EXPLORATION OF FUTURE RISKS ON THE GLOBAL MARKET FOR OIL, COAL AND URANIUM

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SUMMARY

The aim of this study is to investigate the future risks to supply for the global markets for oil, coal and uranium. The study forms part of an integrated project by the CPB Netherlands Bureau for Economic Policy Analysis, which is developing a framework for a cost benefit analysis of energy supply security policy. This study is divided into four sections. The first section deals with the issues and definitions that relate to the meaning of security of supply. The following three sections deal in turn with the risks to future supply for oil, coal and uranium.

The analysis has examined the impact that supply disruptions have had in the past, the events that have disturbed energy supply and the affect that they have had on prices, on the economy and on society. For each commodity we have analysed the political, economic, institutional and technical risks and have qualitatively assessed the impact that each might have on the two price scenarios provided by the CPB. We also discuss the policy responses that governments have adopted in the aftermath of supply disruptions.

The report commences with a discussion of the definition of security of supply and the link to the potential for supply disruptions. The analysis shows that the political concept of 'security' applied to supply does not cover all cases of significant price rises. Security seems to refer more particularly to situations free from physical interruptions of production or distribution due either to political factors and events or to accidents. Security is a matter of probability: the greater the chances of these accidents or events occurring the weaker the security. But price rises may occur because of depletion, miscalculations about the rate of investment required, flawed policies, shifts in demand and a host of other causes. One need therefore to consider the issue in a broader framework than primarily suggested by the term 'security' unless it's meaning is stretched so wide that it becomes both all-embracing and devoid of analytical power. It is for this reason that in this study we have examined the issue of supply disruptions in the context of economic, technical, institutional and political factors.

Our conclusions for the potential for supply disruptions for oil show that in the short term under both the 'High Growth' and 'Low Growth' scenarios, the most probable

disturbance that may occur in the near future will be due to a war in Iraq. The immediate impact will be a loss of 2 million b/d of Iraqi oil in the world petroleum market. Should Iraq succeed in retaliating on oil installations in Saudi Arabia or Kuwait (probability 10 per cent) oil prices will quickly rise to the $40 per barrel level. If major damage is caused to these installations prices may well move higher, that is close to $45 or $50 per barrel and depending on the damage the duration of the price rise will be of the order of several months. If Iraq fails to attack its neighbours, the military operation ends quickly and Saddam Hussein does not set the oil wells on fire, oil prices will quickly fall from the current $25 per barrel level to $20 or even $18 d/b. Under both the 'Low Growth' and 'High Growth' scenarios, terrorist action against oil instillations or tankers is possible (probability 30 per cent for oil fields, 60 per cent for pipelines, tankers and other isolated plants) but the probability of major disruptions is low (less than 5 per cent).

In the medium term the potential for supply disruptions to oil under both the 'Low Growth' and 'High Growth' scenarios, include the probability of a crisis in Saudi Arabia and indeed in other major Gulf countries (including Iran) increases with the passage of time. But the period from 2005 to 2010 is one during which additional supplies may be reaching the market from the Caspian, the West African offshore and perhaps from a pacified Iraq. Russian output would have built up in the immediately preceding years. While the probability of a crisis increases the magnitude of the impact on prices may be mitigated by the increase in supply. Terrorism will continue to represent a threat (similar probability as for the short term) but the risk of serious damage is likely to diminish because of improved security measures.

In the medium term, however, certain political forces relating to human rights, environmental issues, or an anti-corruption drive may have gained momentum. Other things being equal these may restrict investments in capacity and restrict supplies. Economic difficulties in certain countries, not only in Latin America, Africa or Indonesia but also in Russia or the Caspian could restrict investment. The overall supply situation will thus depend on the magnitude of the positive shifts due to new capacity compared with the negative shifts due to insufficient investment in new capacity or in workovers needed to fight natural decline in old fields.

Our view of the medium-term is one of fairly weak oil prices with the possibility of a price spike resulting from a political incident in Saudi Arabia. During that incident whose probability is in the order of 20-25 per cent prices could well climb to $50 per barrel. The risk of a political incident in Saudi Arabia is more likely under the 'Low Growth' scenario, which envisages flat real oil prices

The very long-term problem is one of oil depletion and the rate at which fuel substitutes and new fuel-using types of engines are developed and enter the market. But this is a problem that will begin to be felt around 2020 or a bit later. The period between 2015 and 2020 or 2025 could witness the beginnings of a tighter supply situation because the big increases from Iraq, Russia, West Africa and Venezuela would have occurred in earlier years. Oil prices will then rise and stimulate R & D substitutes, actual substitution and reduction in demand. In other words this would be a period leading to major adjustments in the longer term (2025 – 2040). The risk of supply disruption in the longer term due to depletion is much more likely under the 'High Growth' scenario than under the 'Low Growth' scenario.

With regards to the policy response to disruptions of oil supply, our view is that governments are always inclined to favour fiscal policies as a means to limit the demand for oil and, other things being equal, to reduce imports. The first reaction to a crisis is therefore likely to be an increase in excise taxes on automotive fuels. This is preferred to subsidies to alternative fuels or research and development since taxes bring in revenues whereas subsidies are an expense. There are instances, however, where encouraging new supplies may be more effective than discouraging demand.

Coal still makes a significant contribution to primary energy demand and is at present only exceeded by oil. Although coal reserves are vast and are widely dispersed, consumption is increasingly concentrating in a small number of countries and in a few main uses. Nearly two-thirds of total world coal consumption is accounted for in just four countries namely China, United States, India and Russia. However, the volume of remaining reserves remains high with OECD countries accounting for over 60 per cent of exporting countries. In addition, the USA is expected to remain the swing producer for coal in the longer-term. As a result, concerns over coal supply security are likely to remain minimal especially as almost half of current reserves are located in OECD countries.

The key potential supply disturbance that we have identified relates to environmental pressure and the impact that this could have on demand. Coal is particularly vulnerable as it contributes 38 per cent of the world's total carbon emissions from commercial fuels, and is also a major source of sulphur dioxide and nitrous oxides emissions as well as particulates and other environmental hazards. The greater the environmental pressure on the industry the greater the likelihood that this could lead to downward pressure on prices in the medium-term. In the longer-term this could affect investment decisions and put upward pressure on prices. However, this upward pressure could be fully mitigated by improvements in technology, the constant pressure to reduce costs combined with the vast resource base available.

With regards to uranium, current demand can be met by primary production and by secondary sources from stockpiles and inventories. The uranium resource base is large enough to support even the most optimistic of demand assumptions and the reserves are located mainly in OECD countries. In the near-term, primary and secondary uranium resources will be able to meet both optimistic and pessimistic demand forecasts. In the medium-term, secondary sources will be depleted but current production and current developments of primary uranium should be sufficient to supply both optimistic and pessimistic demand forecasts. In the long-term, significant new sources of uranium will need to be developed to meet rising demand. This will require significantly higher prices to justify new investment.

In the near term, the real risks to supply could come from disruptions in secondary supplies of uranium. Such disruptions are likely to be short-lived and cause spikes in the uranium price. In the longer term, economic factors are more likely to cause supply disruptions if prices do not recover to levels that justify new investment decisions. However, political factors and the introduction of new technology could suppress demand for uranium if the nuclear industry goes into decline.

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1. PROJECT OUTLINE AND METHODOLOGY

The aim of this study is to investigate the future risks to supply for the global markets for oil, coal and uranium. The study forms part of an integrated project by the CPB Netherlands Bureau for Economic Policy Analysis, which is developing a framework for a cost benefit analysis of energy supply security policy.

This study is divided into four sections. The first section deals with the issues and definitions that relate to the meaning of security of supply. The following three sections deal in turn with the risks to future supply for oil, coal and uranium.

The analysis has examined the impact that supply disruptions have had in the past, the events that have disturbed energy supply and the affect that they have had on prices, on the economy and on society. For each commodity we have analysed the political, economic, institutional and technical risks and have qualitatively assessed the impact that each might have on the two price scenarios provided by the CPB. We also discuss the policy responses that governments have adopted in the aftermath of supply disruptions.

The CPB provided two scenarios named ‘low growth’ and ‘high growth’. The scenario period stretches out fifty years with the short term defined as within 5 years, medium term within 20 years and long term within 50 years. The ‘high growth’ scenario assumes a highly integrated world economy unhindered by environmental and social policies. In contrast, the ‘low growth’ scenario is more regionalised, with intensive international environmental policies and significant local problems. In essence the difference between the two lies in the degree of globalisation.

The CPB provided price scenarios for each scenario. In the ‘high growth’ scenario the demand for oil is assumed to be around 2 per cent per annum, high relative to historic rates. The high rate of growth is aimed at establishing whether the resource base is capable of meeting such ambitious targets. In any event, this scenario is considered to be a high price scenario as far as oil is concerned as it is assumed that oil will become scarce toward the end of the scenario period. The CPB estimate that under this scenario the price of oil will rise to $40 per barrel in real terms ($60 per barrel in nominal terms) because of scarcity, monopoly rents accruing to supply countries and higher costs. Given the ample supplies of world coal in a diverse number of countries the CPB estimates that coal prices will remain constant or show only a small increase in real terms. The CPB did not provide any estimate for the future price of uranium.

