ENERGY

Prime Minister (2)

MCS 23/12

Treasury Chambers, Parliament Street, SW1P 3AG
01-233 3000

Conclusions at flag A

PRIME MINISTER

OIL PRICES IN THE LONG TERM

see LHS of title cover.

I attach a study, written by an interdepartmental group of officials under Treasury chairmanship, which examines the longer term prospects for the supply and demand of energy and the possible implications for oil prices.

2. I think this is a useful document, which is suitably modest in its objectives. It acknowledges the immense difficulties involved in making projections, and does not make a forecast, let alone a unique one, for the oil price. Rather, by looking at the likely supply and demand position, it attempts to provide guidance on a broad range of possible oil prices in the long term, stressing the need to allow for the risks and uncertainties involved. This guidance should be helpful to those in the public sector concerned with decisions about policies and projects for which the price of oil is a relevant consideration.

3. Also attached to this minute is a note by the Chairman of the inter-departmental group which summarises the conclusions of the study.

4. The note recommends, and I agree, that the study (like its predecessor, written in 1980) should be made generally available in a low key way. I understand that Nigel Lawson would be content with this. It would be made clear that it is a study by officials, intended as broad guidance for decision-makers in the public sector. It would not be presented as an oil price forecast to which Ministers were necessarily committed.

5. My officials are therefore arranging for a copy of the study to be placed in the House of Commons Library today and for this to be announced in answer to a written PQ.

6. I am copying this minute to the other members of E and to Sir Robert Armstrong.

(G.H.)
23 December 1982

PROSPECTS FOR THE OIL PRICE IN THE LONG TERM

CHAIRMAN'S NOTE

see LHS of file cover.

The attached study sets out an interdepartmental working group's view of the prospect for oil prices to the year 2000 and beyond.

2. Events in the oil markets in the last few years have underlined the difficulty of making exact predictions even for a short time ahead. Nevertheless those analysing policies and appraising projects which involve energy supply and energy use need to make price assumptions. But they should take full account of uncertainty. Hence the study, unlike its predecessors, has not attempted to produce a central planning figure for the oil price. Instead, likely price bands are set out on the basis of a number of assumptions and hypotheses.

3. The rate of economic growth is a key factor in determining the future price of energy. Hence two price bands have been estimated, one relevant to a world of low economic growth and one relevant to a world of higher growth. (The growth assumptions are slightly lower than the ones made two years ago.) In each case the price range takes account of uncertainties about energy conservation as well as about the supply of other forms of primary energy (coal, gas, hydro-electric power, etc.) and of oil production from both OPEC and non-OPEC sources. The group looked at the supply of OPEC oil on the basis of different political and economic assumptions.

4. The price of oil affects both the supply and demand of oil and of other forms of energy. The evidence of the last two years suggests that energy demand is becoming increasingly responsive to price changes. This limits the likelihood of sustained large increases in price. We also allowed - to a greater extent than previously - for the effect of higher oil prices on the supply of other fuels. In extending the work into the next century, we took account of the development of alternative energy sources on a scale sufficiently large to restrain possible further growth in oil prices.

. Oil markets have been particularly susceptible to shocks of one kind or another. In the 1980 study, it was assumed that oil price increases would take the form of discontinuous jumps often induced by shocks and that subsequent real price reductions would be rare. Recent events have shown this to be a defective approach. In a world of lower economic growth, where high energy prices seem to be leading to conservation on a significant scale, some real price reductions are likely to take place from time to time. How far they might go will depend in part on OPEC and the extent to which OPEC members are ready to support prices by restricting output. Our analysis suggests that the interests of the members may be more divergent than in the past. Nonetheless, OPEC's influence is likely to mean that prices in the short term will not wholly reflect the free operation of markets.

6. The early chapters of the study set out the supply and demand for energy on a number of scenarios concerning economic growth, availability of non-OPEC fuel supplies and price and income elasticities of demand for energy. On the basis of this work we discuss OPEC's potential for influencing oil prices. Overall supply and demand are then brought together and feasible price zones set out for the late 1980s/early 1990s, the end of the century and the early 21st century. Final results are shown in the form of two broad price paths - one for each economic growth scenario - in Figure K after page 22.

7. These price bands are in no way forecasts. They indicate longer term trends rather than the actual position at any one point in time. Also they are "surprise free", that is, they do not allow for major disturbances which would have a lasting effect on energy prices such as a large scale nuclear power accident, nor do they allow for major fuel discoveries or new forms of conservation. It is quite likely that oil prices will fluctuate, even in the absence of major shocks of this kind. Moreover, sudden and temporary changes in the supply/demand balance (e.g. arising from disruption to oil supplies in the Middle East) could take the price outside the bands we have indicated, either in particular years, or for a longer period of time. But these more temporary disturbances should not affect the long term trend. For general uses the price bands in Chart K offer a reasonable compromise between the increased confidence that a wider range would

ncompass the outturn and the greater practical usefulness of a narrower range.

8. For this reason, and for others, those using the results of the study in policy analysis or project appraisal should look as carefully at the underlying assumptions as at the final results. They will need to choose the particular numbers relevant to the particular analysis or appraisal in hand. They will also have to choose the range of uncertainty over which they consider it right to test their analysis.

9. The study should be of value outside the Government, particularly in the nationalised fuel industries. The group considers, therefore, that the work (but not this cover note) should be made generally available in the form of a study by officials. The 1980 report was only published in an expurgated form after a delay of 18 months, although the main conclusions were given to the nationalised energy industries and to the Select Committee on Energy. This time we have avoided a central planning figure, so there is even less of a flavour of a Government position.

10. The group looked at the relationship between our projections and those made by other bodies during the last couple of years. Most forecasters are revising down their views about future energy demand and prices, so comparisons need to take account of precisely when studies were carried out. Oil companies, where they have been prepared to publish, generally give price projections covering the lower two-thirds of the price range covered in our recommendations. We discussed our work with Shell, who have also been revising their figures. They told us that although their range for the year 2000 was somewhat below ours, the difference was within the margin of error inherent in this work and that they broadly agreed with our analysis. Academic forecasters, on the other hand, tend to give a price range covering the upper half of our recommendations. Some of the latter include the possibility of the oil price rising even higher, though in most cases these high projections are based on studies which are two or more years old and therefore do not reflect recent evidence on energy conservation. Some experts, such as Professor Odell, think that in the short term oil prices will be weak, but their central guesses on longer term prices are generally within the range we recommend.

11. The study looks a long way ahead. Currently the market is very uncertain and there could well be a break in the nominal oil price within the next few months. We think that the low end of our range for the 1980s - a real oil price of $25, some 25% below present prices - allows for as large a fall as could be expected to persist for more than a few months. In the 1990s economic growth is likely to raise energy demand, leading to at least a recovery of prices and quite probably to real price increases.

I C R BYATT

HM Treasury
Parliament Street
London SW1

15 December 1982

OIL PRICES IN THE LONG TERM

an examination of trends in energy supply and demand and their implications for the price of oil.

A Study by

An interdepartmental Group of Officials

LONDON

DECEMBER 1982

OIL PRICES IN THE LONG TERM

An examination of trends in energy supply and demand, and their implications for the price of oil

A study by an Interdepartmental Group.

(The following were represented on the Group: Department of Energy, Foreign and Commonwealth Office, HM Treasury, Department of Trade, Central Policy Review Staff, Bank of England).

CONTENTS

December 1982

I. INTRODUCTION

1. Those concerned with a variety of investment appraisals and energy policy decisions need to take a view about the longer term price of energy, in particular about the likely trends in world oil prices. There is, of course, a great deal of uncertainty about this. World oil prices will be affected not only by uncertain economic factors, such as the rate of economic growth, but also by political choices affecting, for example, the expansion of nuclear power in the West, and depletion policies in important oil producing countries. Oil price forecasts can easily go wrong, and attempts to indicate a single assumption for planning purposes have not proved to be very useful.

2. This study has therefore concentrated on assembling the evidence on energy supply and demand in order to indicate a range of feasible projections for oil prices in the longer term. So it is more in the nature of general guidance for decision makers than specific advice on the price assumptions they should use in their work. Individual decision makers should themselves consider carefully the price assumptions against which proposals should be tested: this study provides a framework for them to do this.

II. PREVIOUS WORK

3. Since the first oil price shock in 1973, there have been several inter-departmental studies of long term oil price prospects. Figure A shows the central projections made in each of these studies, against the background of the actual price path since 1945. A review of these studies shows how the perspective on future oil prices has changed over the period. Perhaps inevitably, some of the projections may have been over-influenced by the current state of the market and the short term outlook. It also needs to be borne in mind that over the years the studies have become more sophisticated, if not more certain about their end-product.

4. The 1974 study, written in the immediate aftermath of the first price shock, now seems very much a product of its times. Predictions of OPEC's imminent demise and the reversal of the previous year's sharp price increases influenced the mood. Addressing itself only to the medium term, the study envisaged a substantial fall in the real oil price by 1985.

5. Subsequent studies looked further ahead, to 2000. Table 1 below compares their central cases:

TABLE 1: PREVIOUS OIL PRICE PROJECTIONS (CENTRAL CASES)

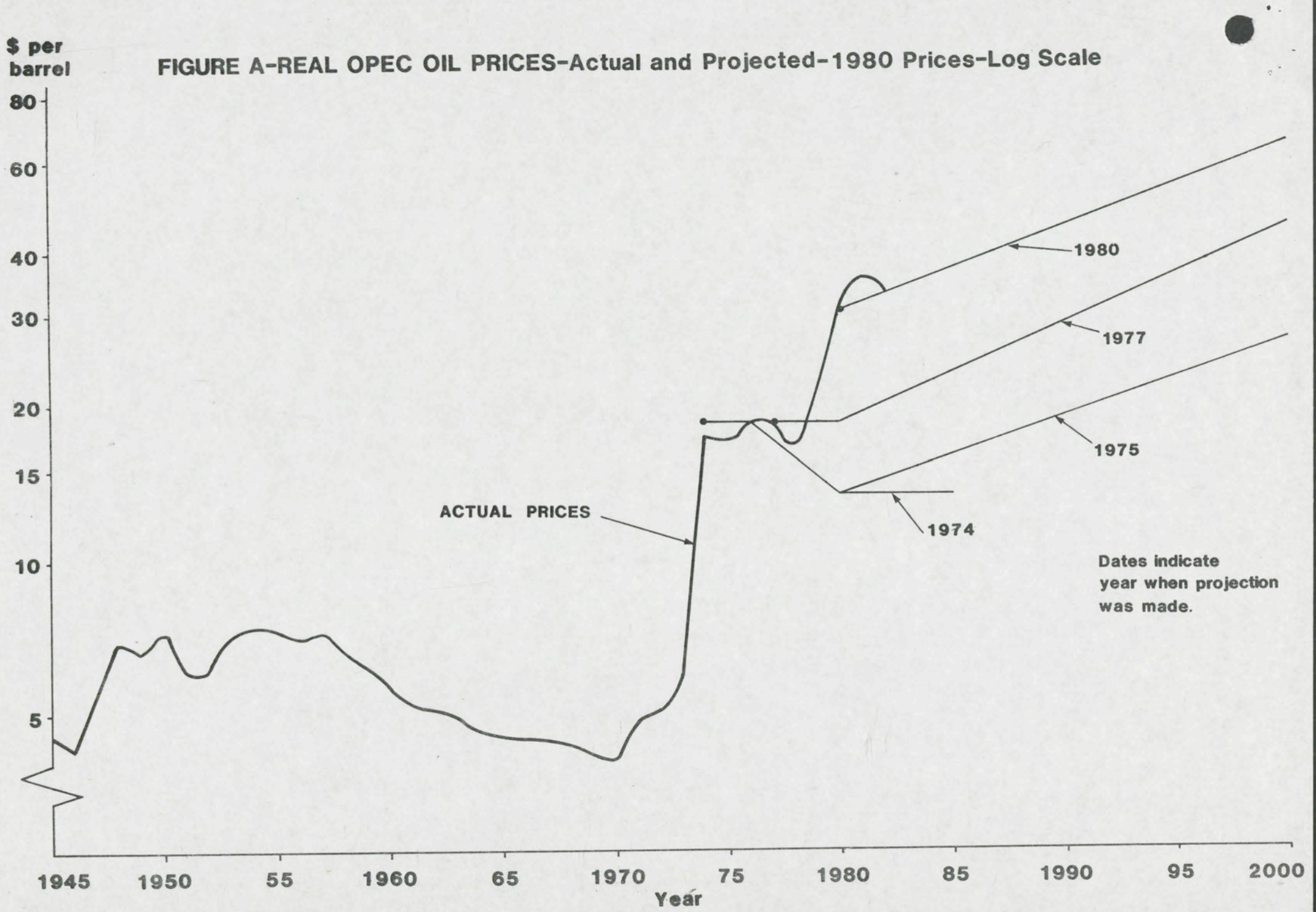
	$ 1980 prices	
	Oil price in 2000	Annual rate of increase to 2000
1975 Study:	27	3½%
1977 Study:	44	4½%
1980 Study:	65	4%

6. The 1975 Study concluded that a broad doubling of the real price by 2000 should be the central estimate for planning purposes, though a higher price than this was a little more likely than a lower one. The 1977 Study confirmed its predecessor's conclusion that the price in the long term would be significantly higher. Assuming a world growth rate averaging 4 per cent a year, the Study projected a central estimate for the real oil price in 2000, nearly 2½ times the then current level.

7. The 1980 Study* was written just after the second oil price shock, triggered off by the Revolution in Iran. Its thinking was coloured by proposals discussed in OPEC (which, at the time, seemed attainable) to increase the oil price in line with real economic growth in the West and by further evidence of slippage in the development of non-oil fuels. These factors outweighed the Study's projections of energy demand which were rather lower than in the preceding study. The Study concluded that, for 2000, an appropriate price range for planning purposes was $55-87, with a central estimate at $65 representing a rough doubling of the price over the period.

8. Leaving aside the first Study in 1974, each of these studies has projected a significant increase in price in the long term and also a much higher range of prices for 2000 than its predecessor. In the case of the 1975 and 1977 Studies, this was despite the reductions in energy demand assumed to result from the first price shock; and in the case of the 1980 Study, there was the further effect on demand consequent

*A summary of this study was given in a Supplementary Memorandum by the Department of Energy to the Select Committee on Energy, reproduced in the Committee's minutes of evidence of 17 December 1981.


