FORETELLING THE ENERGY FUTURE

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Introduction

Half a decade has passed since the world economic system suffered the shock of a massive increase in oil prices. In the intervening years there have been many conflicting forecasts of future energy developments, ranging from "no problem" to alarmist warnings of another, even greater, shock to come - a second energy crunch. The latter variety have tended to predominate. The multiplicity of forecasts would be confusing enough and undoubtedly contribute to indecision and lack of action by the policy makers, but the picture is still further obscured by the current situation. At the time of writing (November 1978), oil consumption is only just back where it was five years ago, energy supply is in potential surplus and the sense of urgency seems to be gone. What is the truth? Is the second energy crunch, so widely predicted, real or not? If it is, how can the confusing messages be rationalized so that the actions necessary to ameliorate it can be set in motion?

A Methodology for Coping with Uncertainty

"Those who foretell the future lie, even if they tell the truth" Arab Proverb

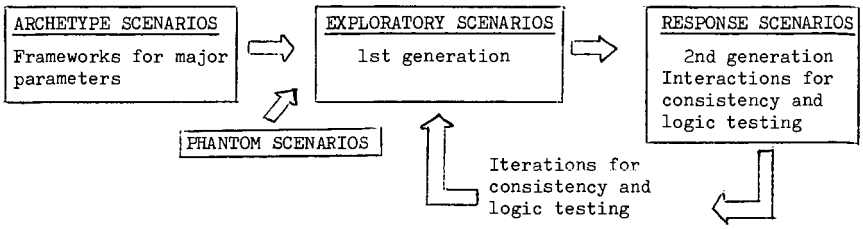
This quote is appropriate at the beginning of a discussion on the future of world energy supply and demand in view of the important role which the Middle East has had, and will continue to have, in shaping the future world energy scene. This particular proverb also makes another very important point - the future cannot be predicted. In fact there are many possible futures dependent on how events and decisions yet to be taken are linked and interact. Assertions about the future in general and about energy developments in particular may or, more likely, may not, turn out to be accurate but if we are to avoid confusion, indecision and too many mistakes, we need a methodology to cope with the uncertainties.

A scenario is logically coherent, future state of the world. It is not what will happen but what can happen - a subtle but important distinction. We can distinguish, and will be referring to, three distinct types of scenario - the archetype, the phantom and the exploratory scenario (see Box 1). Archetype scenarios form a starting point; they provide alternative views of the world or of specific issues in rather stark terms, i.e. the future economic framework, oil price developments etc. Phantom scenarios are similar, but they consider issues which have a low probability of occurring but a major impact on the future if they do occur. Exploratory scenarios are rather different; they combine the variables that emerge as important from the essential analyses of the archetype and phantom scenarios to develop routes or pathways into the future. This involves making assumptions about how the world will react to a given set of conditions, so exploratory scenarios tend to evolve into second generation response scenarios.

The scenarios have several functions. Their construction is a learning process which helps us to understand the past and the present and to structure in a rational way the uncertainties of the future. As a possible instrument of change, they have an important role in strategic planning. By identifying the features common to all scenarios - the pre-determined elements - we provide a hardcore of information, some solid facts on which we can base our plans.

The scenarios also provide a rational framework for discussion with outside organisations such as governments, academic institutions etc. We can thus share our view of the world in an unemotional and professional way. This is particularly important in the international energy sphere, where as we have mentioned, the dialogue has become confused because of the concentration on conflicting single-line forecasts.

SCENARIO DEVELOPMENT — BOX 1



ARCHETYPE SCENARIOS - A pure or prototype scenario describing important scenario aspects in stark, rather black and white terms. A useful analogy comes from psychology where the personality archetypes "introvert" and "extrovert" describe very few actual human beings. However, most of us have elements of both types in our make-up, so an understanding of the two archetype personalities is helpful in analysing and hence understanding individual personalities. In the same way, the construction and analysis of archetype scenarios is helpful in understanding and preparing for the future, even though that future is most unlikely to correspond to a single archetype.