In the 'low growth' scenario demand for oil and coal is assumed to increase slowly because of the low GDP growth. An increase in demand for oil of just 1 per cent per annum implies that production will peak no sooner than 2050. It is also assumed that although investment in production and transportation will be limited, demand can be easily met and as a consequence prices for oil will be subdued. Under this scenario the CPB assumes that real oil prices will show a downward trend towards 2040 reaching a level of $17 in 2040. It is also assumed that real coal prices will also fall. The CPB did not provide any forecasts for the price of uranium.

Using both of these scenarios, OIES analysed the resource base for oil, coal and uranium. It was then decided to examine whether these resource bases would be capable of meeting the demand forecasts under both the CPB scenarios. Once this analysis had been completed, OIES examined the political, economic, institutional and technical factors that could affect supply, in the short, medium and long term. Using this qualitative analysis, estimates were made of the risk to supply disruptions and from this estimates were made of the potential impact that they might have on the 'low growth' and 'high growth' price scenarios. For each commodity the policy responses for each supply disruption are discussed.

The study has been written in four self-contained parts. Therefore it is possible to read the whole section on the potential for supply disruptions to oil without reference to the sections on coal or uranium.

2. SECURITY OF SUPPLY DEFINITIONS

How to define 'security of supply'? To economists, supply is the schedule of quantities that will be on offer at different prices. Given the demand curve for a good, commodity or service the smaller the quantity on offer, the higher will be the price. Economists rarely talk about 'security' a concept that to them seems to belong to other disciplines such as politics or psychology. In fact, some of them will go as far as denying that there are supply problems that the market cannot solve. In a free market price will ration the quantity available among consumers. They would argue that queues and visible physical shortage only appear when governments attempt to intervene with the market by fixing prices below the market clearing level or by introducing quantitative rationing.

For the ordinary consumer the perspective is different however. Ideally a consumer wishes to find the good, commodity or service he/she desires to purchase available at any time, in every accessible market, and at an 'affordable' price. Supply is about quantity and price. Availability is the quantitative aspect, affordability a characteristic of price *relative* to the wealth, income and other demand preferences of the consumer. There are cases, rare as they may be, when a good, commodity or service is just not on offer in a market. I would like to eat custard apples but no greengrocer happens to stock them. In these instances all potential consumers of custard apples will be frustrated. In all other instances when an item is indeed available at a given price the set of potential consumers willing to pay this price will be satisfied and the set of those who judge the price too high given their means and other preferences will be frustrated. Put more concisely, in most situations scarcity is a relative concept.

For governments and more generally politicians, security refers to stable situations ('business as usual' in the jargon of business schools), which are judged on the basis of some criteria to be broadly satisfactory although never near perfect. Security is threatened by any event or force that renders the situation unstable.

These different perspectives can be reconciled to some extent. When the economist moves from micro- to macro-economics he/she will point to the impact that a price rise (though it clears a market) can have on macro variables such as inflation, the balance of payments or the rate of economic growth. The significance of the impact depends however on the share of the good, commodity or service in question in national expenditures or in the import bill, on the strength of linkages in the input/output set of relationships and on whether a close substitute for the item affected by the price rise is immediately available or not. Much depends on the elasticity of demand.

The economist, therefore, will consider a large *shift* in the supply curve of a good, commodity or service affected by low demand elasticity as disruptive, because of the macro-economic impact.

What to the economist is a *shift* causing prices to rise significantly will be perceived by governments and public opinion in general as a price *shock*. Although the approaches, or the terminologies, are different the perceptions of economist, politicians, the media and the ordinary citizen meet at this point.

There is shock only when the supply shift is fairly sudden, the price rise significant and the commodity involved, as is the case for energy in general and gasoline in particular, has no immediate substitute. The sudden supply shift may be due to a variety of causes such as an interruption of production, of lifting for export, or of internal distribution. These sudden disruptions may be caused by political events (wars, revolution, terrorism), labour unrest (strikes), accidents due to fire, explosion or storms for example, or policy decisions by producers organized in a cartel.

Because shocks are sudden they capture public imagination and media interest. But since the real issue is one of supply shifts causing prices to rise, one needs to consider situations when the increase is substantial but occurs over a long period of time. One may argue that a sudden price change is more disturbing than one of the same, or even greater, magnitude that occurs over a number of months or years simply because adjustments are essentially a matter of time.

Supply shifts resulting in price rises over time may be due to a failure to invest at a rate that ensures output growth equivalent to demand growth; to gradual increases in the degree of cartelization or more precisely in the ability of a cartel to steer prices on a rising path; or in the case of an exhaustible resource to physical depletion.

Price rises are not exclusively caused by shifts in supply. Price is the outcome of an interaction between supply and demand. One can imagine situations where the demand schedule shifts to the right against a fairly stable supply curve. If the price elasticity of supply is low the demand shift could cause significant price increases. Consider for example a situation where substantial economic growth in large countries such as China or India enables more and more people to own a car. The demand for oil would increase significantly causing prices to rise if the supply schedule remains fixed, or if it shifts over a smaller distance than demand.

The analysis shows that the political concept of 'security' applied to supply does not cover all cases of significant price rises. Security seems to refer more particularly to situations free from physical interruptions of production or distribution due either to political factors and events or to accidents. Security is a matter of probability: the greater the chances of these accidents or events occurring the weaker the security. But price rises may occur because of depletion, miscalculations about the rate of investment required, flawed policies, shifts in demand and a host of other causes. One need therefore to consider the issue in a broader framework than primarily suggested by the term 'security' unless it's meaning is stretched so wide that it becomes both all-embracing and devoid of analytical power.

We have argued that the issue is essentially one of price changes and their impact on the macro-economy, the consumer's income and expenditure basket, and in the case of oil on the functioning of a wide range of services that constitute the structure of modern life.

A new question arises here. As commodity prices (and this is very relevant to oil) usually display volatility, and given that some of this volatility (when the commodity price is determined on futures markets and with the use of other derivative trading instruments) is due to other factors than the economic fundamentals, it may prove difficult on certain occasions to distinguish between a fluctuation and a price surge. It is not sufficient to focus on the size of the price change because short-term volatility may involve movements of large magnitude. Recall the oil price movements in 1998-9 when we witnessed a fall from $18/barrel to $10/barrel, and then a rise to $30/barrel. The duration of a price change is an important dimension. But how can big changes that are reversed after a few months or a year by a movement of similar magnitude and opposite direction be explained.

In the case of oil we do not always find discernible trends (in the sense of a sustained movement in a particular direction over long periods of time). A more noticeable pattern is one of price episodes separated by discontinuities. The peculiar features of this pattern are that (a) the episodes involve a normal level around which prices fluctuate so that real average prices always fall during the episode; and (b) the discontinuities which separate episodes are of varying duration and take different forms: they may consist of a sudden shock or of a sequence of changes in opposite directions.

In oil, we had the $2/barrel episode, which lasted from 1960 to 1969; a $10/barrel episode between the end of 1973 and the end of 1978; a $18/barrel episode from 1988 to the end of 1997. The discontinuities included the 1973/4 sudden rise; the ups and downs of 1979-86 and the ups and downs of 1998-9. We may be now at the beginning of a new $23-25/barrel episode that started in 2001 or still in the midst of a long discontinuity prolonging the 1998-9 events.

The points of time in this long pattern when the price of oil rose significantly because of a shift in the supply curve were in the years 1973 and 1979. The shifts were partly due to political factors. Price falls in the first half of the 1980s (which became significant in 1986) were due to a glut while the 1998 price fall had more to do with wrong information about production levels than actual output increases.

The fundamental analytical problem about the price of oil is the difficulty of relating its movement to actual developments of supply and demand. But the supply adjustments involve long lead-in time and demand for oil products in most countries (the USA is a notable exception) is more directly and strongly influenced by domestic taxation than international prices.

Another difficulty relates to forecasting. Forecasters looking at the years ahead usually show a trend line. That this ignores short-term fluctuations does not constitute a problem. That it fails to reflect the more realistic pattern of episodes and complex discontinuities is much more serious. [i]

An oil supply disruption (a shock) or a gradual but significant shift in the supply/demand balance (a tightening) which causes its price to rise by a high percentage will have a more severe impact on a poor country with a high degree of oil import dependence than on a rich country with the same or a lower degree of dependence. A wealthy individual faced with an increase in the price of gasoline may continue to drive his/her gas guzzling cars while a much poorer citizen may have to reduce drastically his use of the car and have greater recourse to public transport or the bicycle. The issue is that what may be construed as a shock or a significant change by some may be of no great importance to others.

The energy system may not have identical characteristics in different countries. Some enjoy greater flexibility in switching from one fuel to another, particularly in power generation, than others.

And in the case of a politically induced supply disruption (a war or a revolution in a major exporting country) the oil importing countries with entitlements to suppliers from an international energy arrangement will suffer less (other things being equal) than countries not covered by the safety net.

All changes in an economic variable induce sequences of adjustments. Adjustments involve time but the lags are of very different duration. They also involve costs. Commentators inclined to minimize the significance of crises by arguing that economies and individuals always adjust in the end sometimes forget this. This is true in most cases. One should recall that in most cases, once again, costs are incurred. A charge, which elicits smooth, painless and costless adjustments, is not a significant event; it cannot be labelled a crisis.

