

3. Future Non-Communist World Oil Supply

Introduction

Estimating the geological resource, as was done in Section 2, is not sufficient to determine non-Communist world oil supply (the rate in million barrels per day (MBD) of oil available to the non-Communist world). Non-Communist oil supply will not actually reach the limits set by geological considerations. Future supply depends on production which in turn depends upon political, technical, and economic factors as well as geology.

The relative importance of these factors varies in time and between countries. For example, the geologic resource is the primary factor determining production levels in the United States. On the other hand, reserves do not limit production in Kuwait. Instead a decision by the Kuwaiti government to limit production, based on political and economic considerations, is the limiting factor.

These factors introduce a large uncertainty associated with any answer to the second question in the introduction "At what rate will oil from conventional sources be available?" Nevertheless, based on analysis discussed in this section, OTA projects high confidence that non-Communist world oil supply will be between 47-60 MBD in 1985 and 40-62 MBD in the year 2000 (compared with 52 MBD in 1979).

For the years 1985 and 2000 the highest and lowest estimates are less probable since those estimates depend upon a unique combination of circumstances. Moreover, these projections assume that there are no major disruptions (such as the revolution in Iran) which could lead to temporary or permanent disruptions in the production of major suppliers.

It should be noticed that even the high estimates of world production given here are below most estimates of future world production made before December 1978. Prior to the revolution in Iran, many projections simply assumed that oil exporters would produce at (or close to) their maximum production rates in order to meet the anticipated world demands.

The events in Iran have made it clear that an overly rapid increase in national income could be socially disruptive and that maximum production may not be consistent with optimum economic development programs. Moreover, many exporters have reduced production in anticipation of further price increases. These exporters perceive oil left in the ground as the best investment for the future.

Approach

The analysis here of future oil supply is divided into sections considering the following regions:

- (A) the production rate of the developed countries.
- (B) the production rate of OPEC.
- (C) the production rate of the non-OPEC LDC's.
- (D) effect of the Communist countries on non-Communist world oil supply.

For each of these regions the consequences of the known or estimated geologic, technical, economic, and political factors are used in making projections. Details are given below for each of the major suppliers.

OTA has utilized various sources in determining the estimates of production utilized in this report. Published information in various periodicals (Petroleum Intelligence Weekly, World Oil, Oil and Gas Journal,

and Middle East Economic Survey, and others) as well as reports by DOE, CIA, United States Geological Survey, and other organizations (Rand Corporation, etc.) have been used. In addition, OTA has contacted experts in oil companies, government organizations, and other petroleum related organizations.

No primary geological assessments have been attempted in the course of preparing this report.

A. Developed Countries

Production in the developed countries will decline, with a significant reduction in production possible by the year 2000. Geology is the primary limiting factor.

Production in the developed countries, averaging 14.9 MBD* in 1979, may range between 13-15.5 MBD in 1985 and 7.5-13 MBD in the year 2000 (see Table 9). Although production in the North Sea by the United Kingdom and Norway will increase for the next few years, this increase will be offset by declining production in the United States.

The basis for the OTA estimates of production rates for the developed countries is described in detail below.

TABLE 9

FUTURE PETROLEUM PRODUCTION RATES IN THE DEVELOPED COUNTRIES (MBD)

	<u>1979</u>	<u>1985</u>	2000 +
United States	1002	7.2-8.6	4-7
North Sea	201	2.8-4	1.7-3
Canada	1.8	106-108	
Other Developed Countries	.8	.8*	
TOTAL	1409	13-15.5	7.5-13
(may not add due to rounding)			

* range of production considered insignificant for estimates of total petroleum availability.

SOURCE: OTA estimates based upon assumptions stated in text.

*
MBD = million of (42 gallon) barrels per day.

U.S. Production

Based upon the reasoning discussed in this section, OTA estimates that liquid petroleum production will decline from the 1979 average production rate of 10.2 MBD to a level of approximately 7.2-8.5 MBD in 1985. In the year 2000, U.S. production could be as low as 4 MBD although under optimistic assumptions U.S. production could be 7 MBD (see Table 10).

TABLE 10
FUTURE U.S. PETROLEUM LIQUIDS PRODUCTION (MBD)

	Year				
	<u>1979</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Primary and secondary recovery from existing 1979 reserves	8.1	4.7	2.7	1*4	008
Primary and secondary recovery from addition to reserves		0.8-1.5	0.8-2.1	0.7-2.4	0.7-2.5
Natural gas liquids	107	1.2-1.5	1.1-1.4	1*1-1.3	1.0-1.25
Production from enhanced recovery techniques	0.4	0.5-0.9	0.7-1.04	101-2	1.5-2.5
TOTALS (may not add due to rounding)	10.2	7.2-8.6	5.3-7.6	4*3-7*1	4.0-7.0

SOURCE: OTA estimates based upon assumptions stated in text.

Future U.S. production will arise from the following four sources: (1) primary and secondary recovery from existing (as of January 1979) proved reserves of 26.5 billion barrels, (2) primary and secondary recovery from additions to existing reserves, (3) natural gas liquids and (4) applications of enhanced recovery techniques. Production from each of these sources is

discussed below in detail.

(1) Primary and secondary recovery from existing reserves may decrease from approximately 8.1 MBD in 1979 to 4.7 MBD in 1985 and .8 MBD in the year 2000. (This estimate assumes that U.S. fields can produce at a rate where annual production is 1/8 of known reserves subject to a near term upper production constraint of 1.6 MBD from existing Alaskan reserves.)

(2) The second source of future production is primary and secondary recovery from additions to reserves. Additions to reserves totalled approximately 1.3 billion barrels in each of the years 1977 and 1978.* This quantity includes additions due to the use of enhanced recovery techniques on existing fields (which will be considered separately as the fourth source). Hence, additions to reserves for which primary and secondary recovery will be utilized averaged less than 1.3 billion barrels.