PHANTOM SCENARIOS - These are Devil's Advocate type of scenarios. They have a low probability of occurring but the impact on the future if they do come about is very high indeed. Their ultimate aim is to reinforce the resilience of strategic planning.

EXPLORATORY SCENARIOS - Exploratory scenarios combine the variables that emerge as important from the analysis of Archetype and Phantom scenarios to develop routes or pathways into the future. This involves making assumptions about how the world will react to a given set of conditions, so exploratory scenarios tend to evolve into second generation response scenarios.

Archetype Scenarios for Energy Planning

Energy is fundamental to virtually everything we do. We need it to build and then heat or cool and illuminate our houses, grow our food, power our transport systems and to make all those countless things which we now consider essential to our way of life. Insofar as these all-embracing factors can be described in economic terms, archetype scenarios can be expressed in macro-economic indicators such as GNP growth rates, but this is only the starting point. Energy supply and availability depends on political factors, international trade, the future climate for investment etc. Demand is governed, not only by economics, but also by society's changing attitudes which will be reflected in changing life styles.

Two archetype scenarios are described below (see Box 2), The World of Internal Contradictions (WIC) and Business Expands (BE). Growth, in the sense of increasing added value from man's activity, can be seen as a natural phenomenon in human society. The WIC and BE scenarios differ in the extent to which the barriers to growth are removed or institutionalised. Both scenarios are catastrophe-free i.e. no world wars, and assume that the balance of power between East and West is not seriously disrupted.

A WORLD OF INTERNAL CONTRADICTIONS	BUSINESS EXPANDS — BOX 2
- A world which fails to liberate the forces making for growth	- Barriers to growth removed
- Systems proliferate and decay, alienation is widespread	- Systems performance improved, alienation mitigated
- Greater government intervention in the market economy	- Reached by reaction against low growth
	The Condition
- Diversion of resources to non-marketed sectors. Low commitment of risk capital	- Effective political leadership
- Low growth of international trade (protectionism)	- Governments understand and foster the process of wealth creation
- Strong move towards further egalitarianism	- Strong links into the international trade system
- GDP growth 2.6 - 3.0%	- GDP growth 4 - 4.5%

We can get some idea of how demand for energy might develop by quantifying the archetype scenarios. One way of doing this would be simply to look how demand has increased with economic growth in the past and to project this, or a subjectively modified relationship, into the future. Such type of analyses quickly indicates that demand for energy, and for oil in particular, will grow to exceed available supply - to result in a gap or the next crunch - any time from the early 80's onwards, depending on the economic growth rates chosen. But such an analysis is far too simplistic. The historic relationship between energy and economic growth was established over a long period of abundant, low-priced oil. The oil price hike in 1973/74 was enough to begin to change our way of using energy, our attitudes towards conservation, self-sufficiency etc. and changes in oil price in the future remain a key element in influencing future demand. Hence it became clear that the price-dimension had to be introduced in the energy quantification work as a critical separate variable.

The price of a commodity is normally determined by the supply/demand interplay, i.e. provided supply is free to increase in pace with demand. If there is interference with the free supply/demand play, as there has been in the case of oil, then the price could be driven up to the eventual cost of alternative fuels. In theory, this upper level should provide a new norm for oil prices, but, in practice, because of the long lead times necessary to change the pattern of energy supply, the point at which some consumers, or more particularly consuming countries, will find it difficult to pay may well be reached earlier. Considering the economic disruption that has already been caused by the price rises of 1973/74, it would seem that we are already close to some consumers' ability to pay at current prices. At this stage, economics have been completely overtaken by political forces and there is no economic theory that will tell you what the oil price is going to be. It is a question of "realpolitik".

