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Future Role of Oil and Natural Gas in OPEC and Non-OPEC Regions to the Year 2000 and Beyond

by

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Oil and natural gas are very much interrelated. They are both discovered in sedimentary basins and exist in nature in equilibrium under reservoir conditions deep inside the earth. In many cases they are found associated with each other in the same reservoir rocks, and hence the name "petroleum" is used to indicate both oil and natural gas. Their ultimate resources in nature are always comparable. Certain volumes of the associated or non-associated natural gas transform to oil under atmospheric conditions forming field condensate or Natural Gas Liquids (NGLs). Oil and natural gas can easily be substituted for each other as energy sources. It is, therefore, not surprising to find a close link between the price of natural gas and that of crude oil. It must be stated, however, that this parallel between oil and natural gas has its limits since natural gas, unlike crude oil, is far from being an international commodity that could benefit from international trade of global scale. The huge bulk of natural gas is still consumed on a regional basis, and there is still a substantial volume of it either flared or re-injected inside the earth. Also, its uses are not as diversified as those of oil, and it is less safe to use.

The supply of natural gas in the world is abundant. However, the utilisation of indigenous gas resources for internal requirements in most nations, particularly the developing countries, has not been handled properly and a lot of wastage is taking place. Most gas discoveries in developing countries remain undeveloped despite the obvious need for energy supply. A gas discovery has, therefore, been a disappointing or even undesirable event up to the very recent past. This is because of the difficulty of exporting gas to world markets. This is not the case, of course, in industrial countries where a large local market exists, but it is constantly an obstacle in a number of developing countries which lack natural gas infrastructure.

In the past, gas was viewed as a factor to moderate world increasing demand for oil. However, more recently, and due to the environmental regulations, natural gas is considered a cleaner source of energy, as compared to the other fossil fuels, since it has lower CO_2 emissions. Therefore, environmental pressures and carbon dioxide emission control could stimulate future development of the natural gas industry and thus increase natural gas share in the primary energy mix and particularly in the total fossil fuel share. Furthermore, if the carbon content of fossil fuels is considered, then any future reduction in energy consumption would impact coal more than oil since the former contains more carbon than the latter.

In order to project the future role of oil and natural gas, it is essential to consider their past and present performances in the primary energy mix. During the 1980s, the combined share of oil and natural gas in the total world primary energy consumption was more than 60%. It was 64.0% in 1980, declined to 59.7% in 1985 before rising to 60.2% in 1990. Although the share of oil indicated a slight drop from 44.9% in 1980 to 39.4% and 38.6% in 1985 and 1990 respectively, the share of natural gas, however, showed clear improvement from 19.1% in 1980 to 20.3% and 21.6% in the respective years 1985 and 1990, as depicted in Table 1.

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Table 1
Evolution of Total World* Primary Energy Consumption, 1980 - 199[illegible]
(mtoe)

Fuel Type	1980	1985	[illegible]
Natural Gas	1286.1	1459.1	1736.1
Oil	3024.0	2833.7	3101.4
Coal	1815.3	2045.0	2192.1
Hydro-electricity	431.5	508.3	540.6
Nuclear	172.0	347.4	461.1
Total	6728.9	7193.5	8033.3
Natural Gas, %	19.1	20.3	21.6
Oil, %	44.9	39.4	38.6
Coal, %	27.0	28.4	27.3
Hydro-electricity, %	6.4	7.1	6.7
Nuclear, %	2.6	4.8	5.7

* Including the former CPEs.
Source: BP Statistical Review of World Energy, 1991.

Proven Reserves and Resource Base

The discovery of natural gas resources, until very recently, was achieved, by coincidence, during the worldwide search for oil. Development of these discovered natural gas reserves was made only when they occurred close to the consumption centres. More recently, intensive exploration activities for search of additional natural gas reserves tended to centre on areas where transportation system and established gas market already exist.

The Ultimate Resources (sum of cumulative production, identified and undiscovered reserves) of oil and natural gas are comparable. They were estimated at the beginning of 1990 at 296 and 268 billion tons of oil equivalent respectively, as shown in Table 2.

Table 2
Total World Ultimate Resources of Oil and Natural Gas
(1.1.1990)

		Cumulative Production	Identified Reserves*	Undiscovered Reserves	Ultimate Resources
Oil	(bb)	629	1053	489	2171
	(bt)	(86)	(144)	(67)	(296)
Natural Gas	(tcm)	45	128	125	298
	(btoe)	(41)	(115)	(113)	(268)

* Identified reserves here include proven, probable and possible categories of reserves
Source: C.D. Masters, D.H. Root, and E.D. Attanasi (US Geological Survey), 13th World Petroleum Congress, 1991.

Although the identified reserves of oil are higher than those of natural gas, the reserve-to-production (R/P) ratio is much higher in the case of natural gas due to the low

level of production of natural gas as compared to oil production. Also the undiscovered reserves of natural gas estimated at 113 btoe, are almost twice as much as those of oil (67 bt).

The evolution of the addition in world proven oil and natural gas reserves is illustrated in Figures 1 and 2. Total world proven oil and natural gas reserves currently stand at 1053 billion barrels of oil and 128 trillion cubic metres of natural gas respectively. At current production levels, these reserves would last 46 and 57 years respectively.

However, if we consider the undiscovered oil and natural gas resources, the life-spans of these two important sources of energy could be extended by about 50 per cent for oil and more than double the current life span for natural gas at current production rates (Table 3).

Table 3
Total World Proven Reserves, Production, and R/P Ratio for Oil and Natural Gas
(End of 1990)

	Oil	Natural Gas
Remained Ultimate Resources (R_1)	1542 bb	253 tcm
Proven Reserves (R_2)	1012 bb	131 tcm
Production	60.2 mb/d	2.3* tcm/year
R_1/P Ratio (years)	46	57
R_2/P Ratio (years)	70	110

* Gross production minus reinjected natural gas.

During the last three decades there was substantial oil and natural gas reserves addition, estimated at 259, 115 and 347 bb for oil and 26, 38 and 48 tcm for natural gas at the end of the 1960s, 1970 and 1980s respectively, as demonstrated in Table 4. During this period, OPEC added considerable amounts of oil and natural gas reserves, estimated at the end of the 1980s at about 335 bb or 97% share of total world net oil reserves addition and about 18 tcm or 38% of total world natural gas reserves addition.

Table 4
Oil and Natural Gas Reserves Growth
1960 - 1990

	1960	1970	1970/1960	1980	1980/1970	1990	1990/1980
Oil Reserves (bb)							
Total World	291.2	549.76	258.5	664.7	115.0	1012.1	347.4
Total OPEC	218.2	402.2	184.0	436.0	33.8	771.3	335.3
OPEC Share, %	74.9	73.2	71.2	65.6	28.7	76.2	96.5
Natural Gas Reserves (tcm)							
Total World	19.2	45.0	25.8	83.4	38.4	130.9	47.5
Total OPEC	7.4	15.9	8.5	31.6	15.7	49.5	17.9
OPEC Share, %	38.5	35.3	33.0	37.9	40.9	37.8	37.7

Oil and natural gas reserves for OPEC and non-OPEC during the period 1960 - 1990 is shown in Table 5. The steady increase of the natural gas reserves is obvious and this trend is most likely to continue in future. Also, the growth in total world oil reserves is apparent, particularly during the second half of the 1980s. OPEC's share in total world oil reserves has steadily improved whereas its share of natural gas has stagnated. However, non-OPEC share of total oil reserves declined with time whereas the natural gas share enhanced.

