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LONG-TERM SCENARIOS FOR GAS SUPPLY POTENTIAL IN WESTERN ASIA*

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ABSTRACT

Development of gas resources in western Asia is examined here from the supply point of view. The resources of western Asia are reviewed, including the unproven conventional gas resources. The natural gas resources in this region are so large that no constraint to exports is expected, probably up to the year 2030.

Two scenarios are presented: a favourable "Golden Opportunity" and an unfavourable "Unfulfilled Promise". In both cases, gas development is likely to grow, albeit at different paces. In essence, the scenarios are constrained by market opportunities. One of the emerging markets of particular importance to western Asia appears to be the Indian sub-continent, despite rapid development of the local gas resources there. One of the major unknowns is the further development of Russia as a major competitor in the western European market.

INTRODUCTION

The share of gas in the total spectrum of primary energy supply has grown steadily over the last few decades. It is likely that gas will eventually surpass oil as a primary energy carrier on a global scale. Despite the fact that gas was used industrially in as early as medieval times by the Chinese and others, it is a relative newcomer to the energy scene with regard to market share.

The advent of liquid petroleum had its historical roots in the use of oil for lamps and in the invention of oil-fired stoves and the motorcar. Among many alternatives, oil and its liquid derivatives have the greatest energy density of fuels. Gas, on the other hand, has a very low energy density; very roughly speaking, 1,000 m^3 of gas is equivalent to 1 m^3 of oil in terms of energy, making its competion in the transport market difficult. Gas is also expensive to transport, requiring liquefaction for its conveyance to distant markets and a well-developed network of pipelines in order to allow its wide usage.

Energy prices, uncertainty about oil supplies and technology -- and lately, environmental concerns about the use of oil and coal -- have given considerable impetus to further development of the world gas markets. It is likely that this trend will continue, so any analysis of the scope of gas development in western Asia has to be set in this global context.

Because gas deposits are very often associated with oil, the use of natural gas is constrained to some extent by oil development needs; the amount of associated gas produced is thus largely determined by the amount of oil production. This involves flaring, where gas cannot be easily utilized, a wasteful practice that will continue to decline. Another option is re-injection, where ultimate recovery of oil can be improved -- a process that will continue to grow in importance, even in the oil-rich Middle East. Analysis of gas developments can therefore not be entirely separated from the outlook for oil production.

The other important consideration is the gas resource base, which consists of the remaining proven reserves in the existing fields and the as yet undiscovered future potential resources that will be identified by further exploration. A third category might also be added: "unconventional" gas may exist in western Asia and might be of importance in the future.

As development of gas resources assumes customer availability, the outlook for supply has to be seen in the light of existing and emerging markets. Some of these regional markets -- Europe and the Indian sub-continent -- are of prime importance to the western Asia region, while the more distant markets may also contribute to demand, especially in the long term.

An overview of the complex subject of regional gas development may be conveniently presented in the form of supply modelling for the region as a whole, taking the economic, political, internal and external market constraints into account.

The result is only a general view, limited by the scarcity of reliable data on reserves and by the lack of information related to various development projects. However, the views expressed may stimulate thought about the many opportunities for western Asia to become a major player in the international gas markets. These opportunities can only be taken advantage of if timely and aggressive efforts are made, as developments of gas supplies in Africa and Russia may give rise to increased competition in the existing and emerging markets.

I. THE GAS RESOURCE BASE IN THE ESCWA COUNTRIES

The total of a recoverable resource comprises the sum of what has already been produced, the remaining reserves and that which is as yet undiscovered. For gas it would be most useful to distinguish between associated and non-associated gas; in western Asia, several countries have published figures reflecting such a distinction. In Qatar, the Syrian Arab Republic, Egypt, Oman, the United Arab Emirates, Iraq, and Saudi Arabia, the non-associated gas is reported to be around 99 per cent, 94 per cent, 82 per cent, 78 per cent, 76 per cent, 48 per cent, and 31 per cent, respectively.

The data related to gas totals are sometimes contradictory, however. Usually the most reliable data are those on cumulative production, then those on reserves, with the least reliable being the estimates of undiscovered gas resources which may be identified by future exploration. The latter is best reported in the form of a probability distribution, as a single estimate rarely has any credibility. One important source is the United States Geological Survey.

The basis for assessing undiscovered resources is geological and geophysical knowledge. Most western Asian countries are situated in one of the largest sedimentary basins of the world -- one which originated some 620 million years ago during an extensional phase affecting the Arabian plate and surrounding areas. While the area was extending and subsiding, the Tethys ocean flooded the eastern part; carbonates and evaporites were deposited, forming the infra-Cambrian and Cambrian formations which are so widespread in the region.

These early deposits in the Middle East basin play an important role in the habitat of oil and gas. First, the sometimes restrictive conditions of sedimentation in shallow seas gave rise to sediments rich in organic materials. Source rocks have been observed in the Huqf group formations in southern Oman and are believed to be present over large areas of the Arabian plate. In the centre of the basin such rocks are buried very deeply and, having already passed through the oil generation window, have generated or are still generating considerable amounts of natural gas.