$ per barrel
FIGURE A-REAL OPEC OIL PRICES-Actual and Projected-1980 Prices-Log Scale
80
60
40
30
20
15
10
5
1980
1977
1975
1974
ACTUAL PRICES
Dates indicate year when projection was made.
1945
1950
55
1960
65
1970
75
1980
85
1990
95
2000
Year

on the second shock. The main factors sustaining expectations of a rising oil price in the long term have been:

(i) increasing acknowledgement of OPEC's strength, along with declining estimates of OPEC countries' maximum production potential;

(ii) increasing doubts about the prospects for nuclear power;

(iii) rising cost estimates and production delays for the supply of crude oil from tar, shale and coal;

(iv) recognition that, the two price shocks notwithstanding, the rate of economic growth will be the principal factor determining energy demand in the longer term;

(v) above all, a view that a rising real oil price would be the outcome of a rising demand for depleting fossil fuel reserves.

III RECENT DEVELOPMENTS

9. Since the 1980 Study was written, the oil market has been weak, despite the Gulf War and other disturbances in the Middle East. Demand for oil has fallen considerably as a result of weak economic growth, increased efficiency of oil use, and substitution of other fuels. But there is not yet enough evidence to decide how much of the demand fall is due to short term and reversible factors and how much represents more lasting changes. This has widened the range of uncertainty about the size of the long term response of energy demand to price increases. As a result of the recent fall in demand, considerable surplus capacity has emerged in OPEC; earlier this year, OPEC output was little more than half its 1979 level. The possibility of demand remaining weak in the longer term raises questions about the effectiveness of OPEC at much lower levels of output. Despite these factors the real oil price in 1982 ($32½) is about 5% higher than in 1980, when the last Study was written.

10. These developments have set in train reappraisals of longer term price prospects, including this Study.

IV METHODOLOGY

11. The "oil price" referred to in this Study is the average price of OPEC crudes, all expressed in terms of the OPEC marker (Saudi Arabian light 34° API crude oil fob Ras Tanura.) It is expressed in real terms, based on 1980 world price levels. We have

chosen a 1980 price basis for technical reasons. Because world prices expressed in dollars are unlikely to have changed significantly between 1980 and 1982, use of a 1982 basis would have produced broadly similar results. For convenience, the numeraire used is the dollar, because this is the currency in which oil prices are set. However, this is not intended to indicate that if, over the long run, the dollar tends to be stronger or weaker relative to other currencies, then the oil price would be stronger or weaker. Rather, it is assumed that if the dollar were persistently stronger than in the base year, the dollar oil price would be lower, and vice-versa. Thus oil prices in the Study can, in effect, be regarded as given in terms of a broad currency basket.

12. Energy demand and supplies are all expressed in a common unit of measurement - millions of barrels of oil per day (mbd) or equivalent (mbdoe).

13. As in previous studies the first step is to make assumptions about economic growth in the World Outside Communist Areas (WOCA). Averaged over the period to 2000, these are a high case of 3½ per cent and a low case of 2¼ per cent. The build-up of these cases by region is shown in Table 2 below. Growth is assumed to be marginally lower than in the last study. In the high growth case it has been assumed that the world manages to get back to a rate of productivity growth somewhere between the growth of the 1970s and the high growth rates of the 1950s and 1960s. It would be difficult fully to recover the high growth rates of the 50s and 60s. That period was marked by non-repeatable post-war recovery gains (eg rapid expansion of world trade, with erosion of trade barriers; the diffusion of US technology gains to other countries; and productivity improvements resulting from labour force movement from agriculture to manufacturing). Their cumulative effect was to create a "virtuous circle" of growth that was reinforced by increasing access to abundant cheap oil and minerals on a scale which is unlikely to be repeated. The low growth assumption has productivity growth continuing at a marginally weaker rate than in the slow growing 1970s.

TABLE 2: GDP GROWTH RATES BY REGION SHOWING HIGH AND LOW ASSUMPTIONS 1980-2000

Region	OECD				LDCs			OPEC	WOCA (average)
	USA	Europe	Japan	Average	Low income	Oil exporters	NICs & S.Africa		
High growth	2.6	3.2	4.4	3.2	3.9	5.5	5.4	5.5	3.6
Low growth	1.6	1.6	2.2	1.9	2.8	4.0	3.8	4.0	2.3

14. For the oil price, two initial working assumptions have been used. These are a high case in which the price rises to $45 by 2000 and $60 by 2010; and a low case in which the price falls to $25 by 1985 and remains at that level through 2010. The high price case is roughly in line with the single starting assumption used in the 1980 Study. The low price case reflects some current suggestions about likely short term price developments and the possibility that the price may not change much in real terms over the longer term.

15. On the basis of these assumptions, we have constructed long term projections for energy supply and demand. The relationship between these projections indicates which way the price is likely to move. Actual energy prices tend to rise when demand exceeds supply and to fall when supply exceeds demand. The intersection of the hypothetical supply and demand projections determines the feasible ranges for the price on a range of assumptions about growth, conservation and energy supplies.

16. The aim in our approach is to eliminate combinations of economic growth, energy demand, energy supplies and the oil price which look highly unlikely. When these have been eliminated, feasible ranges remain within which the price could fluctuate. No allowance has been made for major surprises e.g the possibility that world growth will be outside the $2\frac{1}{4}$-$3\frac{1}{2}$ per cent range or that there will be an important and lasting gain or loss to fuel supplies. (Major surprises are discussed further in Section VII). However, the approach does provide for quite large variations in the supply and demand projections. A temporary loss of supplies would, in many cases, result only in a perturbation within the price range we identify. If the loss were substantial, the price might move outside the range for some years, but it should eventually move back within the range projected for the long term.

17. For the first time in this series of Studies, the period beyond 2000 is considered. For this period, an assessment has been made of whether the development of non-oil fuels could, by that time, increasingly limit the extent to which the oil price might rise.

18. As in previous Studies, oil (particularly OPEC oil) is treated as the marginal fuel, balancing world energy supply and demand. Three considerations justify this. First, oil will continue to have a role, albeit a diminishing one, as a general purpose fuel for heating and power at least for the rest of this century. Second, the supply to the consumer of fuels other than oil can usually adjust only slowly to sudden fluctuations in demand. Third, we expect some OPEC producers to have a margin of spare capacity which could be used to cope with such fluctuations in demand.

V ENERGY DEMAND

19. We have generated energy demand projections for the different growth cases and using different price assumptions. Rather than use single assumptions for the price and income elasticities we have drawn on the many analytical studies of energy demand and on our own work to choose a fairly wide range of assumptions about conservation. We have chosen assumptions to span the range of parameters used by most other experts and to be consistent with our own statistical analysis of energy demand in the last decade.

Disaggregation by region and sector

20. Energy demand is projected separately for industrial and developing countries because there are significant differences between them in the way in which energy is used and conserved. Within the developing countries group, separate projections have been made for OPEC, for other oil exporters, for the new industrialising countries (NICs), and for the low income countries. For the industrialised countries, energy demand has been analysed by sector - Transport, Domestic and Commercial, and Industrial users. For each sector, energy demand has been divided into electricity demand and the demand for other fuels, since these fuels are highly interchangeble, while electricity is less interchangeable and uses more primary energy per unit of delivered energy. We expect the bulk of the growth in energy demand to occur in the developing countries, because they should enjoy stronger economic growth than the industrialised countries, while their energy savings through conservation are likely to be smaller.

Construction of Energy Demand Projections

(a) Income Effects

21. GDP growth increases demand for energy, partly through income effects as a richer society demands higher standards of thermal comfort, more energy using devices and more transport, and partly because energy inputs are needed to fuel the higher pace of industrial activity. The sensitivity of energy demand to growth in GDP (its income elasticity) may vary, depending on the stage of a country's development, the pace of change of its industrial structure, the size of economies of scale, and changes in consumer preference. Table 3 below shows the range of income elasticities which have been used. Generally, for industrialised countries, the income elasticity ranges from about 1.0 to about 0.9 implying that, with constant prices, energy demand will tend to grow at around the same rate as GDP growth or a little slower. This range reflects different assumptions about the degree of scale economies available to the commercial and industrial sectors; the degree to which consumer energy demand rises with incomes; and the degree to which the recent decrease in energy demand reflects changes in the industrial structure. In developing countries, higher income elasticities have been used ranging from about 1¼ to about 1: this partly reflects growth in the use of commercial energy supplies, as traditional fuels such as firewood decline.

(b) Non-price Conservation trends

22. Most conservation appears as a response to higher energy prices and is captured in the price sensitivity discussed below. However, we also allow for the possibility of technical progress, energy saving innovations and improved working methods leading to reductions in demand independently of income and price effects. These conservation trends are also shown in Table 3.

TABLE 3: RANGE OF INCOME ELASTICITIES AND CONSERVATION TRENDS

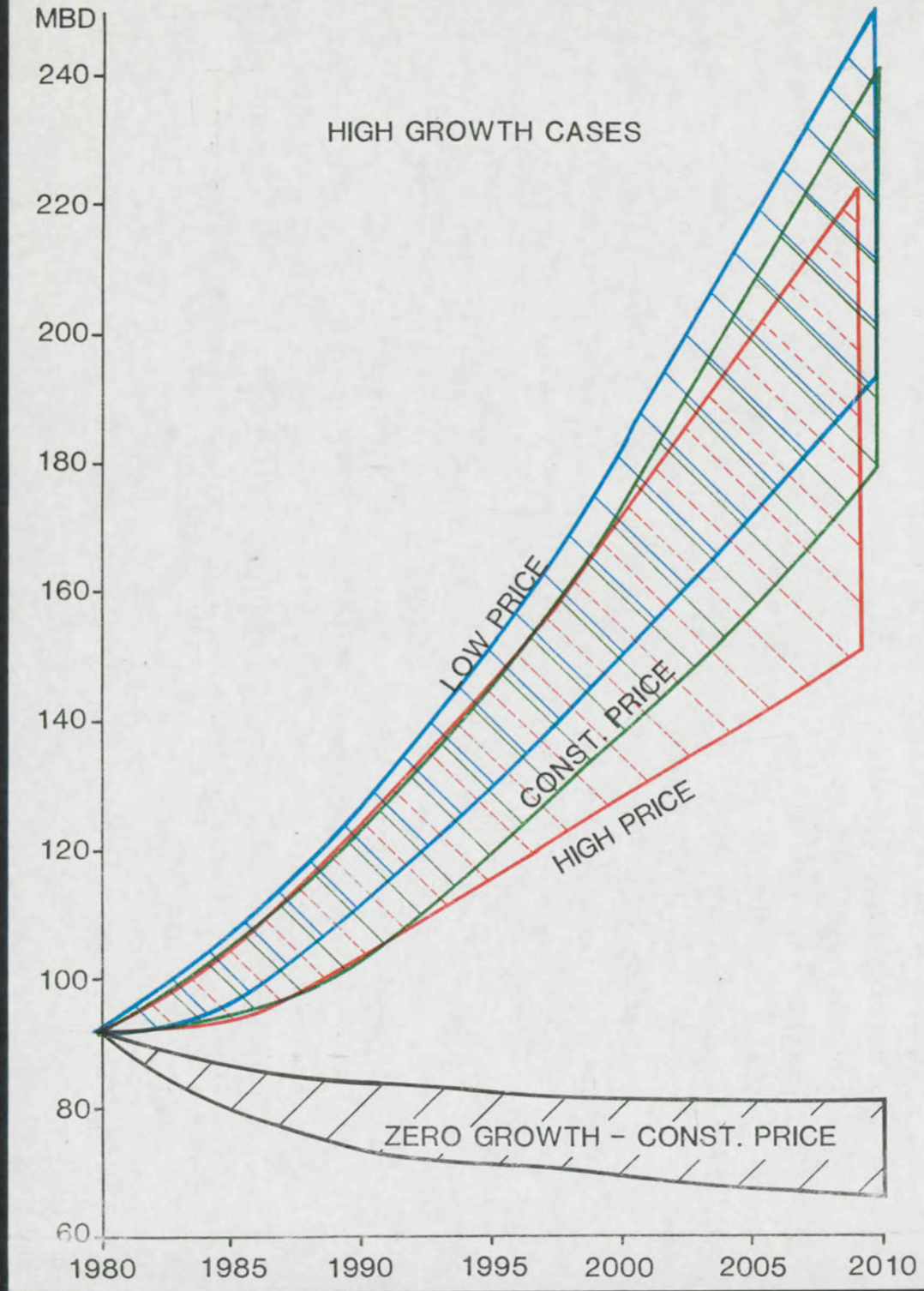
		High Conservation Case		Low Conservation Case	
		Income Elasticity	Trend % pa	Income Elasticity	Trend % pa
OECD:	Industry	0.8	-½	0.9	-¼
	Domestic & Commercial	0.9	-½	1.0	-¼
	Transport	1.0	-1	1.1	-½
LDCs	NICs and S.Africa	1.0	nil	1.1	nil
	Oil exporters	1.1	nil	1.2	nil
	Low income	1.1	nil	1.3	nil
OPEC	High absorbers	1.0	nil	1.2	nil
	Low absorbers	1.05	nil	1.2	nil

(c) Price effects

23. Increases in energy prices relative to other prices induce reductions in demand as energy consumers switch towards other sources of comfort, tighten energy management, increase insulation and switch to newer, more energy-efficient plant. Some of these responses can occur soon after a price rise; others can be delayed until existing plant gets nearer to its originally planned replacement date. The speed of these responses, the lag structure, strongly influences the pattern of energy demand. As part of the conservation range, two lag hypotheses have been adopted in this study: a short lag structure, in which half of the fall in demand comes through in the first 5 years after a price increase; and a longer lag structure over 20 years, in which half of the effect comes through in the first 8 years.

24. Detailed assumptions about the response of energy demand to final user prices are shown in Table 4 below. Again we have used high and low figures for these elasticities to give a plausible spectrum of results, reflecting the large measure of uncertainty. The upper and lower elasticities were derived from our own statistical studies designed to obtain the likely boundaries; they span the assumptions used by most commentators. The elasticities are assumed to be much lower for OPEC and the LDCs than for the OECD and the New Industrialised Countries (NICs). This is because, in general, LDCs have fewer opportunities to substitute capital for energy in their production processes.