3. EXPLORATION OF FUTURE RISKS ON THE GLOBAL MARKET FOR OIL

1. Summary

The issue of supply security for the global market for oil has recently been given exaggerated importance by both the USA and the EU. Dependence on imports has always been a feature of a world where nations trade. However, the oil issue is complicated immensely by political factors, the emotions that some of them elicit and the memory of the 1973 embargo which hurt the pride of industrialised countries because they were aggressed by developing nations. In this paper we attempt to disentangle the subjective elements from the positive factors that underlie the perceptions of risks.

2. The Key Exporting Countries

2.1 Oil Reserve Base

The current supply situations in the 20 oil-exporting countries and the type of risks they may face are now provided in a series of tables. Table 1 shows the top 20 oil producers in 2001 who account for just over 70 per cent of world supply of oil and nearly 90 percent of remaining proven reserves. From Figure 1 it is possible to see that the major producing country is Saudi Arabia with Russia a close second.

Most of the OPEC nations feature in the top ten producers. Although Norway and the United Kingdom feature in the top ten producing countries their current levels of production are disproportionate to the level of their remaining reserves. For example, the United Kingdom has reserves to production ratio (R/P ratio) of just 5.8 years compared to the United Arab Emirate's ratio in excess of 100 years and yet it produces annually the same volume of oil.

In Figure 2 we show the main exporting countries in 2001. This table shows that over 50 per cent of world production is exported annually with the Middle East accounting for over 46 per cent of total world exports. Latin America and Africa accounted for 15 per cent of world exports with Europe and Russia accounting for around 10 per cent each. On a country basis, Saudi Arabia is the leading exporter followed by Russia but

Figure 1: Top 20 Oil Producers in 2001

Region/Country	World crude Production 2001	Share of Crude Production	Exports (Production-consumption	Proved reserves at end 2001	Share of world reserves	R/P ratio
	1,000 b/d	(%)	1,000 b/d	billion bbls	(%)	Years
Saudi Arabia	8,768	11.8%	7,421	261.8	24.9%	85.0
Russia	7,056	9.5%	4,600	48.6	4.6%	19.1
Norway	3,414	4.6%	3,201	9.4	0.9%	7.8
Iran	3,688	5.0%	2,557	89.7	8.5%	67.4
Venezuela	3,418	4.6%		77.7	7.4%	63.5
Nigeria	2,148	2.9%	2,927	24	2.3%	30.8
United Arab Emirate	2,422	3.3%	2,139	97.8	9.3%	100+
Kuwait	2,142	2.9%	1,936	96.5	9.2%	100+
Iraq	2,414	3.2%		112.5	10.7%	100+
United Kingdom	2,503	3.4%	853	4.9	0.5%	5.6
Mexico	3,560	4.8%	1,747	26.9	2.6%	21.7
Canada	2,763	3.7%	822	6.6	0.6%	8.8
Libya	1,425	1.9%		29.5	2.8%	57.3
Algeria	1,563	2.1%	1,363	9.2	0.9%	17.6
Oman	959	1.3%		5.5	0.5%	15.8
Indonesia	1,410	1.9%	315	5	0.5%	10.1
Qatar	783	1.1%	753	15.2	1.4%	55.5
Kazakhstan	828	1.1%	673	8	0.8%	27.6
Angola	731	1.0%		5.4	0.5%	20.3
Colombia	627	0.8%	407	1.8	0.2%	7.7
Sub-total	52,622	100%		936.0	89%	n/a
World Total	**74,482**	**100%**		**1,050**	**n/a**	**40.3**

Source: BP, Statistical Review of World Energy, June 2002

Figure 2: World Crude Exports 2001

Region/Country	Crude oil exports	Refined products exports	Refined products imports	Refined products exports	Total oil exports 2001	Share of total oil exports	Ranking
			1,000 b/d			(% of total)	
North America	1,154	1,375	1,998	-624	530	1.4%	
Latin America	5,061	2,132	1,474	658	5,719	14.7%	
Western Europe	4,905	4,454	5,262	-808	4,097	10.5%	
Eastern Europe & Russia	3,346	1,512	221	1,291	4,637	11.9%	
Middle East	15,391	2,963	363	2,600	17,990	46.3%	
Africa	5,262	1,194	447	746	6,008	15.5%	
Asia & Oceania	2,215	2,870	5,191	-2,321	-106	-0.3%	
Saudi Arabia	6,036	1,083		1,083	7,119	18.0%	1
Russia	3,344	1,247	10	1,237	4,581	11.6%	2
Norway	2,979			250	3,229	8.2%	3
Iran	2,446	308		308	2,754	7.0%	4
Venezuela	1,965	761		761	2,726	6.9%	5
United Arab Emirates	1,787	398		398	2,185	5.5%	6
Nigeria	2,098	46	13	33	2,131	5.4%	7
Kuwait	1,214	642		642	1,856	4.7%	8
Iraq	1,710	25		25	1,735	4.4%	9
United Kingdom	1,646	417	355	62	1,708	4.3%	10
Mexico	1,883	96	365	-268	1,614	4.1%	11
Canada	1,130	411	210	201	1,331	3.4%	12
Libya	988	225		225	1,213	3.1%	13
Algeria	442	556		556	997	2.5%	14
Oman	917				917	2.3%	15
Indonesia	599	196		196	795	2.0%	16
Qatar	606	78		78	684	1.7%	17
Kazakhstan	630				630	1.6%	18
Angola	660				660	1.7%	19
Colombia	576				576	1.5%	20
TOTAL	33,705	6,489	953	5,786	39,441	100%	n/a
World Total	**37,333**	**16,499**	**14,955**	**1,543**	**38,876**	**100%**	**n/a**

Source: OPEC, Annual Statistical Bulletin 2001, p.86, except Kazakhstan, from US Energy Administration these two countries provided nearly 30 per cent of world exports in 2001. Specific comments on each of the top twenty exporters are included below.

Saudi Arabia

Saudi Arabia is the leading nation in terms of production capacity and proven reserves. In 2001, as well as producing 8.8 million b/d (of which over 6 million were crude exports), the country still had a spare capacity of almost 3.3 million b/d. Indeed, the last time a production peak at over 11 million b/d was attained was in1980. Hence, it has significant flexibility in its production, as output comes from large, well-behaved fields. Its proven reserves of over 260 billion b/d account for about one quarter of the world known reserves of conventional oil, and give Saudi Arabia an R/P ratio of 85 years.

Saudi Arabia can look confidently at its long-term supply capacity, which could be increased to 20 million b/d if demand calls for such an expansion. However, Saudi Arabia faces political risks in the short-term and medium term. These are risks of political instability arising from the possible strengthening of Islamic extremists in response to US policy towards Palestine, Iraq, and Muslim countries in general.

Russia

Russia is the world's second largest oil exporter. Russian exports stood at 4.6 million b/d in 2001, with crude exports at 3.3 million b/d. Oil production was at 7 million b/d, which is way below the previous peak reached in 1987 of 11.5 million b/d. Russia at present does not hold spare capacity, and is unlikely to hold it in the future. However, output and exports have been increasing in the past two years, and is likely to do so at the rate of 0.4-0.45 million b/d until 2005-2006. Thereafter the increase may be limited to 0.1 million b/d because expansion will require the development of new oil fields in difficult areas. At the current R/P ratio of 19 years, its proven reserves of near 49 billion barrels should last into the long term, but heavy investment will be needed to prevent a decline in production in the medium term.

The most important problem facing Russian production and exports is the significant economic risk from a fragile economic performance and continuing strains from social needs. These pressures could cause political instability for some time in the future.

Norway

In 2001, Norway's net oil exports were at nearly 3 million b/d. Oil production totalled 3.4 million b/d (estimate includes condensates and natural gas plant liquids), which was also a historical peak. It ranked as the third largest exporter in the world but it is has no spare capacity. Its proven reserves of near 9 billion barrels are small, and cannot sustain high production levels for a long time. Natural depletion in the medium term, rather than political, economic or institutional risk, will be the main problem that will affect Norwegian supplies.

Iran

Iran is the world's fourth largest exporter. In 2001, it exported just under 2.7 million b/d (of which 2.4 million b/d were crude). Production reached 3.7 million b/d, which has been near the peak since 1978/1979 (the last time 6 million barrels were produced was 1973). Current installed capacity is higher that the OPEC quota of 3.19 million b/d. However, beyond that, Iran has limited flexibility in output, with many fields in need of upgrading and modernisation, and few significant discoveries except in the Caspian Sea. At a current R/P of over 67 years, Iran's proven reserves of near 90 billion barrels should last into the very long term.

Sorting out production arrangements with its Caspian neighbours is an immediate task to be tackled. But Iran's main problem is to overcome the economic risk resulting from the currently insufficient provision of government funding for investments, and to make the current contractual framework more attractive to foreign companies.

Venezuela

In 2001, Venezuela was the world's fifth largest exporter, and accounted for 4.9 per cent of world production. Of the 3.4 million b/d allegedly produced that year, (Venezuelan data tend to overestimate actual output) 2.7 million b/d were exported, of which 2 million were crude oil exports. Venezuelan exports are one of the top four sources of supplies for the USA. With little new explorations and poor maintenance in recent years, current capacity stands just above production levels. It is estimated that future investment levels by PdVSA will need to double in order to protect and upgrade this capacity. Venezuela is also important in terms of proven reserves (currently at 77.7 million barrels), which are expected to last well into the long term. In addition, its Orinoco Belt holds hundreds of million barrels of heavy-oil and bitumen. Venezuela, together with Canada, will be able to supply non-conventional oil in large quantities in the very long-term.