Second, the presence of thick salt deposits at considerable depths has been instrumental in creating domes, anticlines and salt piercements that have formed paths for oil and gas migration in place where otherwise only weak tectonic movement occurred.

In addition, deep basement features which have been tilted - fault-blocks at great depth -- have caused a north-south grain in the large, gentle structures in a large part of the basin, notably in Saudi Arabia.

Another period in the sedimentation history of the basin is the Jurassic (roughly 135 to 192 million years ago), which is responsible for the very important Hanifa source rocks that have generated the enormous amounts of oil and gas that make the Middle East basin unique.

Other source rocks are present in the Silurian and the Cretaceous levels.

Seals and reservoirs must also be present. Extensive carbonate and sand reservoirs are both widespread and are often sealed by evaporites such as the Ara halites or Hith anhydrites. Shales such as the Nahr Umr formation also play an important role in sealing the hydrocarbon accumulations. For large gas columns a good seal is necessary, as is a gentle structure (preferably) without too much faulting. The in situ density of gas causes considerable differential pressures at the top of the accumulation -- generally substantially higher than in the case of oil. Thin and fractured seals may not be able to contain such pressures, and the gas leaks out of the reservoir, becoming dispersed through overlying formations or forming seeps at the surface.

The tectonic features of most of the basin favour the trapping and retention of large amounts of gas. In Iran, more violent deformation took place, but good seals there also allow gas retention.

Exploration usually progresses from the rims of the basin towards the centre and from shallow to deep objectives. The knowledge gained over the years leads to the revision of earlier geological concepts and this information leads to more efficient exploration after what is sometimes referred to as the "learning curve." This means that the average amount of oil found per exploration well is actually increasing with time. However, at later stages the average degree of success per well eventually declines. This process is observed in almost any basin in the world. It is certainly evident in Middle East oil data though its relevance to gas exploration in this area has not been analysed. Some general observations suggest that the processes for gas production are not nearly as advanced as those for oil exploration.

The importance of oil over gas has meant that many opportunities for gas exploration have been bypassed. An exception to this tendency evolved from the need in Saudi Arabia for domestic gas supplies and the concurrent restriction of oil production in the early 1980s. As gas supplies depended on associated gas sources, non-associated gas had to be located quickly, so deeper wells in existing fields were used to tap new gas-bearing reservoirs. More generally, what is left to explore in western Asia countries usually lies at greater depths, where the exploration density is only moderate. A proven productive formation is the Permian Khuff, which already accounts for much of the discovered non-associated gas (as in Qatar's North Field).

Deeper gas reservoirs benefit from having a greater storage capacity because of higher expansion factors. In addition, geo-pressured reservoirs are more likely to occur. One disadvantage of deeper traps is a diminishing porosity and permeability. Another drawback may be the occurrence of sour gas. The geochemical reasons for H^2S occurrence are not well understood, but it seems that highly mature source rocks may favour the generation of such an admixture along with the more valuable methane.

On the other hand, deeper oil reservoirs suffer from greater shrinkage or may be flushed by excessive amounts of free gas generated by the deeper source rocks.

Because of these geological considerations, it appears that there should be more possibilities for undiscovered gas resources than for undiscovered oil. When looking at the various estimates of undiscovered resources it should be noted that for western Asia only 11 per cent of the total oil resource base remains to be discovered, while 33 per cent of gas resources are as yet undiscovered.

The total gas resource distribution among the countries in western Asia is given in figure I; the cumulative production to date is also included. For the western Asia region, this amounts to about 6 per cent of their own total gas resources. Exploitation of oil is of course more advanced, with the cumulative production amounting to some 18 per cent of total oil resources when disregarding the possibilities for enhanced oil recovery, and to 15 per cent when taking this into account.