FIGURE B - ENERGY DEMANDS 1980 - 2010



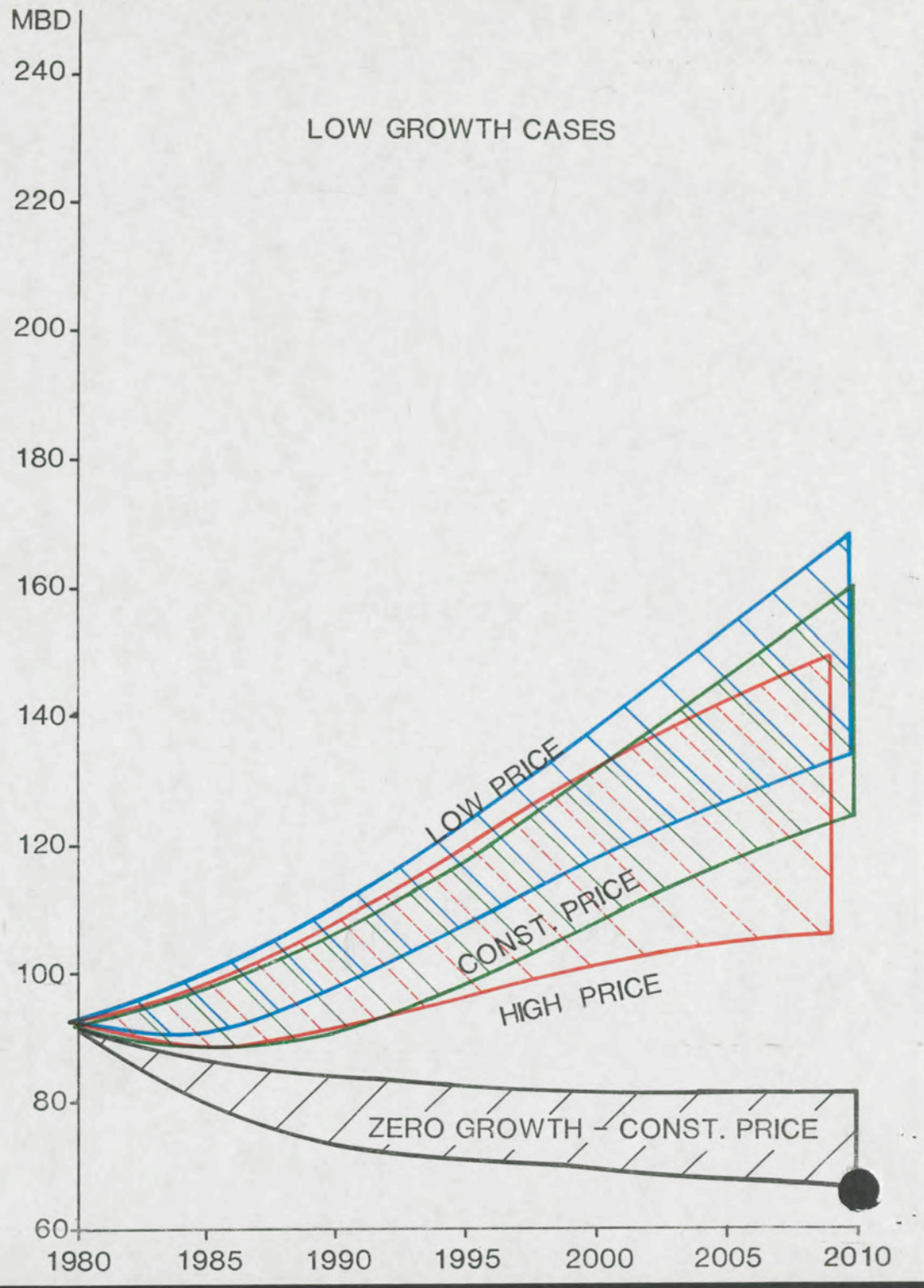


TABLE 4: PRICE ELASTICITY ASSUMPTIONS FOR ENERGY DEMAND

		High Conservation Case	Low Conservation Case
OECD	Industry	-0.7	-0.3
	Domestic and Commercial	-0.7	-0.3
	Transport	-1.0	-0.5
LDCs*	NICs & S Africa	-0.7	-0.4
	Oil exporters	-0.4	-0.2
	Low income	-0.5	-0.2
OPEC*	Low absorbers	-0.3	0
	High absorbers	-0.4	-0.2

*In the case of LDCs and OPEC, these are average elasticities for the whole period. It was assumed that the income elasticity would fall and the price elasticity rise over the period.

Energy Demand Results

25. Figure B illustrates the results of our demand analysis for the WOCA. If economic growth were to be zero and the oil price constant (the lower segments shown), the analysis indicates that energy demand would fall by about ½% - 1½% pa. This would reflect the conservation response to the oil price shocks of 1973 and 1979, as the capital stock is replaced with energy efficient plant. The green upper segments show how the cumulative effect of economic growth (at constant energy prices) would gradually overwhelm the conservation response to past price rises. Total energy demand is shown to rise by ½% to 1½% a year in the low growth case and by 2% to 3% a year in the high growth case. In both cases the rise in energy demand is less than the growth of output principally because of the continuing response to past price rises. The red segment in Figure B indicates the effect of the higher price assumption, and the blue segment the lower price assumption. Broadly, the higher price profile reduces the demand range by about ½% a year, and the lower price raises it by ¼% a year.

26. Figure C shows the breakdown of a typical set of demand projections on the higher starting price assumption but where economic growth assumptions have been averaged. It shows demand growing at 4% to 5½% a year in OPEC and 3%-4¼% in the LDCs; while energy demand in the industrialised countries is projected to grow at ½% to 2% a year. In the industrialised countries, a switch to electricity is a feature of the projection and, although travel demand is thought likely to be buoyant, increased efficiency of the transport fleet seems likely to contain the growth of energy used for transport.

27. Table 5 gives our energy demand projections upto 2000. The energy demand growth rates are in all cases significantly higher in the 1990s than the 1980s. Demand growth is lower with higher prices. In 2000, demand in the higher growth cases is about 30-40mbd greater than with low growth. Demand in the high conservation cases is 20-40mbd less than in low conservation cases.

TABLE 5 **WOCA ENERGY DEMAND**

mbdoe

Oil Price	Economic Growth	1980	1990	2000	Annual % Growth 1980-2000
High	High		102-122	126-168	1.6-3.0
High	Low		90-106	99-128	0.4-1.7
		92			
Low	High		109-126	149-179	2.4-3.4
Low	Low		97-109	117-137	1.2-2.0

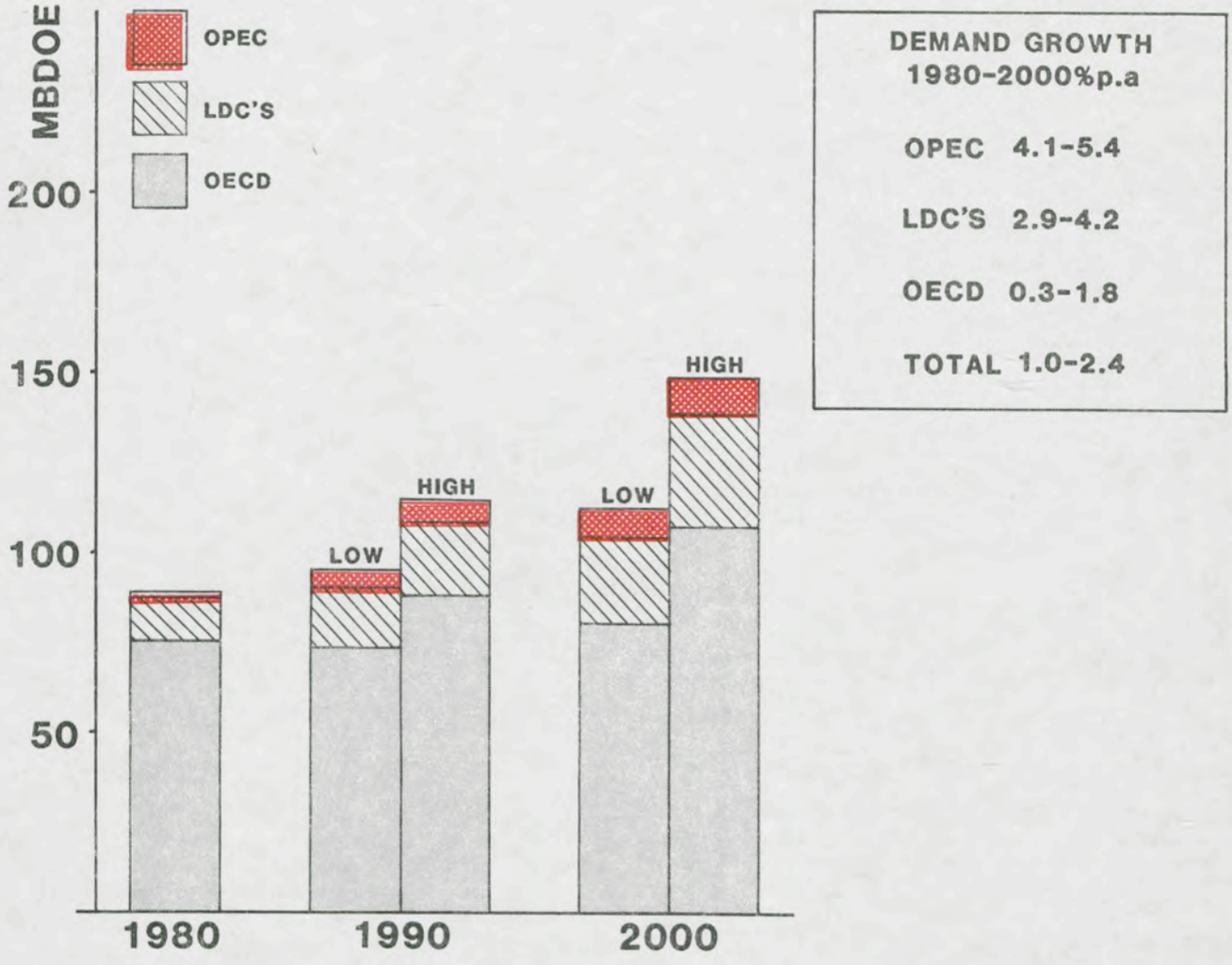
28. Whilst these projections assume that the effects of economic growth, price and the degree of conservation are independent of each other, that is unlikely to be the case. In particular, lower economic growth with a consequently slower turnover of the capital stock, may not create favourable conditions for higher conservation so that the lower end of the low demand ranges is less likely. Of course, not all the price paths tested in this demand analysis are possible and to determine which pathways are feasible it is necessary to show the interactions between energy demands and energy supplies for each price path. (See Section VII.)

29. The demand projections allow us to trace in demand schedules showing for a particular year how much energy would be demanded at different price levels on the different economic growth and conservation assumptions. Figure D shows what these schedules would look like for the year 2000 on a wider range of prices than those used in the starting assumptions, assuming that the price adjusts smoothly to those levels.

VI ENERGY SUPPLIES

30. In this Section, the prospects for each of the primary sources of energy for WOCA are considered. The estimates have been built up region by region from studies of fuel reserves, combined with assumed rates of likely extraction and by taking account of production and investment plans for non-fossil fuels. Estimates of energy exports from Communist countries are then added to the total. A range of possible supplies is shown for each fuel. Different assumptions about economic growth and the