Figure 1
Proved Oil Reserves Addition for OPEC and Total World

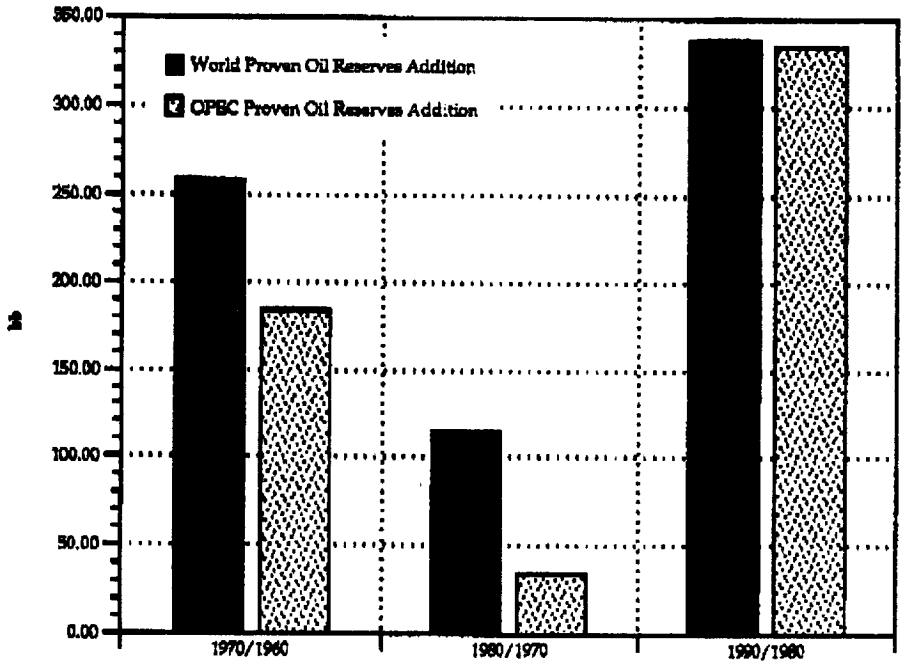


Figure 2
Proved Natural Gas Reserves Addition for OPEC and Total World

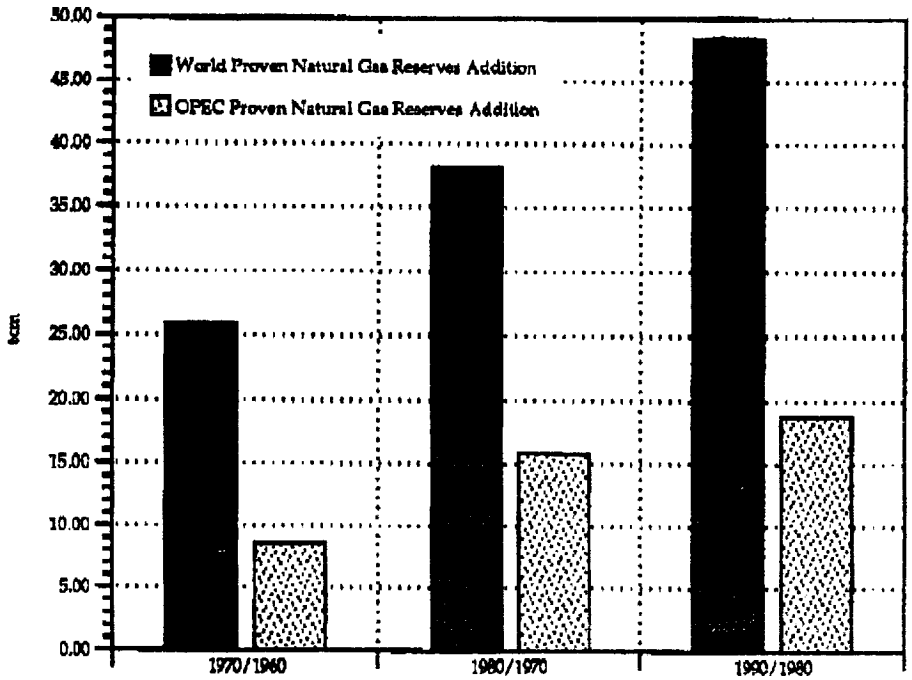
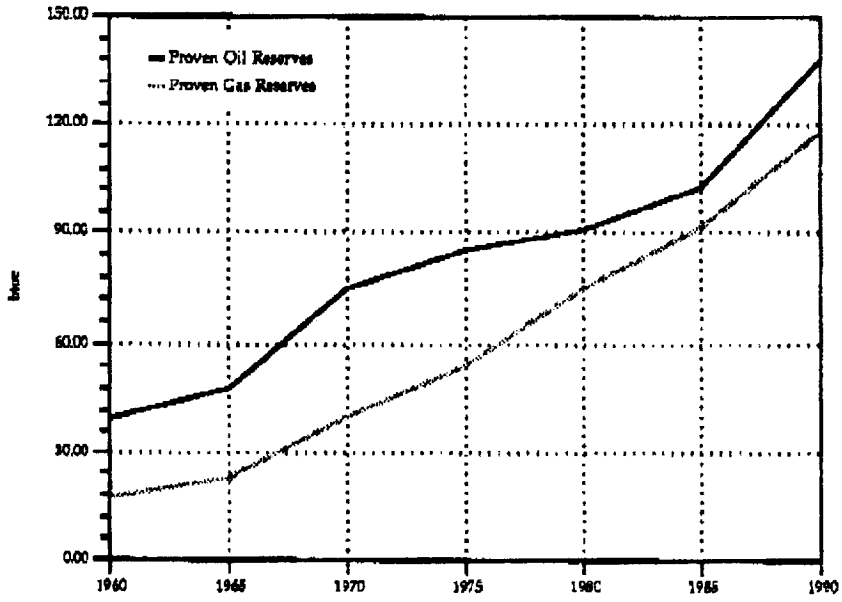


Table 5
OPEC, Non-OPEC and Total World Oil and Natural Gas Reserves 1960 - 1990
(btoe)

Region	1960	1965	1970	1975	1980	1985	1990
Total World							
- Oil	39.7	48.2	75.0	85.2	90.7	103.1	138.1
- (bb)	(291.2)	(353.2)	(549.7)	(624.6)	(664.7)	(755.7)	(1012.1)
- Natural Gas	17.3	22.8	40.5	54.5	75.1	91.7	117.8
- (tcm)	(19.2)	(25.3)	(45.0)	(60.5)	(83.4)	(101.9)	(130.9)
- Gas/Oil Ratio, %	43.6	47.3	54.0	64.0	82.8	88.9	85.3
Total Petroleum	57.0	71.0	115.5	139.7	165.8	194.8	255.9
OPEC							
- Oil	29.8	35.5	54.9	61.2	59.5	73.3	105.2
- (bb)	(218.2)	(260.4)	(402.2)	(448.9)	(436.0)	(537.0)	(771.3)
- Oil Share, %	75.0	73.7	73.2	71.9	65.6	71.1	76.2
- Natural Gas	6.6	8.3	14.3	20.3	28.4	32.3	44.5
- (tcm)	(7.4)	(9.2)	(15.9)	(22.5)	(31.6)	(35.8)	(49.5)
- Natural Gas Share ,%	38.4	36.2	35.3	37.2	37.8	35.2	37.8
Total Petroleum	36.4	43.8	69.2	81.5	87.9	105.6	149.7
OPEC Share of Total Petroleum, %	63.9	61.7	59.9	58.3	53.0	54.2	58.5
Non-OPEC							
- Oil	9.9	12.7	20.1	24.0	31.2	29.8	32.9
- (bb)	(73.0)	(92.8)	(147.5)	(175.7)	(228.7)	(218.7)	(240.8)
- Oil Share, %	25.0	26.3	26.8	28.1	34.4	28.9	23.8
- Natural Gas	10.7	14.5	26.2	34.2	46.7	59.4	73.3
- (tcm)	11.8	(16.1)	(29.1)	(38.0)	(51.8)	(66.1)	(81.4)
- Natural Gas Share, %	61.6	63.8	64.7	62.8	62.2	64.8	62.2
Total Petroleum	20.6	27.2	46.3	58.2	77.9	89.2	106.2
Non-OPEC Share of Total Petroleum, %	36.1	38.3	40.1	41.7	47.0	45.8	41.5

Source: OPEC Annual Statistical Bulletin, Cedigaz, BP Statistical Review of World Energy.

Figure 3
Evolution of Proven Reserves of Oil and Natural Gas in the World



The evolution of proven reserves of oil and natural gas for total world during the period 1960 - 1990 indicated almost a parallel increase with time affirming the strong association in nature between the two hydrocarbons, as illustrated in Figure 3.

Production, Utilisation and Trade

The evolution of OPEC and non-OPEC oil and natural gas production during the period 1960 - 1990 is shown in Table 6. Figure 4 illustrates total world oil and natural gas production during the same period. It is important to notice that there is a strong parallel in production between the two except for the decline in oil production during 1980 - 1985. The ratio of total world natural gas production to oil production has improved from about 47% in 1960 to about 69% in 1990. OPEC's share of total world oil production has deteriorated from 41.6% in 1960 to 38.2% in 1990 and its natural gas share has improved from 6.3% in 1960 to 13.5% in 1990.

Table 6
OPEC, Non-OPEC and Total World Oil and Natural Gas Production
1960 - 1990
(mtoe)

Region	1960	1965	1970	1975	1980	1985	1990
Total World							
- Oil	1045.3	1503.9	2254.4	2626.5	2984.3	2653.6	2997.7
- (mb/d)	(20.9)	(30.2)	(45.3)	(52.7)	(59.8)	(53.3)	(60.2)
- Natural Gas*	487.3	649.1	1121.7	1344.2	1572.6	1747.0	2058.6
- (bcm)	(541.4)	(721.1)	(1246.2)	(1493.4)	(1747.2)	(1940.9)	(2287.1)
- Gas/Oil Ratio, %	46.6	43.2	49.8	51.2	52.7	65.8	68.7
Total Petroleum	1532.6	2153.0	3376.1	3970.7	4556.9	4400.6	5056.3
OPEC							
- Oil	434.3	714.0	1165.9	1352.2	1342.2	769.2	1145.3
- (mb/d)	(8.7)	(14.3)	(23.4)	(27.2)	(26.9)	(15.4)	(23.0)
- Oil Share, %	41.6	47.5	51.7	51.5	45.0	29.0	38.2
- Natural Gas*	30.5	67.7	126.1	168.6	201.3	200.4	277.4
- (bcm)	(33.9)	(75.2)	(140.1)	(187.3)	(223.7)	(222.7)	(308.2)
- Natural Gas Share, %	6.3	10.4	11.2	12.5	12.8	11.5	13.5
Total Petroleum	464.8	781.7	1292.0	1520.8	1543.5	969.6	1422.7
OPEC Share of Total Petroleum, %	30.3	36.3	38.3	38.3	33.9	22.0	28.1
Non-OPEC							
- Oil	611.0	789.9	1088.5	1274.3	1642.1	1884.4	1852.4
- (mb/d)	(12.2)	(15.9)	(21.9)	(25.5)	(32.9)	(37.9)	(37.2)
- Oil Share ,%	58.4	52.5	48.3	48.5	55.0	71.0	61.8
- Natural Gas*	456.8	581.4	995.6	1175.6	1371.3	1546.6	1781.2
- (bcm)	(507.5)	(645.9)	(1106.1)	(1306.1)	(1523.5)	(1718.2)	(1978.9)
- Natural Gas Share, %	93.7	89.6	88.8	87.5	87.2	88.5	86.5
Total Petroleum	1067.8	1371.3	2084.1	2449.9	3013.4	3431.0	3633.6
Non-OPEC Share of Total Petroleum, %	69.7	63.7	61.7	61.7	66.1	78.0	71.9

* Gross production minus reinjected gas.
Source: OPEC Statistical Bulletin, Cedigaz, BP Statistical Review of World Energy.

