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ENERGY SUPPLY/DEMAND OUTLOOK 1980-1985

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ENERGY SUPPLY/DEMAND OUTLOOK 1980-1985

1. This paper is divided into four parts:

A. Historical Background;

B. Alternative non-OPEC Energy Supply Developments;

C. Demand Changes; and

D. Energy Balance -- Projected Requirements of OPEC Oil.

A. Historical Background

2. Modern society is characterized by high and continually increasing levels of energy consumption. "Technological Man" (U.S. 1970) is using about one million BTU of energy per capita per day.[1] His consumption is three times that of "Industrial Man" (Western Europe, 1870's); ten times that of "Renaissance Man" (Europe, 16th century); and 100 times of that used by "Primitive Man" (100,000 B.C.) whose prime concern was getting the 10,000 BTUs needed to feed himself. Today's energy consumption per capita in different societies varies almost as broadly as the historic range.[2]

3. Until 1800 the main fuel in use was wood. With the industrial revolution the coal age arrived; up to 50 years ago it provided 85% or more of world energy requirements. With the advent of the internal combustion engine and its suitability for transportation, the petroleum industry developed very rapidly, first in the U.S. and after 1950 in the Middle East and Africa. The present age of hydrocarbons--oil and natural gas--had begun.

1/ 1 BTU = 0.25 Kcal.

2/ World average is about 1/5 of U.S., Europe 1/2, India 1/10, Rural Africa 1/100.

4. Table 1 summarizes past developments in the world energy mix since 1925. It shows the changing roles of the various primary energy sources, it also gives the growth of total energy consumption, and the proportion of it which goes through the secondary form of electricity.

Table 1

World Consumption of Primary Energy: 1925-1970 /1

	Actual 1925	1950	1970
Total Primary Energy, 10^{13} kcal (MToe)	1200	1800	5100
	% Distribution		
Coal	81.7	60.4	33.6
Oil	13.1	24.6	39.6
Natural Gas	3.1	10.4	19.9
Hydro	2.1	4.6	6.5
Nuclear	-	-	0.4
	100.0	100.0	100.0
Electricity % of Total	7	14	25
Nuclear % of Electricity	-	-	2

/1 Including centrally planned countries. Energy is expressed in millions of tons of oil equivalent (Mtoe) or 10^{13} kcal which is its approximate heat content. Other conversion factors are shown in Annex 1.

Source: International Atomic Energy Agency Bulletin, Vol. 15, No. 5, 1973.

Table 1 shows the increasingly rapid shift of primary energy consumption from coal to oil and gas as well as the growth of the electric sector as a final form of energy use.

5. More recent (1960-1973) evolution of world consumption of energy by type of resource and by main groups of countries is illustrated in Table 2.

Table 2

World Consumption of Energy 1/

(in MToe)

(1960-1973)

	N.A.	W. Europe	Japan	Others	Total	%
1960						
Coal	253	363	41	97	754	36
Oil	516	205	30	169	920	45
Gas	332	11	1	20	364	17
Primary Electricity 2/	21	19	5	6	51	2
Total	1,122	598	77	292	2,089	100
(% of World)	53.7	28.6	3.7	14.0	100.0	100
1973						
Coal	335	260	55	130	780	19
Oil	896	736	236	432	2,300	57
Gas	653	135	4	70	862	21
Primary Electricity	50	35	8	20	113	3
Total	1,934	1,166	303	652	4,055	100
(% of World)	47.7	28.7	7.5	16.1	100.0	100

Growth 1960-1973 (% per year)	N.A.	W. Europe	Japan	Others	Total
Coal	2.18	-2.53	2.29	2.28	0.26
Oil	4.34	10.33	17.19	7.49	7.30
Gas	5.34	21.27	11.25	10.12	6.86
P.Electricity	6.90	4.81	3.68	9.70	6.31
Total	4.28	5.27	11.11	6.37	5.23

1/ Excluding centrally planned economies.

2/ Primary electricity is of hydro, geothermal and nuclear origin. Total electric production includes secondary electricity generated in coal, oil and gas burning plants.

Source: P.E.L. Consultants, May 1974

The substitution of petroleum for coal was particularly strong in the period 1960-1973. The growth rate per year was only 0.26% for coal while for oil and gas it was about 7%. In W. Europe and Japan oil and gas were growing at percentages between 10 and 20% while coal was actually declining in Europe, and increasing only slowly in Japan.

6. The changes in the composition of the world energy mix are a reflection of the high degree of substitution which is feasible in the energy sector. Broadly speaking primary energy resources are used in modern societies about equally for (1) transportation, (2) industry, (3) commercial and residential heating, and (4) electricity production. 1/ Electricity is finally consumed in the other three groups but principally in the second and third.

7. The transport sector accounts for about 15-25% of total energy consumption. For technical and/or economic reasons it has become a virtually exclusive province of petroleum. Automobiles and airplanes are a "captive" market with present engine technologies. Railroads and shipping have been converted from coal to petroleum as a result of overall system economics: lower capital and operating costs, flexibility of operation, customer preferences (e.g., cleanliness) all have been factors which made oil more attractive in spite of its higher cost vs. coal as measured by heating value alone. 2/

1/ For instance in the EEC in 1971, primary energy usage was distributed: (i) industry 33%, (ii) transportation 16%, (iii) residential/commercial 24%, (iv) electricity 23%, and (v) other 4%.

2/ In 1925 more than 90% of locomotives and 50% of ships used coal. Today these percentages are negligible.

8. Residential and commercial use accounts for about 20% of primary energy consumption in industrialized countries and about 10% in the developing world. Lighting and the electric motors in air-conditioners, refrigerators, and other household appliances represent a "captive" market for electricity. Domestic and industrial space heating, which together represent up to 40% of all energy consumption in industrialized countries, present ample opportunity for competition and substitution among energy sources. Heating is presently dominated by gas, having in the past relied in succession on wood, coal and oil. Availability, price, installed cost of appliances, and convenience (cleanliness, automation) are the main factors usually considered in making a choice between fuels. Electricity has also been used for space heating, mainly in the U.S. in connection with commercial buildings where saving in duct space is an important cost factor. In the past this practice has been criticized as wasteful of energy, 1/ but it need not be. The more prevalent use of the heat-pump 2/ and other heating devices, together with significantly improved insulation, will encourage more efficient electric heating, which under appropriate circumstances will be both economically attractive and conservative of primary fuel. This will be especially significant as power systems begin to rely on nuclear plants for most of their off-peak generating needs.

1/ Power plants convert only one-third to two-fifths of the heat in fuel they burn to electricity, and so direct reconversion of electric power into heat in space heating applications cannot be more than 33%-40% efficient in terms of original fuel.