Venezuela continues to experience considerable social, economic, and political difficulties, and the organisation of the oil industry has been a key issue in the confrontation between president Chavez and the opposition. One cannot exclude the possibility of a downward spiral dragging down Venezuela including its oil sector in the short term.

UAE

The UAE exported 2.1 million b/d in 2001 of mostly crude oil, out of a total crude output of 2.4 million b/d. As such, it ranked as the sixth largest exporter. The UAE has some spare capacity as its total oil output capacity is near 2.65 million b/d, with a peak output of 2.6 million already achieved in 1990. The nature of its fields, sustained increases in recovery, recent offshore finds, and the absence of financial constraints, means that it has the ability to expand its output capacity. Proven reserves are estimated to be 98 billion barrels and with a R/P ratio in excess of 100 years (Table 1) should last well into the long term.

There are no reports of technical constraints on future plans of expansion. As with most countries in the Arab Gulf, the UAE faces geo-political risk resulting from the Arab-Israeli conflict and a possible war in Iraq, which could destabilise the political regime.

Nigeria

Nigeria was the world seventh largest exporter of crude oil in 2001, with 1.9 million b/d of mostly crude oil exported in that year. Total crude production in 2001 was at an estimated 2.15 million b/d. This was marginally below the 1997 peak of 2.4 million b/d, which was also achieved in 1979. Nigeria's crude production continues to experience noticeable disruption to supplies. Every year there are many attacks and disruptions by the local population, particularly in the delta region, who are seeking to halt the perceived usurpation of their economic and environmental rights. In addition there are also many incidents of vandalism and illegal siphoning. Oil spills that cause deaths and further environmental degradation are still marring the industry, with somewhat substandard installations not helping.

Nonetheless, the outlook for Nigeria has been buoyed by recent discoveries in the deep-water, and by measures taken by government to encourage further exploration by private oil companies. The country has ambitious plans to expand its current production capacity to 4 million b/d after 2020. It is already claimed that oil reserves will reach 30 billion barrels next year, and 40 billion barrels in the long term, but this will not materialise without at least doubling current levels of investments. With proved reserves at 24 billion barrels that should last into the longer term, its share of world reserves was slightly below 2.3 per cent in 2001.

Nigeria's short and medium term problems are the high overall political risk, as its emerging democracy and political stability are fragile. In particular, there is increasing concern in the international community of breaches in human rights law which could in the extreme case might cause companies to reconsider significant capital investment programmes, particularly if this might cause them problems in their domicile as has already happened to Shell. Nigeria should be able to at worst maintain its current position, and more likely and hopefully expand its production and market share, once the aforementioned problems are tackled and public finances reformed.

Kuwait

Kuwait was the world's eighth largest exporter. It exported in total 1.86 million b/d in 2001, including 1.2 million b/d of crude. Kuwait has a spare capacity of some 300,000 b/d above current production. An old ambitious plan to take production from 2.1 million b/d to 4.0 million b/d by 2004 will not be realised before many years. Its proven reserves are very large at 96.5 billion barrels.

In the short-term, Kuwait faces technical constraints following last's year incident (the fire at Rawdhatain oil field in January 2002), and a more significant risk from the present geo-political conjuncture. In the medium and longer term, the main sources of uncertainty are internal politics, relating respectively to the stability of the ruling elite, and to the issue of foreign participation and ownership in the sector.

Iraq

Despite drastic difficulties, dilapidated facilities, and strained oil fields, Iraq ranked as the world's 9th largest exporter. While total crude output managed to reach 2.4 million b/d, Iraq exported some 1.7 million b/d in 2001. These production levels are well below recent peaks of 2.5-3 million b/d, below the 3.5 million b/d produced in 1978, and way below ambitious long-term targets to produce aggressively at 6 million b/d. Current supplies are really produced in crisis mode, and the industry is in urgent need of spending money on rehabilitation of all aspects of production. Iraq's potential as a major supplier remain buoyed by proven reserves of over 112 billion barrels, which should enable production in the very long-term..

Iraq faces immediate economic constraints arising from sanctions preventing export increase. Its entire supplies are at risk in the likely event of an American strike, Iraq's entire production and exports will come to halt, and the speed of recovery is difficult to predict.

UK

In 2001, the UK was the world's 10th largest exporter. Its net oil exports for that year were at nearly 1.7 million b/d. Oil production was at much higher level of 2.5 million b/d, but below the 1999 peak of 2.9 million. It has no spare capacity. Its current R/P ratio is a mere 5.6 years, and with proven reserves of under 5 billion barrels, the UK faces an immediate technical risk of the natural depletion of supplies.

Mexico

At 3.56 million b/d of crude produced in 2001, Mexico accounted for just under 5 per cent of world production, and with 1.6 million b/d exported, it ranked as the 11th largest exporter. It has no significant spare capacity. PEMEX has historically pursued a policy of maximising output from existing fields. Indeed output for 2001 represents a historical peak. It plans to raise output to 4 million b/d in the next few years. Its proven reserves have been stagnant recently and currently stand at 27.7 billion barrels.

Unless new fields are discovered and brought into production, it is hard to see Mexico satisfy growing domestic consumption.

Mexico's oil production may well face significant supply tightness and technical risks by 2020 if it does not secure the necessary investments. A hotly debated issue is the opening up of the oil upstream sector to foreign investment.

Canada

In 2001, Canada was the world's twelfth largest exporter, although it had a much larger share of world oil production. While output for that year reached a historical peak of nearly 2.8 million b/d, its net oil exports were at over 1.3 million b/d. It has no significant spare capacity. Its current R/P ratio is at a under 9 years, and proven reserves at under 7 billion barrels. However, Canada is known to have huge potential in terms of non-conventional oil in the form of oil sands. Canada will probably cease to be a supplier of conventional oil in the long term because of the natural depletion of reserves but is likely to retain an important player in world oil.

Libya

Libya exported just over 1.2 million b/d of crude and products in 2001, while output reached over 1.4 million b/d. It was the world's thirteenth largest exporter. Libya's current production capacity is estimated at 1.5 million b/d, which is the peak reached in 1997. This is below the historical peak of 3.4 million reached in 1970. Libya could still be said to have a small volume of spare capacity but output flexibility is limited. In the medium term, Libya hopes that output can be restored to 2 million b/d with foreign investment. Proven reserves currently stand at 29.5 billion barrels but under explored acreage and lack of recent investment suggests that this figure could rise as more of Libyan territory is explored. Libya's immediate problem is the US-led embargo. It also faces economic and institutional constraints on its ability to raise production.

Algeria

In 2001, Algeria ranked as the world fourteenth largest exporter. It produced 1.56 million b/d and exports stood at 997,800 b/d (estimates include refined products, condensates and natural gas plant liquids). Its existing fields still have large reserves, and exploration success rates in other areas have been high, indicating great medium term potential. Its proven reserves are near 9 billion barrels. However, recent exploration activities, including the use of enhanced oil recovery systems, may soon imply upward revisions of these reserve estimates. Algeria faces in a number of severe social, economic, and political difficulties in the short to medium term. These have not threatened supplies but may constrain growth.

Oman

Oman exported 917,000 b/d in 2001, and produced 959,000 b/d of crude, which is very near the 2000 peak of 961,000 b/d. As such, it was the world's fifteenth largest exporter. Despite significant exploration and development investment in recent years, including the used of enhanced recovery techniques, Oman's proven reserves have remained stagnant and currently stand at 5.5 billion barrels with a R/P ratio of just over 5 years. As a consequence, Oman will face the prospect of declining output in the medium and long term, as well as problems in maintaining current levels of crude supplies in the short term.

Indonesia

In 2001, Indonesia was only the world's sixteenth largest exporter. Its net oil exports for that year were nearly 795 000 b/d (of which 599,000 were crude oil). Oil production has remained flat at around 1.3-1.4 million b/d for the past few years down from the maximum output of 1.6 million b/d that was reached in 1994. It is has no significant spare capacity, its current R/P ratio is just 10 years, and proven reserves stand at 8 billion barrels. There is political unrest and civil strife in Indonesia and terrorist incidents have occurred. A decline in oil production, combined with increasing domestic consumption, is expected to cause significant fall in exports in the next few years.

Qatar

Qatar is one of the world's smaller exporters, and is ranked seventeenth in the league of exporters. In 2001, it produced 783,000 b/d, which is just below the peak level of 790 reached in 2000. Exports in 2001 stood at 684,000 b/d, most of which consisted of crude oil. In the last few years, Qatar has been investing significantly and taking several measures to encourage foreign firm participation. This should help extend the life of existing fields and lead new discoveries, although no great surprises are likely. Its proven reserves are likely to remain at around 15.5 billion barrels, and they should last into the long term at the current rate of production. Qatar faces significant geo-political risk. A US-Iraqi war could have a long-term destabilizing impact on the political regime.