Total world reserves-to-production (R/P) ratios for oil and natural gas are demonstrated in Figure 5. Both oil and natural gas have exhibited steady improvement in their R/P ratios since 1980. Oil reserves in OPEC will last more than 90 years and natural gas would last more than 160 years at current production rates. However, non-OPEC proven

Figure 4
Oil and Natural Gas Production during 1960 - 1990

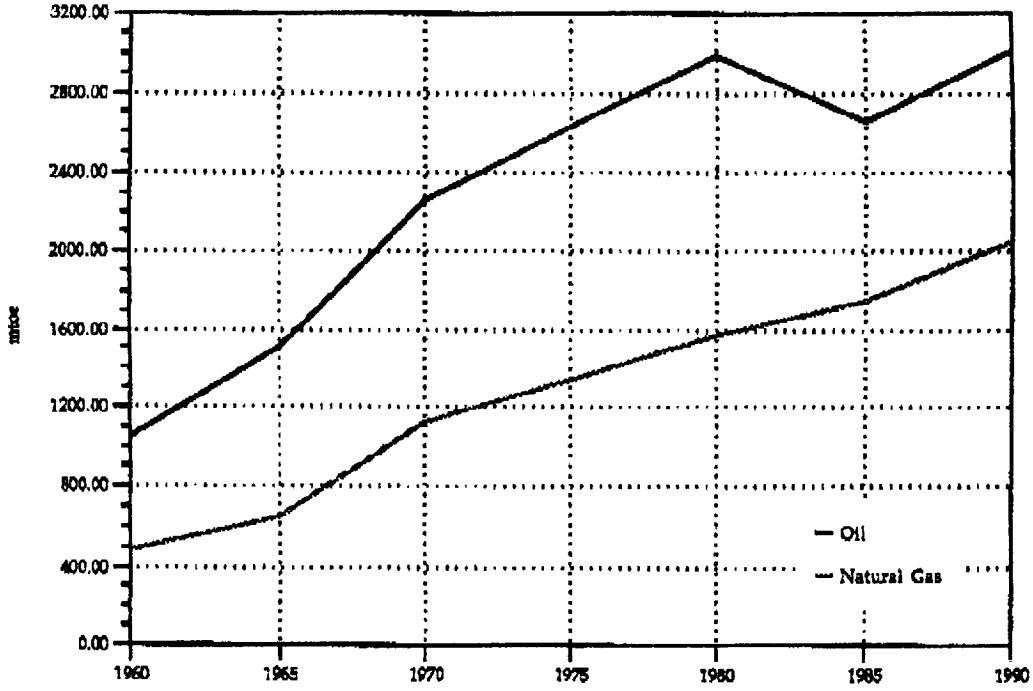
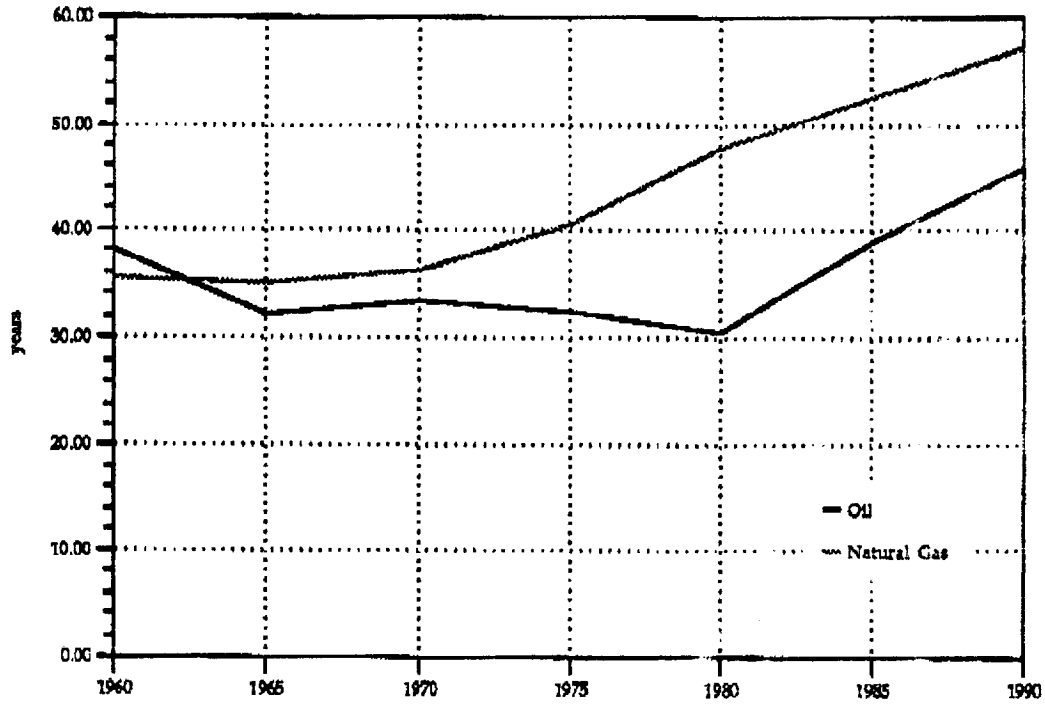


Figure 5
Oil and Natural Gas Reserves-to-Production (R/P) Ratios during 1960 - 1990



oil reserves will only last about 18 years and natural gas for about 41 years at current production levels. Thus, total world proven oil and natural gas reserves are expected to continue for about 46 and 57 years respectively. This clearly indicates the importance of OPEC region not only at the present time but also in future, as will be further discussed later.

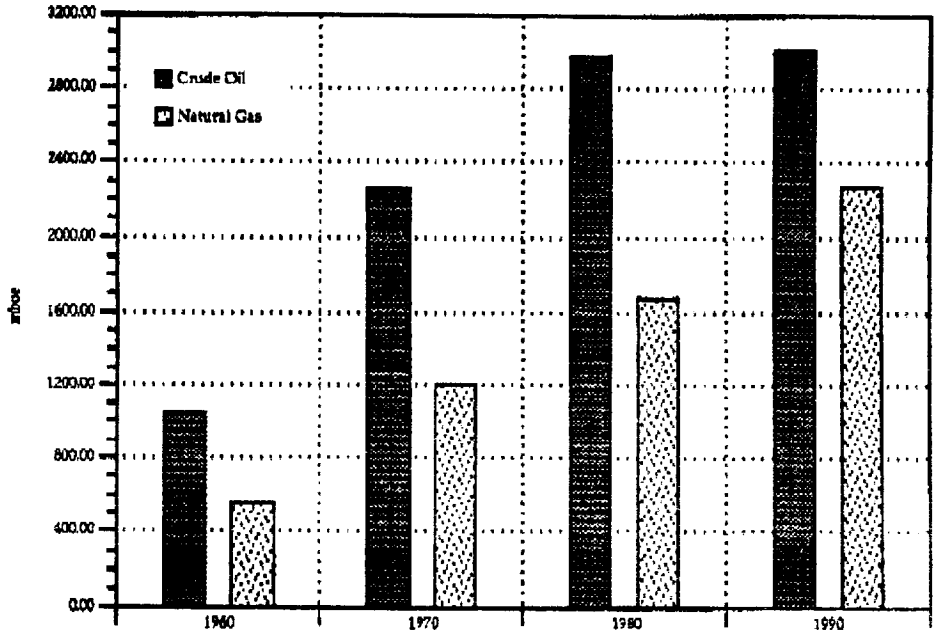
Table 7
OPEC, Non-OPEC and Total World Reserves-to-Production* (R/P) Ratios
(years)

Region	1960	1965	1970	1975	1980	1985	1990
Total World							
- Oil	38.0	32.1	33.3	32.4	30.4	38.9	46.1
- Natural Gas	35.5	35.1	36.1	40.5	47.8	52.5	57.2
- Gas/Oil Ratio, %	93.4	109.4	108.4	125.0	157.2	135.0	124.1
OPEC							
- Oil	68.6	49.7	47.1	45.3	44.3	95.3	91.9
- Natural Gas	216.4	122.6	113.4	120.4	141.1	161.2	160.4
- Gas/Oil Ratio, %	315.5	246.7	240.8	265.8	318.5	169.2	174.5
Non-OPEC							
- Oil	16.2	16.1	18.5	18.8	19.0	15.8	17.8
- Natural Gas	23.4	24.9	26.3	29.1	34.1	38.4	41.2
- Gas/Oil Ratio, %	144.4	154.7	142.2	154.8	179.5	243.0	231.5

* For natural gas, production equals gross production minus reinjected gas.

While produced oil is totally utilised for domestic use and/or trade, natural gas is still being partly wasted. The development of total world crude oil production and gross production of natural gas is illustrated in Figure 6 (see also Table A1 in the Annex).

Figure 6
Development of Total World Crude Oil and Gross Natural Gas Production



Unlike crude oil, natural gas has never been fully utilised and there have always been losses due to flaring, reinjection and shrinkage. The evolution of these losses during the period 1960 - 1990 is illustrated in Table 8. Total world gross natural gas production increased from 613.6 bcm in 1960 to 2514.4 bcm in 1990. Reinjected natural gas increased from 72.2 bcm in 1960 to 227.3 bcm in 1990. Flared natural gas surged from 75.9 bcm in 1960 to 173.2 bcm in 1975 before falling to 104.4 and 107.1 bcm in 1985 and 1990 respectively. Thus, total losses increased from 168.4 bcm in 1960 to 450.0 bcm in 1990, giving rates of utilisation of 75.9% in 1960 and 86.7% in 1990, as shown in Table 8.

Table 8
Evolution of the World Natural Gas Production and Losses
(bcm)

	1960	1970	1975	1980	1985	1990
Gross Production	613.6	1331.1	1571.3	1860.1	2111.9	2514.4
Reinjection	72.2	84.9	77.9	112.9	171.0	227.3
Flaring	75.9	160.8	173.2	164.1	104.4	107.1
Other Losses	20.3	44.5	52.2	58.5	88.3	115.6
Total Losses*	168.4	290.2	303.3	335.5	363.7	450.0
Marketed Production	445.2	1040.9	1268.0	1524.6	1748.2	2064.4
Rate of Utilisation, %	75.9	81.5	84.0	85.1	87.0	86.7

* Shrinkage resulting from natural gas processing for purification and extraction of NGL.

Note: Rate of Utilisation = $\frac{\text{Gross Production - Reinjected and Flared Gas}}{\text{Gross Production}}$

Source: Cedigaz, Natural Gas in the World, 1991 survey.