Moreover, additions to reserves for primary and secondary recovery can be expected to decline. A portion of the 1.3 billion barrel total is due to extensions of old reservoirs. As U.S. fields reach a more mature state of development, these extensions can be expected to decrease. New discoveries, on the other hand, have averaged only .3 billion barrels annually in 1977 and 1978.**

For these reasons, OTA estimates a range for the level of additions for primary and secondary recovery. The high level is 1 billion barrels annually through the year 2000 while the low level is 1 billion barrels in the year 1980 declining linearly to 0.5 billion barrels in the year 2000.

* American Petroleum Institute, Reserves of Crude Oil, Natural Gase Liquids, and Natural Gas in the United States and Canada, volume 32, p. 10 and volume 33, p. 10.

** Ibid

If additions occurred at the high level, production from this source would result in production of 1.5 MBD in the year 1985 and 2.5 MBD in the year 2 000. * On the other hand, if additions occurred at the lower level, then production of 0. 8 MBD in 1985 and 0.7 MBD in the year 2000 would result.

Summarizing, OTA estimates a range of production levels of .8-1.5 MBD in the year 1985 and .7-2.5 MBD in the year 2000.

(3) The third source is natural gas liquids production which was 1.7 MBD in 1979. Future production levels are dependent upon conventional natural gas production for which declining production has been projected.** Production levels of 1.2-1.5 MBD in 1985 and 1-1.25 MBD in the year 2000 are estimated based on these declines.

(4) Enhanced recovery, the fourth source, contributed approximately .4 MBD to 1979 production. Over two-thirds of this contribution arose from steam recovery of heavy oil in California while a recovery process involving the use of carbon dioxide (CO₂) was responsible for the majority of the remaining enhanced recovery production.***

Enhanced recovery production is anticipated to increase through this century, but the production rate is subject to much uncertainty. Because of this uncertainty, OTA projected in its January 1978 report **** a wide range of production possibilities for enhanced recovery. This report included a scenario where enhanced recovery could contribute as much as 5 MBD in the

*Assuming annual production of 1/8 of known reserves.

**Exxon, World Energy Outlook, December 1979.

Oil and Gas Journal, March 31, 1980, p. 79.

**** OTA, Enhanced Oil Recovery Potential in the United States, January 1978.

year 2000. As stated in that report, however, the estimate was heavily dependent upon the following conditions:

- (1) satisfactory development of the CO₂ and surfactant/polymer processes which were then in an early development stage.
- (2) a low inflation rate making a rate of return of 10% on capital satisfactory.
- (3) availability at a certain price of large amounts of CO₂ required for enhanced recovery using the CO₂ Process.

None of these conditions have occurred as expected. First, the surfactant/polymer process, which was expected to account for 20% of year 2000 production, has not performed as well as expected.* Second, high inflation rates have made a 10% return on capital less satisfactory. Third, the price of CO₂, which has a significant effect on the extent of the use of CO₂-enhanced recovery, has risen much faster than anticipated in the scenario. Consequently, the production of levels approaching 5 MBD from enhanced recovery seems much less likely now than in January 1978 in spite of oil price increases.

Production levels of .5-.9 MBD in 1985 and 1.5-2.5 MBD in the year 2000 are now estimated for enhanced recovery production.** Steam recovery of heavy oil may account for .4-.6 MBD in 1985 and .4-.7 MBD in the year 2000. Production from the CO₂ Process is anticipated^{d, 0} to account for much of the remaining enhanced recovery production.

* Oil and Gas Journal, March 31, 1980, p. 94.

**Estimates are based on results in the OTA report cited above.

U.S. Production Summary

Adding the totals from the four sources, one obtains the OTA range of production of 7.2-8.5 MBD in 1985, 5.3-7.6 MBD in 1990, and 4-7 MBD in the year 2000 (See Table 10). In its recent forecast Exxon* forecasts U.S. production at 6.1 MBD in 1990 and 6.3 MBD in the year 2000 which fall within the range given here.

North Sea (United Kingdom and Norway)

Liquid petroleum production in the North Sea has risen sharply from less than 0.1 MBD in 1973 to over 2 MBD in 1979. Increases will continue over the next few years as existing fields are developed. Peak production will occur in the mid-1980's with declines probably before the year 2000 due to diminishing reserves.

OTA estimates that production in 1985 will range between 2.8-4 MBD based upon industry and government plans. The basis for this estimate is discussed below.

Recently, the UK government has released its estimate of oil production in the UK waters of the North Sea for the five year period 1980-1984. The UK government estimates production to increase from 1.6-1.7 MBD in 1980 to 1.9-2.8 MBD in 1984.** The high estimate of 2.8 MBD has been suggested as peak production from fields currently under development. OTA estimates production levels of 1.9-2.8 MBD in the year 1985 based upon the 1984 estimate.

* Exxon, World Energy Outlook, December 1979.

** oil and Gas Journal, July 7, 1980 P. 61.

Current development plans of the Statjord oil fields call for increasing total Norwegian production from .4 MBD in 1979 to .9 MBD in 1984 and 1.2 MBD in 1985.* Since some slippage in development is possible, OTA estimates production levels of .9-1.2 MBD in 1985.

Adding the OTA estimates for UK and Norwegian production, one obtains a range of production of 2.8-4 MBD for the year 1985.

The current reserves** of 15.8 billion barrels in the UK sector and 5.8 in the Norwegian sector are insufficient to maintain peak production long. Without any reserve additions, North Sea production would be as low as 1 MBD in the year 2000.

However, reserve additions are likely and 10 billion barrels has been suggested as a reasonable estimate of additions to the existing 21 billion barrels of reserves by the year 2000.*** OTA estimates that the additions would permit North Sea production of 1.7-3 MBD in the year 2000 depending upon the peak level of production achieved in the mid-1980's. If peak production was 4 MBD, OTA estimates that production would be 1.7 MBD. If peak production was held to 3 MBD for conservationist reasons, OTA estimates that these additions would enable production to be maintained at 3 MBD up to the year 2000.****

*Petroleum Intelligence Weekly, April 7, 1980.

**Oil and Gas Journal, December 31, 1979, pp. 70-71. Estimate for end of 1979.

*** Based on R. Nehring, Giant Oil Fields and World Oil Resources, and private communication.

**** Estimates are based on the following calculations. Ten billion barrels are added to existing reserves during the **period** 1980-2000. These reserves are added at a rate declining linearly in time with 1 billion barrels added in 1980 and no additions in the year 2000. Annual joint UK and Norwegian production is assumed 1/8 of existing reserves subject to a post-1985 upper production constraint. This constraint is either 3 or 4 MBD depending upon the 1985 production level.