FIGURE C-COMPOSITION OF FREE WORLD ENERGY DEMAND.
FOR "HIGH PRICE"-"AVERAGE GROWTH"CASE



OECD DEMAND SHARES
PRIMARY ENERGY

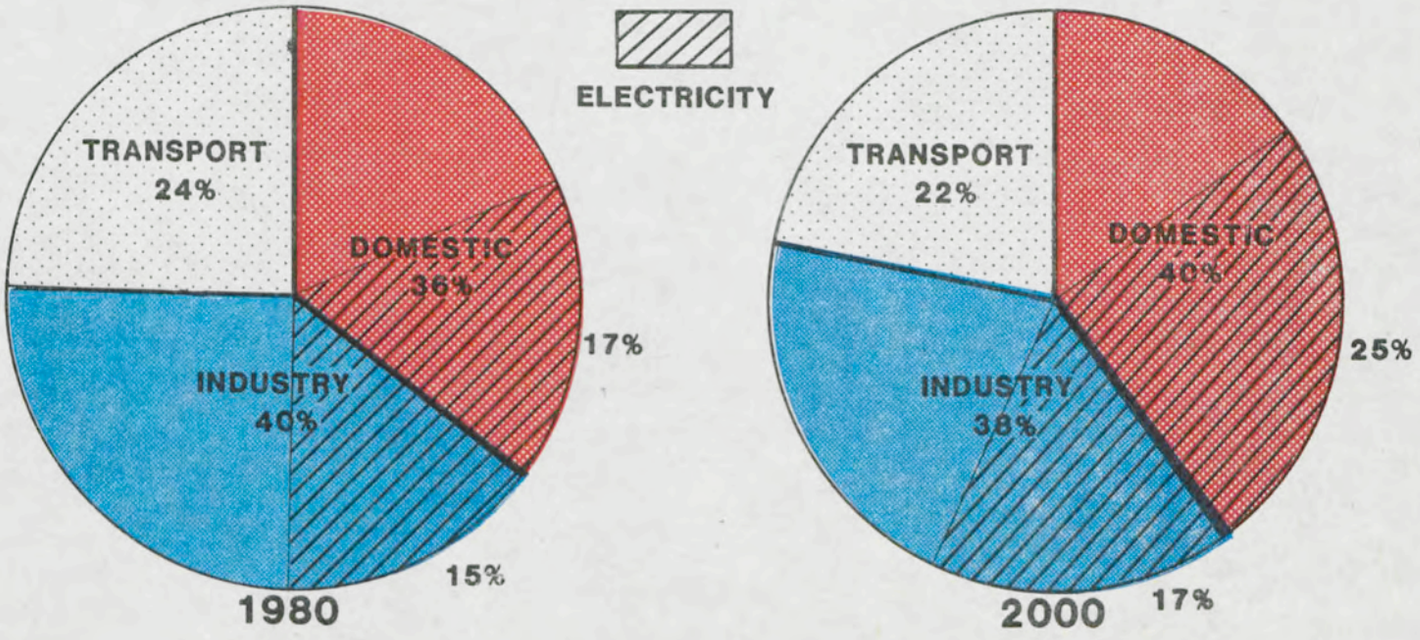
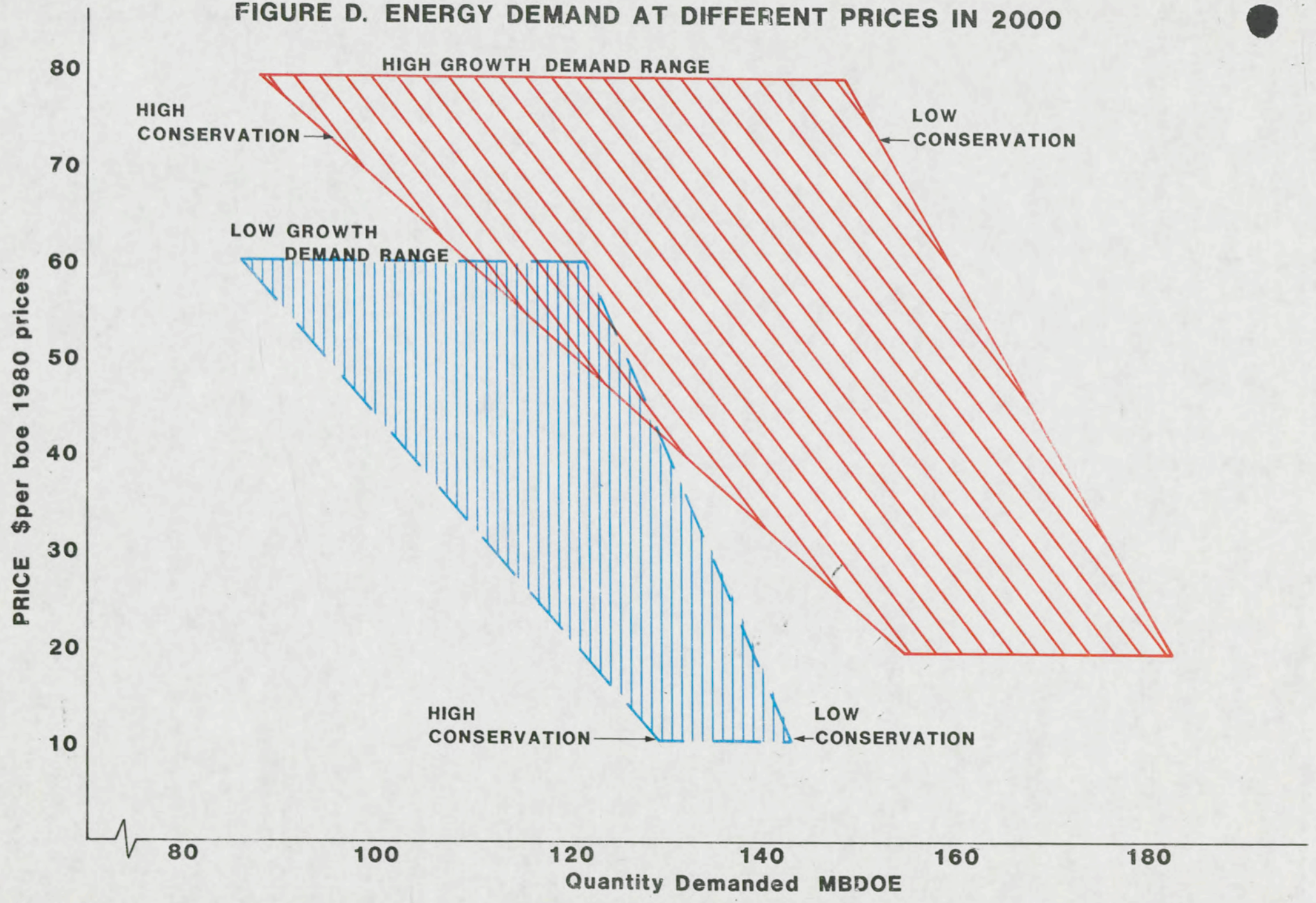


FIGURE D. ENERGY DEMAND AT DIFFERENT PRICES IN 2000



oil price (described in paragraphs 13-14 above) and the uncertainty about new energy finds and technological developments generate the ranges.

31. We think that, apart from coal, high growth will tend to increase fuel supplies because of its association with more rapid technological advance and greater economic dynamism. We also think that the price of energy will have a significant effect in bringing forward or postponing marginal developments, though time lags may be considerable, and price expectations may intervene. The ranges shown for uncertainty do not attempt to cover all possibilities; they were chosen to cover the more plausible outcomes.

(a) Coal

32. These projections are broadly in line with those in the 1980 study:

Economic Growth	Oil price	1980 actual	1990	2000	mbdoe 2010
Low	Low	18.5	22	26-28	32-36
Low	High		25-27	33-37	43-49
High	Low		21-22	24-25	27-30
High	High		24-26	31-35	40-46

Note: The projections include supplies of brown coal and peat; the latter could account for about 2 mbdoe by 2000.

33. Reserves of coal are large enough to support production at many times current levels. But these reserves will be exploited only if the price is high enough to cover costs and yet low enough compared to other fuels, especially oil, to make the use of coal attractive. Even if the price is right, expansion of coal supplies could be delayed by the long lead times involved in developing new mines, environmental opposition (particularly in the case of opencast mining), and the need to build the necessary infrastructure to permit increased international trade in coal.

34. The level of coal supplies by 2000 will depend upon how much coal prices rise compared with marginal costs. At the lower output levels shown in the table, marginal costs will be lower and those output levels could be delivered with a 1 per cent a year rise in coal prices. The higher oil price levels could permit coal prices to rise by 2 per cent a year and this would allow marginal costs to be met at higher output levels. Higher economic growth is likely to mean higher costs in the coal industry. The major expansion in coal output foreseen for the high oil price case occurs in the USA, Australia and S.Africa. Lower coal prices would reduce output in all these countries

to some extent but eastern USA, which is generally seen as a marginal supplier of world coal trade, would be most affected.

(b) Gas

35. Our projections of gas supplies are now slightly lower than those made in the 1980 study:

Economic growth	Oil price	1980 actual	1990	2000	mbdoe 2010
Low	Low		16-19	13-18	12-19
Low	High		18-21	17-24	16-27
		16.6			
High	Low		17-19	14-20	13-21
High	High		19-22	18-26	18-29

36. Gas output is now predominantly in OECD countries, where production is expected to fall over the period (though price-deregulation in the USA, if it goes ahead, could affect this trend). The main uncertainty is how far output will expand in a number of OPEC countries and other LDCs, particularly Mexico.

37. With fast economic growth and a high oil price, gas output from OPEC countries could treble by 2010, with notable increases in Algeria, Indonesia, Iran, and Nigeria. At the high oil price, expensive gas transportation projects would become sufficiently attractive to make producers willing to accept the investment risks and difficulties involved, while high economic growth should increase demand. But, even given these propitious circumstances, there is considerable uncertainty about how many projects would be implemented. International trade in gas involves heavy expenditures in liquefaction plant or pipelines, with consumers and producers committing themselves in long term contracts. The question is whether there will be sufficient mutual confidence between potential OPEC suppliers and their customers in industrialised countries to get additional export facilities built; this is likely to be an important consideration in the Middle East in view of the political uncertainties there. Although at least some of the new projects are likely to go ahead, the wide range of gas supplies projected for the long term reflects the large measure of uncertainty attached to the future of trade in gas.

38. On the low growth/low oil price assumptions, we think that some OPEC countries would be more interested in expanding gas exports because their revenues from oil would probably be insufficient to finance even modest development plans. Against that, a low oil price would put a ceiling on gas prices and, because of the higher costs involved in gas production, would reduce returns to gas producers disproportionately.

Any expansion of OPEC and LDC supplies in these circumstances may do little more than offset the decline in output among industrialised countries.

(c) Nuclear

39. Nuclear power was responsible for 12 per cent of electricity generation in 1980. And at current oil prices, it is cheaper than oil in generating electricity. Up to 1990, its expansion is largely determined already, because of long lead times on nuclear investment. Later, the range of possibilities widens considerably:

mbdoe

Economic Growth	Oil Price	1980 actual	1990	2000	2010
Low	Low	2.9	4-6	6-9	7-12
Low	High		5-6	7-11	9-14
High	Low		5-7	9-12	11-16
High	High		6-8	10-15	12-24

The projections for 2000 are some 3-5 mbdoe less than those in the 1980 study.

40. In the longer term, political considerations and public acceptance are likely to be crucial in determining the degree of nuclear expansion and this is reflected in the ranges above. Stronger economic growth and a higher oil price might reinforce the case for nuclear power and could help to secure a greater degree of public acceptance. Opposition to nuclear could diminish in the absence of accidents and through demonstration of effective safety measures. But doubts about the growth of electricity demand and also the heavy capital cost of nuclear plant could slow down development.

(d) Hydro-electric power and other Renewable Sources

41. The principal renewable energy resource is likely to remain hydro-electric power. Contributions from other sources - wind, solar, etc - will probably be fairly

small; even though R&D work will be extensive, widespread commercial usage seems unlikely within the period of the study. Our projections are as follows:

mbdoe

Economic Growth	Oil Price	1980 actual	1990	2000	2010
Low	Low	6.4	8	9	9-10
Low	High		9	9-10	11-12
High	Low		9	10	12-13
High	High		9	11-13	13-16

The projections for 2000 are some 2-4 in mbdoe less than those in the 1980 study.

42. As with nuclear, the prospects for hydro-electric power to 1990 are already largely determined because of long lead times. Beyond that, there is scope for expansion, particularly in LDCs, as new hydro plant can generally provide cheaper power than oil, even under the lower working assumption of a $25 oil price. The pace of expansion will depend largely on expectations about growth in electricity demand in regions where hydro development is feasible.

43. Over the next twenty years or so, output of renewables other than hydro-electric is likely to grow slowly. By 2000, it could be limited to less than ½ mbd if growth and prices are low. Even with stronger growth and a high oil price, circumstances in which governments might give more support to development of renewables, their contribution may not rise much above 1 mbd. But some renewables should play a significantly greater role in the 21st century.

(e) Oil

44. We have considered future oil production in three main categories: conventional oil supplies outside OPEC, OPEC capacity, and non-conventional supplies (eg syncrude). For conventional oil, we have surveyed the estimates of total known reserves and have based our production estimates on the rates of depletion which we thought plausible without damaging ultimate recovery. World known reserves would last for about 30 years at present rates of production but our estimate of ultimately recoverable reserves could sustain current rates of consumption for 60 to 100 years. Prospects for OPEC capacity are considered separately in paragraphs 47-48 below and OPEC supplies are considered further in Section VII.

45. Our projections for the remaining two categories are set out below:

Conventional Oil (excluding OPEC)

mbd

Economic Growth	Oil Price	1980 actual	1990	2000	2010
Low	Low	19.8	19-22	18-22	16-21
Low	High		23-26	22-27	21-27
High	Low		19-22	18-22	16-21
High	High		23-26	22-27	21-27

Production is likely to decline in OECD countries and to increase in LDCs. How far total non-OPEC supplies increase will depend largely on the incentives for exploration, development, and production provided by the oil price.

Non-Conventional Oil

mbd

Economic Growth	Oil Price	1980 actual	1990	2000	2010
Low	Low	0.3	½-1	½-2	1-4
Low	High		½-2	2-7	5-14
High	Low		½-1	½-2	1-4
High	High		½-2	2-7	5-14

Note:

The projections for coal and gas supplies in paragraphs 32 and 35 omit the amounts of these fuels which we think could be used in projects to convert them to oil; the associated quantitities of oil are included in the table above.

These projections include heavy oil, oil extracted from tar sands and shale, and synthetic oil manufactured from fossil fuels (coal or gas) or from biomass. As with supplies of conventional oil, the oil price should be the key determinant of production.

OPEC Oil Capacity

46. The upper limit to OPEC production at any point will be determined by the installed production capacity. The high-absorbing members of OPEC are mainly low-income developing countries, and several of them are likely to become net energy importers during the period under review. It is likely that they will install sufficient

oil production capacity to enable them to produce at the maximum level which will not harm ultimate recovery and that they will aim to use their full capacity continuously. OPEC members around the Gulf will have rather more flexibility. Their oil reserves are much greater relative to their revenue needs, so they are unlikely to build up their productive capacity as rapidly as their reserves will allow. Capacity in the Gulf States may be influenced not only by their estimates of what could be required for revenue purposes but also by a desire to have a margin of spare capacity so as to permit flexibility in production policy. Our projections of OPEC's maximum production capacity are:

mbd

	1982 actual	1990	2000	2010
Gulf	19½	22-26	21-27	21-29
Non-Gulf	10½	7-9	6-7	5-7
Total OPEC	30	29-35	27-34	26-36

47. While the table above shows the expected range of maximum capacity, actual output will depend on a number of factors, including oil demand, the nature of OPEC's pricing and market-sharing policies, and the extent of any supply disruptions. These are considered in Section VII below.

(g) Net Energy Exports from Communist Countries

48. The projections are as follows (the range covers each of the four combinations of economic growth and oil price starting assumptions):

mbdoe

1980 actual	1990	2000	2010
+1.8	-½ to +½	+½	+1 to +1½

49. It is likely that the Communist countries (the USSR, China, Eastern Europe and other centrally planned LDCs) will have a small energy surplus with the non-Communist world during the period. During the 1980s the surplus may decline to low levels owing to lower oil production in the USSR and slower growth in Poland's coal output, slower growth in both oil and coal production in China, and a continuation of the growth in domestic energy consumption (although at lower levels than in the 1970s). Although the USSR will remain a net exporter of energy, with additional gas exports partly off-setting the projected decline in oil supplies, the energy position of the Comecon countries as a whole could be in balance by 1990. The energy import

requirements of Eastern Europe should continue to rise, because of the limited availability of domestic supplies. In addition, if the Soviet Union's oil exports decline, then Eastern Europe will need to buy an increasing quantity of its oil from the world market. Thus the actual levels of the region's energy imports will depend on its foreign exchange position in the 1980s. There are many uncertainties beyond this period. During the 1990s the Communist countries' energy surplus could increase slightly to the extent that there are further increases in gas production in the USSR and development of off-shore oil fields in China.

Overall Energy Supply Position

50. Projections for total WOCA energy supplies, including net exports from Communist countries, are shown in Table 6 below for each of the price and economic growth starting assumptions. The ranges of uncertainty reflect optimistic and pessimistic assumptions about the developments of fuel supplies and technologies. At the upper end of the ranges, OPEC output is included at the maximum capacity levels shown in paragraph 46. At the lower end, OPEC output is entered at the minimum levels which we think OPEC could sustain on the strongest assumptions about its cohesion in defence of price objectives; we estimate this at about 20 mbd up to 1990 and at around 25 mbd in 2000 and beyond. The Table shows that the growth assumptions have little effect on the energy supply projections compared with the effect of price and the range of uncertainty; by 2000 the price assumptions and the range of uncertainty each give about 20 mbd difference, the growth assumptions about 5 mbd.