2/ A reverse refrigeration-type machine, electrically-driven, which delivers heat from the environment (e.g., the air) to the space to be heated. An efficient installation will deliver two times the heat value of the electricity to run it.

9. Industry and electric utilities account for another 20-30% each of the primary energy market (with the latter growing at nearly twice the rate of the other users). Coal, oil, gas and nuclear power will compete for these markets primarily on the basis of their respective costs per unit of heat delivered at the plant. 1/ The outcome of this competition depends very much on local conditions, especially proximity to coal mines. In the case of the utility industry, coal transport costs can be minimized as power plants can be built near the mines and the electricity transported. For these reasons coal, at least in many regions of the U.S., the U.K. and Western Europe, has maintained a very significant share of the utility market. In the U.S. where coal is relatively cheap, its choice as a boiler fuel is dictated by purely economic considerations. In the U.K., Western Europe, and Japan, however, it continues to be used largely because government policies have protected it against the inroads of (then) cheaper imported oil. In the long run, nuclear energy seems destined to become the dominant utility source.

10. The sharp increases in petroleum prices which took place in late 1973 and early 1974 roughly quadrupled f.o.b. crude oil prices. In the period 1955-1970 Persian Gulf f.o.b. crude oil prices had decreased from about $1.90 to $1.30, a drop in real terms of about 60%. The new high prices of crude oil thus drastically change the comparative advantage between oil and alternative sources of energy, domestic or imported. In addition higher energy costs influence choice of machinery and appliances in favor of more

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1/ Plants burning coal usually have slightly higher capital costs than those burning oil or gas. This can be offset by a fairly small fuel cost differential. Nuclear plants, on the other hand, have much higher capital costs, and become attractive only where substantial differentials exist between nuclear and fossil fuel costs.

efficient, less energy-consuming equipment and processes. Over and above the results of multiple, decentralized market decisions based on the new cost relationships created by the higher oil prices, the Governments of oil importing countries, pressed hard by the very significant effects of these costs on their balances of payments, are likely to adopt accessory policies (in taxation, prices, regulatory codes, etc.) directed to energy conservation, demand compression, and rapid development of cheaper energy supplies--often with a preference for domestic sources.

11. In what follows we discuss the effects which these actions--and the changed world economic outlook--are likely to have on the energy supply/demand prospects as compared with what had been expected under the conditions prior to the events of October-December 1973.

B. Alternative Non-OPEC Energy/Supply Developments

12. In global terms 1/ and for the period up to 1985 major non-OPEC energy developments will be concentrated in the traditional sources of primary energy: coal, crude oil and natural gas. Coal production which has been growing at about 2% in most areas and actually decreasing by 2.5% per year in W. Europe (see Table 2, p. 3) is now expected to increase at about 4.5% per year, particularly in the U.S. and Australia. Its share of total energy which almost halved in the period 1960-1973 from 36% to 19% is expected now to stabilize at about 20%. Non-OPEC oil and gas production which was expected to grow slowly, by about 25% in the 13-year period 1972-1985, is now projected to grow by as much as 55% (Table 6, para. 65). The

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1/ Global figures in this report will generally include market economies only, and exclude centrally planned countries.

most important non-traditional new form of energy to be added in this period will be nuclear power, which is expected to represent the equivalent of about 750 Mtoe 1/ by 1985 or about 30% of the total energy supply additions to be made in the period 1974-1985. During this period it is also expected that a significant technological and financial effort will be made to develop commercial production of oil-like fuels from tar sands (Canada), shales (USA) and coal (USA); maximum feasible volumes of production are estimated at about 200 Mtoe by 1985 from all these sources combined, but this could only be achieved with considerable support from Government. Actual expected production figures by 1985 are estimated to be considerably less, about 50 Mtoe per year. Other sources, conventional such as hydro or less conventional, such as geothermal, solar heating and wastes, are also expected to make some contribution to total energy supplies; but in global terms they are considerably less important (altogether they may be about 5% for hydro and 1-3% for all the rest). A more detailed discussion of the various non-OPEC sources mentioned above follows. Estimates of possible production volumes and costs are given.

Crude Oil and Natural Gas

13. At the new oil prices it has become economic to accelerate exploration and production of oil and gas in all geologically promising areas. Initial efforts would probably be concentrated in North America and the North Sea. The comprehensive US National Petroleum Council study of 1972 considered that US domestic production of oil could be increased from about

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1/ Mtoe = million tons of oil equivalent = 10^{13} kcal = 1.4 million tons standard coal. 1 million barrels per day (mbd) = 50 Mtoe/year.

520 Mto to about 665 Mto by 1980 and 775 Mto by 1985 if a policy of maximum development of domestic resources were undertaken. Without such a policy, domestic production would stagnate at the 500 Mto level. A similar situation exists in natural gas. An intensive development policy would mean an increase from present levels of US production of about 500 Mtoe to 650 Mtoe in 1980 and 775 Mtoe in 1985. Without such a program, natural gas production would be expected to decrease by about 25%. In the light of present conditions some of the assumptions underlying NPC's above quoted forecasts, particularly those regarding price evolution in the period 1973-1985, have in fact been over fulfilled. 1/ The supply estimates used in this report are about 5 to 10% lower than the figures quoted above. The capital requirements needed for the intensive development of US domestic oil and gas as indicated above were estimated at about $250 billion, of which about $170 billion would be used in exploration and production. 2/ This is about double the investment required to maintain the current output level.

14. Developments in the North Sea might increase indigenous supplies of oil in OECD-Europe from current levels of 25 Mto to about 220 Mto in 1980 and 285 Mto in 1985. Oil consumption by these dates is projected at about 870 Mto and 1100 Mto. Thus, requirements from outside sources will remain high. Western Europe's natural gas production is expected to increase from about 110 Mtoe to about 230 Mtoe in 1980 and 290 Mtoe in 1985, while total

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1/ E.g., the "required" prices for intensive development were about $5 per barrel of oil in 1975 and $7.50 in 1980 (in 1974 US$).

2/ Measured in 1970 US$. In current dollars these amounts could be 40-50% higher, depending on the timing of these expenditures.

consumption is projected at 290 and 385 Mtoe by the same dates. In this way W. Europe dependency on petroleum imports might be reduced from about 85% of petroleum consumption in 1972 to about 60% in 1985.

Oil Prospects in Non-OPEC LDCs

15. There is considerable scope for oil and gas exploration and production in non-OPEC LDCs. The development of this resource base may be important for the economic well-being of many present oil importing LDCs; however, it is unlikely that major production additions will materialize before 1985.