Figure I. Western Asia gas resources, bar chart

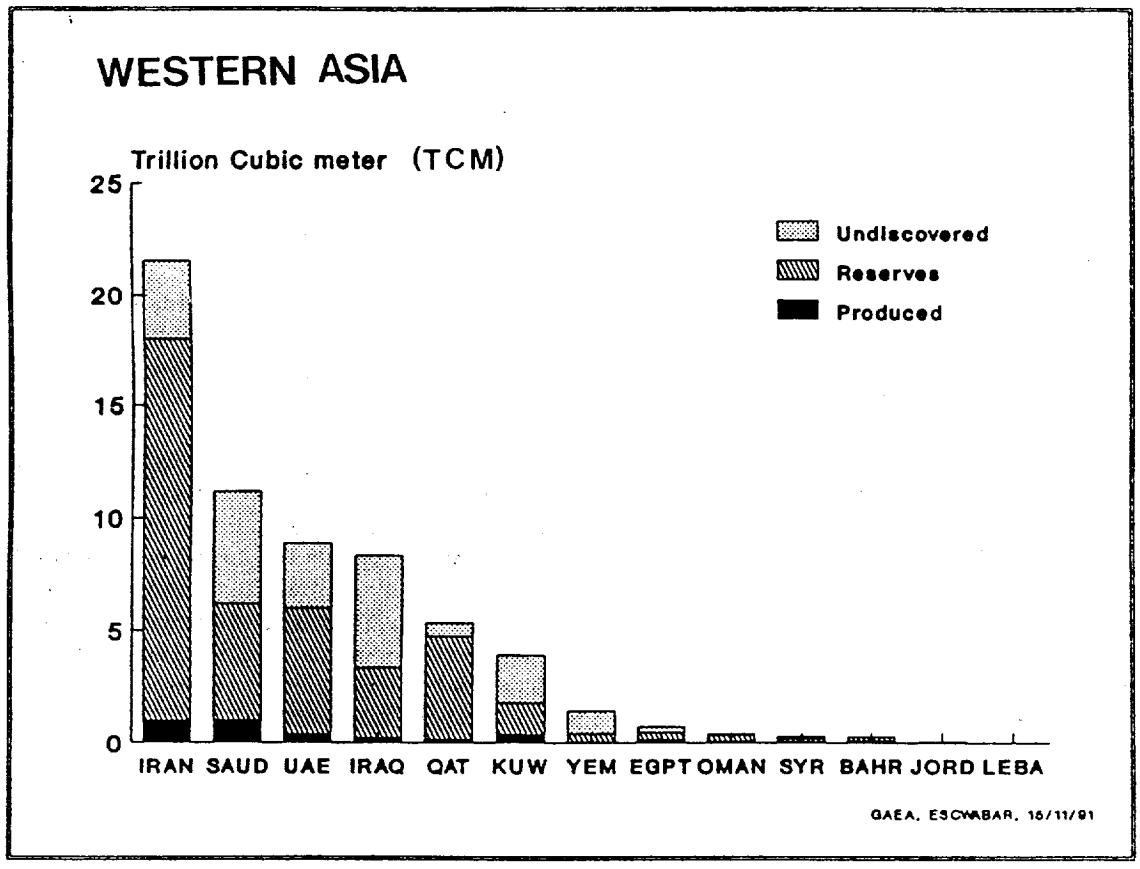


Table 1. Natural gas resources in western Asia countries
(Billion cubic metres)

Cumulative production	3 643	6 per cent
Remaining reserves	38 373	61 per cent
Undiscovered resources	20 500	33 per cent
Total remaining resources	58 873	94 per cent
Total resources	62 516	100 per cent

Note: Conventional gas only.

Very little is known about unconventional gas resources in western Asia countries. It is quite possible that tight reservoirs exist in the deeper parts of the stratigraphy, with non-commercial accumulations of gas. In some cases, new technology being developed elsewhere might create commercial opportunities, particularly in the countries where there is a scarcity of conventional gas.

In view of the overwhelming amounts of conventional gas available in most of the countries it is unlikely that much development of this type of resource -- if any -- will be carried out before the second half of the next century. Other types of unconventional gas -- such as coal-bed methane, offshore gas hydrates and shale gas -- are unlikely to exist or to be of any significance in the area.

The qualitative message this analysis offers is that supply scenarios for western Asia as a whole cannot necessarily be limited by the resource base in the coming decades. The great differences among the individual countries of western Asia, however, will be reflected in the supply pattern described below.

II. THE MARKETS

A. Internal markets

The first consideration must be to satisfy the growing needs of the internal markets of western Asia countries. In the highly populated countries such as Egypt, Iraq and Iran, much work is being done to create the necessary infrastructure for the domestic and commercial uses of gas. In Jordan as well, gas from the Risha field is being used for power generation and could possibly meet 15 per cent of Jordan's energy requirements. In the Syrian Arab Republic, the Omar gas development project will bring gas to the Tishrin power station in the Damascus area, 440 km away. In Qatar, exploitation of the giant North Field is progressing, first concentrating on the supply to Qatar's own market, and later on liquefied natural gas (LNG) exports. In Dubai (the

United Arab Emirates), a large combined power and water desalination plant will be constructed with a 400 Mw electricity and 273,000 m^3 per day drinking-water output. In Oman, local use of gas for various purposes is already at 1.6 billion cubic metres (BCM) per year and is growing rapidly.

Local production of gas naturally includes the opportunity to sell "embodied" energy. The gas is used as a raw material to make petrochemicals such as methyl tertiary butyl ether (MTBE) and methanol, with the advantage of more value per unit of volume. Even more gas energy is embodied in products such as aluminium, manufactured for both domestic use and for export. In this context, it is interesting to note the efforts made in the Gulf countries to build new aluminium smelters, added to those already operating in Dubai and Bahrain. Three projects were considered by mid-1990 -- one each in Iraq, Saudi Arabia and Qatar -- all in the 200,000 ton/year class.