There are forces pushing the price in both directions and, as a lever to extract insight, we can develop these into two oil price scenarios. Upward pressure leading to Escalating Prices in real terms stems, inter alia, from the influences of those producing countries which have, or face, balance of payments difficulties. Particularly those with limited oil reserve to production ratios will argue most strongly that the price should escalate in real terms to reach the cost of alternative means of obtaining oil or gas (e.g. derived by synthesizing coal) at a not too distant point in the future, say 1990. Higher oil, and hence energy, prices will also render the exploitation of the gas reserves, which most of these producers possess, much more attractive - such projects almost invariably

require expensive liquefaction, conversion or pipeline projects to deliver the gas to distant consumers. Then there is the perception that most OECD countries are in a better position to pay for oil; there is a general belief that U.S. imports will continue to increase and of course there can always be further accidents in the Middle Eastern political situation. These and other factors would tend to push the oil price up in real terms, i.e. by considerably more than the rate of global inflation.

The major forces pushing in the direction of Price Moderation include the concern, particularly expressed by the key producing country, Saudi Arabia, with the economic stability of the West. Other factors such as major new oil discoveries or a belated success for President Carter's energy policy in the USA may also have a part to play. There has been considerable restraint on the part of the producers since 1974 so that it would appear that, at present, we are in a "symbiosis" scenario which could keep prices roughly at today's level - although inflation corrections could either over or under compensate from time to time. Whether this price moderation scenario will prevail is far from certain and depends interalia on future geopolitical developments. Our purpose for developing these contrasting, essentially politically based, archetype price scenarios was as a tool to increase the understanding of the interaction with the other scenario parameters (described above) in the energy supply and demand field.

Exploratory Scenarios for Energy - combining the important variables from the archetype scenarios.

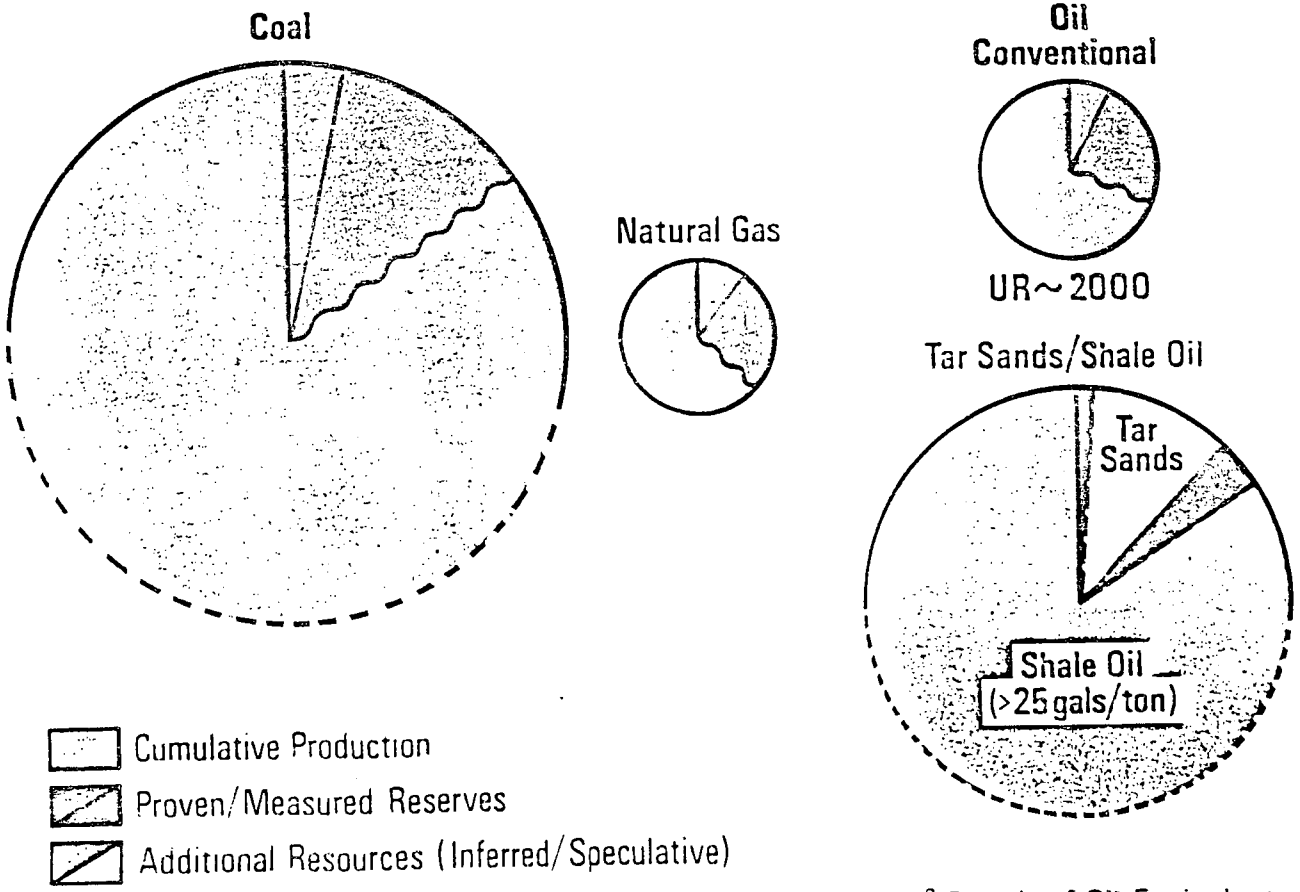
It is clear that the relationship between economic growth and the amount of energy needed to fuel that growth can change in the future, but to get an idea of by how much and in what ways it may change we need to take a detailed look at the markets - the end uses for energy. Similarly, one can use the price scenarios to test for the price sensitivity of demand, but price elasticity is an unreliable concept and we have not found any really worthwhile study that we could use with confidence. No short cut, using for example ex-ante assumptions about changing income and price elasticity of demand for energy, appeared satisfactory. Thus we were driven to the conclusion that a detailed market breakdown coupled with subjective judgement on how each will be affected by higher prices was needed. We had to assess how consumers will react to prices under the different economic scenarios and, more importantly, how governments will react. This is because the private consumer (micro) reaction is often insufficient in view of the national (macro) problem created in balance of payments terms as a result of an oil price increase. For example, an increase of one dollar in the price of a barrel of crude oil can be very serious in balance of payments terms, yet the price of gasoline at the pump, if the crude price increase were spread evenly over the products, would not go up by more than about two cents a gallon.