Kazakhstan

Kazakh exports continued to rise and peaked at 631,000 b/d in 2001, and crude output reached 882,000 b/d. The local oil industry faces significant technical and economic constraints in the short-term, as Kazakhstan lacks the required infrastructure and pipelines, with recent projects also delayed. Its proven reserves of near 8 billion barrels are low but recent exploration activities suggest that these reserves estimates are very conservative. Kazakhstan's future export plans are ambitious because of recent significant exploration successes. The main problem for Kazakhstan's oil industry are its limited installed production and export facilities, which will require economic resources and political stability if they are to be expanded.

Angola

Thanks to steadily rising output over the last decade, Angola is now Africa's second largest producer after Nigeria. Exports reached 660,000 in 2001, the same year that it produced 731,000 b/d compared to a peak of 745,000 in 2000. Virtually of Angola's oil reserves are located offshore and its capacity is being developed gradually. Investments in the sector have reached $4 billion recently, but are expected to rise to around $18 billion in the short-term. This will allow production to double by 2007. Angola's proved reserves are currently at 5.4 million barrels, but are expected to increase significantly given the major investment in exploration by the major companies.

Angola is still currently considered as facing high overall political risk as civil war only ceased a few months ago. Further expansion of the oil sector will require the government to upgrade its administrative capacity in order to speed up investment decisions. However, the political structure remains fragile because of allegations of corruption, abject poverty and starvation amongst a very large proportion of the population.

Colombia

In 2001, Colombia accounted for 1.5 per cent of world oil exports, exporting 526,000 b/d. Production was 616,000 b/d in 2001 compared to a government target of 636,000 b/d and to a peak of nearly 840,000 b/d reached in 1999. The main risk to Colombian supplies is primarily geo-political in nature. The oil industry witnessed a record number of guerrilla attacks in 2001. The 170 attacks on the main Cano Limón oil pipeline are estimated to have disrupted the supply of 24 million barrels, equivalent to 11% of 2001 production. High geo-political risk in the medium term may lead to more disruptions. Domestic and foreign capital needed to maintain current production capacity and identify new reserves is unlikely to materialise until the political situation improves. Colombia does not have large proven reserves, currently estimated at less than 2 billion, with an R/P ratio of under 8 years. Colombian ministerial sources hope new investment could sustain production in the range of 800,000 b/d but there is a technical risk resulting from natural depletion.

2.2 Near-, medium- and long-term supply of oil

Figure 3 summarises the current reserves and export capacity of the main oil exporting countries. The table is based on our own subjective judgment although those countries with immediate spare export capacity are well documented in the literature. Of the top twenty exporters Saudi Arabia, United Arab Emirates and Kuwait are identified as the only three countries with significant spare capacity. Nigeria, Libya and Algeria all have limited spare capacity but this is considered insufficient to materially affect world markets.

Most countries do appear to have the potential to increase their proven reserves base. However, there is a difference between having the ability to increase the reserves base and the actual requirement to do so. For example, Saudi Arabia and the United Arab Emirates have the ability to significantly increase their reserves, but they have no incentive while they have significant spare productive capacity. In contrast, countries such as the UK, Oman and Indonesia do not appear to have much scope to

Figure 3: Main Exporters: Summary of Reserves and Export Capacity

Country	**Country with immediate spare export capacity**	**Potential to increase proven reserves**	**Potential to increase exports in medium term 2010?**	**Country to remain exporter by 2020**
Saudi Arabia	yes	no need	yes	yes
Russia	no	yes	yes	yes, declining
Norway	no	no	no	yes, declining
Iran	no	may be	yes	yes
Venezuela	no	yes	yes	yes
Nigeria	little	yes	yes	yes
United Arab Emirate	yes	yes	yes	yes
Kuwait	yes	no need	yes	yes
Iraq	no	yes	yes	yes
United Kingdom	no	no	no	no
Mexico	no	yes	yes	yes, declining
Canada	no	*	*	*
Libya	little	yes	yes	yes
Algeria	little	yes	yes	yes
Oman	no	no	no	yes, declining
Indonesia	no	no	no	no
Qatar	no	little	little	yes, declining
Kazakhstan	no	yes	yes	yes
Angola	no	yes	yes	yes
Colombia	no	no	no	yes, declining

Notes: This table combines information from OPEC, BP, and the US Department of Energy.

* non-conventional oil

Figure 4: 2001 Production, Capacity and Spare Capacity (‘000 bbl/d)

	Prod	Capacity	Surplus
USA	7717	7949	232
Canada	2763	2846	83
Mexico	3560	3667	107
Total North America	**14040**	**14461**	**421**
Argentina	822	847	25
Brazil	1337	1377	40
Colombia	627	646	19
Ecuador	416	428	12
Peru	102	105	3
Trinidad & Tobago	135	139	4
Venezuela	3418	3521	103
Other S. & Cent. America	144	148	4
Total S. & Cent. America	**7001**	**7211**	**210**
Denmark	342	352	10
Italy	79	81	2
Norway	3414	3516	102
Romania	130	134	4
United Kingdom	2503	2578	75
Other Europe	341	351	10
Total Europe	**6808**	**7012**	**3850**
Azerbaijan	300	309	9
Kazakhstan	828	853	25
Russian Federation	7056	7268	212
Turkmenistan	162	167	5
Uzbekistan	172	177	5
Other Former Soviet Union	134	138	4
Total Former Soviet Union	**8652**	**8912**	**260**

Figure 4: 2001 Production, Capacity and Spare Capacity (‘000bbl/d) (continued)

	Prod	Capacity	Surplus
Iran	3688	3799	111
Iraq	2414	2486	72
Kuwait	2142	2300	158
Oman	959	988	29
Qatar	783	807	23
Saudi Arabia	8768	11000	2232
Syria	551	567	17
United Arab Emirates	2422	2650	229
Yemen	458	472	14
Other Middle East	49	51	1
Total Middle East	**22233**	**25119**	**2886**
Algeria	1563	1610	47
Angola	731	753	22
Cameroon	80	82	2
Republic of Congo (Brazzaville)	271	279	8
Egypt	758	781	23
Equatorial Guinea	181	186	5
Gabon	301	310	9
Libya	1425	1500	75
Nigeria	2148	2212	64
Tunisia	73	75	2
Other Africa	284	293	9
Total Africa	**7814**	**8081**	**267**
Australia	733	755	22
Brunei	195	201	6
China	3308	3407	99
India	782	805	23
Indonesia	1410	1452	42
Malaysia	788	812	24
Papua New Guinea	57	59	2
Thailand	178	183	5
Vietnam	350	361	11
Other Asia Pacific	143	148	4
Total Asia Pacific	**7943**	**8182**	**238**
TOTAL WORLD	**74493**	**78978**	**4486**

Figure 5: Projections of Oil Production Capacity 2010-2020 under 'Low Growth' scenario (OIES base case) and 'High Growth' scenario ('000bbl/d). (cont'd overleaf)

Country	**2001**	**2010**	**Home 2020**	**Best 2020**
USA	7949	7700	5700	5800
Canada	2846	3000	3500	4200
Mexico	3667	4000	4800	5500
Total North America	**14461**	**14700**	**14000**	**15500**
Argentina	847	1000	900	1000
Brazil	1377	1500	1700	2400
Colombia	646	850	700	850
Ecuador	428	300	200	200
Peru	105	90	60	60
Trinidad & Tobago	139	90	60	60
Venezuela	3521	4600	6000	7500
Other S. & Cent. America	148	50	30	30
Total S. & Cent. America	**7211**	**8480**	**9650**	**12100**
Denmark	352	100	50	50
Italy	81	90	50	50
Norway	3516	3000	1700	1700
Romania	134	90	50	50
United Kingdom	2578	1500	700	700
Other Europe	351	300	200	200
Total Europe	**7012**	**5080**	**2750**	**2750**
Azerbaijan	309	1200	1300	1500
Kazakhstan	853	2000	2400	2700
Russian Federation	7268	9500	10000	10500
Turkmenistan	167	200	120	150
Uzbekistan	177	150	100	100
Other Former Soviet Union	138	100	100	150
Total Former Soviet Union	**8912**	**13150**	**14020**	**15100**

Notes: Includes crude oil, shale oil, oil sands and NGLs (natural gas liquids - the liquid content of natural gas where this is recovered separately)Source: Data for 1995 and 2001: BP, Statistical Review of World Energy, June 2002. Projected data are by OIES.