TABLE 6: WOCA ENERGY SUPPLIES

Oil Price	Economic Growth	OPEC Low Output		OPEC High Output		Annual Growth %
		1990	2000	1990	2000	1980-2000
High	High	102-110	124-141	117-125	134-151	1.4-2.4
High	Low	101-108	120-135	116-133	130-145	1.3-2.2
Low	High	92-98	103-113	107-113	113-123	0.5-1.4
Low	Low	91-97	100-111	106-113	110-121	0.3-1.3
OPEC output included		20	25	35	35	

Notes:
(i) 1980 total energy supply was 93½ mbdoe.

(ii) The range of uncertainty for the total is narrower than the sum of the ranges for each fuel, because being at the end of the range for all fuels in the same year is less likely than for any one fuel.

51. Figure E shows the ranges within which WOCA energy supplies are likely to develop under the two starting price assumptions (as in paragraph 14). Two variants are shown for each price path; the high variant has high economic growth, non-OPEC supplies at the top of the range of uncertainty and OPEC production at maximum capacity; the low variant has low economic growth, non-OPEC supplies at the bottom of the range of uncertainty and restrained OPEC production.

52. For each of the four variants described above, Figure F shows the share of each fuel in WOCA energy supplies. In the low price cases, most of the growth in energy supplies between 1980 and 2000 comes from the growth in coal capacity. Although nuclear shows a rapid growth, it starts from a low base. In the high price cases, coal accounts for about one third of the growth in energy supplies. Nuclear and renewables contribute a similar amount, with some growth also in oil and gas. The range is widest for oil, because of the potential variation in OPEC supply. This study shows a smaller growth in renewables and unconventional oil than earlier assessments. Projects have been postponed recently because of expectations of softer oil prices throughout the 1980s, but if the necessary investment eventually goes ahead, they could make an increasing contribution to energy supplies after 2000. Overall, energy supplies are shown to be growing at about ½ per cent to 1½ per cent a year on low price assumptions and by1¼ per cent to 2½ per cent a year on high price assumptions.

FIGURE E - WORLD ENERGY SUPPLIES AT DIFFERENT PRICES AND GROWTH RATES

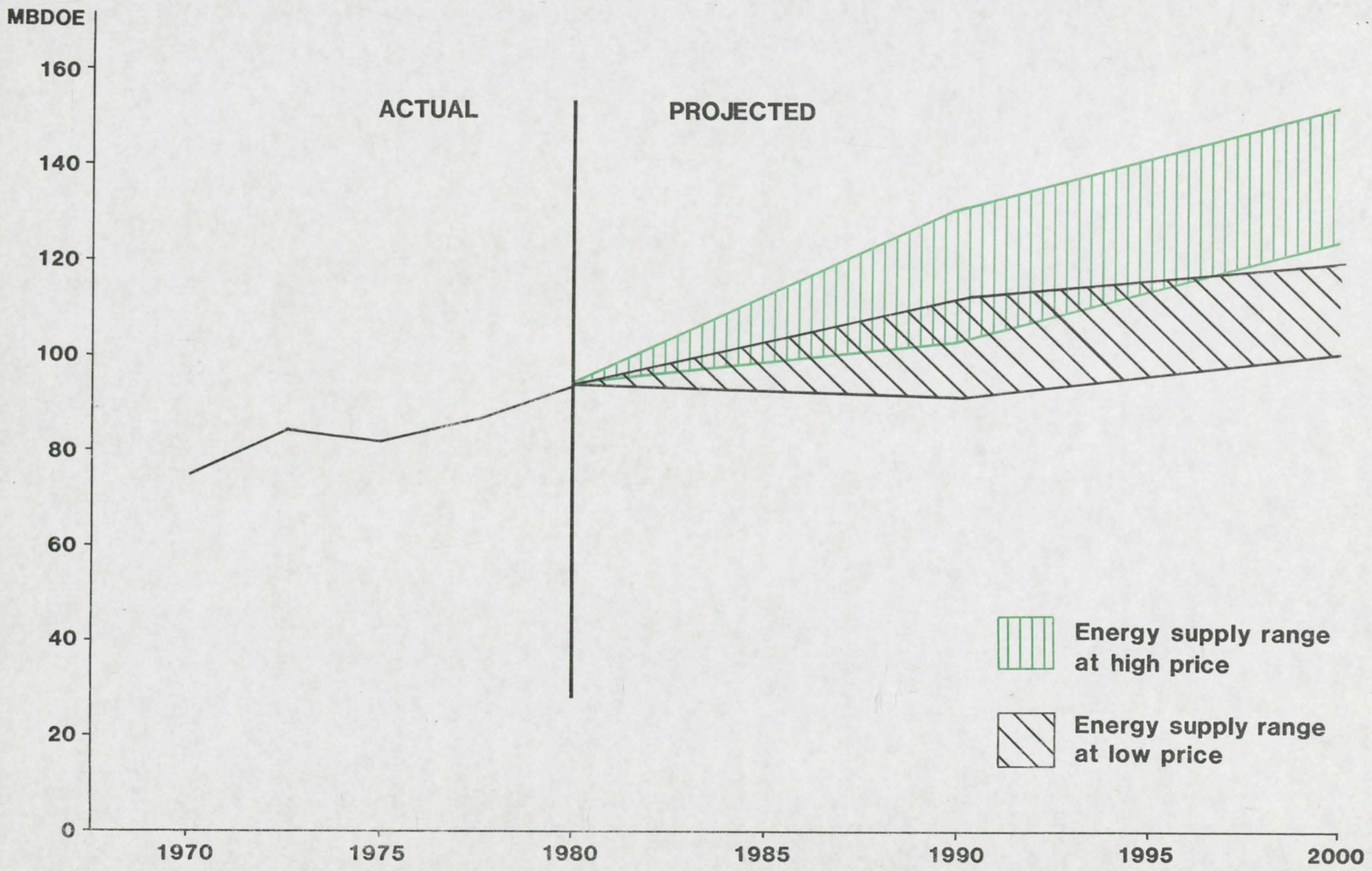


Figure F : SENSITIVITY OF WOCA ENERGY PRODUCTION IN 2000 TO ASSUMPTIONS MADE

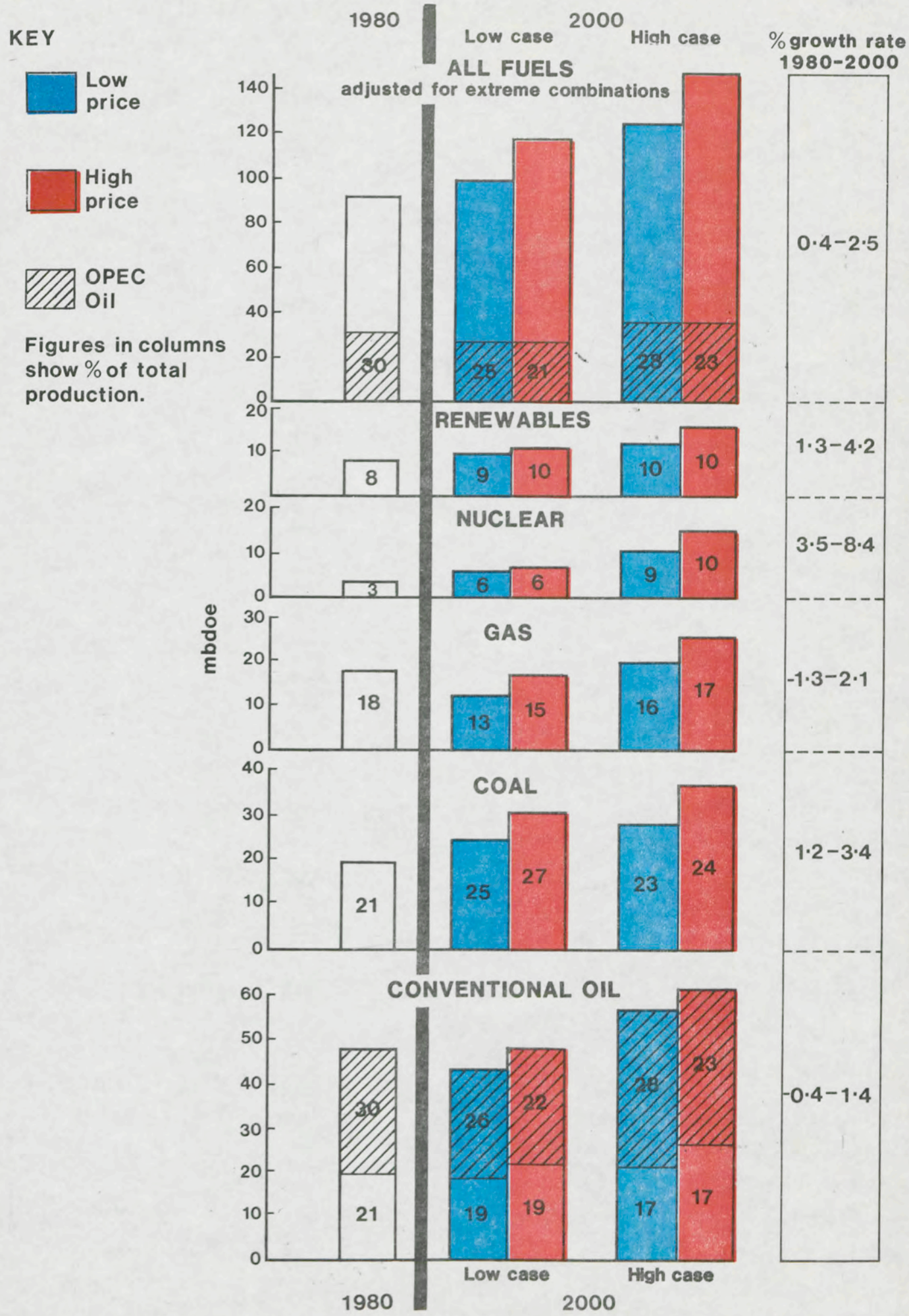
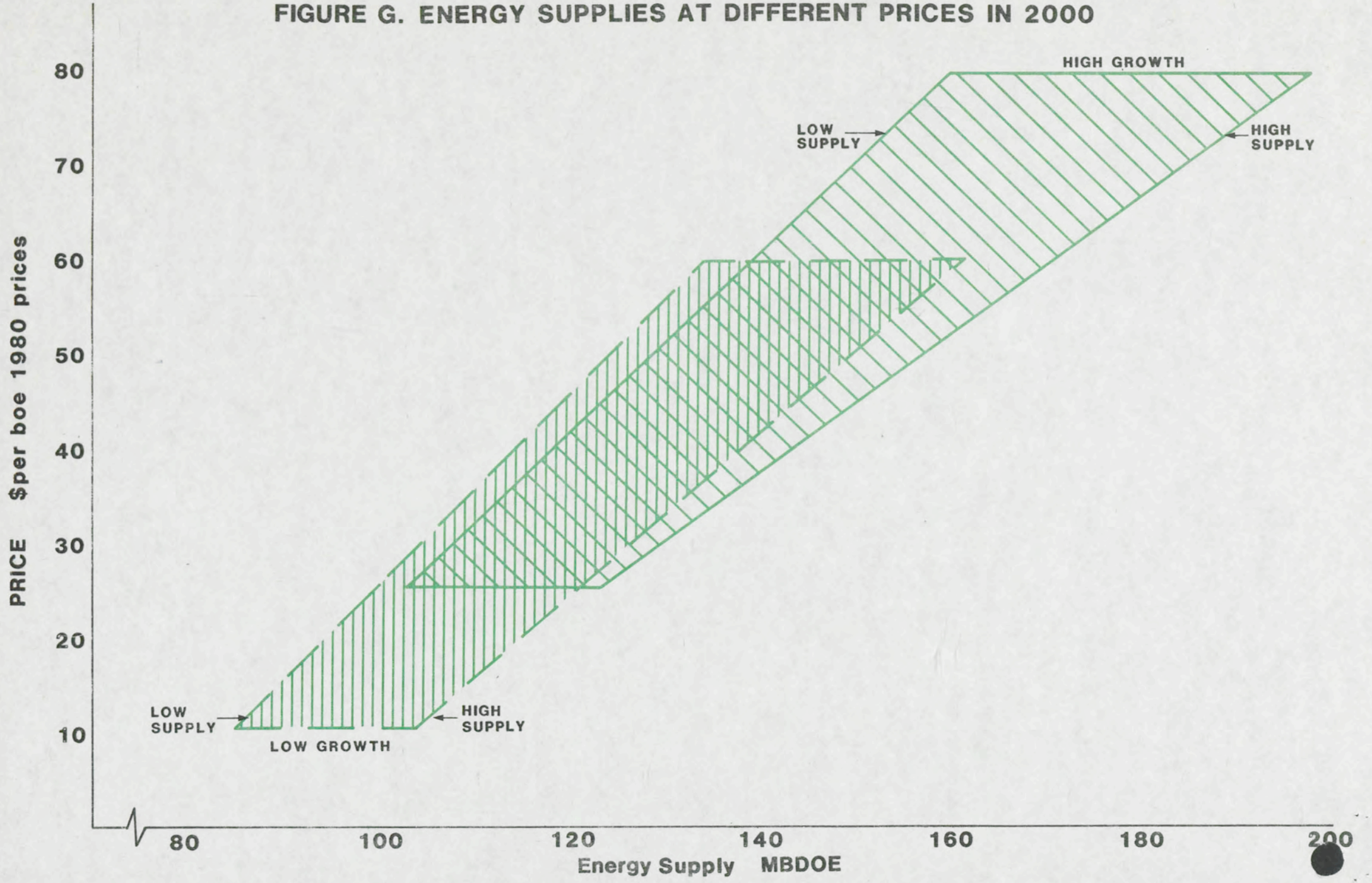


FIGURE G. ENERGY SUPPLIES AT DIFFERENT PRICES IN 2000



53. The estimated relationships between energy prices and energy supplies enable a supply schedule to be drawn up on the lines of Figure G for the different years. For 2000, the Figure shows the upper and lower end of the supply ranges at different prices, assuming that the price adjusts smoothly to these levels. Higher growth is shown as increasing energy supplies. In the next Section, we show the interaction between these supply paths and the energy demand paths.