OTA estimates include no allowance for production from the Norwegian offshore prospective petroleum areas north of the 620 parallel. Norway has delayed exploration and development of these areas due to environmental as well as economic considerations.

Exxon* forecasts 4 MBD as the production rate in the year 2000 from the North Sea which is higher than the range of OTA estimates (1.7-3 MBD). This Exxon estimate would require 1.7 times the level of additions to reserve assumed by OTA for its estimate.

Canada

OTA estimates that conventional liquid petroleum production is unlikely to increase with declines occurring before the mid-1990's. OTA estimates production levels of 1.6-1.8 MBD in the year 1985 and 1-2 MBD in the year 2000.

There have been no large oil discoveries in established areas since the mid-1960's. As a result of its deteriorating reserves situation, the Canadian government began to limit production in 1973, reducing production from 2.1 MBD. During 1976-78 Canadian production averaged 1.6 MBD, while in 1979 production was raised to 1.8 MBD following the Iranian revolution. OTA estimates that levels of production of 1.6-1.8 MBD are probable for 1985.

*Exxon, World Energy Outlook, December 1979.

**Based on OTA calculation. Calculation assumes production increases to 4 MBD in 1985 with level production of 4 MBD through the year 2000. Production during 1980-2000 would use approximately 27 billion barrels. Production of 4 MBD in the year 2000 would require reserves in 2000 of 11 billion barrels based upon a reserves to production ratio of 8 to 1. The 38 (27 + 11) billion barrels of required reserves in the year 2000 plus production in the period 1980-2000 would require 17 billion barrels of additions to current reserves of 21 billion barrels.

***See footnote below for calculation.

Declines thereafter are likely. Based upon an addition to reserves of 3 billion barrels by 1995, OTA estimates that conventional production would be as low as 1-1.3 MBD in 1995.*

Beginning in the mid-1990's, potential production from some promising Arctic areas, such as the Beaufort sea, may be able to stem the decline in conventional production. Increases are also possible if large discoveries are made and developed. Hence, production levels of 1-2 MBD are projected for the year 2000.**

OTA estimates do not include any amount for unconventional production from tar sands and heavy oil. Production from these sources may be able to offset the projected declines in conventional oil production. Exxon*** has projected total Canadian production in the year 2000 at 2 MBD including 1 MBD from unconventional sources.

* The basis for the estimate is as follows. Canadian National Energy Board (Canadian Oil: supply and Requirements, Sept. 1978) estimated potential **reserve** addition of 4.9 billion barrels including 2.8 billion barrels through enhanced recovery. Given the slow rates of development of enhanced recovery, OTA estimates that 3 billion barrels of the remaining 4.9 billion barrels would be added by 1995. These additions are assumed added at a uniform rate of .2 billion barrels annually. Annual production **is** assumed 1/8 of existing **reserves** subject to conventional petroleum production constraints of 1.4-1.7 MBD (crude production constraints of 1.1-1.4 MBD).

** Low estimate assumes additions added .2 billion barrels annually during 1995-2000, equal to the assumed 1980-1995 rate. High estimate includes a 1 MBD allowance which requires a new large discovery (approximately 10 billion barrels, the size of **Prudhoe** Bay fields). Production from the **Prudhoe** Bay fields in 1980 was approximately 1.5 MBD. Production commenced in 1977 seven years after the fields were added to reserves. Production from any Canadian **Arctic** areas will require as long, if not longer, lead times between discovery and production".

*** Exxon, World Energy Outlook, December 1979.

Other developed countries

Production in the other developed countries (principally Australia with contribution by some countries in Western Europe) is currently small (.8 MBD). Production prospects are not particularly bright due to limited geologic resources.

OTA estimates that production will be approximately .8 MBD through the year 2000 with some declines probable after 1985.*

OPEC Production

Future OPEC production is not likely to differ significantly from the 1979 average production rate of 31.4 MBD. Since the year of the Arab embargo 1973, total OPEC production has remained relatively constant, differing by less than 1 MBD of the 1979 average.

It is possible that OPEC production both in the year 1985 and the year 2000 will be less than the 1979 rate. OTA's subjective review of OPEC production possibilities indicates that a reasonable range of estimates would be 28.5-35 MBD in the year 1985 and 27-37 MBD in the year 2000. (In its latest world outlook, Exxon** estimates OPEC liquid petroleum production at 33 MBD both in 1990 and 2000.) Our analysis of the future production

* Range of decline considered insignificant for estimating total world petroleum availability. However, percentage declines in some countries may be important for those countries

** Exxon, World Energy Outlook, December 1979.

possibilities given in Table 11 is described below for each individual country.

TABLE 11
FUTURE OPEC LIQUID PETROLEUM PRODUCTION (MBD)

	<u>1979</u>	Year <u>1985</u>	<u>2000</u>
Saudi Arabia*	9.803	9.1-11.01	9.1-12.6
Iraq	3.445	2.7-4.5	3-5
Iran	3.045	3-4	3-4
United Arab Emirates	1.865	1.9-2.5	1.9-3
Kuwait*	2.622	1.9-2.4	1.9-2.4
Other OPEC Countries	10.575	9.5-10.05	8-10
Algeria	1.165		
Ecuador	.215		
Gabon	.205		
Indonesia	1.630		
Libya	2.105		
Nigeria	2.305		
Qatar	.515		
Venezuela	2.435		
TOTAL	31.4	28.5-35	27-37.0
	(may not add up to rounding)		

* Including share of Neutral Zone

SOURCE: OTA estimates based upon assumptions stated in text.

The dominance of the Arab OPEC countries and the Persian Gulf region is expected to continue. Except for Iran, only the Arab OPEC countries of Saudi Arabia, United Arab Emirates (UAE), and Kuwait have sufficient reserves and Iraq the estimated potential to sustain more than marginal increases in production (see Table 11, 12). However, existing government restrictions on production levels in the countries of Saudi Arabia, UAE, Kuwait and Iran, if continued, would limit OPEC production to no more than 32 MBD (5 MBD less than the highest OTA estimate of year 2000 production).