16. Presently known oil fields can only sustain world oil requirements for the next 2-3 decades and are heavily concentrated in 8 OPEC members plus the US and the USSR. Undiscovered oil, however, may be 1.7 to 5 times the above amount; and about half of it probably lies in developing countries of Latin America, Africa, and Asia which are not already playing a major productive role. Undiscovered oil is assumed to exist in areas with geologically favorable characteristics--geosynclines and cratonic formations. 1/ Without exploratory drilling it would be very difficult to ascertain which basins in these petroleum "prospective" areas would contain petroleum in commercially recoverable form.

17. Estimates of "ultimate" recoverable reserves from all these prospective areas would add about 1,700 to 5,000 billion bb to the 1,000 billion bb quoted as existing in known fields. It is estimated that Latin America may hold about 500 to 1,200 billion bb; Africa and Madagascar about 470 to

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1/ Geosyncline: a great downward flexure of the earth crust filled with folded and faulted sediments. Cratonic: relatively stable segment of earth crust overlain by not too deformed sedimentary deposits.

1,200 billion bb; and South and South East Asia about 130 to 325 billion bb. That is, Latin America and Africa may each hold as much ultimate oil reserves as those of the Middle East. Among most promising new oil countries not in OPEC are: Mexico, Colombia, Brazil, Peru, Argentina in Latin America; Mali, Niger, Egypt, Mauritania, Chad, Tanzania, Somalia and Mozambique in Africa; India, Pakistan, Burma, Bangladesh, S. Vietnam and Thailand in South Asia.

18. The above estimates are based on correlations with average geologic conditions; some further allowances might be made for the eventual occurrence of abnormal clusters of giant accumulations such as those of the Middle East, which may not be unique. Candidate regions for such clusters are the north slopes of Canada and the USSR, Gulf of Mexico, Argentine continental shelf, the offshore areas between Mozambique and Madagascar and between Australia and New Guinea.

19. As suggested above most of the undiscovered oil potentially lies in regions (on and off-shore) belonging to non-OPEC LDCs. To explore and develop these resources a major reorientation of past drilling efforts would be required. It is a remarkable fact that the US, with only 5% of the world's oil prospective area, has concentrated two-thirds of all past world drilling. The density of drilling per square mile of "prospective" area is in the US 8 times that of the USSR and 20 to 300 times that of other promising regions (see Table 3).

Table 3

Past Drilling Efforts

	Wells drilled per 1,000 sq. mile of prospective area	Prospective area (100,000 sq. miles)
US	1,117	79.0
USSR	150	34.8
Argentina, Mexico, Venezuela	50)	48.9
Latin America (rest of)	10)	
South and S.E. Asia (including Indonesia)	10	30.0
Africa and Madagascar	3	47.2
Middle East	10	12.0

The drilling in the US may have been excessive (this was particularly the case in the past). A reasonable drilling density would be of the order of 500 wells per 1,000 sq. mile for average conditions. 1/ This would mean to increase ten-fold the effort in Latin America and about 100 times that in Asia and Africa.

20. Many well known and obvious factors explain past concentration of efforts in such areas as the US, the USSR, Middle East and Africa. In the first two cases an increasing domestic demand accompanied by a large domestic resource potential; in the others the accessibility provided by direct or indirect political control by the West. In this second group of countries we now witness a process of recuperation of control and ownership by the host governments through the establishment of national oil companies. The major international companies and the many private entrepreneurs which were responsible for the discovery and development of the great oil fields in

1/ The Middle East is an abnormal region characterized by very large clusters where considerably less exploratory drilling is required to ascertain reserves.

OPEC countries are not likely to try again in other LDCs on the basis of past arrangements. Nor are non-OPEC LDCs likely to accept them. Developing countries and agencies should become aware of the great potential value of "undiscovered" oil and begin to work out appropriate policies for its rational and beneficial exploitation. Developing countries with petroleum prospects need to train immediately a minimum number of top level petroleum-related scientists, technologists, engineers and executives, first to deal effectively with foreign counterparts in arranging for technical and financial cooperation, and secondly, to do an increasing part of the work themselves. Foreign companies should realize that they are unlikely to maintain stable associations with LDCs in petroleum development unless mutually satisfactory arrangements can be worked out. These are likely to be service contracts, joint ventures, or other balanced type agreements, rather than the concession contracts which are now generally collapsing.

Synthetic Oil and Gas Fuels

21. Oil can be produced also from shale oil, tar sands and coal.

Oil Shale

22. Major known reserves of oil shale have been identified in the US and Brazil; significant reserves are also reported in Sweden and Thailand. The regional breakdown of world reserves presented below is taken from a 1965 report of Duncan and Swanson; Column 1 is known reserves very likely to be recoverable with current state of technology (adequate content of oil per ton of shale and at reasonable depth). They are about equal to the presently proven reserves of crude oil, i.e., about 600 billion barrels.

Column 2 is a best guess as to the magnitude of total oil shale formations with a minimum of 10 gallons per ton of rock; these are indeed very large, about a hundred times present estimated ultimate reserves of crude oil; but what fraction of these deposits may be commercially developed is not known.

Estimates of Oil Shale Resources
(billions of barrels)

Region	(1)	(2)
Africa	100	84,000
Asia	90	115,000
Australia/New Zealand	-	21,000
Europe	70	27,000
North America	600	53,000
South America	50	42,000
Total	910	342,000

23. Some oil from shale is being produced in the US, Brazil and Scotland and other areas on a small scale (a few thousand barrels a day). Massive production of shale oil will involve difficult environmental problems if current technology (above ground as against underground in situ retorting of oil shale) is used. Degradation of the landscape (volume of crushed rock is greater than the original hole), contamination of the water table, and water requirements, which according to some studies may be the most critical limiting factor, are the main difficulties. The best available estimates of the capital cost of plants producing 100,000 barrels per day range from \$600 to \$900 million (in 1974 US\$). The construction time for such plants is estimated to be about 4 years. A recent report to the US Senate 1/ estimates that

1/ "Energy Research and Development - Problems and Prospects." 93rd Congress, 1st Session. Serial No. 93-21 (92-56). US Government Printing Office, 1973.

3 to 4 plants could be built per year starting operations in the late 1970's under a crash government supported program. At this rate, about 3 million barrels per day of production could be available by 1985 or about 150 Mtoe. Oil from shale may under these conditions be competitive in the US market with f.o.b. Persian Gulf crudes at $5 to $7 per barrel (1974 US$).