One way in which governments have already reacted to the earlier price hikes is in the encouragement of energy conservation. Again, the individual consumer is unlikely to use the same criteria for deciding whether or not to implement energy-saving methods. A detailed market breakdown approach turned out to be the only way to manage the assessment of just how much conservation and substitution may be achieved.

Fossil fuel resources, as shown in Figure 1 which looks a bit like planets in the solar system, appear more than adequate but, to come down to earth again, there are economic, societal and geopolitical problems to be overcome if shortages are to be avoided. The warnings of a world rapidly running out of oil are well known and we shall return to these below, but each of the "big three" fossil fuel alternatives also has its problems. There is a great deal of gas around, but most of it is in the wrong place - a long way from the market. Similarly, there is plenty of coal but general aversion to dig it out and reluctance to burn it. The importance of the potential role of tar sand and more particularly, shale oil, in the international energy context has been exaggerated.

World Fossil Fuel Resources

(Estimated Ultimate Recoverable Resources)



UR=Ultimate Economic Recovery in 10^9 Barrels of Oil Equivalent

n.b. The size of the circles should be taken as indicative only of the order of magnitude of hydrocarbon resources. With the exception of conventional oil, insufficient exploration has been carried out to define the size of the resources base accurately and the technologies for exploiting the reserves are not yet fully developed.

If one looks outside the carbon-based, fossil fuels spectrum nuclear energy is, of course, very important, but generally most unpopular. This is an area where a phantom scenario can be useful. We developed a scenario called Nuclear Disappointment in 1975 to analyse the effects of a major slowdown of such magnitude that at the time it was considered highly unlikely, but would, of course, have a major impact on the world energy situation. Such slowdown in the rate of introduction of nuclear power would have resulted from the lack of consensus over the complex set of technical, economic and socio/political issues surrounding it.