Figure 5: Projections of Oil Production Capacity 2010-2020 (continued)

Country	**2001**	**2010**	**Home 2020**	**Best 2020**
Iran	3799	4800	4500	4800
Iraq	2486	5000	6000	6000
Kuwait	2300	2800	2800	3500
Oman	988	600	400	400
Qatar	807	700	600	600
Saudi Arabia	11000	13000	18000	20000
Syria	567	300	100	150
United Arab Emirates	2650	3500	3500	3700
Yemen	472	200	100	150
Other Middle East	51	50	50	100
Total Middle East	**25119**	**30950**	**36050**	**39400**
Algeria	1610	2650	2650	2800
Angola	753	1300	1700	2200
Cameroon	82	50	40	40
Republic of Congo (Brazzaville)	279	250	180	180
Egypt	781	500	300	300
Equatorial Guinea	186	250	250	250
Gabon	310	200	120	120
Libya	1500	1800	1800	1800
Nigeria	2212	2800	3000	3500
Tunisia	75	50	10	10
Other Africa	293	160	100	100
Total Africa	**8081**	**10010**	**10150**	**11300**
Australia	755	600	570	570
Brunei	201	100	60	60
China	3407	4000	3300	3600
India	805	1100	700	700
Indonesia	1452	900	600	600
Malaysia	812	600	400	400
Papua New Guinea	59	30	10	10
Thailand	183	150	80	80
Vietnam	361	250	100	100
Other Asia Pacific	148	170	100	100
Total Asia Pacific	**8182**	**7900**	**5920**	**6220**
TOTAL WORLD	**78978**	**90270**	**92540**	**102370**
Of which: OPEC	30181			
Non-OPEC	48797			

significantly increase reserves. These mature provinces are struggling to sustain let alone grow reserves. Elsewhere some countries, such as Norway might have the potential to increase reserves but it is likely to be limited in comparison to countries such as Iraq and Iran.

Of course there is a real linkage between the potential to increase exports in the medium term and the potential to increase reserves. Therefore those countries, such as the United Kingdom, Oman, Indonesia and Norway, which we identified as having limited potential to increase proved reserves, will also have difficulty in increasing export capacity.

Looking longer term, it is possible to identify those countries that might be unable to continue exporting oil. We have identified the United Kingdom and Indonesia as being two countries that will become net importer by 2020. In addition, we expect Russia, Colombia, Oman, Qatar and Norway to remain net exporters, but the impact of depletion could reduce their relative importance. The major resource holders of the Middle East, such as Saudi Arabia and Kuwait, are expected to remain major exporters.

In Figure 5 we have estimated the maximum productive capacity for the major oil exporters over the medium- and long-term. For 2020 we have estimated maximum production capacity under our own scenario (equivalent to the 'Low Growth' scenario) and our High Growth expectation of production capacity under ideal economic conditions ('High Growth'). In our view, medium term (by 2010) productive capacity could rise by 16 million b/d to 92 million b/d. However, our analysis suggest that the major exporting countries will have difficulty in sustaining this production capacity beyond 2010 and without further investment, production capacity could fall back to 88 million b/d by 2020.

This has important implications. If demand for oil rises at historical levels then there will be sufficient spare capacity by 2010, which could be utilised to meet oil demand after that date. For example, productive capacity only rose by 6 million b/d in the six year period from 1995 to 2001 to meet rising demand, and it seems unlikely that in eight years to 2010 oil demand will rise at almost twice the rate. However, if demand for oil did reach 90 million b/d by 2010, there would be considerable tightening in the market after that date if productive capacity became as constrained as we envisage.

Current estimates of spare production capacity available in January 2003 are shown on Figure 4. Most countries have spare capacity of around 3 per cent to take account of down time and to allow some flexibility in the system. However, relative to 2002 levels of production, Saudi Arabia has approximately 3mb/d, which could be activated over 4 months by tranches (1mb/d within one month, another 1mb/d within the second month, 0.5mb/d within the third and 0.5mb/d within the fourth month). In addition, the UAE could increase production by 100,000b/d within a month, another 100,000b/d within the third month. Kuwait could add 100,000b/d within one or two months and Libya 50,000 to 75,000b/d within two months.

In Algeria, the constraints are more to do with lifting rather than production capacity, which is expected to rise to 1.5mb/d by the middle of 2003. Current production is 900,000/950,000b/d. Algeria does not have the 1.2mb/d midstream capacity (pipelines, SBMs, storage and other port facilities) required to export the maximum volume corresponding to the 1.5mb/d production volume. In fact, new pipelines are unlikely to be completed before the end of the year with port facilities taking longer to complete.

We do not believe that Nigeria can produce more than they are achieving at present on a sustained basis. The production volume fluctuates from month to month due to a host of factors: technical, managerial, institutional (like in Iran) and because of strikes and other incidents. Therefore all the talk that Algeria and Nigeria are presently constrained by OPEC policies is not credible.

2.3 OIES production capacity estimates and implications for 'Low Growth' and 'High Growth' scenarios

The 'High Growth' scenario assumes 2.6% growth in oil demand from 2000 to 2200. This is extraordinarily unrealistic. For demand to grow at that rate requires the world economy to grow at 4% per annum (at least) over 20 years and oil production capacity in 2020 to reach the very implausible level of 124 mb/d. The 4% rate of economic growth is arrived at assuming that oil demand increases at about 0.66 times the rate of economic growth, which is a generous assumption. The capacity level of 124 mb/d in 2020 is needed to meet the 121mb/d of demand in 2020 generated by the 2.6% annual growth rate over 20 years and allow for 3mb/d surplus capacity which the system must hold to avoid friction and cope with any supply or demand contingencies.

If we assume that extant capacity for oil liquids (crude oil and condensates) is 79mb/d today, the additional capacity required under the High Growth scenario will be of the order of 45 mb/d. The most bullish estimates that we are able to conceive for capacity increases by 2020 by country are shown in Figure 6 (our 'High Growth' scenario). In our view, the 45mb/d of additional capacity is unattainable. In fact even an additional capacity of a more modest 30mb/d is outside the range.

The Low Growth scenario assumes 1% annual growth until 2020. This projects demand for liquids to 90mb/d in 2020, which will require a capacity of 92-93 b/d. That is an increase of 13-14 mb/d, which is achievable. In summary, our High Growth possible scenario would take demand to 103mb/d in 2020 and our low scenario (identical to Low Growth) to 90 mb/d (Figure 5).

Figure 6: Realistic capacity increases 2000-2020

Country	**mb/d**
Saudi Arabia	9
Russia	3
Iraq	3
Venezuela (conventional oil)	2
Kuwait	1
UAE	1
Iran	1
Other Latin America	2
Caspian	2-3
Algeria	1
West Africa	2-3
Others	1
Sub-total	28-30
+Canada & Venezuela non-conventional	3-4
Total	**31-34**
Less capacity reductions:	
North Sea	3-4
ME non OPEC and Egypt	1
US and others	2-3
Net	**24-28**

3. Potential Supply Disruptions

A table showing the main risks of supply disruptions is shown below.

	Home			Best		
	Near	Medium	Long	Near	Medium	Long
Economic	Low	Low	Low	Low	Moderate	Moderate
Political	Sporadic	Sporadic	Sporadic	Sporadic	Sporadic	Sporadic
Institutional	Low	Low	Low	Low	Moderate	Moderate
Technical	Low	Low	Moderate	Low	Moderate	High

The rationale behind each of these subjective judgments is discussed below.

3.1 Geo-politics/National politics

3.1.1 The Middle East

Recent history tells us that oil supply disruptions in the Middle-East (or more precisely the Gulf region) were due to two different types of events: the Arab-Israeli conflict and political instability leading to a revolution in a major oil-exporting country. The former was responsible for disruptions of different degree in importance in 1956 and 1973; the latter for the 1979 supply problems. History also tells us that disruptions do not necessarily follow every Arab-Israeli war or Palestinian *intifada*, every regional war or political regime change. The 1967 Arab-Israeli war had a negligible impact on oil supply, as there was sufficient surplus capacity to compensate for the short-term disruption of Middle East supplies. Similarly, the rise in oil prices in 1973 was inevitable given the lack of investment in the upstream business in the five presiding years and therefore the shortage of spare capacity in the even to f any supply disruption. The regime changes in Algeria were not noticed on the oil front. More remarkably the long Iraq-Iran war of 1981-8 coincided with a period of falling oil prices. The Iraqi invasion of Kuwait and the subsequent UN military response (Desert Storm) disturbed the oil market over a relatively short period of five and a half months. The episode, however, was remarkable in one respect: the speed with which a sudden supply reduction of about 4.5mb/d to the world market was fully compensated by increased supplies from Saudi Arabia and the UAE. Serious conflicts or destabilizing political events may or may not cause a significant disturbance in oil markets, and when they do the duration of the crisis could be so short in some instances as to leave no real impact, or sufficiently long as to have durable effects.

History tells us nevertheless that in assessing the contemporary situation we must consider as potential causes of oil supply disruptions: the Arab-Israeli conflict which has been going through a violent phase today, the US-Iraqi conflict that may lead to war, and the threats to the stability of political regimes in countries such as Saudi Arabia, Kuwait or Iran.

The Arab-Israeli conflict is expressing itself today not as a war between nation-states (Egypt, Syria, Jordan versus Israel) as in 1948, 1956, 1967 and 1973 but as an *intifada* that is a civilian uprising involving acts of violence from Palestinians against both Israeli civilians and military personnel. These actions lead to Israeli retaliation, which also involves acts of violence that induces further Palestinian responses. Neither Israel, nor Palestine are oil-exporting countries. The Arab world, which holds huge hydrocarbon reserves, produces and exports considerable volumes of oil feels for the Palestinians. There is enormous frustration at the US policy towards the conflict and at the failure of the Arab regimes to stand up to either the USA or Israel. There is also deep sympathy for the sufferings of the Palestinians – an oppressed people on territories occupied by a colonial and repressive power.

Whatever the merits of the respective cases of Israelis and Palestinians, the relevant point in the context of this study concerned with the security of oil supplies is the perceptions of Arabs and other Muslim countries (e.g. Iran), which happen to be sitting on huge oil reserves.