TABLE 12

OPEC PRODUCTION DATA

Country	Reserves Barrels	1979 Crude Oil Production Barrels	(Reserves) Production	Current Production Could Be Maintained With No Additions
Saudi Arabia	163.4	9.245	48.4	40.4
Iraq	31.0	3.435	24.7	16.7
Iran	58.0	3.035	52.4	42.4
United Arab Emirates	29.4	1.835	43.9	35.9
Kuwait	65.4	2.215	80.9	72.9
Algeria	8.4	1.025	22.5	14.5
Ecuador	1.1	.215	14.0	6.0
Gabon	.5	.205	6.7	0.0
Indonesia	9.6	1.590	16.5	8.5
Nigeria	23.5	2.065	31.2	23.2
Qatar	17.4	2.305	20.7	12.7
Venezuela	3.8	.505	20.6	12.6
Venezuela	17.9	2.355	20.8	12.8

* Assuming reserves to production ratio of 10 to 1 would be feasible.

Source: OPEC

There appears to be a growing tendency among other OPEC exporters to limit production for conservation reasons and in expectation of higher prices. Libya, for example, has recently announced its intention to cut liquid petroleum production from 2.1 to 1.7 MBD. * Clearly, the higher production numbers given here will also not occur if this tendency is sustained.

Detailed Country Descriptions

Saudi Arabia. In the early 1970's Saudi Arabia had been projected in many forecasts to substantially increase productive capacity levels to 16-20 MBD.** However, in 1977 the Saudi's announced officially a lower target of 12 MBD for maximum sustained productive capacity and imposed financial constraints that deferred attainment of this target level until 1987 at the earliest. Production of 12 MBD level could be sustained through 2005 with existing reserves.***

*Based on Petroleum Intelligence Weekly, May 19, 1980.

**For example, the CIA projected net capacity in 1985 of at most 18 MBD in their April 1977 report, The International Energy Situation: Outlook to 1985.

***The Future of Saudi Arabian Oil Production, U.S. Senate Committee on Foreign Relations, April 1979.

It has been reported recently that construction has begun on the planned capacity expansion. * However, production of 12 MBD is not guaranteed even if construction does take place. The Saudi's have frequently expressed their desire to stretch their petroleum producing horizon. As stated by Crown Prince Fahd on April 19, 1978,

"Saudi Arabia has worked and is working sincerely and earnestly to provide an appropriate level of oil and gas production as an expression of its feeling of shared responsibility in the international community, but our feelings of responsibility toward future generations in Saudi Arabia also claim careful consideration and the establishment of a calculated balance between the present and the future.

Moreover, Yamani, the Saudi oil minister, has announced that Saudi intentions are not to exceed production of 9.5 MBD even under higher levels of capacity. ***

On the basis of these facts, Saudi Arabian crude oil production for 1985 is projected to lie between the official ceiling in early 1978 of 8.5 MBD (the Saudi's have raised at least temporarily the ceiling to 9.5 MBD following the Iranian disruption) and 10.5 MBD (approximately the current maximum sustainable production rate).**** For the year 2000 crude oil production is projected to range between 8.5 MBD and 12.0 MBD.

Adding to each of these estimates .3 MBD from the Saudi's share of the Neutral Zone and .3 MBD of natural gas liquids, OTA obtains ranges of 9.1-11.1 MBD in the year 1985 and 9.1-12.6 MBD in the year 2000 for liquid petroleum production. However, it should be emphasized that current Saudi statements indicate that future liquid petroleum production will not exceed 10.1 MBD.

*Petroleum Intelligence Weekly, June 2, 1980.

**The Future of Saudi Arabian Oil Production, U.S. Senate Committee on Foreign Relations, April 1979.

***Petroleum Intelligence Weekly, June 2, 1980.

Petroleum Intelligence Weekly, May 19, 1980.

Iraq

Production possibilities for Iraq are subject to much speculation. This speculation is due to both geological and political considerations.

Geologically, there is an enormous number of undrilled structures. These undrilled structures suggest that increases are possible above the 1979 average production rate of 3.4 MBD. Current existing reserves are sufficient to maintain through the year 2000 the 1979 rate of production (assuming that a reserves to production ratio of 8 to 1 is feasible).

Politically, the Iraqis have expressed contradictory views regarding future production levels. On the one hand, the CIA* has reported that the Iraqi oil minister has expressed a preference to produce at 60% of capacity. This statement suggests that production declines might occur since current capacity is estimated at 3.8 MBD.**

On the other hand, the Iraqi government is attempting to assert its influence in the developing world. For example, it has been reported that the Iraqi government has awarded 15 long term low interest loans in compensation for oil price increases.*** It is thought that the Iraqi government will maintain and possibly increase production to use both the produced petroleum and generated revenues to maintain influence in the developing world.

*CIA, The World Oil Market in the Years Ahead, August 1979.

**petroleum Intelligence Weekly, May 19, 1980.

***Petroleum Intelligence Weekly, April 28, 1980.

Consequently, there is considerable uncertainty regarding future Iraqi production. In 1977, the CIA* suggested productive capacity levels of 5-6 MBD were possible for the year 1985. These levels now appear too optimistic based upon current development plans. Current development plans indicate an increase in sustained production to approximately 4.5 MBD with some further increase possible after 1985.

Based on the above information, OTA estimates that production will range between 2.7-4.5 MBD in the year 1985 and 3-5 MBD in the year 2000.

*CIA, International Energy Situation: Outlook to 1985. April 1977.

Iran

The current turmoil in Iran has made projecting future production levels difficult . Current estimates of production fluctuate weekly. In April 1980, the production rate was reported at 2.7 MBD while in May 1980 it was reported as low as 1.1 MBD. * Both of these weekly estimates are below the 1979 (post revolution) average production rate of 3 MBD.

Iran has announced a production ceiling of 3 MBD. ** According to several sources sustained levels above 4 MBD are unlikely without significant external assistance.*** Gas injection, now required in older fields, will be required in all fields by the late 1980's.