The gross production, marketed production, losses, exports and domestic use of natural gas in OPEC during the period 1980 - 1990 are revealed in Figures 7 and 8 (see also

Figure 7
OPEC Losses of Natural Gas, 1980 - 1990

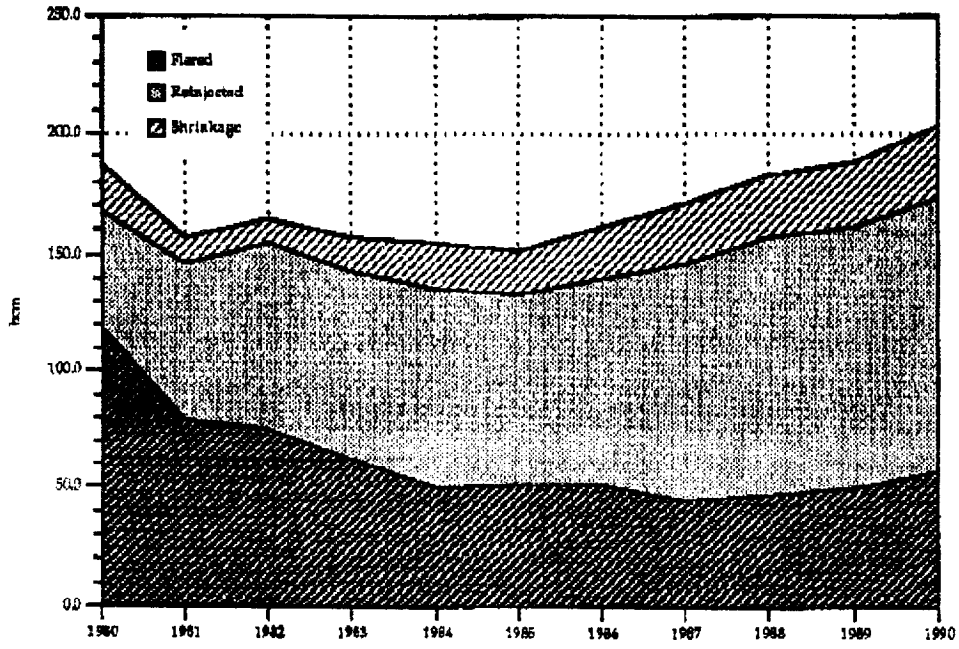


Figure 6
OPEC Exports and Domestic Use of Natural Gas, 1980 - 1990

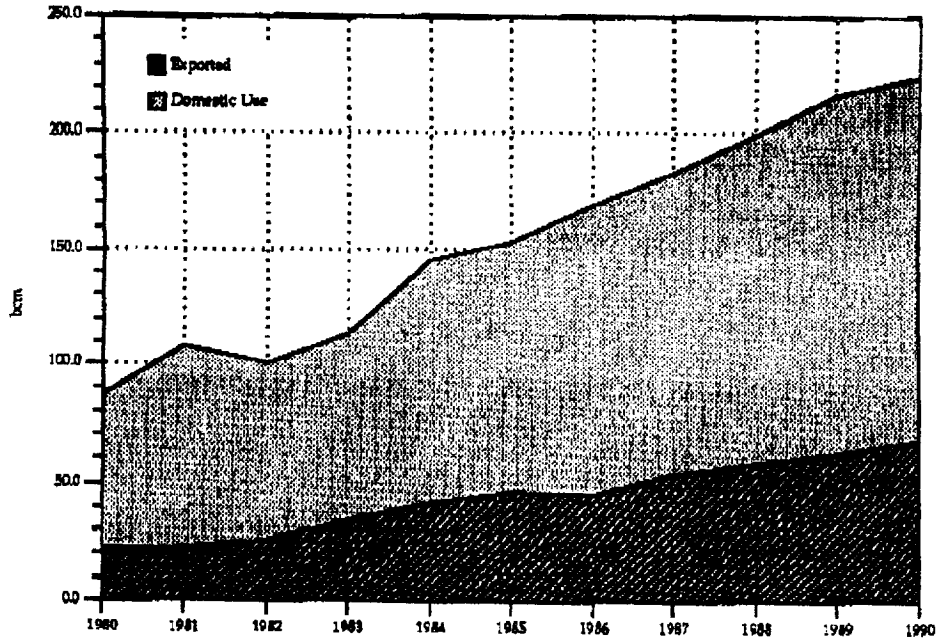


Table A2 in the Annex). From this, it can be noted that flaring losses have been tremendously reduced and OPEC Member Countries have started to wisely exploit this important depletable source of energy.

Natural gas flaring losses as a percentage of gross production for the individual OPEC Member Countries and total world during the period 1973 - 1990 is illustrated in Table 9. It is obvious from the table that total OPEC flaring losses dropped from 63% in

Table 9
Flaring Losses as Percentage of Gross Production for OPEC Member Countries and Total World
(in % of gross production)

Country	1973	1980	1990
Algeria	58	22	5
Indonesia	84	22	9
Iran	59	47	3
Iraq	86	85	50
Kuwait	57	16	10
Libya	34	22	31
Nigeria	99	96	76
Qatar	75	19	0
Saudi Arabia	86	72	11
UAE	91	54	4
Venezuela	30	6	13
Others	83	95	73
Total OPEC	63	43	14
Total World	13	9	4
% OPEC/World	76	72	55

Source: Cedigaz, Natural Gas in the World, 1991 survey.

Figure 9
Flaring Losses of Natural Gas in OPEC and the World, 1975 - 1990
(% of gross production)

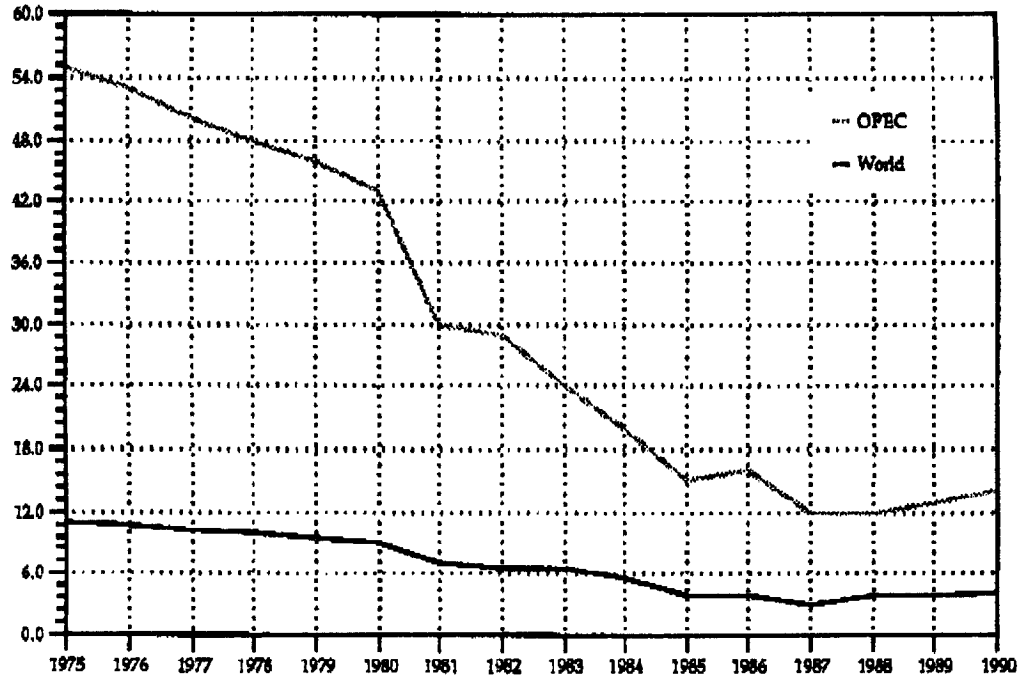
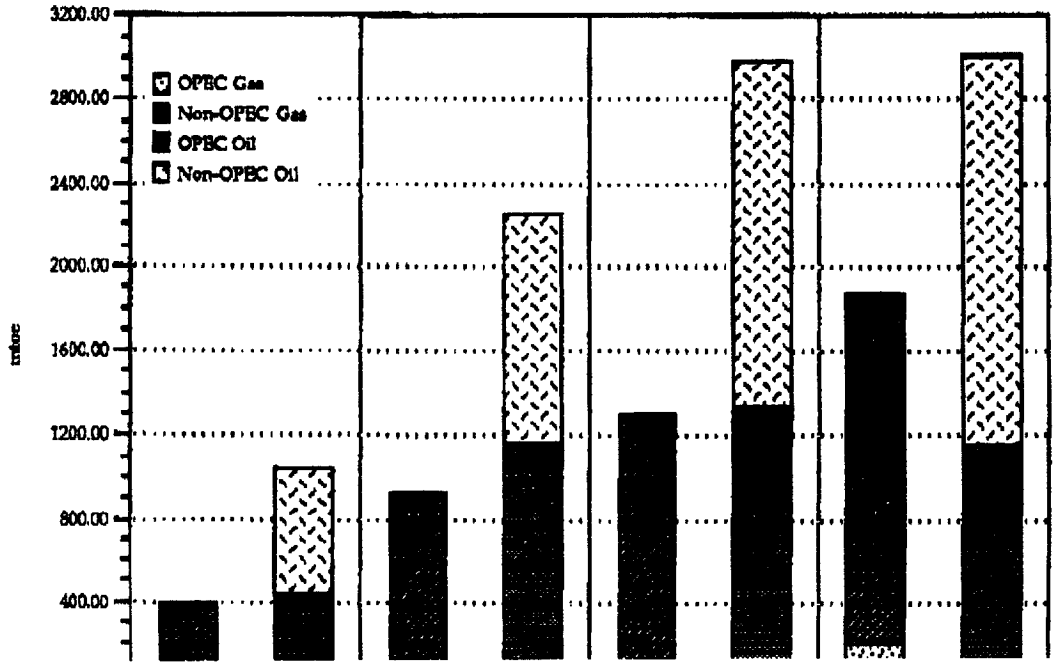


Figure 10
Marketed Production of Oil and Natural Gas



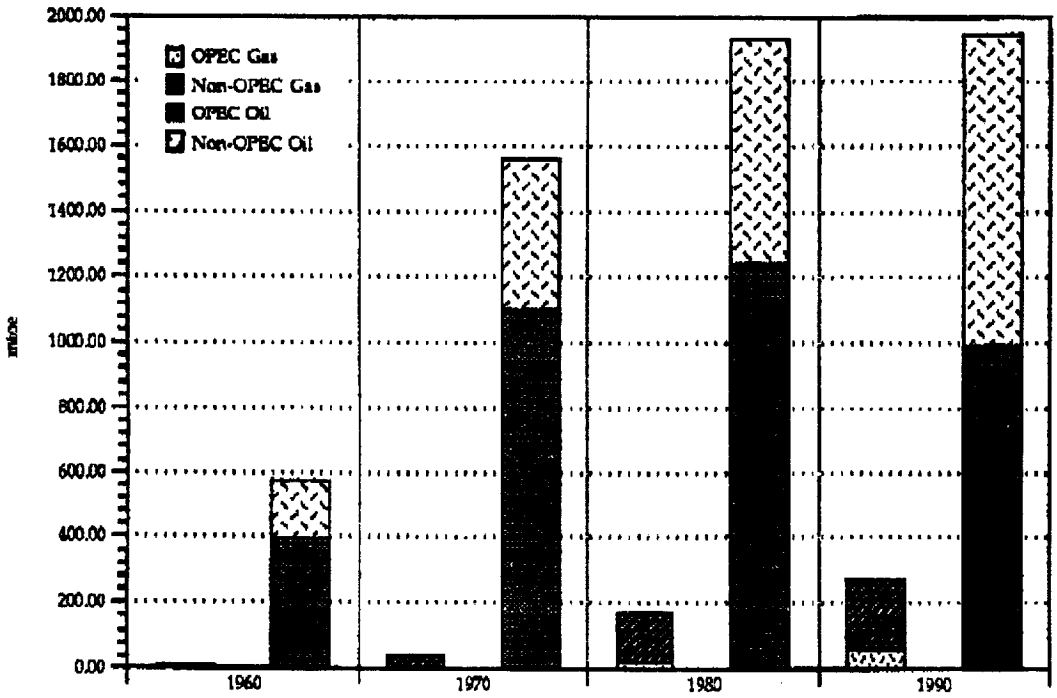
1973 to 43% and 14% in 1980 and 1990 respectively. These flaring losses were, of course, much higher than those for average world and constituted 76% in 1973, 72% and 55% of total world flaring losses for the respective years 1980 and 1990, as illustrated in Figure 9.