Tar Sands

24. Major deposits of tar sands containing hundreds of billions of barrels of oil have been reported in Canada, Venezuela and Colombia. In general, the inventory of these deposits is very incomplete; relatively small deposits may also exist in the US, USSR, Trinidad, Albania and Romania. Oil from tar sands is produced commercially in Athabasca (Alberta, Canada) in a plant with a capacity of 50,000 barrels per day. Intensive development of new facilities could bring Canadian production up to a level of about 1 million barrels per day (mbd) by the mid 80's. Oil from Canadian tar sands would be competitive in the North American market with f.o.b. Persian Gulf oils at about $6 per barrel (1974 US$). Similar facilities could be initiated in the Venezuela and Colombian tar areas, though further exploratory work would undoubtedly be required. Production before 1985 is therefore unlikely.

Oil from Coal

25. Two processes for extracting oil products from coal were successfully developed in Germany during the 1930's. 1/ Other plants were also operating in the UK, Italy, Korea and the USSR during the last war. Since 1955 a modernized plant consuming 4 million tons of coal per year has been

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1/ Over 5 million tons of gasoline were produced by these plants during World War II.

operating in South Africa. In all these cases strategic factors have overriden economic considerations. Past efforts also were directed primarily to the production of gasoline, whereas future efforts are more likely to emphasize the production of substitute heating and fuel oils as well. Future commercial plants would be designed for a 100,000 barrel per day capacity and are estimated to cost about $600 to $900 million. 1/ Overall coal liquefaction costs would be competitive with Persian Gulf f.o.b. crude oil prices of about $7 to $9 per barrel (1974 US$), using low cost US coals. The environmental problems will be the same as those associated with coal mining in general and somewhat less than those of oil-shale mining. However, some of the technological problems associated with coal liquefaction processes themselves are complex and it is unlikely that major plants would be built without considerable testing of the processes in pilot operations. Consequently, oil production from coal before 1980 is unlikely; however, if the technology proves out, production may expand more rapidly than that of shale oil. A production level of about 100 Mtoe for 1985 might be feasible.

<u>Gas from Coal</u>

26. Coal gasification, particularly the production of high BTU gas equivalent to natural gas--is one of the most promising and significant developments in the energy field. Several processes have been tested in the pilot stage and one of them (the Lurgi process originally developed over 30 years ago) has been used on a commercial scale. At least 3 processes are far advanced for the production of low BTU gases suitable for power and industrial uses. Over 8 processes have been proposed for production of SNG (natural

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1/ US Senate report quoted para. 23.

gas substitute) which is more suitable for domestic and established users. Estimated costs of coal based synthetic natural gas are about $1.00 to $1.60 per thousand cubic feet. US well head natural gas prices in inter-state commerce (regulated by the Government) are about $0.42, but intrastate prices range up to $1.00; and imported LNG may cost anything between $1.30 to $2.00 when it is delivered in quantity in the late 1970's.

27. 176 potential coal gasification sites have been identified in the US. The main requirements are: (1) an adequate adjacent coal reserve base (i.e., about 200-500 million tons) for operating a commercial size gasification plant (250-750 million cubic feet per day) for 30 years; and (2) abundant water supplies to provide the steam required by the hydrogeneration process. In addition, it is essential that coal be available at reasonable costs; open cast mines and moderate depth underground mines are the most suitable. It seems reasonable to suppose that suitable sites also would exist in the UK, Germany, and other coal mining countries; however, no important programs of this type outside the US have been announced.

28. It is estimated that thirty plants might be put in operation in the US by 1980 and about 70 by 1985. Each plant would produce 250-750 million cubic feet (MCF) per day. The capital cost would be about $1 million per MCF per day of capacity, equivalent to about $600 million for 100,000 barrels per day production of oil. Total energy from this gas would represent about 50 Mtoe in 1980 and about 150 Mtoe in 1985.

Coal

29. For the last decade coal consumption has been increasing at a very low rate of 0.26% per year, while oil and gas increased at about 7% and overall energy by an average of 5.2% (Table 2, page 3). Furthermore, one of the major coal markets--the electric utilities--recently began to turn towards nuclear power. 1/ All previous forecasts regarding the future of coal had, therefore, assumed a continual decrease in importance, so that for the year 2000 only about 10% of primary energy was foreseen as originating in solid fuels in spite of the fact that coal reserves are about 15 times those of oil or gas.

30. Average coal prices in major markets were in 1973 equivalent to anything between 30¢ and 90¢ per MBTU 2/--the lowest prices prevailing in the US, Canada, Australia and South Africa, and the highest in the U.K., W. Europe and Japan. In these latter regions, oil was a very competitive alternative at its 1973 price of about 50¢ to 60¢ per MBTU. With current and foreseen oil prices of about $1.30-$1.50 per MBTU, there is an economic incentive for substitution back to coal, even allowing for additional environmental and pollution control costs.

31. The most promising areas for increasing coal production are the US, Australia and some parts of Africa, where open cast mining is possible and production facilities can be expanded in a few years. The UK and Germany, which also have a large coal base, as well as Japan, may find it difficult to activate more mines, mainly because of labor recruiting problems for underground mining.

1/ World coal consumption of about 2,300 million tons per year is shared by Utilities 900, Iron and Steel 470, Industry 700 and Domestic 230; these figures include centrally planned countries.

2/ About $8 - $25 per ton of standard coal.

32. In the US the investments needed, in terms of dollars per ton of additional annual production, are about \$18-\$22 for underground mining and \$10-\$13 for strip mining. Expansion is expected to be shared about equally by each type of mine, so that a good average figure is \$16/ton/year of capacity. Therefore, total investment requirements up to 1985 to produce an additional 700 million tons of coal per year (including replacing about 200 million tons of existing capacity) would total about \$11 billion. To this one should add about \$3 billion for investment in coal transportation facilities. In Europe and Japan, the investments required to maintain present levels of production are estimated at about \$4 billion through 1985 on the basis that about 100 million ton/year of new production would be required in order to replace pits closing during the period; and that investment per ton per year of additional capacity is about \$36 in these regions, due to the less favorable characteristics of the mines.

33. Major new extraction facilities for coal may require a lead time of about 1-2 years for strip or open-cast mining (depth 0-100 ft); 3-4 years for adit and drift mines (depth up to 200 ft); and 4-8 years for deep underground mines (up to 2000 ft depth).

34. An intensive coal production drive in the US would mean that coal production may grow from the current 500 MTon/year to about 1,000 MTon/year by 1985. Part of the new increase would be used for the production of synthetic gas and oil mentioned previously. The main problems are the environmental requirements of land reclamation in open cast mine areas and air pollution from combustion gases. Both these problems can be solved by existing and foreseeable technologies but at a rather significant cost--estimated at about \$0.35 per MBTU.