The above examples only begin to describe the potential for development in the local western Asia markets. Further growth, even at an accelerated pace, must be anticipated, at least for the medium term.

B. The European market

Despite significant gas reserves in the Netherlands, the United Kingdom and Norway, gas penetration in the energy market is so high that self-sufficiency from western European reserves will not be reached. The supply/demand gap of some 70 BCM/year is bound to increase as was predicted at the Berlin World Gas Conference in 1991. With this gap growing to some 230 BCM/year by 2020, there would be great possibilities for penetrating this market from western Asia.

C. The Far East market

This already quite well-developed market may have to increase supplies from outside the region. Exploration for gas is reasonably advanced in places such as Indonesia, Malaysia, and Australia, where local demand is growing at a considerable pace. Again, a supply gap of some 100 BCM/year by 2020 is foreseen, and again there may be interesting opportunities for western Asia. The export of gas from the Middle East (Abu Dhabi) is currently being expanded, and Iran and Qatar are developing plans related to the export of LNG.

D. The Indian sub-continent market

This region (which includes Pakistan, India, Sri Lanka and Bangladesh) will contain over a billion inhabitants by the beginning of the next century. If economic development continues at the present rate, and gas infrastructure is further developed in concert, a very significant increase in the demand for gas can be anticipated.

This may be the market par excellence for western Asia countries, especially Iran, which last year proposed a gas line to Pakistan and India the so-called Asian gas pipeline of about 3,000 km with a capacity of 80 million cubic metres (MCM)/day (30 BCM/year). LNG exports to this market are another possibility. There is not much competition from east African sources in sight.

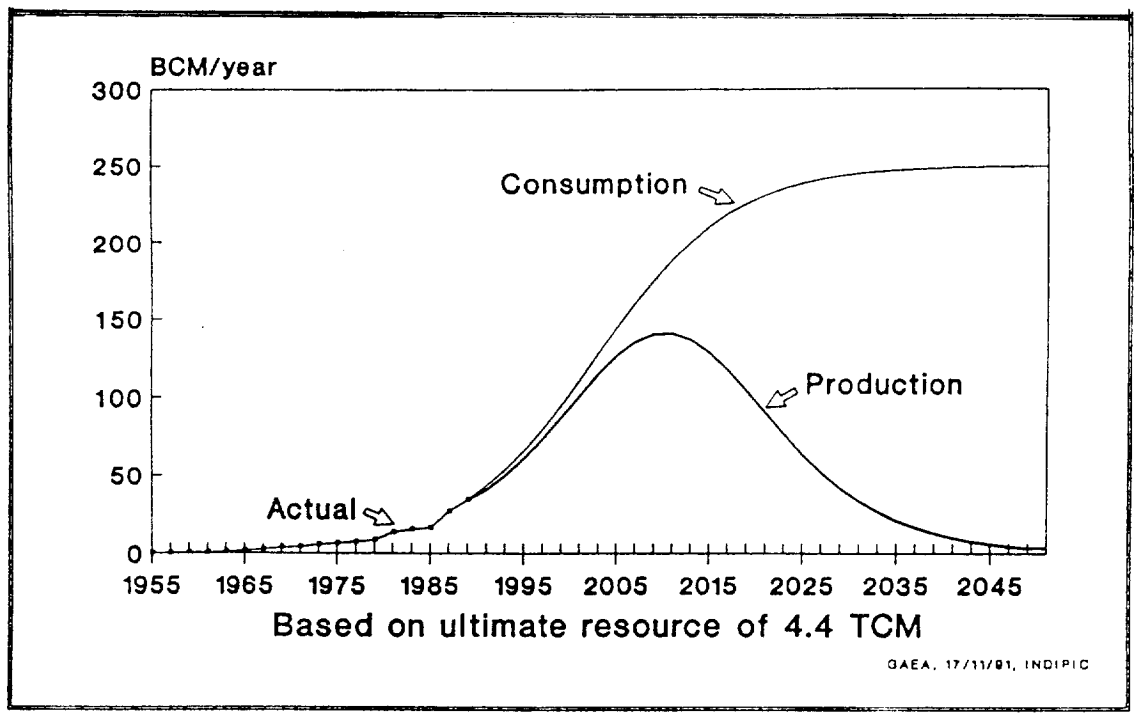
Because of the importance of this market, certain aspects require more detail; first is the resource base for conventional gas, for which estimates are given in table 2. Exploration in the Indian sub-continent is likely to accelerate when more foreign investment can be attracted in the future, a more reasonable discovery rate for the remaining undiscovered oil can be expected. Also, better use is expected to be made of associated gas in India when the high percentage of flared gas is reduced.

Table 2. Natural gas resources, Indian sub-continent
(Billions of cubic metres)

Cumulative production	410	8 per cent
Remaining reserves	2 736	62 per cent
Undiscovered reserves	1 328	30 per cent
Remaining resources	4 064	92 per cent
Total resources	4 474	100 per cent

Note: Conventional gas only.