Arab frustration with the unresolved Israeli-Palestinian conflict has important impacts on the polity of Arab countries. The possible political effects include:

- the expansion of underground terrorist groups and consequent increases in violence both within and outside the Muslim world.
- a strengthening of legitimate Islamic and nationalist political parties or movements who may either become the majority party in those countries where democratic elections are held or induce non-democratic regimes to adopt policies advocated by Islamists and more generally by nationalists.

- Islamic radicals managing in some countries to overthrow the existing regime either through a military coup d'état led by officers sympathetic to the radical Islamic tendency or by a popular revolution as was the case in Iran in 1979.

The implications of these three types of political effects on oil supplies may be as follows:

Case 1 that is terrorism may result in damages done to an oil installation (oilfields, pipelines, processing plants, terminals, refinery) or to oil shipping. This could also happen to gas installations/tankers with repercussions on oil prices. The terrorist action could take place anywhere in the world, not exclusively, not necessarily in oil-exporting countries. The probability of such incidents occurring is far from negligible but the damage they cause is likely to be small when assessed at the global level. One or two tankers hit once every six or twelve months does not cripple oil shipping; the sabotage of a pipeline is usually rapidly repaired; and a fire in a refinery or in a few oil wells do not disrupt world supplies in a very noticeable way. Acts of terror have, however, a psychological impact that causes prices to rise over a short period. The terror incidents that would have a significant impact on oil supplies are those that cause great damage to a major oil export terminal (Dhahran in Saudi Arabia for example) through say the hijacking and ramming of a tanker or, to pumping stations along an important pipeline or to gas separation and other processing plants on a major oilfield. The probability of these types of incidents occurring is very small.

Case 2 being a significant increase of the Islamist and nationalist political influence (direct or indirect) in an oil-exporting country could have two different effects on oil. The first is increased militancy in oil policy, including demands for restrictive production programmes in OPEC or in association with OPEC, and greater reluctance to open doors to foreign investments in the upstream sector. The second set of effects arise from the loss through emigration of competent oil professionals who may leave the country because of their liberal or secular inclinations, from the difficulties of (or the refusal to) recruit Western technicians, and from the introduction of restrictive laws and regulations which hinder performance. In all these instances oil production may fall either in a sudden single drop or in a decline over a period of time. Sooner or later the decline will however stop but the higher output levels obtained earlier on are never recovered.

Case 3 being a change of the political regime through a military coup or a popular revolution that brings Islamists or radical nationalists to power would have effects similar to Case 2 in nature, but more marked in intensity. The immediate impact on the oil market of a revolution in a major oil-exporting country is a price increase due to uncertainty. Prices will rise even if oil production is not reduced or interrupted but in this case the increase will be short lived. If the revolution results in a drop or an interruption of production the price rise will be both significant and of longer duration. This case is similar to what happened in 1979 because of the Iranian Islamic revolution.

The impact in the medium-term is a fall in oil production, which stabilizes (as mentioned above under Case 2) well below peak levels previously attained.

The US-Iraq conflict, which is likely to lead to a US military intervention in Iraq, unless the Saddam Hussein's regime is overthrown by a military coup d'état, will have the following impact on the oil market. It is important to distinguish a number of stages in a military intervention scenario.

Stage 1 refers to the military action itself. As soon as the war begins there will be a complete interruption in Iraqi oil exports. The supply loss to the world export market will then be as high as 2 million barrels/day if the intervention occurs at a time when Iraq would be producing at maximum current capacity. But the volume of Iraqi exports has been fluctuating in recent years from close to nothing to a maximum of 2.2 million barrels/day. These fluctuations are due to the outcome of negotiations with the United Nations over the oil for food programmes and the oil price formulae that have to be agreed upon at regular intervals.

Clearly the immediate oil supply, and therefore price, impact at the beginning of a military intervention will depend *among other things* on the size of the Iraq, export volume at that time. Other factors will plan an important role however. If Iraq immediately responds to the military attack by launching scud missiles on Israel, Kuwait or Saudi Arabia oil traders will panic and push prices up. If, on the contrary, traders see that Iraq has failed to use the small number of missiles it is believed to possess and any weapon of mass destruction, we could well witness a fall in price.

The loss of Iraqi exports – assuming it to be as high as 2 m/barrels per day – may or may not be compensated for by increases in oil production in Saudi Arabia (and to a smaller extent in Kuwait, the UAE and other countries holding small amounts of surplus capacity). If quickly compensated for, the oil price is likely to fall. If not, and if on top of that, the USA and the IEA fail to implement credible measures for releasing strategic stocks and distributing emergency supplies to affected nations, then the oil price (once again other things being equal) will rise.

The question of whether Saudi Arabia will immediately compensate for the Iraqi shortfall will depend on whether the Saudi government sees greater risks in refusing US demands for higher production or in acceding to these demands and alleviating a Saudi population deeply upset by US policy or Palestine and Iraq. The Saudi action (producing more oil or not) will depend on the outcome of a judgement on what constitutes the greatest risk to the stability of the regime. What is certain is that the Saudi government will be slow at reaching a decision.

We need next to ask whether Iraq will blow up its oil wells as it did in Kuwait in 1991. President Saddam Hussein is convinced that the Americans are not only after him and his regime but after Iraq's oil wealth. If he had any doubts about that they would have been swept away by the views expressed by many Western commentators and journalists. The prize is Iraqi oil. Aren't we constantly reminded that President Bush, Mr Cheney and other prominent members of the current US administration had, or still have, interests in the oil industry as shareholders, former executives or consultants? President Hussein will want to deny the prize to his US enemies but since he cannot deny it altogether, blowing up the wells and other installations will at least delay the moment when the US will be able to enjoy the access to this wealth.

If Saddam Hussein succeeds in blowing up the oil wells and some important plants (and this depends on whether his men will obey his orders and on whether US troops will occupy the oil fields before the fuses are lit etc) then the world export market will be denied some 2 million barrels/day of Iraqi oil for at least one year after the end of the military operations. Compensation from increased Saudi production is particularly critical in this case.

Stage 2 refers to the political situation in Iraq after the military intervention. In our view the military phase is likely to be short (let us say a *maximum* of 3 or 4 months and most probably a shorter period) because the Iraqi army is no match to the superior US technology. The army morale is low, and urban guerrilla warfare led by elements of the Republican guard, the security services and the apparatchik of the Party may be very bloody but unlikely to last a very long time. The difficult task that will face the USA is not so much the military operation but the management of the political situation in Iraq after the intervention. There will be unrest, incidents and instability (even if this does not involve a civil war) whether attempts are made to install a 'democratic' government, or the government is handed to a military dictator, or the USA decides to govern directly as in Germany or Japan after the Second World War (although this is unlikely).

There will be unrest because a 'democratic' government will not be able to achieve a peaceful consensus among the different ethnic and religious groups that constitute other Iraqi population and between the various political tendencies existing in the country (baathists, Arab nationalists, Islamists, communists, secular liberals etc). A military dictator who cannot afford to be as ruthless as Saddam just after his demise will have difficulties in stabilising the country. A Sunni dictator will face either or both Kurdish and Shia unrest; a Shia dictator will face challenges from Sunni military officers. The Sunni Arab minority has dominated Iraq both under the Ottoman rule and since independence. It will not give up its historically privileged position without a fight.

The oil industry will not flourish in an unstable Iraq. The idea that Iraq will open its doors to the foreign oil companies who will rush in, develop new oilfields and mend existing ones very rapidly is not realistic. The negotiation of new contracts between the Iraqi government and foreign oil companies will take time. Political instability in the country will cause the companies to hesitate and take their time. Expect delays therefore.

Will a US military intervention in Iraq have an impact on the Arab world and by implication on oil supplies? The answer is yes but the impact is likely to be of the same *nature* as (but of greater intensity than) that of the Arab-Israeli conflict which was discussed earlier on: more terrorism, strengthening of Islamist political tendencies, possible Islamic revolutions in one or two countries. The impact on oil will be as discussed as before. The combination, however, of frustrations due to the Arab-Israeli problem and new frustrations due to the US action in Iraq will increase the likelihood of political effects and aggravate the possible impact on oil. The nature of the effects due to the Palestinian and the Iraqi problems are the same if looked at separately, but adding one to the other may prove to be more than a change in degree. The combination may trigger a response that each crisis on its own will only threaten without actually causing it.

The issue that remains to the raised in this context is whether Arab or more generally Muslim countries will have recourse to the oil weapon that is a policy of oil production reductions combined with an embargo on exports to some countries such as the USA.

The use of oil as a weapon is tempting for both oil importing and oil exporting countries because oil is a 'political' commodity.

The political importance of oil is due, among other things, to the dependence of exporting countries on revenues and the dependence of importing countries on a fuel that is justly considered to the blood of the modern economy.

The dependence of oil-exporting countries on revenues makes them vulnerable to the use of the oil weapon by the consuming countries that have a propensity to impose sanctions. In the past two decades sanctions have been imposed on Libya, Iraq and Iran, and on occasions their use was threatened against Nigeria, for example. These sanctions have been imposed over very long periods and have caused serious hardships, especially in Iraq.