Solar energy and its derivatives, wind, waves, biomass, etc. are superficially attractive because of their abundance, renewable nature and familiarity. The problems arise from their intermittent, diffuse and sometimes unpredictable characteristics. It is too early to say which of the many alternatives will ultimately prove successful and become significant but all are likely to make some contribution depending on local conditions.

At the 1977 World Energy Conference, a Delphi exercise put the ultimately recoverable world crude oil resource base at about 2×10^{12} barrels. About three-quarters of this total is thought to be outside Communist areas (WOCA) and if this was developed at the fastest technically feasible rate, production would peak in the 90's and then start to decline (Figure 2). We also know that the oil-producing countries have many other considerations and they will undoubtedly choose to develop their resources at a slower rate. Analysis of the production profiles for individual countries suggests that the maximum acceptable level of production will be considerably lower than the technical ceiling resulting in a flatter profile of what we call "The Oil Mountain". Nevertheless, there is still significant growth ahead, so that liquid fuels, even from conventional sources, will be with us for many decades to come. The real point, and the reason for the debate about the next energy crunch, is that the demand for oil is likely to be constrained by available supply within the next 20 years, as we shall discuss below.

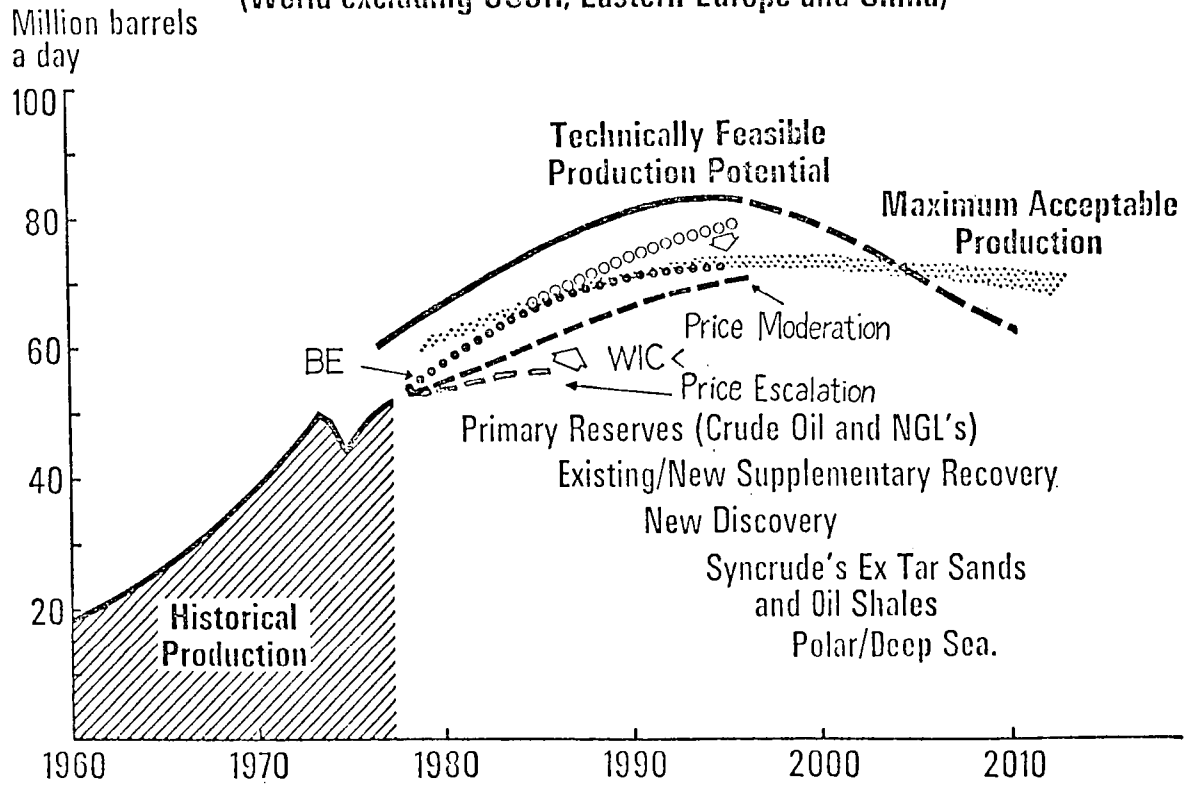
There are critics of the oil industry who think this picture is overly pessimistic and that there may be far more oil to be found than has been assumed. It is certainly true that there are vast reserves of low-grade oil in the form of tar-sands, oil shale etc. (Figure 1) which are only now beginning to be developed and there will undoubtedly be further discoveries of conventional oil as well as improvements in recovery techniques from known reserves. The profile in Figure 2 requires approximately half the oil produced in the year 2000 to come from such "new" sources. This assumes that the huge capital needed can be made available and that the associated technical and environmental problems can be solved. However, the North Sea oil fields have taken over 10 years to bring to present levels and the next oil province might be in even more hostile territories requiring longer to develop. So even if there is a lot more oil, it is not going to change the early part of the production profile very much, but could extend the plateau in Figure 2. The resource base (including unconventional oil) may be adequate but money, technical skills and time may not be.