Figure II. Indian sub-continent, gas production and consumption scenario



The rate of gas production is increasing. So far, demand has been met, but is constrained by this production growth; although the gross production of gas is not the same as the marketed production, a rough assumption is that potential demand is about as high as present gross production and is growing at about the same rate. Figure II gives a rather simplistic scenario of production and consumption growth, constrained respectively by an estimated total resource base of 4.4 trillion cubic metres (TCM) and an estimated market saturation of 250 BCM/year in the next century. The growth in consumption will cause considerable demand for imports by the end of this century. Note that the per capita consumption rates vis-à-vis this maximum 250 BCM/year assumption are still rather low (some 10 per cent) compared to what is observed in the colder developed countries.

There are countries that have a well-established gas infrastructure of principal and regional gas pipelines; 100,000 km of pipelines would not possibly suffice for such development. The financial constraints may preclude the rapid development depicted by this scenario. However, the projected trends are based upon the last 35 years, and may at least be a qualitative reminder of the market potential of this vast area.

E. The African market

Consumption growth is likely to be slow under most scenarios, offset by increased supplies from north and west Africa. Export will be mainly to Europe and the United States. However, there is a possibility of the Middle East supplying a south African gas market showing moderate growth, despite the vast coal resources there. Exports would, of course, be in the form of LNG.

F. The world market

The world market for gas naturally includes the major United States, Latin American and the eastern European markets. The first two may not be of major importance in the context of this analysis. The former USSR market is within reach, but because of its self-sufficiency for a long time to come, may only provide opportunities for "swap deals" directed towards western Europe.

The world gas market may grow in the near future at a rate of some 2 per cent to 3 per cent per year. For the Middle East, estimates of between 5.7 per cent and 8 per cent per annum are quoted for the increase between 1990 to 1992, and between 3.3 per cent and 4.6 per cent per year for Asia/Oceania; the western Asia countries may thus expect a growth rate higher than the world average.

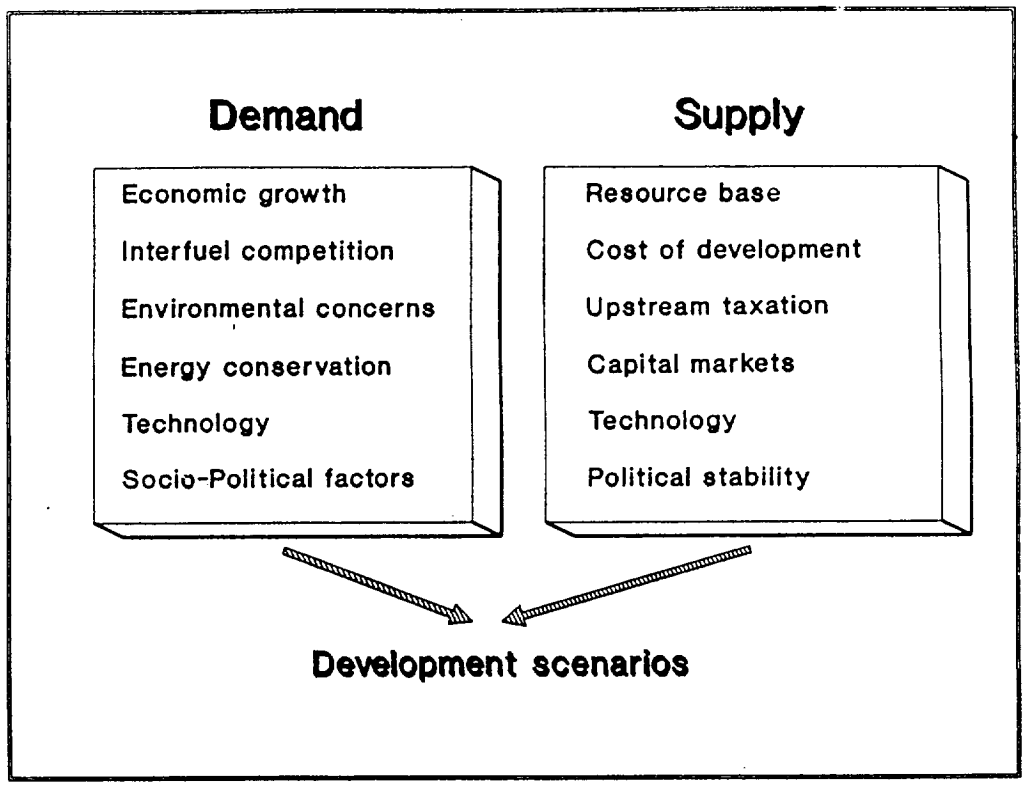
III. GAS DEVELOPMENT SCENARIOS

A. Key factors

The key elements for a discussion of the scenarios are listed in figure III. As energy use is so strongly tied to economic activity, the growth of gross national product (GNP) in the western Asia countries themselves and in the target countries for export is a key factor, but energy use is often difficult to forecast. Interfuel competition, especially in the power-generation market, will play an increasing role. In spite of environmental concerns, it is not very likely that consuming countries will make important shifts from one energy carrier to another based on long-term environmental concerns if these alternatives turn out to be more expensive.