35. A net increase in coal production can also be expected from Australia mainly for export to Japan. The latter are currently about 20 MTon/year and are expected to double by 1980. Europe, on the other hand, was expected to experience a decline in output from present levels of 360 MTon/year to 260 MTon/year in 1985. Major efforts are now likely to at least maintain the present output levels. In order for this production to increase it would be necessary that new underground mining technologies be adopted more widely. The same considerations apply to Japan.

36. The developing countries have generally not exploited their coal resources very extensively, a notable exception being India. Under present conditions these countries may be expected to look again into their coal potential both for domestic as well as for possible export. Coal and lignite may play an important domestic role in a few LDCs (Yugoslavia, Turkey, India, Brazil, Argentina, Chile, Korea, Taiwan, Indonesia). Very few--e.g., Colombia, Botswana, Swaziland--may develop it as an export product.

Nuclear Power

37. Prior to the current energy crisis, nuclear power was already being developed at a very high rate, although the share of nuclear energy in total supplies remained very small. World installed capacity by the end of 1973 was about 50,000 MWe, with over a half in the US. By 1980 this figure could be about five times higher and by 1985 about ten times or approximately 500,000 MWe. In terms of percentage of total installed electrical plant, these figures would represent about 20% by 1980 and 25% by 1985. In terms of energy generated, because nuclear plants are used as base load, the percentages would be higher--about 28% and 35%. It seems very difficult to

increase pre-crisis nuclear programs very substantially before 1980 due to the long lead time--up to 10 years--required for licensing and construction of these facilities, and the difficulties involved in expanding ancillary engineering and manufacturing capacities. A 10% to 20% increase over previous plans may be feasible by 1985.

38. Until recently the economies of nuclear power vis-a-vis oil plants looked marginal at unit sizes below 600 MW. They would now be theoretically competitive at sizes well below that--even 200 MW--and, therefore, they could be located in a larger number of developing countries. However, it is very unlikely that they would be available as the manufacturers with experience in this field are geared to produce the larger units and will be overstrained to meet the increased demand of the industrial countries.

39. Rapid expansion of nuclear power capacity can only take place if a number of present constraints can be overcome. Safety is a major consideration in operating such plants, and opinions still vary widely as to the degree this problem is under reasonable control. Other factors which are of importance are the identification of proper sites (which combines to some extent with the need to dispose properly of nuclear and heat wastes) and the potential of countries acquiring nuclear capacity to use this for military purposes. Nevertheless, a major further expansion can be foreseen, combined with a wider spread in terms of the number of countries relying on this technology.

40. In terms of investment nuclear power requires about twice as much capital per unit of power generated as fossil fuel plants (about $400 per KW of capacity vs $200 for a typical 600 MW unit). However, overall energy costs, are lower because fuel costs in nuclear plants are equivalent to about 20¢/MBTU compared with January 1973 oil costs of 35-50¢/MBTU and current prices of the order of 100-150¢/MBTU.

Hydroelectricity

41. At the present time a large portion of the developing world's electric energy requirements are being met from hydroelectric sources: 44% of all electric production is hydraulic, as compared to 24% in the developed world. Total production of electricity in the developed world is presently some 9 times that in the developing world, but the developing world has a much greater untapped potential of hydroelectric power, particularly in some parts of Africa, most of Latin America and in south central Asia. In some of these areas, it is the energy resource which can be developed most easily.

42. Some of the countries with major hydroelectric resources which have not yet been developed include: in Africa Cameroon, CAR, Congo, Zaire, Gabon, Mozambique, and Malagasy; in the Western Hemisphere Chile, Venezuela, Peru, Brazil and Colombia; in Asia India, Pakistan and Thailand; and in Europe Turkey, Greece and Iceland. In some countries, a substantial part of the total undeveloped resources is located far from the present market for electricity; these sites may nevertheless be attractive for development at the new level of prices of fossil fuels.

Other Sources

43. Geothermal resources are being explored in about 20 countries, most of them LDCs. Geothermal energy is used already in minor amounts in about 8 countries for electricity production and space heating. Until new technology is developed to extract heat from deep rock the only economic sources are rarely occurring brine and steam deposits located at depths between 500 to 2,500 m. Their energy potential is too limited to make a meaningful contribution to world needs but they may be significant for specific locations (e.g, Salvador, Iceland, North of Chile, South Luzon, etc.).

44. Solar energy can be used for residential/commercial space heating and in some industrial processes. We may expect an increase in its use for these purposes, particularly in new construction. Solar heating in temperate countries may reduce residential energy requirements by as much as 50%. It is used extensively in Israel and had begun to be used in California and Florida in the US, till cheaper fuels discouraged further growth. Solar electricity can be produced (and is used in space applications) in solar cells. At current costs it is about 100 to 1,000 times more expensive than conventional power generation. Only major research and development efforts might produce the breakthroughs that are needed to bring these costs down; none are foreseen within the next 10-15 years.

45. Other energy sources frequently mentioned are: wastes, wind, tides, etc. Though instances in which each of them can be of limited help do exist, globally speaking they have been evaluated as potentially small (wastes, tides) or costly except under special circumstances (wind in isolated rural areas).

C. Demand Changes

46. Many studies have been made in the industrial countries in order to forecast accurately the growth of energy demand. Most of these studies project energy consumption, locally and by sector (transportation, industrial, commercial, residential, and electricity); they consider the relations of energy use to total GNP as well as to its sectoral composition; they include appropriate assumptions on population trends, modes of life, environmental policies and technological changes. In exceptional cases (e.g., the 1972 NPC US Energy Outlook Study) assumptions on price trends have also been explicitly incorporated.

47. In the years 1955-1972, energy use has grown at rates fairly close to GNP growth. The elasticity of energy consumption to GNP 1/ in the developed countries generally ranges around unity but appears to be lower with higher levels of development. Thus in the US and Canada energy use increased slightly less per year than real production; in Western Europe the rates were about the same on average, but in Japan and the centrally planned countries energy consumption growth exceeded the rate of growth of GNP. In the developing countries, energy consumption growth has tended to exceed production growth even more, reflecting the modernization of their economies towards more energy intensive production activities.

1/ This elasticity coefficient, also called "income" elasticity, measures the percentage change in energy demand caused by a 1% change in GNP.

48. Most experts 1/ have favored an empirical-historical approach when forecasting demand for LDCs. They have noted that the fairly constant GNP/energy relations observed in most industrial societies do not hold for long in LDCs as these evolve from agrarian to industrial production modes.

49. In estimating the likely impact on demand for energy of the recent oil price increases and the changed world economic outlook, major modifications of pre-crisis estimates should include:

(i) A first impact due to price elasticity of demand 2/ and, to a lesser extent, Government fiat enforcing energy conservation practices.