Marketed production of oil and natural gas is depicted in Figure 10 for OPEC and non-OPEC regions (see also Table A3 in the Annex).

Total world oil production rose from 1045.3 m tons in 1960 to 2254.4, 2984.3 and 2997.7 m tons in 1970, 1980 and 1990 respectively. Similarly, the marketed production of natural gas increased from 402.9 mtoe in 1960 to 929.1, 1295.2 and 1864.1 mtoe in the respective years 1970, 1980 and 1990. OPEC share of total world oil production climbed from about 42% in 1960 to about 52% in 1970 before declining to 45% and 38% in 1980 and 1990 respectively. Although OPEC share of total world marketed natural gas is much lower than that for crude oil, it also increased from about 2% in 1960 to about 3%, 6% and about 11% in the respective years 1970, 1980 and 1990.

OPEC and non-OPEC exports of oil (including refined products) and natural gas during the period 1960 - 1990 are illustrated in Figure 11 (see also Table A4 in the Annex). OPEC share of oil exports increased from about 70% in 1960 to 71% in 1970 before falling to 64% and 51% in 1980 and 1990 respectively. OPEC's exports of natural gas, on the other hand, grew from about 6% in 1970 to 12% and 22% in the respective years 1980 and 1990.

Figure 11
Exported Oil and Natural Gas



As oil is traded in either pipeline or crude or product carriers, natural gas can also be traded either in gaseous form by using pipelines or in liquefied form using LNG carriers. The evolution of the world international natural gas pipelines and LNG trades during the period 1970 - 1990 is shown in Figure 12, as a percentage share of international trade in marketed production of natural gas.

It is obvious from Figure 12 that the LNG trade improved tremendously from 6% in 1970 to as high as 23.4% in 1990. On the other hand, the share of pipeline trade dropped from 94% in 1970 to 76.6% in 1990 (see Table A5 in the Annex).

The growth of LPG seaborne imports by the United States, Western Europe and Japan during the 1980s indicated clear improvement from 13.9 million tonnes in 1980 to 18.1 and 26.0 million tonnes in 1985 and 1990 respectively (Figure 13). Total US imports increased from 1.1 million tonnes in 1980 to 2.9 million tonnes in 1990. Almost half of the US imports came from Latin America and the rest came from the Middle East and other regions. Total West European imports increased from 3.0 million tonnes in 1980 to 8.6 million tonnes in 1990. A large part of Western Europe's imports came from the North Sea. In 1990, 3.3 million tonnes were imported from the North Sea, 2.9 million tonnes from the Middle East, 1.8 million tonnes from Algeria, and 0.6 million tonnes from other regions. Japan is considered the biggest LPG importer; its imports grew from 9.8 million tonnes in 1980 to 11.5 and 14.5 million tonnes in 1985 and 1990 respectively (Figure 13 and Table A6 in the Annex).

Most of Japan's LPG seaborne imports came from the Middle Eastern region. The contribution of this region was 11.3 million tonnes in 1990 with an additional 3.2 million tonnes coming from the Far Eastern region. Western Europe was the second largest consumer of LPG followed by the United States.

Evolution of Oil and Natural Gas Prices

Crude oil yearly average spot price for OPEC basket varied from $27.0/b in 1985 to as low as $14.0/b in 1986 before rising to $22.3/b in 1990, as shown in Table 10. Natural gas prices dropped in the US market from $3.3-4.4/MMBtu in mid-1985 to as low as $1.6-1.9 in mid-1989 before recovering to $2.3-3.1/MMBtu at the beginning of 1990. Prices in the West European market also declined from $3.4-4.4/MMBtu in mid-1985 to their lowest level of $1.8-2.5/MMBtu in mid-1989 before rising to $2.0-2.9/MMBtu at the beginning of 1990. The Japanese market showed relatively higher prices of $4.7-5.2/MMBtu in mid-1985 falling to $3.1-3.5/MMBtu in 1988 before recovering to $3.6-5.0/MMBtu at the beginning of 1990 (Table 10 and Figure 14).

Table 10
Oil and Natural Gas Prices on the Major International Markets
(cif price $/MMBtu)

Market	Mid-1985	Mid-1986	Mid-1987	Mid-1988	Mid-1989	Beg.1990
United States*	3.3-4.4	2.6	2.3	1.8-2.0	1.6-1.9	2.3-3.1
Western Europe	3.4-4.4	3.2-3.6	2.5-2.8	1.9-2.5	1.8-2.5	2.0-2.9
Japan	4.7-5.2	3.2-4.7	3.2-3.5	3.1-3.5	3.1-3.6	3.6-5.0
OPEC Crude Basket Spot Price** ($/b)	27.0	14.0	17.7	14.2	17.3	22.3

Note: cif = cost + insurance + freight.
* Border price.
** Yearly average.
Source: Cedigaz, 1991 survey; OPEC/Energy & Oil Statistics.

Comparison of natural gas prices with those of crude oil during the period 1975 - 1990 is shown in Figure 15 (see also Table A7 in the Annex).

Figure 12
World International Natural Gas Trade
(% share of international trade in marketed production)