Heavy energy taxation in Europe could be instrumental in reducing energy use, including that of gas. Technology factors include new or improved ways to use gas in the transport market and elsewhere.

Figure III. Key factors in supply and demand

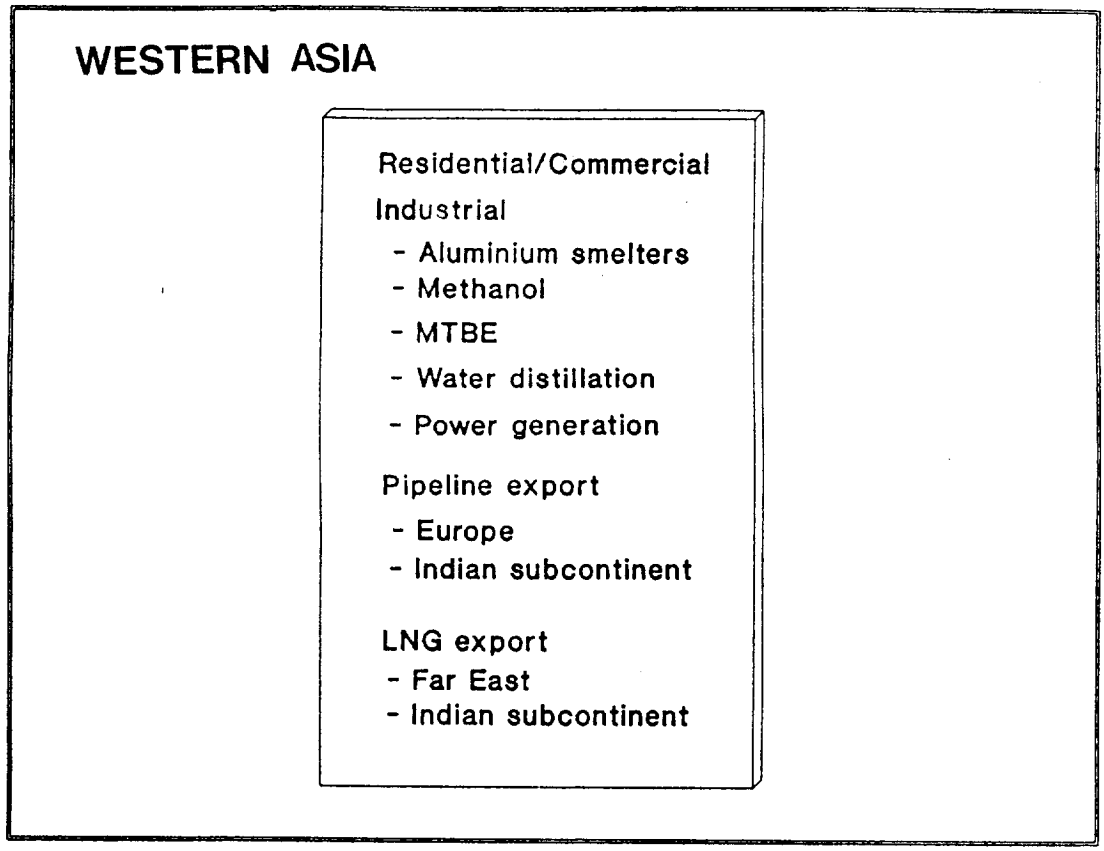


On the supply side, the primary factor is the resource base and its rate of development. Because capacity costs are likely to increase in real terms in the coming decades, financing the resource development will also be increasingly difficult; more foreign capital will be required. In that context, the upstream fiscal conditions of international companies can hamper such a flow of capital. Also, depending on energy prices and the state of the economy, capital markets may constitute a constraint to rapid development. Technology on the supply side may help in reducing -- or at least stabilizing -- unit technical costs of production, and possibly transportation costs.

B. Gas opportunities

Because some of the opportunities for commercial gas development have already been mentioned in the section on markets, it is sufficient here to summarize the major possibilities (see figure IV).

Figure IV. Western Asia gas opportunities



C. Two scenarios for gas development in western Asia

As uncertainties in the key variables are very great, forecasts must be regarded with caution. It has been said that much planning assumes that the future is predictable, good planning assumes that it is unpredictable.

We can only hope to define the range within which events will most likely move, supported by at least a superficial understanding of the complex dynamic economic and other processes at work. Principles such as feedback loops, lag times and the need for internal consistency in building a scenario help in the development of a plausible picture of what might happen in the longer term. Although there is an infinite number of scenarios that could be constructed, all with a certain degree of plausibility, it is more practical to look at two quite different scenarios picked out of the multitude. The two scenarios presented here attempt to contrast a very favourable combination of factors with a much less exciting future: Golden Opportunity versus Unfulfilled Promise, hereinafter referred to as the GO and the UP scenarios. The assumptions are listed in figure V below.