(ii) A second impact due to changes in the previously expected rate of GNP growth.

Price Elasticity of Demand

50. Extrapolation of energy and particularly oil consumption trends for the next decade based solely on energy/GNP ratios measured during the last 15-20 years would be grossly inadequate under present conditions, particularly if one takes into account the fact that energy prices and specially petroleum prices had been falling in real terms and now have suddenly increased by a large step.

1/ E.g., A. Aoki (Japan), F. Felix (USA).

2/ Price elasticity is the percentage change in demand caused by a 1% change in price. A "cross-elasticity" of demand measures the percentage change in quantity demanded of a fuel with respect to a 1% change in the price of another (substitute) fuel.

51. There is considerable literature on energy demand elasticities (as a function of income and price). Some of it relates to specific fuels or uses (e.g. natural gas, fuel oil, residential electricity); most of it refers to the U.S. and Europe. The application of past studies to the present conditions can only be made with a high degree of caution, particularly because, for short-term substitution effects, not only the rigidities of user's equipment but also the limitations of available supply alternatives may act as very important constraints. 1/ For longer term projections (beyond 1985) these constraints should not be so limiting. Caution is also needed before extrapolating linearly for price changes which are much higher and sudden than any previous ones.

52. For these reasons it appears advisable to project lower elasticities than historical over measured and to prefer aggregate sectoral energy elasticities (e.g. change in total residential demand with average energy cost to the sector) rather than cross-elasticities among energy substitutes (e.g. heating oils vs. gas). Typical long-term (above 5 years) price elasticities of demand in the various sectors which have been used in recent studies range between -0.2 and -0.4 (see table below).

1/ In the period 1950-1972 coal was being replaced by oil and natural gas which were not only cheaper and more convenient to handle but also were made available in large amounts as demand increased. Availability of coal and nuclear energy is much more constrained by technical, financial and environmental factors. Therefore cross-elasticities for substitution among fuels are not likely to behave symmetrically (e.g., oil to coal vs. coal to oil).

53. Long-Term Price Elasticities of Demand for Energy by Sector

Sector	U.S.A.	W. Europe		Japan
Residential/Commercial	-0.2 to -0.3	-0.4	-0.4	-0.3
Industrial	-0.4	-0.3		-0.2 to -0.3
Transportation (Gasoline)	-0.3 to -0.5	-0.3 to -0.4		-0.4
Transportation (Other fuels)	-0.20 to -0.40	-0.2 to -0.30		-0.40

Sources: N.P.C. - U.S. and OECD reports

Other studies which have used cross-elasticities rather than average total sector elasticity coefficients quote figures such as: -0.24 to -0.82 for gasoline; -1.0 for residential electricity; -0.76 to -2.0 for various heating oils. 1/

54. For short-term elasticities the values observed are considerably lower. The U.S. Federal Energy Administration for instance is projecting 1974 unconstrained quarterly demands using elasticities of about -0.07 for kerosene; -0.15 to -0.21 for gasoline; and -0.12 to -0.16 for petrochemical feedstocks. They use higher values for longer periods.

55. In the Energy Balance Tables, which are presented in Part D of this paper we have generally used for total energy demand an income elasticity (energy/GNP) of about 1.0 and an average long-term price elasticity of about -0.2. This latter value may be somewhat conservative; its adoption is based on the considerations given in paras. 50-53 above. Out projections thus forecast a higher energy demand than others based on coefficients bigger than -0.2, and accordingly larger OPEC sales and revenues.

1/ Houthakker & Kennedy used these demand price elasticities, and oil supply price elasticities - 0.25 to - 0.67 in a recent World Oil Market Model. The result is to project US consumption in 1980 at the level of 1973 and a return to a US oil surplus position.

56. Price elasticities are naturally applied at the consumer price level. Therefore it has been necessary to make assumptions regarding the effects of crude oil f.o.b. price changes on final costs to the consumer, and not only for petroleum products but also for other fuels and electricity. For petroleum products we have assumed that absolute pre-crisis differentials with crude oil prices will be maintained. To the extent that Governments apply absolute rather than percentage type taxes this may be reasonable; for the time being this appears to be the case in most countries.

57. For gas and coal the assumption made is that their prices would increase up to a level of competitive equilibrium with oil based substitutes in those markets and localities where possibility of substitution exists (e.g. coal and fuel oil in thermal plants compete if prices at plant site are about 25% less per heat unit for coal than for fuel oil). On the whole the above assumptions mean that an increase in Persian Gulf f.o.b. crude oil prices of a 100% would have the effect of raising average retail energy costs by about 15% in the U.S., 20% in W. Europe, 50% in Japan and something like 30-40% in most oil importing LDCs. The differences between percentages result from higher or lesser availability of competing domestic fuels and different national tax levels. On the average for the whole of OECD the energy price increase at the consumer level is about one-fifth of the percentage increase in f.o.b. Persian Gulf crude oil prices.

Energy Conservation

58. In addition to the price mechanism, it is likely that Governments by administrative or legislative fiat, will further constrain the growth of energy use. Examples of these measures would be: new building codes requir-

ing better heating/cooling insulation; minimum efficiency ratings for equipment, vehicles and appliances; higher energy-related taxes and possibly (tail-end) power and gas domestic tariffs; restriction on the use of certain fuels for power generation; rationing of fuels for residential/commercial heating, etc. In 1972 the U.S. Government conducted a study 1/ of the possible short, medium and longer term measures that would be needed to reduce the consumption of energy without impairing GNP growth or most people's freedom of choice and mode of life. The study concluded that conservation policies (many of them relying on higher prices to induce market decisions towards energy conservation) could diminish by about one-third the projected growth of energy consumption up to 1990 (and one-half that of oil). In brief, overall growth in energy consumption could be slowed from a rate of about 3.8% per year to about 2.5% without detectable effects on projected GNP growth rates. It is unlikely that similar reductions can be obtained in other societies, where intermediate energy uses (forming part of the process) are a much higher proportion of total uses than in the US; such reductions could be achieved only through considerable adjustments in the industrial and transportation sectors. Some analysis of these possibilities have begun in Japan and other countries, exploring non-energy intensive domestic patterns of industrial growth which happen to be coincidental with other, mainly environmental, objectives.