VII ENERGY BALANCES AND PRICE DEVELOPMENTS

54. Before putting together our energy supply and demand projections, we consider OPEC's position. As indicated in paragraph 47, OPEC have some flexibility in production policy and thus could influence the price. But their policy will also be affected by the import requirements of their development plans and their wider political objectives.

55. The recent weakness in the oil market has sharply increased the difficulties for OPEC countries in taking the collective action necessary to maintain prices and revenues, but has underlined their common interest in preventing a sharp fall in the price. The tension between high and low absorbers may increase as the latter group's room for manoeuvre on production levels is eroded by growing import requirements and by price weakness. But no OPEC member would gain if the price collapsed, and this will be an incentive for the Organisation to stick together and avoid undermining their pricing arrangements. Political difficulties may be at least as great an impediment as diversity of economic interest. Given the volatility of the region, policy changes among Middle Eastern producers which could radically affect production cannot be ruled out. Among the areas to watch will be the Arab/Israel dispute; any tendency for Islamic assertiveness to increase; and the effects of rapid economic development on the stability of the traditionalist states.

Possible OPEC output levels

56. In order to estimate the likely range for the oil price, we are interested in the range of OPEC output levels which are realistically sustainable. We have attempted to estimate the residual demand for OPEC oil. Table 7 puts together the energy demand estimates shown in Table 5 and the supply projections (excluding OPEC oil) drawn from Table 6. For each case, broad ranges are obtained by combining low conservation with low supply and high conservation with high supply.

TABLE 7 RESIDUAL DEMAND FOR OPEC OIL
(ENERGY DEMAND less NON-OPEC SUPPLY)

mbd

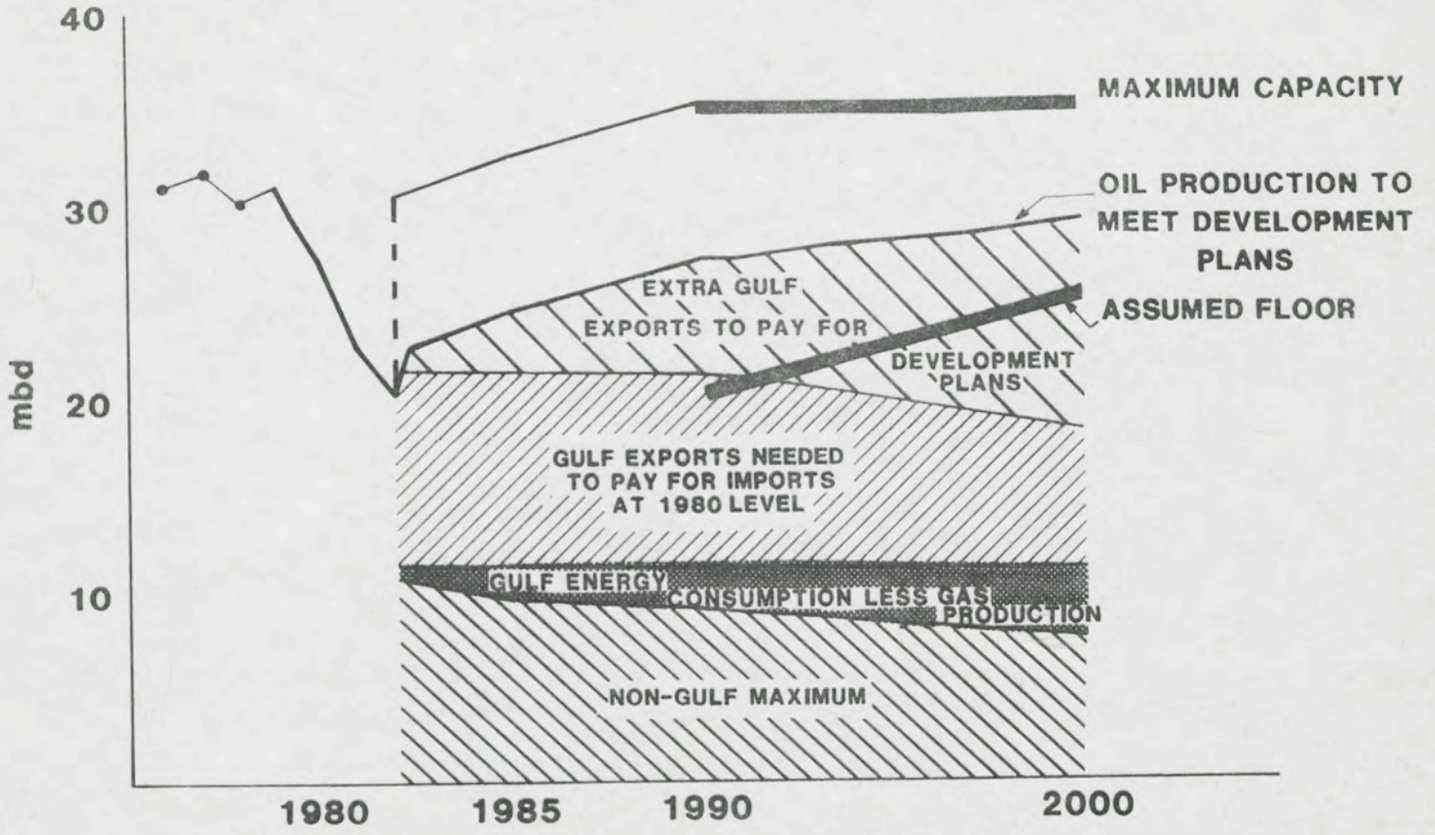
Price	Growth	1980	1990	2000
Low	Low	27	19 to 38	31 to 61
Low	High		32 to 54	60 to 101
High	Low	27	2 to 25	-10 to 34
High	High		12 to 40	11 to 69

Note: A negative residual would require OPEC oil imports to balance the system.

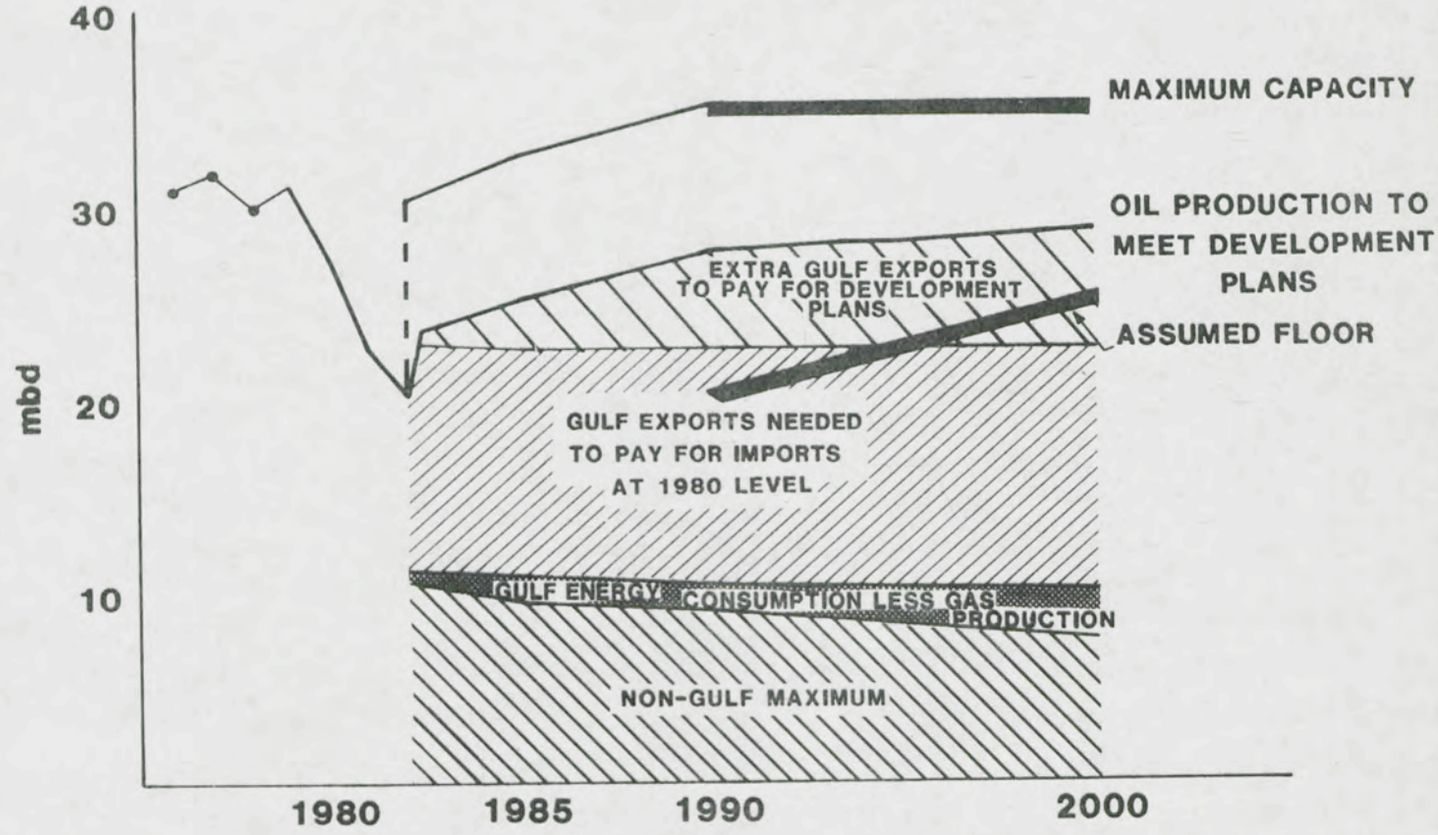
57. Comparing the demand levels with the range for their output indicates the possible extent of OPEC market power. Figure H shows a number of influences on this range. The bottom segment shows non-Gulf OPEC members, who are assumed to produce at the top of the range of their estimated capacity. The upper segments of the figure add on the more discretionary output levels of Gulf OPEC. The minimum realistic production level would arise if the Gulf countries were to hold total OPEC production level to 20 mbd (a similar level to 1982). Beyond 1990, we think that the Gulf States' own energy needs and development plans, even if severely cut back, would force the minimum OPEC output level up to about 25 mbd. Maximum production levels would only arise if OPEC members were to produce at maximum capacity (without regard to price objectives). There are, of course, a number of possibilities within these boundaries.

58. This analysis suggests that OPEC power to influence long run price developments depends on their willingness to continue holding output below capacity. Some OPEC members will be extremely reluctant to do this; their revenue requirements will make them unwilling to cut production. But, in support of OPEC price objectives, the richer Gulf members may be able to vary their output enough to give a production range for OPEC as a whole, which is illustrated in Figure H. This range is from 20 to 30/35 mbd in the 1980s and from 20/25 to 35 mbd in the 1990s. OPEC producing at 25 mbd rather than 35 mbd would increase prices over the period to 2000 by about $10, after taking into account other demand and supply reactions, bringing the price nearer to the levels implied by the long run supply of non-fossil fuels. In the short run, supply and demand elasticities are smaller, and so changes in OPEC output can exert more dramatic influences on the short term paths around these long term trends. However, since OPEC start off in 1982 in a phase of market weakness, we think that (in the absence of accidents) prices in the 1980s are unlikely to jump significantly above long term trends.