Based on this information, OTA estimates production levels of 3-4 MBD through the year 2000 assuming Iran regains political stability.

United Arab Emirates (UAE)

Abu Dhabi, the principal UAE producer, has plans to increase output capacity from 2 to approximately 3 MBD before the end of the 1980's. **** However, higher production goals have not been announced. In fact, government restrictions now limit production in Abu Dhabi to 1.4 MBD (or only 70% of current sustainable capacity). Production in the other two emirates, Duban and Sharjah, totals approximately .4 MBD, and no increases in production are likely.

*Petroleum Intelligence Weekly, May 19, 1980.

**Petroleum Intelligence Weekly, March 10, 1980.

CIA, World Market in the Years Ahead, August 1979, Petroleum Intelligence Weekly, October 29, 1979.

Oil and Gas Journal, July 19, 1979, pp. 74-113.

OTA estimates that UAE production levels will range between current production levels (1.9 MBD) and those that would be possible if government restriction were lifted. OTA estimates production levels of 1.9-2.5 MBD in the year 1985 and 1.9-3 MBD in the year 2000.

Kuwait

Consistent Kuwait production policy is aimed at conserving resources. Production was approximately 2 MBD in the years 1974-1978 in spite of installed production capacity that would have permitted increased production.

Kuwait temporarily increased crude oil production in 1979 during the aftermath of the Iranian revolution to 2.2 MBD. However, Kuwait has recently announced plans to reduce crude oil production to 1.5 MBD.* Hence, OTA estimates that crude oil production in this century will range between 1.5-2 MBD.

Adding Kuwait's share of production in the Neutral Zone (.3 MBD) and natural gas liquids (.1 MBD), one obtains a range of 1.9-2.4 MBD for the OTA estimate of liquid petroleum production.

Other OPEC Countries (Algeria, Ecuador, Gabon, Indonesia, Libya, Qatar, Venezuela)

The remaining OPEC countries are currently producing at close to their maximum possible production rates.** Only marginal increases by individual countries in production are thought possible. Declines from their current production rates are probable in Indonesia, Ecuador, and Gabon by 1985 due to insufficient reserves (see Table 12). Other countries may reduce production

*Petroleum Intelligence Weekly, May 19, 1980

**Ibid.

rates for conservationist reasons. Nigeria has recently announced plans to reduce production 10% from its 1979 average and Libya has announced plans to cut production from 2.1 to 1.7 MBD. * OTA estimates that 1985 liquid petroleum production in these other OPEC countries is anticipated to range between 9.5-10.5 MBD (compared to the 1979 average of 10.5 MBD).

Except for Libya, current reserves are not adequate in the remaining OPEC countries to support existing production levels through the year 2000. Additional declines are likely in Indonesia and declines may occur in some of the remaining countries depending upon the rate of reserve additions.

OTA's estimate of production levels for the year 2000 is 8-10 MBD. This estimate is based upon current capacity levels and possible declines in production due to diminishing reserves in some countries and other potential cutbacks for conservationist reasons.

In this group of countries only Venezuela has the potential of increasing its production from unconventional reserves, but this is unlikely to change the picture materially until well after the year 2000. Venezuela has enormous reserves of very heavy hydrocarbons in the Orinoco region, but the cost of producing and processing these materials is very high. Venezuelan plans call for production to reach 100,000 barrels per day by 1990 growing gradually to as much as 300,000 barrels per day by the year 2000.** In general, Venezuelan policymakers view these resources as a form of alternative energy, likely to become competitive as petroleum substitutes, such as syncrudes, gradually enter the market in the next century,

* Ibid.

** Outlook on Venezuela: Petroleum Policy, prepared for the Joint Economic Committee, Congress of the United States by the Congressional Research Service. (Wash., D.C.: USGPO, June, 1979).

OPEC Summary

Based on the above analysis, OTA obtains a range of 28.5-35 MBD in the year 1985 and a range of 27-37 MBD in the year 2000 for OPEC production possibilities (a detailed breakdown was given in Table 11). This assumes political stability in OPEC.

Neither the high nor low estimates for each year are likely to occur, since they depend upon an unlikely combination of circumstances described above. In particular, the high estimate would require the removal of production restrictions currently existing in the UAE, Kuwait, Saudi Arabia, and Iran. In addition, stability in Iran and continued exploration, development and production of Iraqi oil fields would be necessary.

Recently, Exxon has forecasted OPEC production at 33 MBD in the years 1990 and 2000. These estimates fall within the OTA range of projections.

Non-OPEC LDC's Production

Production in the non-OPEC Less Developed Countries (LDC's) may rise significantly above the 1979 liquid petroleum production level of approximately 5.1 MBD. OTA estimates production ranges of 7.5-9 MBD in 1985 and 7.5-11.5 MBD in the year 2000 based upon the assumptions stated here. Mexican production, which could be as high as 5.5 MBD in the year 2000, may account for over half of non-OPEC LDC production.

Mexico

Future Mexican oil production will be governed by the size of the Mexican oil resource and political decisions by the Mexican government concerning the rate of utilization of the oil resource. The potential

Mexican oil resource is discussed first.

Mexican proven reserves, at the end of 1979, were 31 billion barrels according to PEMEX, the Mexican oil company.* This estimate of reserves included 11 billion barrels in Chicontepec. Classification of the Chicontepec region as proved reserves is considered doubtful by some experts due to its producing characteristics. A Mexican drilling program to develop the Chicontepec area has been indefinitely postponed pending exploration of other areas. This ambitious drilling program would have required 16,000 wells in order to reach a production in Chicontepec of 0.7 MBD.**

However, sizable additions to reserves are considered likely. The Rand Corporation* estimates that there is a 90% probability that ultimate Mexican production will exceed 70 billion barrels, a 50% probability production will exceed 90 billion barrels, and a 10% probability production will exceed 120 billion barrels. These estimates include the 7 billion barrels of oil already produced from Mexican oil fields in addition to current reserves.

*Oil and Gas Journal, December 31, 1979, pp. 70-71.