Figure V. Western Asia gas scenarios: assumptions

Golden Opportunity	Unfulfilled Promise
Stable economic growth of 3 per cent	Low, variable economic growth of 1.5 per cent
Gas is favoured fuel	Greenhouse forgotten
Increased energy conservation	Moderate energy savings
Stable energy prices	Unstable energy prices
Innovation in transport and use	Innovation in supply cost reduction
Limited Eastern Europe exports	Strong competition from Eastern Europe
Indian sub-continent demand	Stagnant growth in Indian sub-continent

Under the GO scenario there is strong average growth in the world economy at a rate of some 3 per cent. Stable (but not necessarily high) energy prices are prevalent, which should imply an oil market that is stabilized by the Organization for Petroleum Exporting Countries (OPEC). Under these conditions, downstream taxation is used to force consumers into further energy savings. At the same time, environmental concerns effectively put gas into the forefront as a favoured fuel, giving it real advantage in interfuel competition. New technology makes use of compressed natural gas (CNG) in automotive transport - a realistic alternative to liquids derived from crude oils. Similar advances make gas-derived methanol a significant alternative motor fuel.

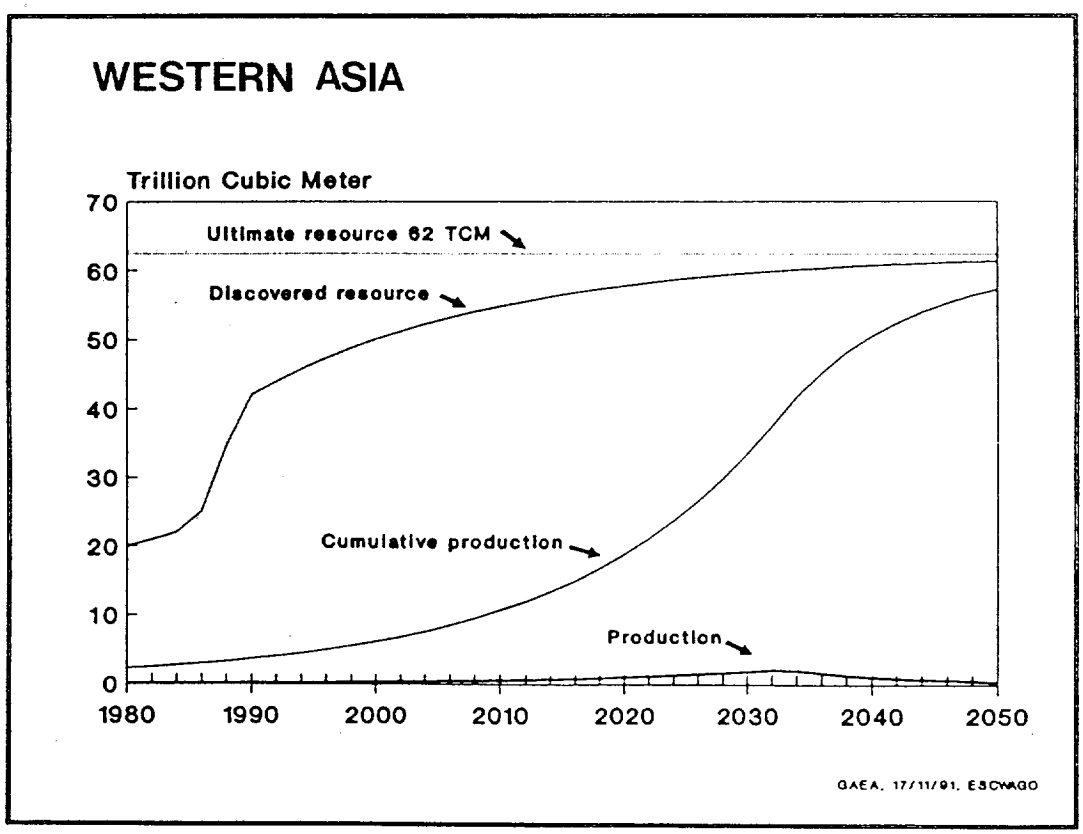
To attract foreign investment to western Asia countries, a climate of political and social stability is required. At the same time, developments in the former USSR delay development of the giant resource base there, or any increase in gas production is absorbed by increased local consumption. Russian market share of gas supply to the growing European market therefore diminishes rather than increases.

Strong demand develops in the Indian sub-continent, which cannot be filled by existing indigenous production after the first decade of the next century.