FIGURE H: INFLUENCES ON OPEC OUTPUT LEVELS



HIGH OPEC GROWTH/HIGH PRICE



LOW OPEC GROWTH/LOW PRICE

FIGURE I - ENERGY DEMANDS, SUPPLIES AND FEASIBLE PRICE RANGES IN 1990

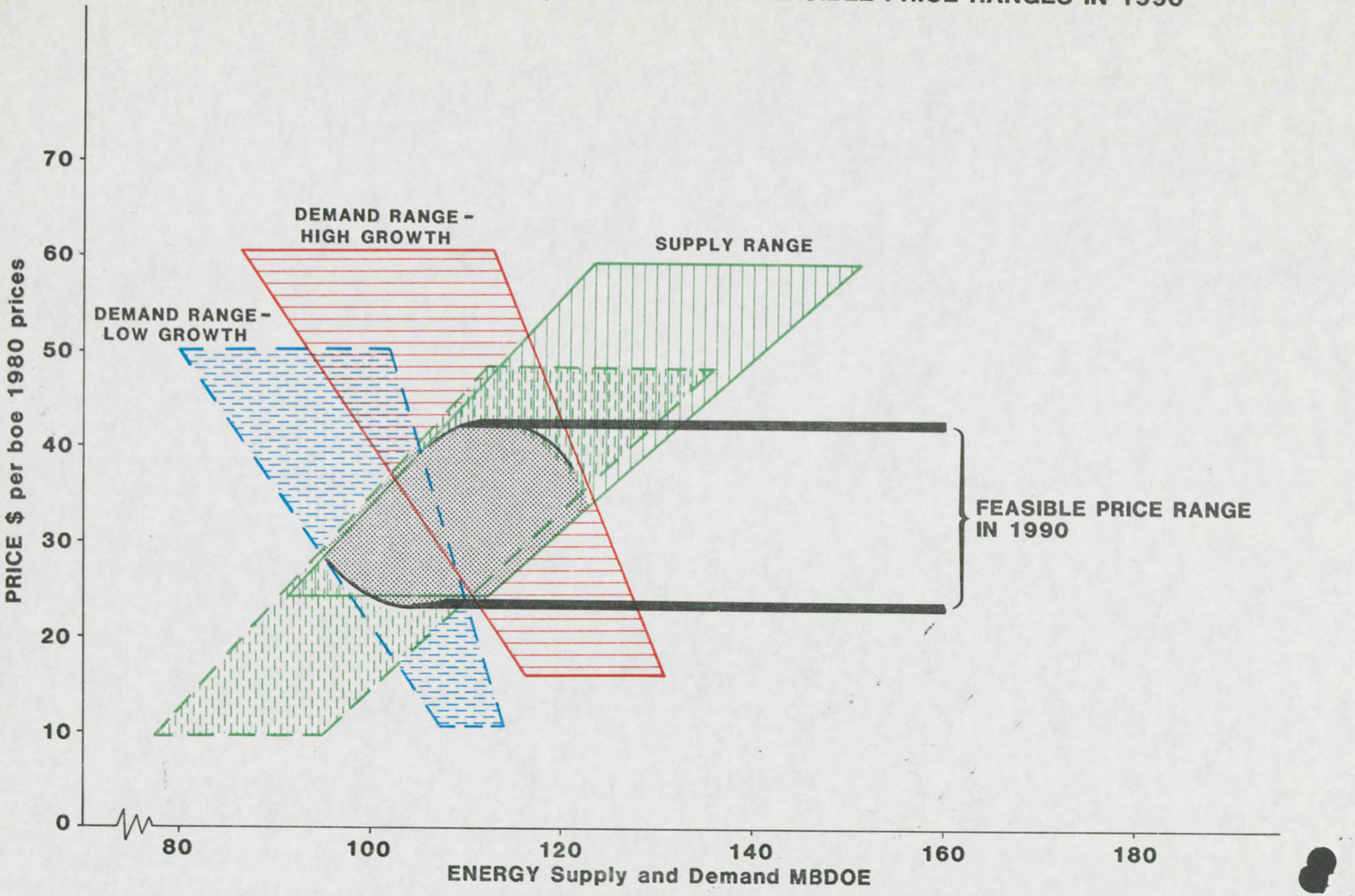
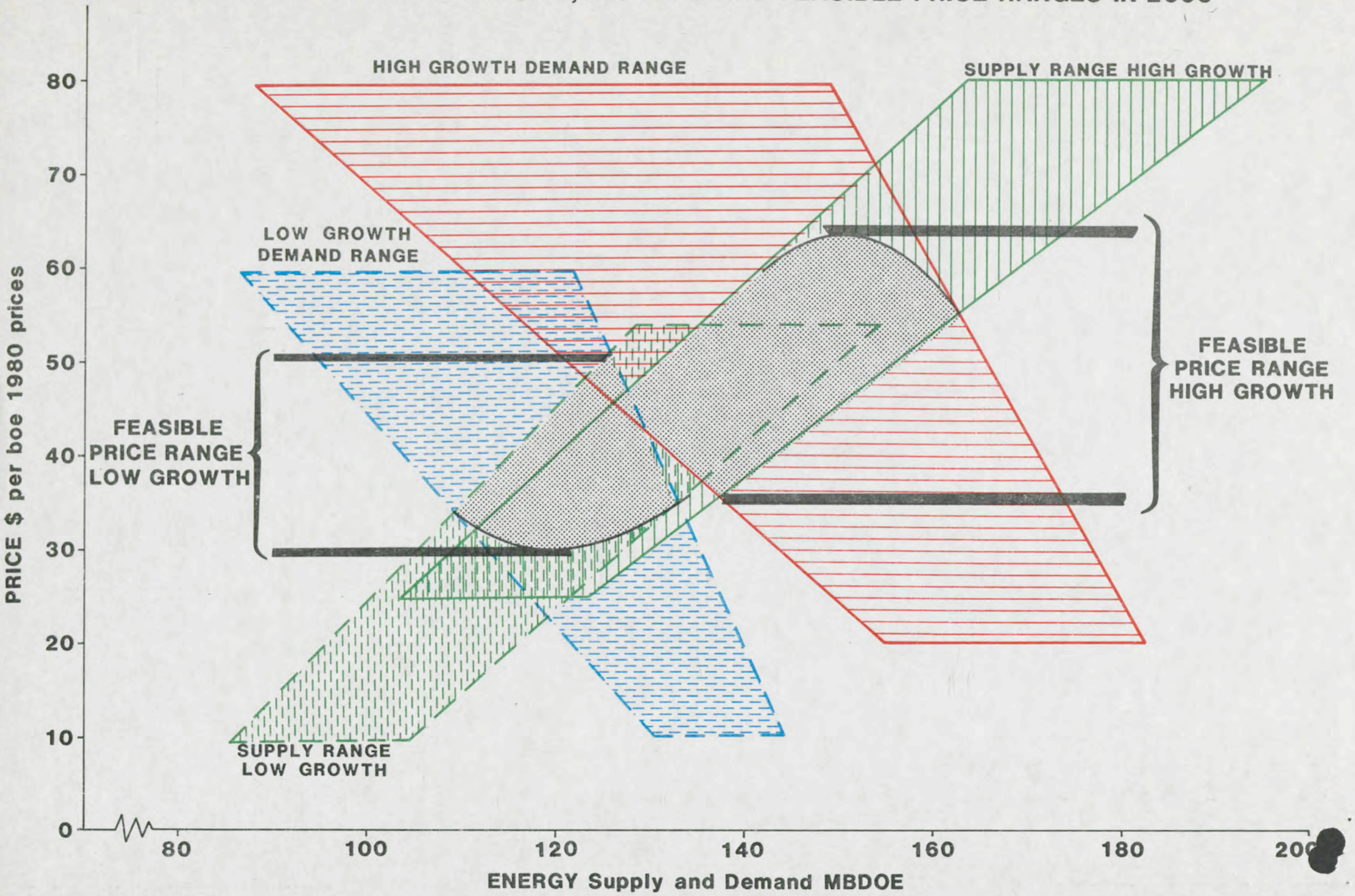


FIGURE J - ENERGY DEMANDS, SUPPLIES AND FEASIBLE PRICE RANGES IN 2000



World Energy Balances

59. Table 8 below shows ex ante energy balances which would arise on particular combinations of demand, supply and price. Demand and supplies must finally reach broad balance so that the real oil price would rise whenever there was excess demand and fall whenever there was excess supply. The table is derived from the energy demand projections in Table 5 and the supply projections in Table 6. An additional higher price assumption (rising to $60 by 2000) has been introduced in Table 8 to show how supplies and demand on the high growth/low conservation assumptions might be balanced.

TABLE 8 ENERGY BALANCES (SUPPLY MINUS DEMAND) ON DIFFERENT ASSUMPTIONS

Excess supply = +
Excess demand = -

mbdoe

Oil Price	OPEC output	Low growth		High growth	
		1990	2000	1990	2000
Low		+16 to -3	+4 to -26	+3 to -19	-25 to -66
High	35	+33 to +10	+45 to +1	+23 to -5	+24 to -34
Highest		+37 to +13	+61 to +13	+27 to -2	+40 to -22
Low		+1 to -18	-6 to -36	-12 to -34	-35 to -76
High	20-25	+18 to -5	+35 to -9	+8 to -20	+14 to -44
Highest		+22 to -2	+51 to +3	+12 to -13	+30 to -12

60. On the highest price case tested (a price rising to $60 by 2000), the net energy balances show an excess of supply over demand in all except the most extreme combination of high growth with low supplies, low conservation, and OPEC output restrictions. On the lowest price case tested (a price falling to $25 by 1985 then held constant to 2010) the net energy balances show excess of demand over supply on all except the most extreme combinations of low growth, high conservation, high energy supplies and maximum OPEC output levels. These results suggest that the price range indicated by the low price case and the highest price case is broad enough to encompass most of the likely developments.

61. Figures I and J take the analysis further, setting out the balances of Table 8 and also our estimates of supply and demand classifications (indicated by the slopes). Figure I shows for 1990 and Figure J for 2000 (in green) the relationships between oil price and energy supply on optimistic and pessimistic range ends, previously shown in

Figure G. The red areas show the relationships between the oil price and energy demand on the high and low conservation assumptions for the high growth case, while the blue areas show the same for low growth. The intersection of the demand and supply areas indicates combinations of demand, supplies and prices which are feasible. At prices below those at the bottom of the feasible zone, demand for energy would exceed supply so that the price would rise. Conversely, at prices above the top of the feasible zone, supply would exceed demand, so that the price would fall.

62. Within these zones is a range of prices at which demand and supply could be in equilibrium on some combinations of growth, conservation, and supply optimism. Some of these combinations may be less likely; for example, high growth is less likely to be combined with pessimistic assumptions on each of the energy supplies and with low conservation. Similarly low growth is less likely to be combined with optimistic energy supplies and high conservation. For these reasons, the upper edges of the high growth intersection and the lower edges of the low growth intersection are ringed off leaving a feasible zone of price/output combinations all of which must be treated equally seriously.

63. The upper and lower price bounds set by these feasible zones are shown in Figure K. The price bands in Figure K give the planning assumptions for oil prices to the year 2000, and beyond, recommended by this study. At the bottom end, we do not think that a price below $25 could be sustainable for more than a few years and even on low growth assumptions combined with optimistic energy supplies, high conservation and OPEC producing at maximum capacity, we would then expect the price to climb back to at least $30 by 2000. At the top end, even with high growth combined with pessismistic energy supplies, low conservation and a restrictive OPEC output, we do not think that a price above $65 would be sustainable for more than a few years, in the period to 2000. But we think that the full range of prices between these two price paths is <u>feasible</u> and that prudent investment appraisals and energy planning exercises should test their results against both ends of the price path ranges which we indicate.

64. In the short term, the conservation effects of the 1970s price shocks, the supply increases consequent on those shocks, competition for market-share within OPEC and low economic growth could together drive the price below these price bands. But this would be temporary as it would sharply improve oil's competitiveness with other fuels and thus increase the demand for oil. We think that such short run possibilities are best ignored for the purposes of long term planning assumptions.

FIGURE K[B] - OIL PRICE PLANNING ASSUMPTIONS TO 2000 AND BEYOND

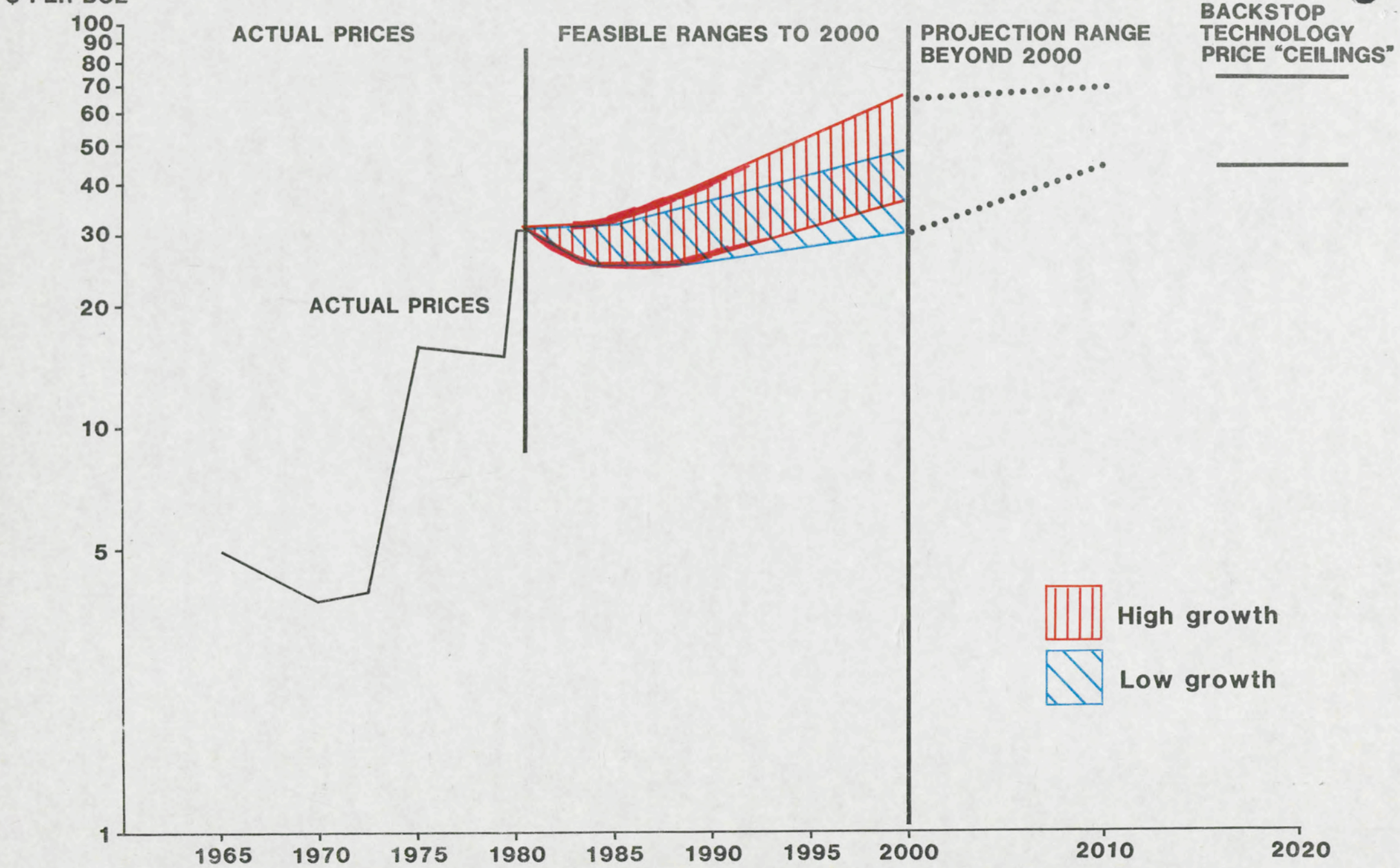
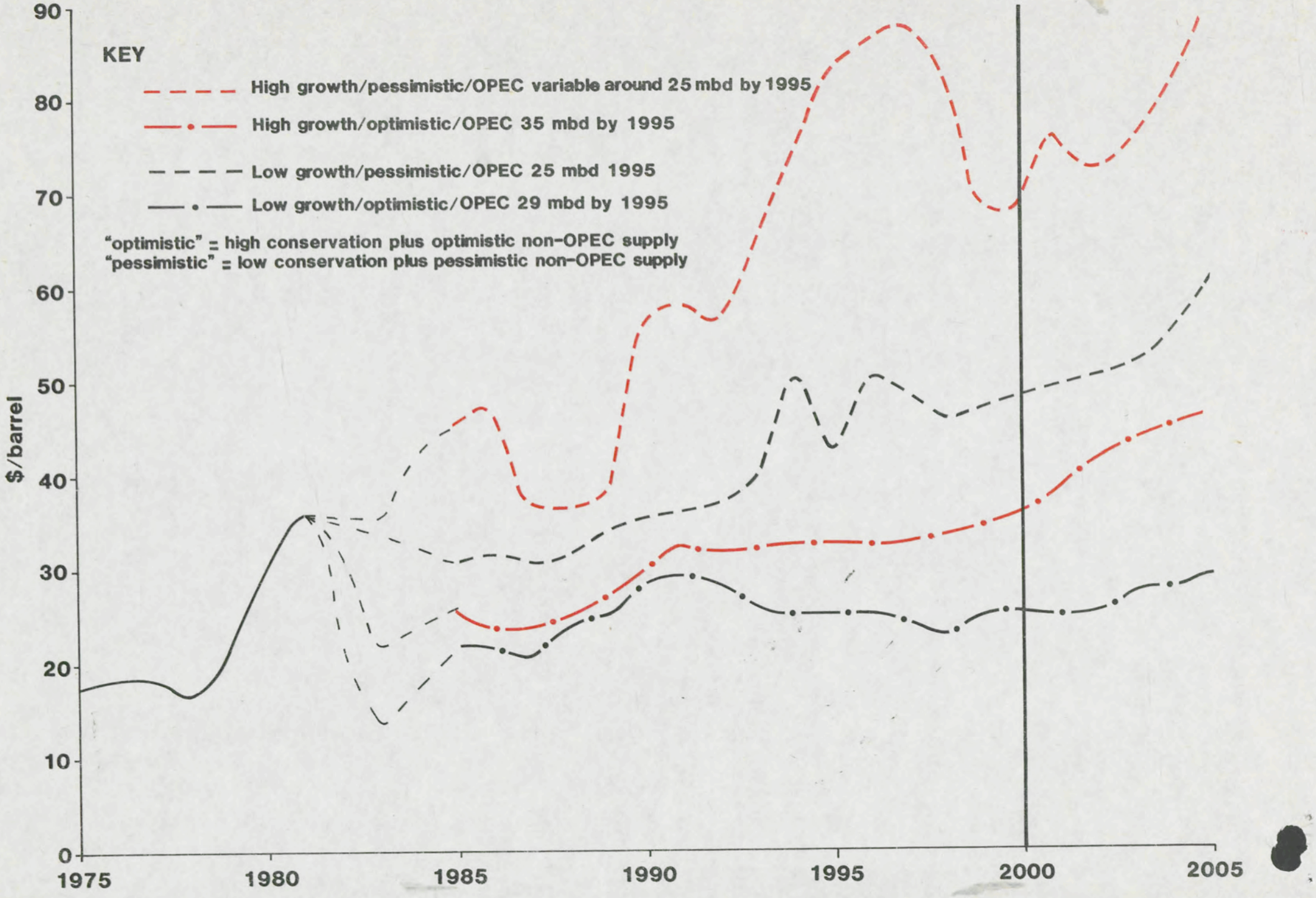