**Oil and Gas Journal, August 20, 1979, pp. 73-85.

R. Nehring, D. Ronfeldt, A. Gandara, Mexico's Petroleum and U.S. Policy: Implications for the 1980's, Rand Corp. report R2510/1-DOE to DOE, Executive Summary, June 1980.

This report concludes that the Mexican potential is concentrated in a small number of highly productive areas. Approximately half of the potential is expected to lie in the offshore Campeche area of southeastern Mexico. The next most important area is the Reforma area, which was the site of the major discoveries touching off **Mexico's** recent oil boom. The Reforma-Campeche area, constituting one petroleum province, is likely to be the second most important province in the world, trailing only the Arabian-Iranian province (the Middle East). However, it is estimated that the Reforma-Campeche area will possess less than 1/10 the ultimate recovery of the Middle East.

The Rand Corporation's high estimate of 120 billion barrels is near the PEMEX estimate for ultimate recovery. PEMEX estimates total hydrocarbon potential, including natural gas, at 200 billion barrels.* Assuming that the current proportion of natural gas in hydrocarbon reserves is maintained (approximately 1/3), the PEMEX estimate for liquid petroleum ultimate recovery is 134 billion barrels.

The Rand Corporation report suggested several production profiles for Mexico. One production profile is based upon peak annual production equal to approximately 1/60 of the total resource. This assumption leads to a production range for the year 2000 of 3.5 MBD-5.5 MBD corresponding to the 70-120 billion barrel range of the ultimate resource.** OTA estimates production levels of 3.0-4.0 MBD for the year 1985 based upon the peak rates of 3.5-5.5 MBD.

* Petroleum Intelligence Weekly, March 24, 1980.

Other production profiles are given in the Rand report to illustrate the effects of certain production strategies. A peak rate of 2.5 **MBD is given if the **Mexican** oil resource is limited to 70 billion barrels and Mexico follows a self-sufficiency policy. A peak production of 7.5 **MBD is given if** the **Mexican** resource achieves the high estimate of 120 billion barrels and Mexico decides to pursue **rapid** development in order to be a major exporter.

These production levels can be analyzed in terms of current Mexican oil policy. Current policy has targeted production so that exports do not exceed internal consumption. The official 1980 production estimate was set at 2.25 MBD with exports targeted at 1.1* or slightly less than half of total production.

Mexican internal consumption is approximately 1 MBD and growing at the rate of 7%-8% per year. At this rate consumption would be approximately 4 MBD in the year 2000. This rate may be reduced, however. If consumption reaches 3 MBD in the year 2000, then production in the 3.5-5.5 MBD range suggested by the Rand report would permit exports of 0.5-2.5 MBD. Under these assumptions about internal consumption, these levels of production in the year 2000 would allow the Mexican policy of internal consumption exceeding exports to be in effect to 2000.

Based on the Rand Corporation analysis, OTA estimates Mexican production as 3-4 MBD in the year 1985 and 3.5-5.5 MBD in the year 2000.

Other Non-OPEC Production

Crude oil production in the non-OPEC countries, excluding Mexico, totaled approximately 3.5 MBD in 1979. Table 13 lists these countries and their production rates. OTA estimates that production in 1985 in the non-OPEC LDC's, excluding Mexico, will total 4.5-5 MBD.

* Petroleum Intelligence Weekly, March 24, 1980, Rand Corporation report on Mexico.

TABLE 13

1979 CRUDE OIL PRODUCTION IN NON-OPEC DEVELOPING COUNTRIES*

	<u>MBD</u>		<u>MBD</u>
AFRICA		ASIA - PACIFIC	
Angola	. 143	Burma	.030
Cameroon	.032	Brunei	.255
Congo Republic	.057	India	.240
Egypt	.500	Malaysia	.270
Tunisia	. 105	Pakistan	.011
Zaire	<u>.021</u>	Phillipines	<u>.015</u>
TOTAL	.860	TOTAL	.821
WESTERN HEMISPHERE		MIDDLE EAST	
Argentina	.470	Bahrain	.050
Bolivia	.030	Oman	.290
Brazil	.165	Syria	. 165
Chile	.018	Turkey	<u>.056</u>
Colombia	. 125	TOTAL	.561
Mexico	1.490		
Peru	. 195		
Trinidad	<u>.215</u>		
TOTAL	2.708		

* Oil and Gas Journal, December 31, 1979.

The OTA estimate relies partially on a DOE report of 1985 production estimates for 21 non-OPEC LDC's (all countries in Table 13 except those in the Middle East, Mexico, and the Phillipines) .* This report estimates 1985 production in these countries to total 3.9 MBD. Egypt is expected to remain the largest producer in the group with production of approximately .75 MBD. Indian production is expected to increase joining Argentina and Malaysia-Brunei as producers of approximately .5 MBD each. Three countries (Trinidad, Brazil, and Angola) are projected to produce .25 MBD while only three other countries (Tunisia, Peru, and Colombia) are projected to producer over .1 MBD .

The CIA** has projected that some minor increases above the DOE estimate would be possible for the countries of Egypt, Brazil, Argentina, and Peru. These increases suggest that production would total as much as 4.4 MBD (or .5 MBD more than the DOE estimate). OTA estimates a range of production of 3.9-4.4 MBD for these 21 countries.

Based upon their current reserves, OTA estimates that no significant increases are likely from the four non-OPEC countries in the Middle East (Bahrain, Oman, Syria and Turkey). OTA estimates that these countries will produce approximately .6 MBD (equal to their 1979 total). The OTA estimate of 4.5-5 MBD for total production in the non-OPEC LDC's, excluding Mexico, is obtained by adding the Middle East production estimate to the estimate of production outside the Middle East. Production from new sources till have a negligible effect on 1985 production due to the normal lag time between discovery and significant production.

DOE (Art Warner), The 1985 Oil Production of 21 Oil Producing Non-OPEC Countries, 1979.

**

CIA, The World Oil Market in the Years Ahead, 1979.

The current reserves in the non-OPEC LDC's, excluding Mexico, total approximately 26 billion barrels. These reserves are insufficient to support through the year 2000 the 1985 levels of production estimated by OTA. However, modest additions to reserves are thought likely in most producing countries and small discoveries may be made in some non-producing countries. *

Based on this information, OTA estimates that production in these areas will range between 4-6 MBD in the year 2000 unless new large discoveries are made. The possibility of large discoveries is considered small since the only non-Communist LDC region with significant potential is the Malvinas basin between Argentina and the Falkland Islands.