The Next Oil Crisis - A Mirage?

When we compare the oil demand figures obtained by quantifying the exploratory scenarios with the resource base (Figure 2) some interesting response situations are revealed. For example, we can put a low probability on rapidly escalating oil prices in a low growth world (WIC) because we found that the resulting reduction in oil offtake was such that it would not seem to be in OPEC's interest to follow this route. On the other hand, a low growth world coupled with prices which are approximately constant or rising only slowly in real terms - price moderation - appears at first sight to be a perfectly tenable one. Oil constraints could, in theory, be avoided for the rest of this century, even though the threat of impending crisis might stay with us. This mirage effect, i.e. a crisis which stays on the horizon but recedes as it is approached, could result if low economic growth allows time for some efficiency improvements to be made and for alternatives and new oil to be brought on stream. As an illustration of the physical

The Oil Era—A Perspective

(World excluding USSR, Eastern Europe and China)



effort required by the year 2000, even in this low growth scenario, it is interesting to note that one is talking about some additional:

- 700 Nuclear Power Stations
- 650 Coal Mines
- 60 Liquefied Natural Gas Projects or similar developments
- 7 Oil fields of Nigeria's size plus a roughly equivalent amount of new supplementary recovery from existing reserves.
- 17% Energy conservation relative to 1973 consumption per unit of economic activity

Naturally the above is of an illustrative nature only but it is important to realise that lead times are long (ranging from say 5 to 12 years) and that a considerable effort in related infrastructure will also be required (coal terminals, unit trains, coal burning equipment in power stations, to mention but a few). Figure 3 illustrates what would happen if no action were taken in the field of non-oil energy and the savings assumed in the WIC scenario. Whilst it is physically possible to develop new energy supplies and to achieve the efficiency improvements a prolonged period of low growth would not be the best environment from which the necessary investment decisions could be taken and might give us other, perhaps more serious, difficulties to cope with.

The Energy Outlook - Some Conclusions.

The quantification of the exploratory scenarios was carried out by a detailed end-use analysis of the various energy-using sectors. The analysis has shown that, under all scenarios, future demand for energy is likely to grow more slowly than in the past. A retrospective breakdown of the results shows that there are three major reasons for this: lower economic growth, structural changes and saturation effects in the developed countries and improvements in end-use efficiency. The relative importance of these factors is illustrated with the total energy projections in Figure 4.

Whilst the energy intensive primary and secondary sectors of the industralised countries move towards saturation, relatively faster growth in demand can be expected from the developing countries. Since these countries are not yet so tightly locked into an oil-consuming demand pattern, greater opportunities might exist here for exploiting alternative energy sources, particularly biomass, although it is unreasonable to suggest that they will not require large volumes of liquid fuels, particularly for transport and other preferred uses for energy liquids.