FIGURE L: DYNAMIC ESTIMATES OF INDIVIDUAL PRICE PATHS



A

Dynamic estimation of individual price paths

65. The general methods outlined above assume that energy prices adjust smoothly from their present levels so that both supply and demand respond progressively. In practice energy prices are likely to move more abruptly and the path taken by prices during the 1980's may significantly influence the path of prices through the 1990's. We examined some of these effects in an alternative computer based model, in which the assumed price is allowed to adjust more abruptly on a year by year basis to clear any projected market imbalances (ie if excess demand appears in the projections, the price for that year rises until the excess demand broadly disappears). Figure L shows, by way of example, some of the price tracks which follow from underlying assumptions about economic growth, the rate of conservation, the level of non-OPEC energy supplies and the level of OPEC output. The upper line is on the combination of high growth with low conservation and low supplies which we earlier judged to be possible, but outside the range which we regarded as being realistically likely. Similarly, the lower line is an extreme combination of low growth, high conservation and high supplies which we also believe to be less probable. Between the upper and lower lines is a wedge within which a wide range of detailed price paths are possible of which just two are shown for illustration. These are not to be detailed projections; they simply illustrate the methods. The wedge between the upper and lower boundaries broadly supports the range of price assumptions which are given in Figure K.

66. This method has also been used to test the expected reaction of the price to a sudden disruption of supplies. Projected supplies in each case were reduced by 5 mbd in 1987 and 1988; the model suggests that the oil price in 1987 and 1988 could rise by $15 in the low conservation cases and by about $5 in the high conservation cases. However, the price in all cases would rapidly fall back to the range and would indeed lie below the undisturbed price path for the following 8 to 10 years. Even in the absence of major shocks, the actual price path could well be marked by a series of over - and under-shootings, as consumers and producers incorrectly perceive the future course of prices, act mistakenly and then in later years seek to correct their mistakes.

Surprises

67. We have considered how far our price bands might be affected by surprise developments. We have distinguished between major surprises, which could have long term consequences for the oil price, and surprises of a temporary nature which should not affect the long term price trend. We think that the chances of long term surprises causing reductions in supply (eg permanent loss of oil production capacity, lack of international agreement on gas transmission) are about the same as those of long term increases in supply (eg new major finds of fossil fuels, technological breakthroughs).

There could also be surprises on the demand side (eg arising from growth rates above or below those we have assumed). However, by their very nature, these surprise developments are difficult to take into account; to attempt to do so would risk widening the price ranges to the point where they would be unhelpful for users.

Prices Beyond 2000

68. Looking ahead to the next century, energy prices will be increasingly influenced by the availability of capital-intensive and non-fossil supplies - eg nuclear, renewables and unconventional oil. For some technologies, the potential contribution to world energy supply is limited by the extent of reserves (eg shale oil) or suitable sites (eg geothermal and hydro). For other technologies, particularly nuclear, the rate of growth is limited by the high capital requirements compared with total world investment.

69. No single technology will be able to meet all likely growth rates of energy demand; increasingly expensive energy sources will have to be used for higher levels of demand. If growth continues at the lower end of the range assumed in this exercise, then sufficient alternative supplies should be available at a cost below $60 per barrel of oil equivalent (boe). If growth continues at the top of the range, energy sources with costs over $60 per boe may have to be used. In principle it should be possible to undertake sufficient investment to expand these alternative supplies more or less as rapidly as any likely growth in demand; so a price beyond $70 looks unlikely to be sustained. If these alternatives are available in significant quantities in the first half of the next century, further increases in the real price of energy will be no more than any increases in the costs of supplying them. For this reason, we think that real price increases are likely to be constrained in this period.

Other Studies

70. The Appendix reviews the results of other recent studies of long term oil price prospects. Many of these indicate a price range similar to that in our own Study. Some of those which indicate a rather higher range reflect earlier work which could not have taken account of more recent market developments.

VIII CONCLUSIONS

71. The longer term impact of the large energy price increases of the 1970s remains unclear. In particular, we are not yet able to disentangle the short term effects and those of the recession on energy demand from the more permanent changes. Uncertainty as to the future course of energy prices has in this way been increased.

We have attempted to cope with this uncertainty by identifying a feasible range beyond which prices are unlikely to go, except perhaps temporarily, in response, for example to sudden supply disruptions.

72. Over the period to 2000, we see WOCA energy supplies increasing by between ½% and 2½% a year. The range is generated partly by the pace of technological development and new fuel finds, and partly by energy prices. Energy demand at constant prices is likely to grow at between ½% and 3% a year, depending on the rate of economic growth and the pace of energy conservation. The market price of energy will inevitably adjust to align the growth of energy demand and that of supply. This process yields a feasible zone for the oil price in 2000 of some $30-65 in 1980 prices. This is made up of two price bands: one relevant to a world of high economic growth and one relevant to a world of low economic growth. Beyond 2000, new energy supply developments seem likely to place a constraint on further, lasting price increases. By about 2030, a price range of $45-75 in 1980 prices seems feasible.

[redacted]/4

REVIEW OF OTHER RECENT STUDIES

1. It may be helpful to consider our projections and recommendations alongside other long term projections of world energy demand, supply and prices. Table 9 summarises some recent projections. The developments that prompted our review of energy prospects have led others to reconsider their projections, and we are still awaiting updated information from some of the major institutions. This makes comparison between projections particularly sensitive to the timing of the studies on which they are based. Generally, most of the new projections have revised downwards their previous views about economic growth, energy demand and prices, as we have done. Several of the major oil companies have become noticeably more reticent about their views than they were formerly.

2. Most of the studies make a single assumption about the rate of world economic growth, the most frequent one being 3½ per cent a year. This is at the highest end of our own range of growth assumptions (2¼ to 3½%) which is marginally wider than that used by the US National Energy Policy Plan.

3. Energy Demand in 2000 is projected by most of the studies as lying in the range 140 to 160 mbd. Our own high growth projections, which are most closely comparable, range from about 130 mbd in our high conservation case to about 160 mbd in our low conservation case. This indicates that we have moved slightly further than other studies in attributing larger effects on energy demand for conservation, though the others may well follow. Our low growth cases include a significantly lower energy demand range of 110 to 130 mbd.

4. Oil supply in 2000 is projected by most of the forecasters to lie in the range 50 to 65 mbd. OPEC output is projected in a fairly narrow range of 25-28 mbd, markedly below present installed capacity of 35 mbd. Our projections of oil supply include synthetic oils, and the top end of our range includes the possibility of OPEC producing in line with a sustained maximum capacity (although the latter possibility is not important in determining the feasible price range).

5. Supply projections for other fuels are also shown in Table 9. Detailed comparisons are not possible because in some studies, including ours, energy supplies are shown on initial working assumptions about price whilst in others they are shown on the basis of final price projections. Our two initial working assumptions lie below the price range which we finally recommend, and calculations on the basis of these price recommendations raise energy supplies as a whole by about 15% (though individual fuels are affected to different extents). For this reason our ex post

projections are broadly similar to the ranges projected by most of the other forecasting institutions, though the International Energy Agency seems to forecast rather more coal, gas and nuclear at their own assumptions for energy prices.

Oil Price Projections

6. The three oil companies which have been prepared to publish up to date projections foresee prices in the range $30 to $55 per barrel in 1980 prices. This broadly covers the lower 2/3 of the price range which we recommend, but it is marginally lower than the $35 to $65 range which we recommend on our high growth assumptions. The Chase Manhattan Bank see a range of $30 to $76, though they focus rather more on their central estimate of $53. The Institute of Energy Economics (Japan) assume similar economic growth ranges to our study and give a range of price projections of $40 to $60. This is similar to though narrower than the range which we recommend.

7. Mr Taher of Saudi Arabia's Petromin points to a somewhat higher price trend, though beyond 1990 that trend is stated to be more uncertain and more dependent on the degree of cooperation or confrontation between producers and consumers. Similarly, the Energy Modelling Forum (a collection of academic forecasts) project a price range of $40 to $90 a barrel. This was obtained by running a constant set of economic assumptions through 9 econometric models of world energy (though most of these models were developed and their relationships chosen two or three years ago). The International Energy Agency (in their recent World Energy Outlook) do not produce price projections but give energy demand and supply projections on the basis of initial working assumptions for price. By 2000, these price assumptions are clearly in disequilibrium, with an excess energy demand of 9-21 mbd. The US Department of Energy use methods which are the most similar to the mixture of econometric estimates, judgements and supply assumptions which we use. Their latest projections (August 1982) for the oil price indicate a range for 2000 of about $40 to $65 on a price-basis comparable to that used in our own Study.

TABLE 9: PROJECTIONS OF WORLD ENERGY IN 2000

PROJECTIONS	Date of Publication	Real Oil Price in 2000 ($ bl)	WOCA Primary Energy Demand (MBDOE)	WOCA Economic Growth Rate (1980-2000 % pa)	OIL PRODUCTION WOCA MBD	OIL PRODUCTION OPEC MBD	WOCA Coal Production MBDOE	WOCA Gas Production MBDOE	WOCA Nuclear Output MBDOE
THIS STUDY	Oct '82	30-65	110-164	2.3-3.6	44-70*	25-35	26-35*	13-26*	6-15*
CHASE MANHATTAN BANK	Sept '81	53 (30-76)	149	3.4	50	24(?)	38	26	13
CHEVRON	June '82	30-55	143	3.5	52	26	37	24	12
CONOCO	Jan '82	45-55	152	3.4	60	28	39	27	14
ENERGY MODELLING FORUM	Feb '82	70 (42-90)	152-161	3.6	49.65	28-34			
INSTITUTE OF ENERGY ECONOMICS, JAPAN	May '82	50 (42-60)	140-155	2.5-3.0	51-62	23-30	37	27	16
INTERNATIONAL ENERGY AGENCY**	Oct '82	28-45**	154-179	3.1-3.7	48-55	24-28	37-45	26-28	***
A H TAHER, PETROMIN	Early '82	[55-98]ø	140	3.1	41	21	47	27	18
TEXACO	July '81	40 (37-45)	150	'below historic trend'	60	34	38	27	13
US NATIONAL ENERGY POLICY PLAN	July '81	58 (41-79)	140	3 (2.4-3.4)	48 (42-54)	26 (21-43)	37 (28-43)	29 (23-36)	16 (10-17)
"	Aug '82	52 (44-61)	137 (132-143)	3 (2.6-3.5)	50 (48-54)	26 (23-29)	34	23	11

* These are estimated supplies on starting price assumptions. In the recommended price range supplies are higher

** The IEA projection is <u>not</u> a forecast. With an energy deficit of 9-12 mbdoe active policy intervention is required to offset further price rises.

*** The IEA project OECD Nuclear capacity at 12-13 mbdoe. Our OECD projection is 7-11 mbdoe.

ø An extrapolation of his 3 to 6% pa range to 1990. Hazarding a guess beyond 1990 is unreasonable given the uncertainty. Prices are lower in a scenario of producer-consumer co-operation but higher in a confrontation scenario.

REFERENCES:

Chase Manhattan Bank - 'The World Energy Outlook through 2000: A Time of Transition'. Chase Manhattan Bank, N.A. October 1981.

Standard Oil Company of California ('Chevron') - 'World Energy Outlook'. Economics Department, June 1982, San Francisco.

Conoco Inc - 'World Energy Outlook through 2000'. January 1982, Stamford, California.

Energy Modelling Forum - 'World Oil, Summary Report'. EMF Report 6, February 1982, Stamford University.

Takao Tomitate and Toshiaki Yuasa - 'Dynamics of Supply-Demand, Prices and Coversion in the World Energy Market: Recent Trends and a Long Term Outlook for the period up to 2000'. Energy in Japan, Bimonthly Report No. 57, May 1982, Institute of Energy Economics, Tokyo.

International Energy Agency - 'World Energy Outlook'. Paris (OECD) 1982.

Texaco Inc. - 'Free World Energy Outlook'. Finance and Economics Department, Economics Department, Economics Division, July 1981.

A H Taher - 'Energy - A Global Outlook - The case for Effective International Cooperation'. Pergammon Press, Oxford, 1982.

US Department of Energy - 'Energy Projections to the year 2000. A Supplement to the National Energy Policy Plan'. Washington July 1981 DOE/PE-0029.