annual net additions of reserves of 9.5 Tcf, the average since 1968.) In order to reach the natural gas output of 17 Tcf, which is assumed by the draft FEA, Commerce, and Exxon projections, net annual additions to reserves of 14.5 Tcf are required, a level that has not been reached since 1967 [1 O]. The "historic trends" estimates do not take into account Alaska gas, which could total 1.0 Tcf a year but which is not likely to be available before 1985, even under the most optimistic assumptions [11].

Total nuclear generating capacity would be 121,000 MWe in 1985 if all existing plants and plants that already have been granted construction permits are completed and operating. The 1985 calculation assumes a capacity factor of 60 percent, compared with the 1976 average of 53 percent [3,8].**

Coal production is estimated at 950 million tons, 10 percent below the FEA forecast but identical to the projection of the National Coal Association. The lower figure implies that environmental problems which now limit the use of high-sulfur Eastern coal will not be fully resolved by 1985 and that its replacement by low-sulfur Western coal will be held down by production and distribution constraints.

The contributions of hydroelectric, geothermal, and solar power are identical to those projected by the FEA draft. Natural gas import estimates are the volumes of liq-

**The capacity factor for January 1977 was 67 percent, a significant increase over the yearly average. It is not known whether this will be sustained but it is possible that the assumption of 60 percent will be low. A 70 percent capacity factor would increase the nuclear contribution by 1.1 Quads or 550,000 barrels per day equivalent.

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uefied natural gas (LNG) that can be delivered through facilities already licensed [12]. The 1.0 Tcf of imported gas in 1976 comes from Canada and is not likely to be available in 1985.

This analysis, using historic production trends, shows a domestic supply of energy about **5.6** Quads higher than the 1970-76 average because coal and nuclear power would more than offset the decline in oil and natural gas production. If, on the other hand, this were not to occur and domestic energy production remains constant at 59.5 Quads as it has since 1970, then the supply/demand gap would increase to 38.1 Quads. Translated into import requirements this would mean that 18.8 million barrels per day of oil would have to be imported to fill the gap.

B. World Implications

The forecasts of U.S. energy supply and demand through 1985 discussed in section III project that the United States will import between 8 million and 12 million barrels of oil a day in that year. They also forecast domestic production of oil and natural gas liquids for the United States of as much as 12 million barrels a day.

The different assumptions implicit in the "historic trends" analysis, however, give a much bleaker picture. The implications of the substantial increase in import requirements indicated by this analysis are clearly seen when the world oil production capability for that time period is examined. Various estimates for that period indicate that the 1985 import requirements for the non-Communist world outside the United States will be about 25.3 million barrels per day [4,13]. This would be approximately equal to the productive capacity of the

OPEC nations outside of Saudi Arabia [4,131. OPEC analysts conclude that, because of internal political pressures, Saudi Arabia may be unwilling to push its production beyond 12.5 million barrels a day before the mid-1980's. Saudi officials also have warned that unless the rate of growth in U.S. demand is reduced in the next few years, Saudi Arabia will make no effort to increase production after 1982.

If the United States were faced with the demand/supply gap projected by the historic trends analysis there would be a shortfall on the world market of 4.5 million barrels per day assuming Saudi production of 12 million barrels per day. In the case discussed above where total U.S. domestic production remained at the 1970-76 levels, this shortfall would reach about 7 million barrels per day under the assumption that non-U.S. world demand remained at the 25 million barrel per day level.

The likely consequences of these developments about potential U.S. imports are one of two options for world producers and consumers in 1985;

- . Saudi Arabia will produce between 4 million and 7 million barrels a day more than Saudi officials have said they are willing to produce in 1985;*
- . the world's industrial nations will be in a bidding war over 4 million to 7 million barrels of oil a day that will drive prices up and still leave some or all nations short of supplies,

*It should be noted that the maximum productive capacity of Saudi Arabia has been estimated by the Petroleum Industry Research Foundation to be about 20 million barrels per day. This is approximately the volume that would be required if the Saudis were to meet the 7 million barrel per day shortfall. Therefore, not only political limits, but very possibly physical limits, would be exceeded by world demand.

V. Conclusion

The "historic trends" analysis suggests that international shortages and price rationing are inevitable if U.S. oil import demands are not reduced. The basic question appears not to be whether the economy can continue to grow under more stringent conservation policies but whether conservation measures can take hold fast enough to head off the crippling impact of abrupt oil shortages in 1985. Even if policies designed to maximize domestic oil and natural gas production succeed, extension conservation still will be necessary. Conversely, if domestic energy production does not exceed present levels, conservation measures probably cannot hold import demands at levels which producers would be willing to meet.

The goals of the OTA Energy Policy analysis are to determine, from the perspective of this paper:

- . Which set of related energy policies is most likely to keep the gap between domestic supply and demand narrow enough so that it can be bridged in the short term; and
- What kind of policies are needed to expand alternative energy supplies over the long term so that the United States will have a solid energy base after world supplies of oil and natural gas are exhausted.

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