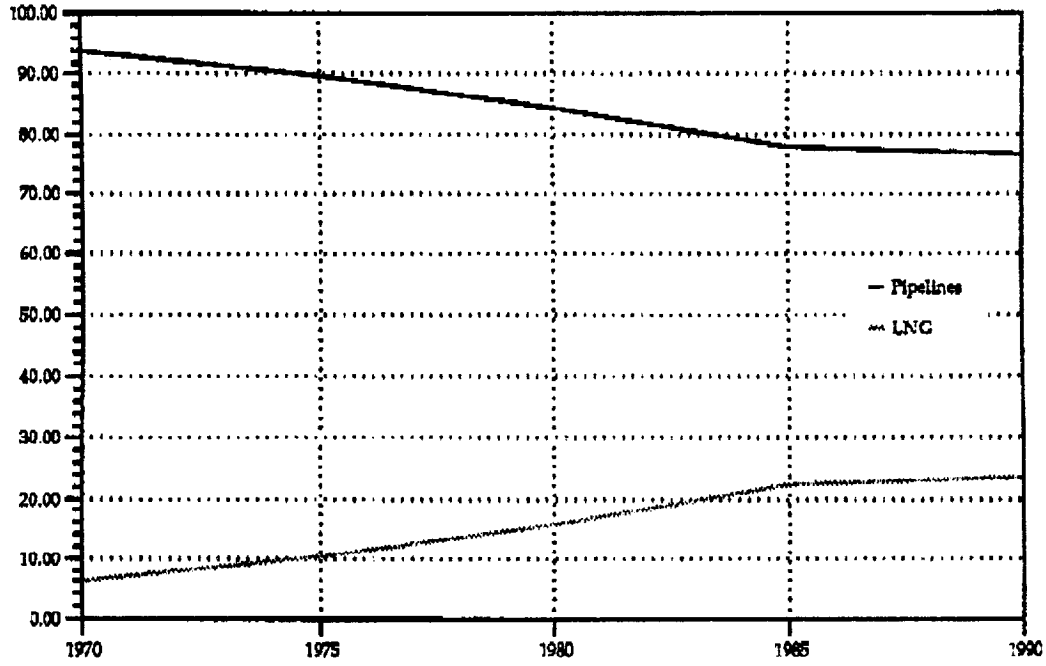


Figure 13
Trade of LPG, 1980 - 1990

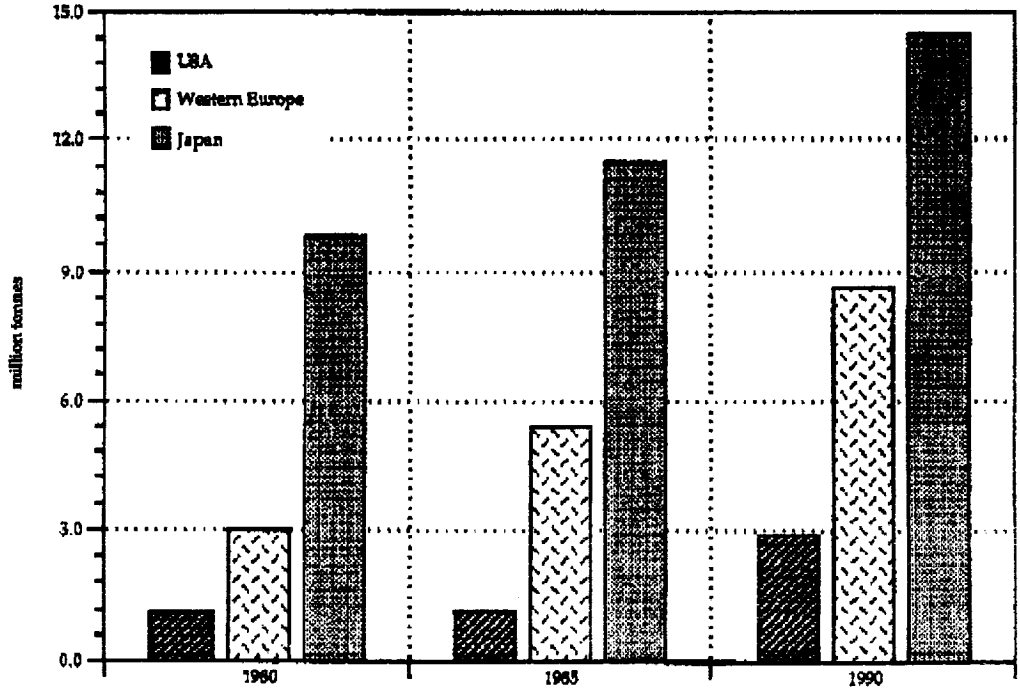


Figure 14
Natural Gas Prices on the Major International Markets

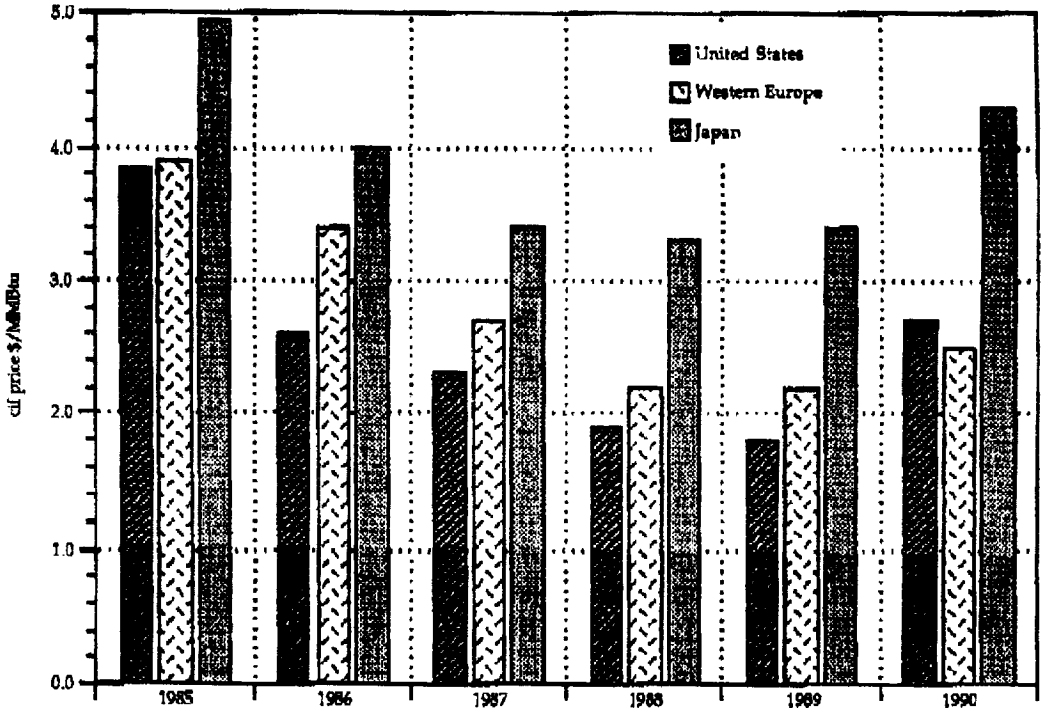
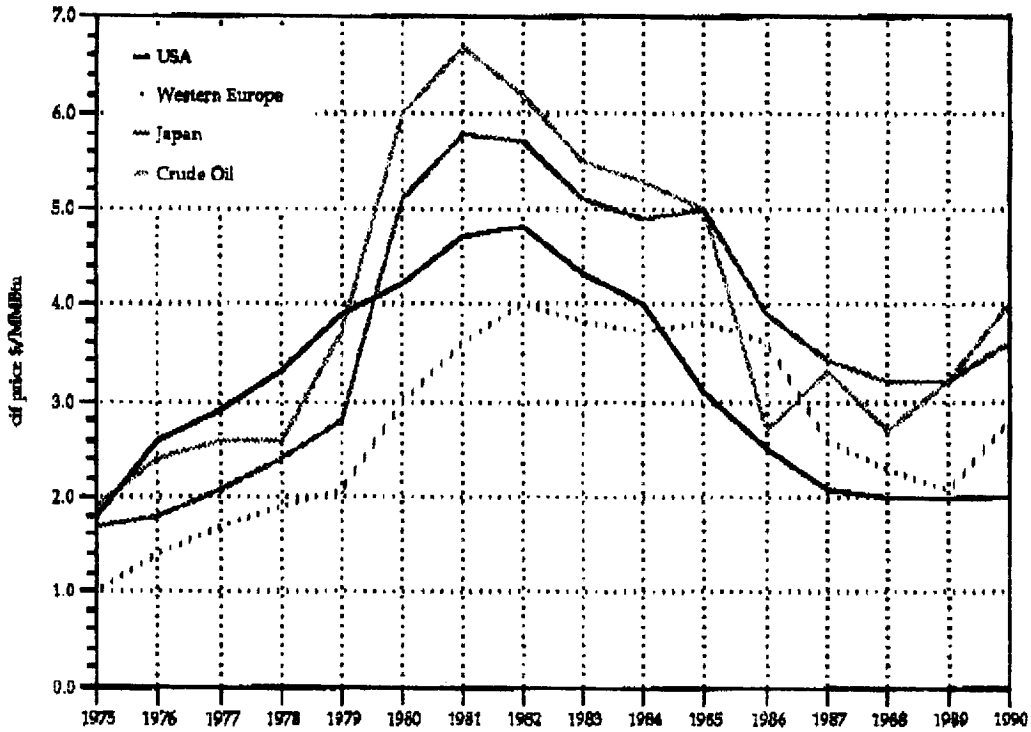


Figure 15
Comparison of Natural Gas and Crude Oil Prices, 1975 - 1990



Future Prospects

There are still plenty of undiscovered oil and natural gas reserves in the world, and part of these reserves will certainly be added in future to the proven oil and natural gas reserves and, consequently, will offset future decline in R/P ratio caused by the projected increase in future natural gas demand. If the net reserves addition during the last few decades is projected for the 1990s, then the lifespan of oil and natural gas reserves could be further prolonged, and other similar projections into the next century will only improve the life periods of oil and natural gas.

The impact of the environmental requirements, and particularly the implementation of CO_2 taxes, is to reduce the demand for fossil fuel and if these taxes are implemented according to the carbon content of the fossil fuel, then coal will suffer most, followed by oil, and natural gas will be the least affected.

Future demand for oil and natural gas may, therefore, be considered according to two scenarios. These are:

- Business-As-Usual Scenario
- Emission Stabilisation Scenario.

Both scenarios are based on the assumption that the oil price of the OPEC basket will remain constant in real terms at $21/b (1991 $) and will only increase with inflation.

1. The Business-As-Usual Scenario

Total world primary energy demand (excluding the former CPEs) according to this scenario is expected to rise from 114.0 mboe/d in 1990 to 125.3, 135.9, 147.3 and 159.7 mboe/d in 1995, 2000, 2005 and 2010 respectively. Oil requirement will increase from 52.0 mb/d in 1990 to 57.7, 60.4 and 63.4 mb/d in 2000, 2005 and 2010 respectively. The demand for natural gas will also rise from 19.0 mboe/d in 1990 to 24.5, 27.3 and 30.2 mboe/d in 2000, 2005 and 2010 respectively. The requirement for other sources of energy is also expected to rise during the above-mentioned period. Thus, the share of natural gas in the primary energy mix will rise from 16.6% in 1990 to 18.1%, 18.5% and 18.9% in the respective years of 2000, 2005 and 2010. The share of oil will decline from 45.7% in 1990 to 42.4%, 41.0% and 39.7% in 2000, 2005 and

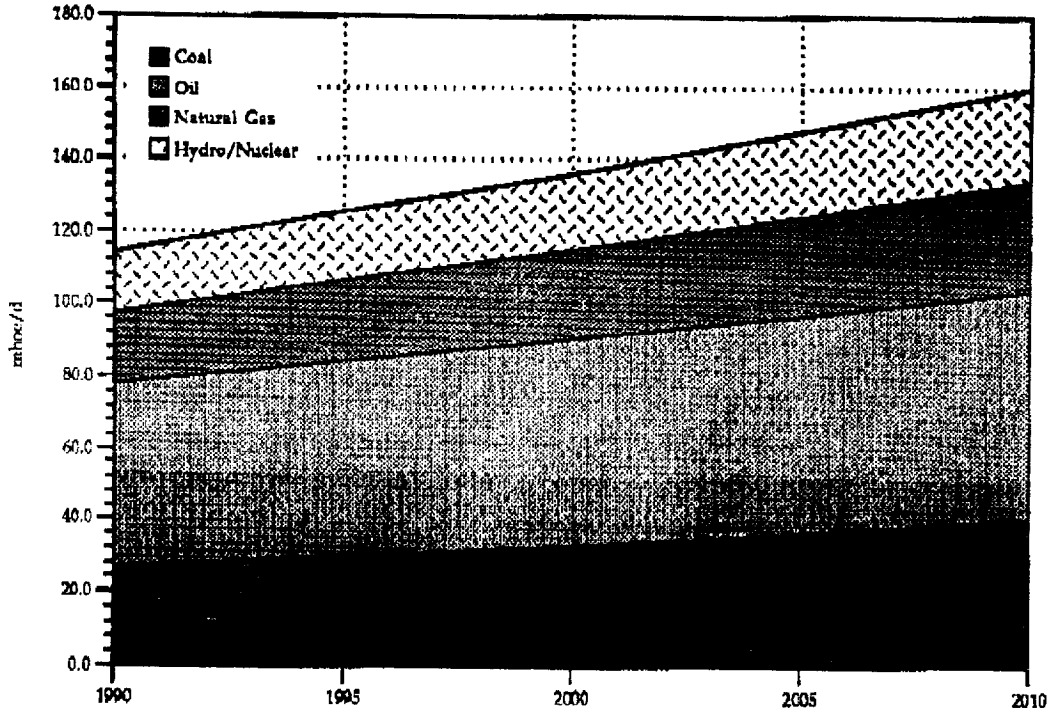
Table 11
Projection of World* Supply and Demand for Primary Energy Sources in the Medium and Long Term
(Business-As-Usual Scenario)
(mboe/d)

	1990	1995	2000	2005	2010
Total Demand	114.0	125.3	135.9	147.3	159.7
Supply					
- Oil	52.0	54.8	57.7	60.4	63.4
- Natural Gas	19.0	21.8	24.5	27.3	30.2
- Coal	26.1	29.6	32.8	36.2	40.1
- Hydro/Nuclear	17.0	19.0	20.9	23.4	26.1
Shares, %					
- Oil	45.7	43.8	42.4	41.0	39.7
- Natural Gas	16.6	17.4	18.1	18.5	18.9
- Coal	22.9	23.6	24.1	24.6	25.1
- Hydro/Nuclear	14.8	15.2	15.4	15.9	16.3

* Excluding the former CPEs.