Although increased energy conservation under such a scenario is a limiting factor for gas as well, the overall effect is of course a rapid increase in demand of this resource from the western Asia region. It is rather hazardous to quantify this growth, if not altogether impossible. However, if a sustained growth of 6 per cent in gross production from western Asia resources is assumed, compared to an 8 per cent actual growth over the last five years, the resource base can be tested to see whether this can be fulfilled from the supply side. Such an analysis is presented in figure VI.

On this graph the actual data from 1980 to 1990 are plotted, together with the effect of a 6 per cent growth in gross production from a resource consisting of the cumulative production, remaining discovered reserves and the undiscovered resources (see table 1). The rapid increase in discovered resources in the late 1980s is due to the large revisions of projected reserve figures in some of the Gulf countries. The further increase is mainly due to the expected discovery rate, with which the undiscovered part is gradually added to the reserve base. The growth of cumulative production is at first exponential, but around the year 2030 slows down due to constraints of offtake from the remaining reserves.

Figure VI. Maximum supply under the Golden Opportunity scenario



It is clear that the resource base is sufficient for enormous (though probably not very realistic) growth under this favourable GO scenario.

Under the UP scenario things do not develop so well, partly because of political and social instability. The world economy suffers from unstable energy prices. At some point, oil and energy prices reach the marginal cost of production when OPEC commitment breaks down. At other times, the "price hawks" have the upper hand, or high prices are induced by the failure to solve the political troubles of the Middle East. This has a negative effect on the world economy, and also on the development of local demand and supply in the western Asia region itself. In this economic climate, rapid development of gas demand in the Indian sub-continent is also excluded.

Technology improvements on the supply side reduce the costs of development in the Organization for Economic Cooperation and Development (OECD) countries as well as in the rest of the world. This prolongs the period of self-sufficiency for many countries, and creates a lower floor price for gas. Improvements or a breakthrough in the domain of gas transportation may also facilitate competition in the market place.

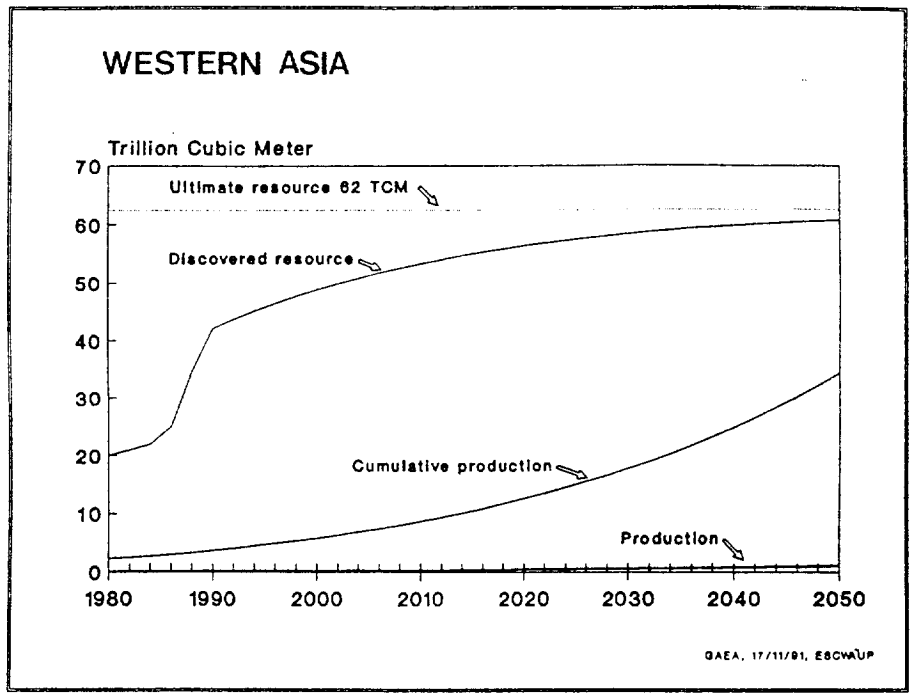
The promise of increased demand for gas in at least the OECD countries because of the environmental concerns proves to be false; price and convenience turn out to be the key factors in interfuel competition. At the same time, the former USSR is able to reorganize its oil and gas industry, partly by the successful entry of international companies providing technology and finance. This allows gas exports from Russia to the West and to Japan and Korea to grow when the potential of eastern Siberia is developed. This provides strong competition against any attempts by western Asia countries to enter or increase their share in those markets.

Still, under such rather negative assumptions, growth in gas production and consumption should be expected, though it is unlikely to be sustained at over 3 per cent per year. The consequences for supply are depicted in figure VII.

The scenarios are constrained by many factors, with the exception of the resource, until at least the middle of the next century. This conclusion is only valid for the ensemble of western Asia countries. Quite a few countries in the area will run out of gas supplies long before that time, but supplies will always be plentiful and available nearby from the other countries in the region.

The timely planning for expansion opportunities will put the more resource-rich countries of western Asia in a strategically good position to take advantage of the possibilities in an increasingly competitive market.

Figure VII. Maximum supply under the Unfulfilled Promise scenario



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