59. There are considerable differences in the composition of energy consumption by end-uses at different levels of development. Power and transport are the major elements in most developing countries but industrial uses

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1/ The Potential for Energy Conservation, Office of Emergency Preparedness, October 1972 (about 150 pages).

take an increasing share at higher levels of development; in the industrial countries household use is a rapidly growing component. Consequently, conservation of energy use as a means to reduce the cost of and dependence on imported oil is clearly more difficult in countries at lower development levels, as it is hardly possible to save energy without at the same time reducing output and income growth. In industrial countries, where household use is important, reduction can be brought about without production losses. But past experience does not provide any basis for estimating demand elasticities of energy use; this makes it hard to estimate the degree to which consumption can be reduced through the use of the price mechanism.

60. A recent study by OECD 1/ assessed the possibilities of reducing the use of energy in its member countries and found that, on the average, a reduction of demand by 7-8% might be feasible without reducing economic growth. This percentage varied from country to country, being highest for the US (8.5%) and lowest for Japan (6%).

Substitution and Technical Constraints

61. The shifts which are likely to take place in the composition of the energy "mix" in the period 1973-1985 under the supply/demand assumptions discussed in this paper are comparatively minor compared with those of the preceding 10-15 years in W. Europe and Japan. Table 4 illustrates the expected shifts in the primary energy composition up to 1985 in the OECD group of countries, which may be compared with the larger changes shown in Table 2 for the period 1960-1973. Background Paper V discusses in more detail the sector shifts which are likely to occur, particularly in electricity production and some energy intensive industries.

1/ OECD: "Economic Outlook," No. 14, dated December, 1973.

Table 4

Changes in the Energy Mix in OECD Countries
(In %)

	1971 Actual	1980 Estimated	1985 Estimated
Coal			
Indigenous	20	17	19
Imported	1	1	1
Total	21	18	20
Oil			
Indigenous	21	22	21
Imported	32	27	24
Total	53	49	45
Natural Gas			
Indigenous	21	21	20
Imported	-	2	1
Total	21	23	21
Primary Electricity	3.5	10	15
(of which Nuclear)	-	(7.5)	(12)
Total Primary Energy			
Indigenous	66	70	75
Imported	34	30	25
Total	100	100	100

Table 5 shows the expected shifts in use of sources of energy by the various user sectors: residential/commercial, transportation and industrial; it also shows the important changes expected in the energy sources required to generate electricity.

Table 5

Shifts in Energy Use in OECD Countries by Sector

			Coal	Oil	Gas	Electricity (Secondary)	Total
Industry:	1972	(MTOE	208.3	290.0	326.1	150.9	975.3
		(%	21	30	34	15	100
	1985	(MTOE	224.4	418.4	534.0	331.3	1508.1
		(%	15	27	36	22	100
Transportation:	1972	(MTOE	2.9	721.0	.1	4.2	728.2
		(%	1	98	-	1	100
	1985	(MTOE	-	1195.7	-	9.1	1204.8
		(%	-	99	-	1	100
Residential/ Commercial:	1972	(MTOE	56.3	402.5	251.3	141.6	851.7
		(%	6	48	29	17	100
	1985	(MTOE	20.4	420.5	516.5	345.6	1303.1
		(%	1	33	40	26	100

			Coal	Oil	Gas	Nuclear	Other	Total
Electricity Production:	1972	(MTOE	329.1	219.4	130.6	34.8	250.1	974.0
		(%	34	33	13	4	26	100
	1985	(MTOE	603.0	224.5	196.6	790.9	390.3	2205.3
		(%	27	10	9	36	18	100

The main sectoral shifts observed are an increasing role of gas and electricity in residential/commercial use - mainly at the expense of oil. Shifts in transportation are nil (it continues to be a captive petroleum market); and shifts in industry are minor, a continuing decline of coal and increase in electricity, while oil and gas have only small variations; in the generation of electricity the most remarkable, but not unexpected, change is towards nuclear power at the expense of all other primary fuels.

D. Energy Balance - Projected Requirements of OPEC Oil

62. In parts B and C of this paper we have discussed the general basis for the following supply and demand estimates. In the case of supply we assume that the new level of oil prices will stimulate a more rapid development of indigenous resources, oil and non-oil -- in all non-OPEC countries. Supply estimates are based on best available data regarding what is feasible to achieve within the period in question and at costs competitive with imports. Constraints of a financial, technological, and social nature at the producer and utilization ends are also taken into account (e.g. coal production could be expanded in the US at a much higher rate than society will allow, due mainly to environmental constraints). In the case of demand, our estimates vary according to the assumptions regarding GNP growth and future prices of crude oil.

63. As explained in the main report, for the purposes of this study a detailed energy balance analysis has been made only for the OECD group of countries. This group represents 81% of world oil consumption and 86% of oil imports (excluding centrally planned countries which have and are expected to continue to have small energy exchanges with the rest of the world). Our estimates, particularly on supply are based on preliminary results of a recent study made by the Long Term Energy Assessment Group of OECD, which had the benefit of inputs and comments from member governments and their specialized agencies.

64. Depending on which assumptions are made on GNP growth and oil prices, many cases could be developed. In Table 6 we have shown 3 such cases for 1980 and 1985 differing mainly in the price assumptions. These are intended to

TABLE 6 [1/]

Consumption and Imports of Primary Energy in OECD Countries - 1972, 1980, 1985
(High GNP variant - 3 oil price alternatives)

		1972 Actual	1980 (a)	1980 (b)	1980 (c)	1985 (a)	1985 (b)	1985 (c)
			Persian Gulf Prices f.o.b. 1974 US$					
		2.60	4.12	8.25	12.35	4.12	8.25	12.35
			Average GNP Growth Rates					
			5.0	4.7	4.7	5.0	5.0	5.0
Primary Energy			(millions tons of oil equivalent)					
Coal	Indigenous	640	770	870	880	940	1080	1090
	Imported	20	10	-	(40)	10	(40)	(90)
	Total	660	780	870	840	950	1040	1000
Oil	Indigenous	680	900	970	1090	940	1090	1380
	Imported	1230	2000	1460	1030	2640	1720	1090
	Total	1910	2900	2430	2120	3580	2810	2470
Gas	Indigenous	760	770	870	960	850	1020	1100
	Imported	(10)	170	120	120	280	190	160
	Total	750	940	990	1080	1130	1210	1260
Primary Electricity								
	Nuclear	30	330	350	350	660	760	760
	Hydro/Geothermal	100	120	130	130	140	160	160
	Total	130	450	480	480	800	920	920
Total								
	Primary Energy	3450	5070	4770	4520	6460	5980	5650
	Indigenous	2210	2890	3190	3410	3530	4110	4490
	Imported	1240	2180	1580	1110	2930	1870	1160
	Dependency (% imported)	(36)	(43)	(33)	(24)	(45)	(31)	(20)

1/ This Table provides data for Fig. 2, page 18 of the main report.