Some studies have speculated about the possibility of higher production from these areas in the year 2000. These studies have suggested that these areas have not been explored extensively. They predict that increased oil prices will lead to a significant increase in the exploration, development, and production from these areas. In general, these studies do not pinpoint the areas where these large increases in production will be made. **

* Based on R. Nehring, Giant Oil Fields and World Oil Resources, and private communications. Reserve additions, however, have not **equalled** production in the last two years. According to the Oil and Gas Journal annual estimates, reserves have declined from 29 billion barrels on January 1, 1978 to 26 billion barrels on January 1, 1980.

** For example, W. Brown and H. Kahn (in "Why OPEC is Vulnerable," Fortune, July 14, 1980, pp. 66-69) project **non-OPEC** oil production to increase at a rate of 5-7% in the 1980's. This rate of increase would result in non-OPEC production increasing from the current level of approximately 20 MBD to 30-40 MBD by 1990. The percentage of this production which will arise from the **non-OPEC LDC's** is not stated. The authors of this paper cite rising prices and advancing technology as reasons for projecting the increase.

The proposition that increased oil prices will lead to increased exploration is qualitatively true. However, OTA estimates that the effect of increased exploration in these areas will not have as pronounced a quantitative effect on total worldwide oil production as suggested in these other studies.

OTA expects that new discoveries in non-producing countries will be made, but that most will be minor. For example, oil was first discovered in 1975 in Guatemala in a field of approximately 25 million barrels.* Production in 1980 from this field is estimated to be only 0.005 MBD (five thousand barrels a day).** This production will have an insignificant effect on total world production, although it may be significant for Guatemala.

Summary of Non-OPEC LDC Production

Adding the non-Mexican and Mexican production estimates, OTA obtains a range of production of 7.5-9 MBD in 1985 and 7.5-11.5 MBD in the year 2000.

The high estimate here for non-OPEC LDC production in the year 2000 is comparable to the recent Exxon forecast.*** The Exxon forecast projected the combination of Australia, non-OPEC LDC, and Western Europe excluding the North Sea at 12 MBD in 1990 and 14 MBD in the year 2000. Assuming constant production for the Western European area and Australia, the Exxon estimate is 11 MBD in 1990 and 13 MBD in the year 2000 for non-OPEC LDC.

* R. **Nehring**, Giant Oil Fields and World Oil Resources, Rand Corporation, 1978, p. 103.

** Petroleum Intelligence Weekly, April 21, 1980.

*** Exxon, World Energy Outlook, December 1979.

SUMMARY OF NON-COMMUNIST WORLD OIL PRODUCTION

Based upon the above analysis of the production rates of the developed countries, OPEC, and the non-OPEC LDC's, non-Communist world oil production is projected to range between 49-60 MBD in 1985 and 42-62 MBD in 2000 (compared to 51.4 MBD in 1979). The projections of production rates of each of the individual areas are given in Table 14.

TABLE 14
PROJECTIONS OF FUTURE NON-COMMUNIST WORLD OIL PRODUCTION (MBD)

	1978	1985	2000
Developed Countries	14.9	13-1505	7.5-13
OPEC	31.4	28.5-35	27-37
Non-OPEC LDC's	5.1	7.5-9	705-1105
Total	51.4	49-60	42-62

(may not add due to rounding)

Source: OTA estimates based upon assumptions stated in text.

The remaining factor determining non-Communist world oil supply is the effect of the Communist countries. This factor is discussed next.

D. EFFECT OF THE COMMUNIST COUNTRIES ON NON-COMMUNIST WORLD OIL SUPPLY*

Historical

Throughout this decade the Communist countries have been net exporters of oil to the non-Communist world with net exports varying from .413 MBD in

*This section relies heavily on non-classified CIA documents. OTA estimates for the year 2000 are subject to much uncertainty as indicated in this section. OTA is currently assessing the impact of U.S. and other Western technology might have on future Soviet production.

1973 to .955 MBD in 1977. These exports arose principally from the Soviet Union which increased petroleum production from 8.6 MBD in 1973 to 10.9 MBD in 1977 (and further to 11.7 in 1979), making it the world's largest producer.

In 1977 the Soviet Union exported 1.4 MBD to the free world of which over 1 MBD went to Western Europe. The People's Republic of China (PRC) has also increased production from 1.1 MBD in 1973 to 1.8 MBD in 1977 (and further to 2.1 MBD in 1979). However, internal needs have absorbed almost all of the increase with only a small amount .17 MBD in 1977 being exported to Japan. Partially offsetting these exports by the Soviet Union and the PRC were imports of .465 MBD by the Eastern bloc countries from OPEC.*

The Situation Until 1985

In their 1977 report,** the CIA estimated that the net exporting trend of the Communist countries will not continue. In this report, the People's Republic of China (PRC) is predicted to be able to supply its growing internal need through increases in production.

Based upon a comprehensive examination of future Soviet petroleum availability, the CIA projected a sharp decline in Soviet production to a level of 8-10 MBD by 1985. A decline of this magnitude could result in a

* CIA, International Energy Statistical Review, 27 June 1979.

** CIA, International Energy Situation: Outlook to 1985, April 1977.

deficit of up to 1.9 MBD for the Eastern bloc countries as a whole by 1985* Part of this deficit may be met by conservation strategies and by the substitution of natural gas and nuclear power for oil, but to the extent that these do not make up the difference, the USSR and its Eastern bloc trading partners face serious dilemmas. The Soviet Union earns approximately half of its badly needed hard currency from oil exports to the West. The cessation of these exports would be a serious economic blow to the Soviet economy, Moreover, the import of significant amounts of oil from non-Communist sources would likely place an intolerable burden on remaining hard currency reserves. These considerations might well lead the Soviet Union to cut back or stabilize its soft-currency exports to Eastern Europe, forcing those nations increasingly onto world markets for oil.