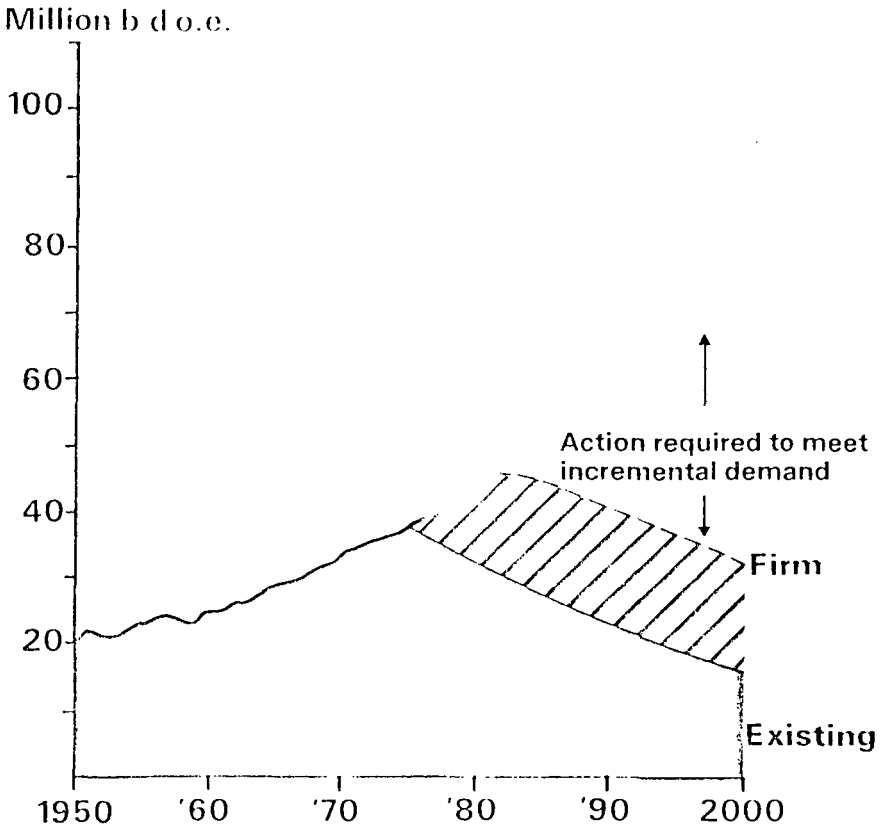
In summary, to return to the question posed in the introduction, as we see it the next energy crunch is either going to be a mirage or it might show itself as a series of mini crises. The future remains uncertain, the outcome remains scenario dependent, but then, as we said, scenarios carry the seeds of their own discontinuity and are therefore likely to pull towards each other. It is a near certainty that a rapid take-off in demand is likely to be followed by a rapid increase in the price of oil which in turn would slow down the world economy and means that the world is in an economic trap - it could be called the "new economic reality".

Thus the mirage represents a relatively smooth energy flight under a rather dull and gloomy (economic) sky. The mini crises seem like more of a bumpy ride, i.e. periods of sunshine (economic growth) followed by thunderstorms (oil price increases in real terms). Naturally, a political upset in the Middle East could disturb the delicately balanced oil supply and demand equation at any time. A sudden drop in the supply ceiling as a result of such a geopolitical scenario is hard to plan for but the emergency sharing scheme of the International Energy Agency has been designed to cope with such a contingency. Figure 5 is an attempt to illustrate these scenario conclusions.

To end with Aristotle again, which seems apposite, "knowledge springs from amazement, and amazement comes from an appreciation of contradictions".