2010 respectively. The share of coal, according to this scenario, will slightly rise from 22.9% in 1990 to 25.1% in 2010. Hydro/nuclear share will increase from 14.8% in 1990 to 16.3% in 2010, as shown in Table 11 and Figure 16.

Figure 16
World* Supply of Primary Energy in the Medium and Long Term according to the Business-As-Usual Scenario



* Excluding the former CPEs

2. The Emission Stabilisation Scenario

The main impact of the environmental requirement is to reduce fossil fuel consumption and particularly those with high carbon content such as coal. It is, therefore, foreseen that the share of natural gas will increase more than predicted in the Business-As-Usual scenario. The aim of the Emission Stabilisation Scenario is to stabilise CO_2 emission at the 1990 level by 2000 in the OECD region. To achieve this objective, an annually rising carbon tax of $1.5/boe or a $20/boe flat tax would be required. According to this scenario, total world primary energy demand will be reduced to 123.0, 130.2, 137.6 and 146.8 mboe/d in the respective years 1995, 2000, 2005 and 2010 (Table 12 and Figure 17).

According to this scenario, the requirement for natural gas in the medium and long term will grow from 19.0 mboe/d in 1990 to 25.3, 28.2 and 31.4 mboe/d in 2000, 2005 and 2010 respectively. Moreover, the share of natural gas in the primary energy mix will increase from 16.6% in 1990 to 19.4%, 20.5% and 21.4% in the respective years of 2000, 2005 and 2010. The share of oil will remain almost the same, whereas the share of coal will suffer most as compared to the previous scenario, and will maintain a level of about 23% during the above-mentioned period.

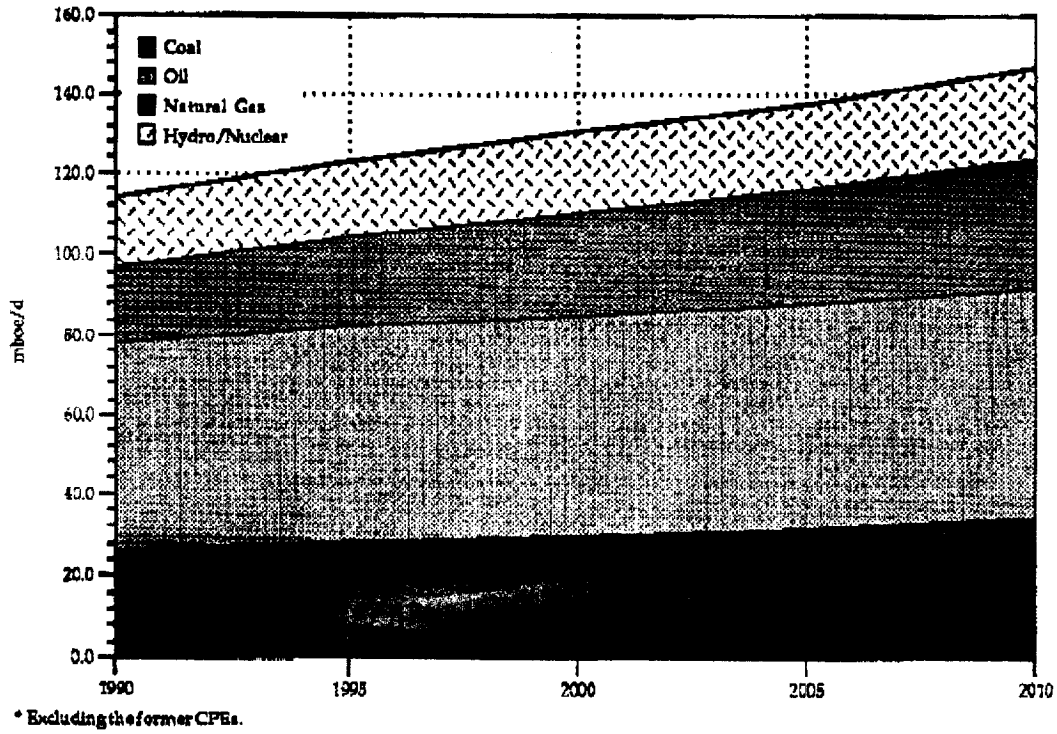
It is clear from the above discussion that oil and natural gas will remain essential energy sources in the primary energy mix and their combined share in total world energy requirement will exceed 60% by 2000 and 2010.

Table 12
World* Primary Energy Supply and Demand in the Medium and Long Term According to the Emission Stabilisation Scenario
(mboe)

	1990	1995	2000	2005	2010
Total Demand	114.0	123.0	130.2	137.6	146.8
Supply					
- Oil	52.0	54.1	55.2	56.4	58.0
- Natural Gas	19.0	22.0	25.3	28.2	31.4
- Coal	26.1	28.3	29.9	31.6	34.2
- Hydro/Nuclear	17.0	18.5	19.9	21.5	23.2
Shares, %					
- Oil	45.7	44.0	42.4	41.0	39.5
- Natural Gas	16.6	17.9	19.4	20.5	21.4
- Coal	22.9	23.0	23.0	23.0	23.3
- Hydro/Nuclear	14.8	15.0	15.3	15.6	15.8

* Excluding the former CPEs.

Figure 17
World* Supply of Primary Energy in the Medium and Long Term According to the Emission Stabilisation Scenario



* Excluding the former CPEs.

Future Role of OPEC

It is worth pointing out that OPEC, at the end of 1990, held more than 76% of total world proven oil reserves and nearly 40% of proven natural gas reserves. At current production rates, their life-span could last for more than 90 years for oil and more than 160 years for natural gas, as compared to about 18 and 40 years respectively for the rest of the

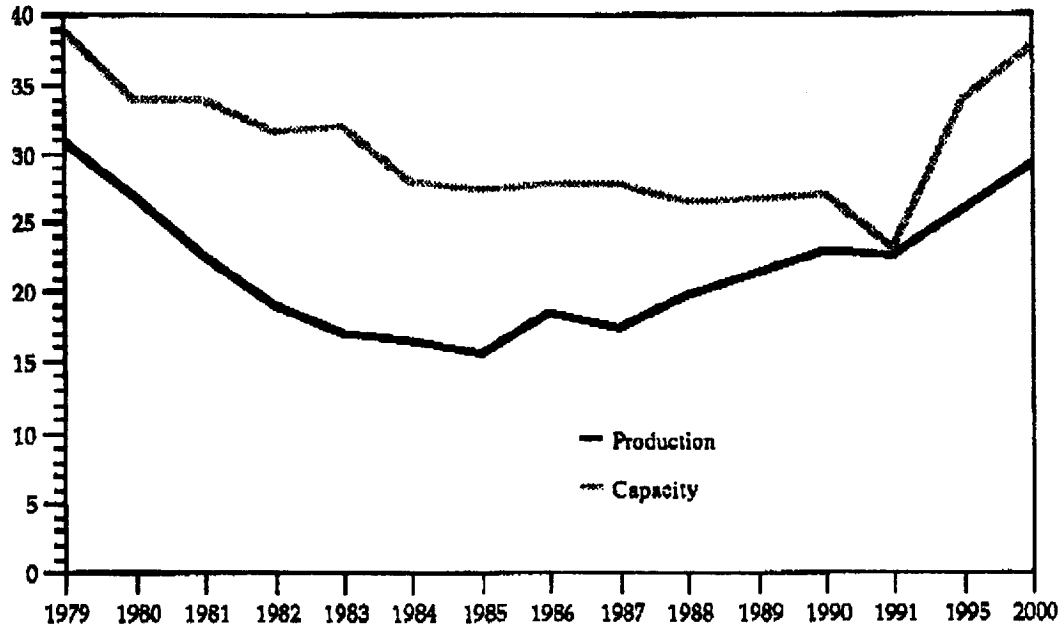
world. OPEC added considerable volumes of proven oil and natural gas reserves during the 1980s, estimated at 335 billion barrels of oil or the equivalent of 97% of total world oil reserves addition, and 18 trillion cubic metres of natural gas or the equivalent of 38% of total world natural gas reserves addition. The potential of OPEC Middle Eastern region is tremendous; it holds more than 647 billion barrels of proven oil reserves or the equivalent of 84% of total OPEC, and about 37 trillion cubic metres of proven natural gas reserves or the equivalent of 75% of total OPEC, as demonstrated in Table 13.

Table 13
Comparison of Oil and Natural Gas Production, Reserves and R/P Ratios for OPEC, OPEC Middle East, Non-OPEC and Total World in 1990

Region	Production (P)		Reserves (R)		R/P Ratio	
	Oil (mb/d)	Natural Gas (bcm)	Oil (bb)	Natural Gas (tcm)	Oil (years)	Natural Gas (years)
OPEC Middle East	15.15	131.5	647.9	37.0	117	281
Total OPEC	22.97	308.2	771.3	49.5	92	161
Total Non-OPEC	37.29	1978.9	240.8	81.4	18	41
Total World	60.26	2287.1	1012.1	130.9	46	57
OPEC Middle East Share to Total World, %	25.1	5.8	64.0	28.3		
Total OPEC Share to Total World, %	38.1	13.5	76.2	37.8		
Total Non-OPEC Share to Total World, %	61.9	86.5	23.8	62.2		
OPEC Middle East Share to Total OPEC, %	66.0	42.7	84.0	74.8		

It is obvious from Table 13 that there is a clear imbalance in the OPEC region between oil and natural gas production on the one hand, and oil and natural gas proven reserves, on the other hand. Whereas OPEC and OPEC Middle East regions hold more than 76% and 64% of total world proven oil reserves and about 38% and 28% of total world proven natural gas reserves respectively, their oil and natural gas production does not exceed 38% and 25% respectively for oil and 14% and 6% respectively for natural gas. This imbalance between proven reserves and production in OPEC region is expected to be gradually moderated and the demand for OPEC oil and natural gas will increase with time since the resource base for these important sources of energy is somewhat limited in non-OPEC regions and abundant in OPEC. Moreover, the predicted rise in world oil and natural gas demand during the 1990s and beyond, and the expected plateauing or decline in oil production of non-OPEC areas at the end of the decade and beyond, are all factors contributing to the increasing call on OPEC oil and natural gas. This, of course, exerts pressure on OPEC to invest in oil and natural gas capacity expansion to meet future demand. In order to expand and maintain oil production capacity to around 34 mb/d and 38 mb/d in the respective years 1995 and 2000 to meet the expected world oil demand, OPEC needs to invest $50 - 77 billion and an additional $60 - 80 billion in the oil sector alone in the respective years 1995 and 2000 (excluding the damage caused by the Gulf war to the Iraqi and Kuwaiti installations). The estimated expansion in OPEC oil production capacity to the year 2000 is projected in Figure 18.