The complexity of this situation and the variety of political and economic factors which will probably influence Soviet policies make uncertain the implications of declining Soviet production. This uncertainty, together with the disagreements which have arisen **over** the CIA'S conclusions regarding Soviet production and consumption, have made the CIA projections quite controversial. This will be one of the issues examined in OTA's forthcoming study of Technology and Soviet Energy Availability.

*CIA, Soviet Energy Problems and Prospects, 9 February 1979.

The Eastern European bloc countries (Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and Yugoslavia) and Cuba can be expected to be particularly hard hit by any sharp decline in Soviet production.

In 1977 the Soviet Union exported 1.8 MBD to these areas with the majority (1.386 MBD) going to Eastern Europe. In 1977, the Eastern European countries were 60% dependent on the Soviet Union for their oil supplies while less than 20% was met by domestic production. The remaining 20% came from imports from OPEC, principally Iran and Iraq.* The Eastern European bloc countries, with proved reserves of only 1.5 billion barrels, will be unable to increase production above the level of .4 MBD.

If Soviet exports to Eastern Europe were to cease in the early 1980's, then the Eastern European countries would be forced to import nearly 2 MBD at today's consumption and production levels. Moreover, since production in Eastern Europe is concentrated almost entirely in the countries of Romania, Yugoslavia, and Hungary, then the remaining countries (Bulgaria, Czechoslovakia, East Germany, and Poland) would be completely dependent on external sources for their oil consumption needs. Currently, however, Soviet policy states that they will maintain oil exports to Eastern Europe. Therefore the most likely occurrence is no increase in these imports rather than cessation. A breakdown on consumption and production by country for Eastern Europe is given in Table 15.

* CIA, International Energy Statistical Review, 27 June 1979.

TABLE 15

1977 EASTERN EUROPEAN PRODUCTION AND
CONSUMPTION BY COUNTRY (MBD)

	<u>Production</u>	<u>Consumption</u>
Bulgaria	.002	.284
Czechoslovakia	.003	.383
East Germany	.001	.341
Hungary	.043	●21 2
Poland	.009	●35 9
Romania	.308	.348
Yugoslavia	.078	.288
TOTAL	.443	2.215

Source: CIA, International Energy Statistical Review, 27 June 1979.

The Situation After 1985

After 1985 the rate of Soviet oil production is highly uncertain. There are promising geological areas near Sakhalin in the Sea of Okhotsk, in the deep structures of the Caspian Sea, in the East Siberian lowlands, and over much of the Arctic offshore regions.

Currently, the Japanese and the Soviet Union are jointly exploring Sakhalin. Exploration so far in the East Siberian lowlands indicates that it may be a natural gas area rather than oil. Soviet offshore drilling is still in its infancy and the Soviet Union lacks both equipment and experience to undertake the deep well drilling in the Caspian region without external technical assistance. Production from these three areas is possible before 2000; however, it is unlikely that the offshore Arctic areas

will be developed this century. The conditions in these areas are such that the technology for development does not currently exist even in the West.

It is therefore possible that Soviet petroleum production may not exceed 8-10 MBD through the period of 1985-2000. Even the maintenance of the production rate of 10 MBD requires, between 1980-2000, the addition of 55 billion barrels to reserves (based upon the CIA estimate (Table 4) of 40 billion barrels for Soviet proved oil reserves).

Unless consumption were reduced these production levels would leave a deficit that could conceivably have to be filled by imports. OTA **estimates that if this is the case, net imports could total up to 2 MBD**, although substitution of nuclear energy and natural gas for oil could help reduce this.

Production levels higher than 10 MBD may be possible if large discoveries are made. But Soviet oil production will be extremely expensive in terms of both **capital, manpower, and equipment**. Therefore, it appears likely that the Soviet Union **will attempt to achieve only the levels necessary to meet its domestic needs and those of its satellite countries**.

While the PRC is expected to increase production until 1985 over its current level of 2.3 MBD; the situation after 1985 is unclear and further increases in production after 1985 will depend upon the rate of new discoveries. A promising region for supporting increases is the offshore areas in the South China Sea where ownership is disputed. The rate at which this area may be explored and developed will depend upon the willingness of the PRC to employ U.S. and Japanese assistance.

Substantial exports by the PRC are not expected. This is due to

political as much as geological assumptions. Self-reliance is considered extremely important in China and it is debatable whether the Chinese would find exports desirable if this would jeopardize their failure to meet growing future domestic needs.

Summary of the Effect of Communist Countries

If the CIA is correct, we estimate an import potential for the Communist countries of 0 to 1.9 MBD in 1985 and 0-2 MBD in 2000. As stated above, however, there is considerable uncertainty about this and further analysis is necessary. For example, Exxon* projects net Communist exports of 1 MBD in 2000 arising principally from increased production by the People's Republic of China.

PROJECTIONS OF NON-COMMUNIST WORLD OIL SUPPLIES

Based upon the OTA analysis of non-communist world oil production and the possibility of net imports by the Communist countries, a range for non-Communist world oil supply of 47-60 MBD for 1985 and 40-62 MBD for 2000 is projected. These ranges should be compared with the 1979 non-Communist world oil supply of 52.4 MBD.

It is thus possible that non-Communist world oil supply (and more importantly the developed countries oil supply) will experience no increase and will, in fact, decline over the next three decades. Moreover, even under optimistic assumptions non-Communist world oil supply will not experience the level of increase that had been anticipated by earlier studies.

Exxon, World Energy Outlook, December 1979.

** Several studies made before the Iranian revolution are analyzed in the next section.

TABLE 16
PROJECTIONS OF FUTURE NON-COMMUNIST WORLD OIL SUPPLIES (MBD)

	1979	1985	2000
Developed Countries	14.9	13-15.5	7.5-13
OPEC	31.4	28.5-35	27-37
Non-OPEC LDC's	501	7.5-9	705-11.5
Net Communist Trade**	1*	(-1 .9)-0	(-2)-0
TOTAL ***	52.4	47-60	40-62

* Estimate

** Negative number indicates Communist imports. As indicated in the text, there is considerable uncertainty in the estimates for the years 1985, 2000.

*** May not add due to rounding.

Source: OTA based upon assumptions stated in text.