FIGURE 3

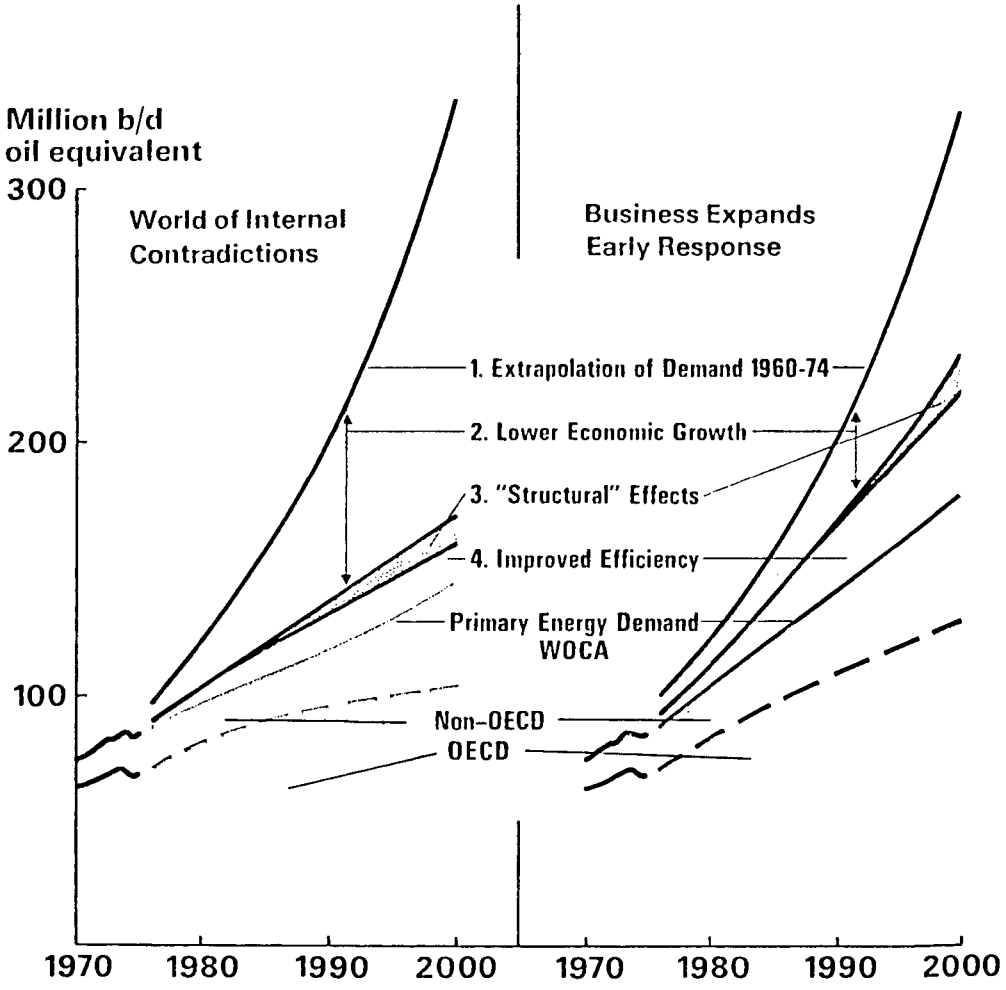
NON–OIL ENERGY PRODUCTION REQUIRED IN WOCA UNDER WIC CONDITIONS (Under BE approximately 66% higher)



n.b. The rate of decline of existing and new firm productive capacity has been calculated on the basis of historic depletion rates of coal and gas resources

FIGURE 4

WOCA PRIMARY ENERGY DEMAND



THE NEXT OIL CRISIS

OIL SUPPLY
OIL DEMAND

MIRAGE

As a result of low economic growth, reaction and pre-emptive action to avoid impending crises, oil supply ceiling remains above demand.

MINI CRISES

Demand hits the oil supply ceiling accompanied by price rise, fall in demand and subsequent repeat of cycle. Crisis made more critical by miscalculation of height of ceiling.

There is also the possibility that the supply ceiling may fall most likely as a result of a political accident.

FIGURE 5