Figure 18
Projection of OPEC Oil Production and Capacity to the Year 2000
(mb/d)



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ANNEX

Table A1
Development of Total World Crude Oil and Gross Natural Gas Production
(mboe)

	1960	1970	1980	1990
World Crude Oil Production	1045.3	2254.4	2984.3	2997.7
OPEC Production	434.3	1165.9	1342.2	1145.3
OPEC Share, %	41.6	51.7	45.0	38.2
World Gross Natural Gas Production	552.3	1198.1	1674.3	2263.2
OPEC Production	41.3	156.7	245.5	382.6
OPEC Share, %	7.5	13.1	14.7	16.9

Source: OPEC

Table A2
OPEC Gross Production, Marketed Production, Losses, Exports and Domestic Use of Natural Gas, 1980 - 1990
(bcm)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Gross Production	272.7	264.9	265.1	271.2	300.8	304.8	331.6	353.4	382.1	404.9	425.0
Flared	118.2	79.6	74.9	61.5	50.7	51.8	51.7	44.7	47.3	49.7	56.3
Reinjected	49.1	66.7	80.0	82.1	85.3	82.2	88.8	102.0	110.1	111.5	116.9
Shrinkage	19.5	11.0	9.7	14.0	19.0	17.9	21.3	23.9	24.9	26.6	29.4
Total Losses	186.8	157.3	164.6	157.6	155.0	151.9	161.8	170.6	182.3	187.8	202.6
Marketed	86.0	107.5	100.5	113.6	145.8	153.0	169.8	182.8	199.8	217.9	224.1
Exported	22.8	22.7	26.4	34.6	41.7	46.2	45.3	54.3	58.0	62.4	67.5
Domestic Use	63.2	84.8	74.1	79.0	104.1	106.8	124.5	128.5	141.8	153.8	156.6

Sources: Direct communication to the OPEC Secretariat; Cedigaz; Arab Oil & Gas; other sources.

Table A3
Marketed Production of Oil and Natural Gas
(mtoe)

Region	1960	1965	1970	1975	1980	1985	1990
Total World							
- Oil	1045.3	1503.9	2254.4	2626.5	2984.3	2653.6	2997.7
- (mb/d)	(20.9)	(30.2)	(45.3)	(52.7)	(59.8)	(53.3)	(60.2)
- Natural Gas	402.9	618.7	929.1	1121.3	1295.2	1581.5	1864.1
- (bcm)	(447.6)	(687.3)	(1032.2)	(1245.8)	(1438.9)	(1757.1)	(2071.0)
Total	1448.2	2122.6	3183.5	3747.8	4279.5	4235.1	4861.8
OPEC							
- Oil	434.3	714.0	1165.9	1352.2	1342.2	769.2	1145.3
- (mb/d)	(8.7)	(14.3)	(23.4)	(27.2)	(26.9)	(15.4)	(23.0)
- Oil Share, %	41.6	47.5	51.7	51.5	45.0	29.0	38.2
- Natural Gas	8.9	15.1	27.6	50.6	78.2	137.7	201.7
- (bcm)	(9.9)	(16.7)	(30.7)	(56.2)	(86.9)	(153.0)	(224.1)
- Natural Gas Share, %	2.2	2.4	3.0	4.5	6.0	8.7	10.8
Total	443.2	729.1	1193.5	1402.8	1420.4	906.9	1347.0
OPEC Share, %	30.6	34.3	37.5	37.4	33.2	21.4	27.7
Non-OPEC							
- Oil	611.0	789.9	1088.5	1274.3	1642.1	1884.4	1852.4
- (mb/d)	(12.2)	(15.9)	(21.9)	(25.5)	(32.9)	(37.9)	(37.2)
- Oil Share, %	58.4	52.5	48.3	48.5	55.0	71.0	61.8
- Natural Gas	394.0	603.6	901.5	1070.7	1217.0	1433.8	1662.4
- (bcm)	(437.7)	(670.6)	(1001.5)	(1189.6)	(1352.0)	(1604.1)	(1846.9)
- Natural Gas Share, %	97.8	97.6	97.0	95.5			
Total	1005.0	1393.5	1990.0	2345.0	2859.1	3328.2	3514.8
Non-OPEC Share, %	69.4	65.7	62.5	62.6	66.8	78.6	72.3

Source: OPEC Annual Statistical Bulletin, 1990.

Note: Marketed production of natural gas in this table slightly differs from Table 8 due to different source.

Table A4
Exported Oil* and Natural Gas
(mtoe)

Region	1960	1965	1970	1975	1980	1985	1990
Total World							
- Oil	570.6	921.4	1557.	1774.9	1935.8	1516.6	1949.2
- (mb/d)	(11.4)	(18.5)	(31.3)	(35.6)	(38.8)	(30.5)	(39.1)
- Natural Gas	4.9	13.7	39.1	108.4	171.9	205.8	274.9
- (bcm)	(5.4)	(15.3)	(44.1)	(120.4)	(191.0)	(228.7)	(305.4)
Total	575.5	935.1	1596.7	1883.3	2107.7	1722.4	2224.1
OPEC							
- Oil	398.6	667.6	1105.3	1275.9	1241.9	662.0	989.8
- (mb/d)	(8.0)	(13.4)	(22.2)	(25.6)	(24.9)	(13.3)	(19.9)
- Oil Share, %	69.9	72.5	71.0	71.9	64.2	43.7	50.8
- Natural Gas	-	0.8	2.2	1.47	20.5	41.5	60.8
- (bcm)	-	(0.9)	(2.4)	(16.3)	(22.8)	(46.2)	(67.5)
- Natural Gas Share, %	-	5.8	5.6	13.6	11.9	20.2	22.1
Total	398.6	668.4	1107.5	1290.6	1262.4	703.5	1050.6
OPEC Share, %	69.3	71.5	69.4	68.5	59.9	40.8	47.2
Non-OPEC							
- Oil	172.0	253.8	452.3	499.0	693.9	854.6	959.4
- (mb/d)	(3.4)	(5.1)	(9.1)	(10.0)	(13.9)	(17.2)	(19.2)
- Oil Share, %	30.1	27.5	29.0	28.1	35.8	56.3	49.2
- Natural Gas	4.9	12.9	36.9	93.7	151.4	164.3	214.1
- (bcm)	(5.4)	(14.4)	(41.7)	(104.1)	(168.2)	(182.5)	(237.9)
- Natural Gas Share, %	100.0	94.2	94.4	86.4	88.1	79.8	77.9
Total	176.9	226.7	489.2	592.7	845.3	1018.9	1173.5
Non-OPEC Share, %	30.7	28.5	30.6	31.5	40.1	59.2	52.8

* Including refined products.

Table A5
World International Natural Gas Trade
(% share of international trade in marketed production)

	1970	1975	1980	1985	1990
Pipeline Trade	4.1	8.9	11.1	10.2	11.4
LNG Trade	0.3	1.0	2.1	2.9	3.5
Total World Trade	4.4	9.9	13.2	13.1	14.9
Share of Pipelines, %	94.0	89.6	84.4	77.8	76.6
Share of LNG, %	6.0	10.4	15.6	22.2	23.4

Source: Cedigaz, Natural Gas in the World, 1991 survey.

Table A6
Trade* of LPG During the Period 1980 - 1990
(million tonnes)

To	From	1980	1985	1990
USA	Middle East	0.1	0.1	0.3
	Latin America	0.9	0.5	1.3
	Others	0.1	0.6	1.3
	Total	1.1	1.2	2.9
Western Europe	Middle East	2.0	1.0	2.9
	North Sea	0.5	2.7	3.3
	Algeria	0.2	1.2	1.8
	Others	0.3	0.5	0.6
	Total	3.0	5.4	8.6
Japan	Middle East	8.2	9.1	11.3
	Far East	1.4	1.9	3.2
	North America	0.2	0.1	-
	Others	-	0.4	-
	Total	9.8	11.5	14.5
Total Imports		13.9	18.1	26.0

* Quantities shown refer to LPG seaborne imports transported in vessel sizes of 10,000 m^3 and above only.

Source: BP Review of World Gas, 1991.

Table A7
Comparison of Natural Gas and Crude Oil Prices, 1975 - 1990
(cif price $/MMBtu)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
USA (Wellhead)	0.4	0.6	0.8	0.9	1.2	1.6	2.0	2.5	2.6	2.7	2.6	2.0	1.7	1.7	1.8	1.7
USA (Imports)	1.8	2.6	2.9	3.3	3.9	4.2	4.7	4.8	4.3	4.0	3.1	2.5	2.1	2.0	2.0	2.0
Western Europe	1.0	1.4	1.7	1.9	2.1	3.0	3.6	4.0	3.8	3.7	3.8	3.6	2.6	2.3	2.1	2.8
Cif Japan	1.7	1.8	2.1	2.4	2.8	5.1	5.8	5.7	5.1	4.9	5.0	3.9	3.4	3.2	3.2	3.6
Crude Oil (cif IEA countries)	1.9	2.4	2.6	2.6	3.7	6.0	6.7	6.2	5.5	5.3	5.0	2.7	3.3	2.7	3.2	4.0

Note: cif = cost + insurance + freight.

Source: BP Review of World Gas, 1991.