Source: IBRD staff estimates based on OECD preliminary results.

provide a broad framework for additional interpolations. Case (a) corresponds to the scenario foreseen prior to the crisis of October 1973. GNP is assumed to grow at about 5% and prices to be $4.12 or about equal to the price assumptions made prior to October 1973. Case (b) assumes a slightly reduced rate of GNP growth and a doubling of the price to $8.25. This price is somewhat less than the average price for 1974 of about $9.60. Finally, Case (c) assumes the same GNP growth as (b) but a further price increase to $12.35.

65. Cases (a) and (b) of Table 6 give a good indication of the approximate impact of the "energy crisis" on projected amounts of energy consumption and oil imports under pre- and post-crisis conditions. Total primary energy consumption in 1980 would be compressed by about 6-7% of which about 1/3 would be due to income elasticity and 2/3 to price elasticity of demand. At the same time the supply of indigenous sources would increase by about 10%. The net effect is a very significant drop in oil imports: from 2,000 tons (40 mbd) to about 1,460 (29 mbd) or about 30%.1/ Another interesting point to note in Table 6 is the fact that pre-crisis projections assumed an increased OECD energy dependency from exports of about 45% by 1980-1985. Under presently foreseen conditions in Case (b) this dependency goes down to about 30%; and in the case of the U.S. (not shown separately) to about 15-10%.

66. Adding to OECDs the oil import requirements of other countries (mainly oil importing LDCs) Tables 7, 8 and 9 were developed. They are given as Annex 2. In these tables Cases I and II correspond to oil prices f.o.b. Persian Gulf of $8.65 and $7 per barrel respectively.

1/ A reduction of the GNP growth rate for OECD countries from 4.7% to 3.5%, together with a price of about $8 per barrel, would lead to even lower projected oil imports, similar to those of 1972 (about 25 mbd).

67. In conclusion the above tables show that future world energy growth is likely to slow down from past levels of about 5% to levels of about 4%, and oil consumption in particular from levels of about 7% to about 4.5%. As for oil imports from OPEC countries, the forecasts range over a wide margin. OPEC oil sales will depend on the actual magnitude of the gap between total demand and indigenous supplies of non-OPEC energy; small changes in either will have a large effect on OPEC exports. For Cases I and II of the tables above OPEC sales are projected to be about 30% below those of pre-crisis forecasts. At these reduced volumes of exports, market sharing agreements among OPEC countries would be needed; this has not been necessary before.

The Transition Period 1974-1980

68. In the interim period 1974-1980 supply and demand are likely to evolve as follows. Energy demand will respond first to Government programs and short term (small) price elasticity effects. It may stabilize in 1974 at near 1973 levels and then slowly grow at the new reduced rate of about 4% instead of 5% per year (for oil these percentages are 4.5% and 7.5% respectively). Non-OPEC supplies are not expected to increase significantly before 1977-78 when the initial impacts of Alaska, North Sea and some US offshore supplies will reach the market. World supplies are expected to remain as much or even more dependent on OPEC at least till then; only after 1977-78 will the impact of longer term (larger) price elasticities and important new supplies begin to become evident.

2 Attachments
(Annexes 1 and 2)

E. Friedmann
July 18, 1974

ANNEX 1

Energy Conversion Factors

Source	Unit	Tons of Oil Equivalent (10^7 Kcal)
Crude Oil	Ton	1.034
Coal	Ton	0.7
Natural Gas	M^3	0.9 (USA) - 0.84)
Gasoline	Ton	1.128
Jet Fuel	Ton	1.133
Gas Oil	Ton	1.095
Fuel Oil	Ton	1.055
Electricity (Nuclear)	1000 Kwh	0.2436 (33% efficiency)
Electricity (Hydro)	1000 Kwh	0.1064 (80% efficiency)

July, 1974

TABLE 7. WORLD OIL CONSUMPTION
(millions of metric tons)

	1970	1972	1973 Provisional	1980 Forecast a/ Case I	1980 Forecast a/ Case II	1985 Forecast a/ Case I	1985 Forecast a/ Case II
United States	695	776	815	958	1110	977	1130
Canada	73	79	84	110	115	130	140
Western-Europe	626	701	748	880	994	1110	1245
Japan	199	234	267	415	430	495	525
Total	1593	1790	1914	2363	2649	2712	3040
Other Developed Countries	52	61	64	103	110	146	160
Developing: Non-OPEC	250	288	306	450	470	633	638
OPEC	40	45	48	96	96	157	157
Increase in Stocks	78	34	71	95	100	105	105
Total	2013	2218	2403	3107	3425	3715	4100

a/ Case I assumes oil price of $8.65; Case II, $7 per barrel f.o.b. Persian Gulf.

Source: IBRD staff estimate based on OECD preliminary results.

Table 8. WORLD OIL PRODUCTION
(million of metric tons)

	1970	1972	1973 Provisional	1980 Forecast a/ Case I	1980 Forecast a/ Case II	1985 Forecast a/ Case I	1985 Forecast a/ Case II
United States	538	532	517	680	680	792	740
Canada	72	89	102	115	115	150	145
Western Europe	23	22	23	220	220	285	275
Japan	...	...	1	1	1	5	5
Total	633	643	643	1016	1016	1232	1165
Other Developed Countries	9	15	18	25	25	28	25
Centrally Planned Economies (net exports)	52	49	44	...	...	...	...
Developing: Non-OPEC	161	175	188	300	300	455	480
OPEC	1158	1336	1510	1766	2084	2000	2430
Total	2013	2218	2403	3107	3425	3715	4100

a/ See Note to Table 7.

Source: IBRD staff estimates.

TABLE 9. NET OIL EXPORTS AND IMPORTS BY AREA
(millions of metric tons)

	1970	1972	1973 Provisional	1980 Forecast a/		1985 Forecast a/	
				Case I	Case II	Case I	Case II
Net Oil Imports							
North America b/	158	234	280	273	430	165	385
Western Europe	603	679	725	660	774	825	970
Japan	199	234	266	414	429	480	520
Total	960	1147	1271	1347	1633	1470	1875
Other Developed Countries	43	46	46	78	85	118	135
Non-OPEC Developing Countries c/	89	113	118	150	170	140	162
Increases in Stocks	78	34	71	95	100	105	105
Total	1170	1340	1506	1670	1988	1843	2277
Net Oil Exports							
OPEC Countries	1118	1291	1462	1670	1988	1843	2277
Centrally Planned Economies	52	49	44	...	...	...	...
Total	1170	1340	1506	1670	1988	1843	2277

a/ See Note to Table 7.
b/ Canada is a net oil exporter.
c/ Includes developing countries which are non-OPEC net oil exporters.

Source: Bank staff estimates.