On the other hand, oil is potentially a powerful weapon in the hands of exporting countries. The reason is that oil is a fuel of choice because (a) it can be substituted for any other fuel in any type of energy use with relative speed and ease while other fuels can be substituted for oil in some of its applications only; (b) it enjoys a dominant and impregnable position in the transport sector (cars, trucks, ships and planes) if not in the very long run but certainly for a least a decade or two ahead.

The transport sector is the linchpin of the modern economy. When paralysed, neither labour nor goods can move, and this paralyses very rapidly the rest of the economy. This phenomenon was observed in the UK in the year 2000 when a strike by the drivers of petrol trucks (used to deliver gasoline from the refineries to the service stations) threatened to bring the country to a stop in a matter of three or four days.

In short, the modern economy is vulnerable to any serious disruption of physical oil supplies. The world economy is also vulnerable to the adverse effects on balances of payments of big and sudden rises in the price of oil. One could say that world economic growth is dependent, among other things, on some stability in oil prices.

It is because of this double dependence, first on physical supplies and secondly on price stability, that the oil weapon was used by Arab countries in 1973. We thus have a situation in which both sides – the powerful industrialised countries and the major oil exporters – may be tempted to wield an 'oil weapon' against one another.

This situation, however, is not symmetrical. The Great Powers impose sanctions on individual oil-exporting countries. The target is specific and can be focused without necessarily causing damage to other countries. Damage will only be caused if sanctions reduce oil output at a time when the world petroleum market is tight. And in that case the countries that impose sanctions and all other importers will suffer from the impact of high oil prices. But if these targets are few in number, if the sanctions result in small reductions in output, and if the world market is oversupplied there will be no fall-out on the countries that impose sanctions or on anybody other than the countries that are targeted. And this is indeed what has been happening in recent years with the sanction regime imposed on three exporting countries.

It is infinitely more difficult for oil exporters to target the oil weapon on a specific country. This is because oil is widely and easily traded. It can be shipped from one location to another around the world. An embargo imposed, say, by Arab producers on oil exports to the USA would result in a reshuffling in the trade pattern of sources and destinations. This will cause some temporary inconvenience but the trade systems will ultimately adjust.

To be effective, the embargo would be supplemented by a cutback in total production. In this way reshuffling will not restore the *status quo ante*. It will redistribute the shortfall in supplies among a number of countries. The result, however, will be a significant increase in oil prices that will affect all importing countries – friends and foes alike. In other words, an embargo *plus* cutbacks cause what the military like to call 'collateral damage'. Theoretically, one could devise a compensation scheme in favour of the friendly countries; but it is difficult to imagine that such a scheme will ever be designed and implemented in practice.

The argument often advanced against the use of the oil weapon by exporting countries is that they are dependent on revenues and cannot afford a production cutback. This is a wrong argument. A significant production cut will raise prices by a higher percentage than the output reduction. Revenues will increase. A loss in revenues will only occur if exports are stopped altogether which is not a credible option.

The correct argument is that although revenues will increase, and probably by a multiple in the short run, oil demand, and therefore revenues, will significantly decline in the long run because the oil-importing countries will seek all means, from energy efficiency measures to fuel substitution, to reduce their dependence on oil. The high costs of these policies will not deter them, so deep will the concern about supply security have become.

We have thus noted two main problems associated with the use of the oil weapon: (a) the difficulties to target correctly the countries that are inimical to the Arab cause and the damages that will inevitably be inflicted on friendly countries in Europe, Africa, Latin America and Asia; and (b) the adverse effects on revenues in the long run.

There is a further consideration. In 1973, two superpowers, the USA and the Soviet Union, stood on the world scene. This limited the US ability to intervene militarily in the Middle East. Today, there is only one superpower. And this superpower has given itself the absolute right to intervene whenever and wherever it feels that its interests are being threatened. There is no Soviet Union to inhibit them from occupying oilfields if they feel hurt by an embargo on a production cutback.

Of course in resisting a military intervention, oilfields can be set alight. That simply means that the use of the oil weapon could almost inevitably lead to a catastrophe. Clearly, this is not what the use of oil power is meant to achieve. The aim is to exert pressure in order to change US Middle East policy from absolute commitment to Israel to a more balanced and neutral stance, and to force the USA out of Iraq.

The conclusion is that the oil weapon is available but will only be used by irresponsible governments because it invites military retaliation by a super-power, which today is not checked by another super power. A radical regime coming to power in Saudi Arabia after a revolution may be inexperienced and foolish enough to use the weapon. But as mentioned before this will have more catastrophic effects on the country itself than on those who are targeted by the weapon.

3.1.2 Oil exporting countries outside the Middle East

We are concerned here with the oil exporters of South America, Sub-Saharan Africa, South East Asia, also Russia and the Central Asian Republics. The reasonable assumption is that no political event is likely to threaten oil supplies from Norway, the UK or Canada for example.

Here again history is a guide. There was a radical political change in Venezuela with the election of President Chavez and its inauguration in February 1999. The cause of Chavez electoral success was the gross mismanagement of the economy and the dilapidation of oil revenues by Venezuelan governments in the preceding 20 or 30 years. The large number of poor in Venezuela became poorer; widespread corruption fuelled social tensions; and economic mismanagement badly affected investment in the oil industry and the rate of growth. The political impact was the emergence of a President who is a nationalist demagogue and unfortunately an incompetent manager and leader. Radicalism has an impact on oil supplied because Chavez understood that OPEC co-operation, which involves a reduction in oil output, leads to a badly needed increase on revenues. Incompetent management, however, also meant that a policy-determined reduction in output which can be easily reversed when circumstances change was accompanied by a reduction in productive capacity that continued the trend begun under previous regimes. At the difference of a policy-determined reduction in output, a decline in capacity cannot be as immediately reversed.

Of course, President Chavez may be overthrown any day before the ink dries up on this paper. But this is not the point. The lesson we draw from the Venezuelan case is that *all* oil-exporting countries of the third world (and this includes the Caspian/Central Asian countries) display similar behavioural characteristics. There is widespread mismanagement corruption, increased income inequalities, poor economic performance almost everywhere. Add to that the dismal human rights record, which was some (fortunately not all) of the third world exporting countries with so-called democratic or semi-democratic governments. We think of Colombia, Ecuador, Angola, Nigeria, and other Western African countries, Indonesia, Azerbaijan and Kazakhstan for example.

Political changes in one or more of these countries will bring in governments with oil policy views similar to Chavez are not implausible. To fight corruption such radical governments may turn against foreign oil companies, which operate in their countries whether or not these companies were guilty, or not of misdeeds. To obtain more revenues they may wish to co-operate with OPEC on production programmes. And should they be incompetent and deprived from the foreign companies' investments they may witness shrinkage of oil production capacity.

Russia presents a slightly different case. The stability of the present Russian political regime depends largely on its ability to achieve economic growth, improve the condition of the rural and provincial population, which is suffering increasing poverty, and to keep within bounds the army's anger at the loss of its status from that of a superpower to a middle-range nation. A regime change is possible should Putin, or a successor of the same type, fail consistently on the economic and political fronts. A new regime will turn against the economic oligarchs affecting, for a while at least, the ability of Russian oil companies to promote ambitious growth targets.

3.1.3 The Human Rights Issue

Concerns about human rights violations in exporting nations and about damages done to the environment by foreign oil companies operating in these countries constitute an important political phenomenon. Their impact in reducing the involvement or the scale of operation of the foreign oil companies in these countries has been small so far albeit not negligible. The withdrawal of some companies from Myanmar, for example, may be an important sign of developments to come. These concerns may generate very strong forces that will oblige oil companies to withdraw from some countries or reduce their scale of activity in order to improve their image and standing with Western public opinion, or avoid incidents similar to those faced by Shell in Germany because of the Brent Spar affair. The companies may also decide to abandon their traditional non-involvement stance and put pressure on most governments to improve the human rights record. In some instances this approach may cause conflicts with the government leading to the cancellation of contracts, even nationalisation.

The impact on oil supplies in most of these instances will be a reduction of the growth potential if not some short-term reduction in capacity.

3.2 Institutional Factors

This includes reductions in supply resulting from the actions of a cartel. We already have a weak cartel – OPEC – in oil. Its performance over 42 years of history has not always been successful. The two major successes attributed to OPEC – the price rises of 1973 and 1979 – had more to do with the market conditions prevailing at these precise moments than to an OPEC show of strength. In both 1973 and 1979 OPEC was blamed by the consuming countries for the oil price shocks because it is easier to focus on an agent standing tall on the world stage than on subterranean and anonymous market forces. OPEC helped in attracting this blame because it believed that the price rise was its own achievement, proclaimed that it had turned the tables against the major oil companies and the industrialized countries, and basked for a while in the glory of an apparent success.

The truth, however, is that no merits are attached to a cartel when a price rise is the outcome of excess demand. In 1973 and 1979 OPEC was sailing with the wind. There are merits when prices are prevented from falling (or their decline is mitigated) in a market suffering from excess supplies. The OPEC golden age was neither in 1973 nor in 1979 but in 1974-8 when the oil price was held almost constant at a time of emerging surplus supplies; and in 1982-5 when a catastrophic fall in prices due to a huge supply surplus was moderated into a slow, gradual decline.

OPEC's performance was judged disastrous in 1986 and 1998 when oil prices collapsed down to $8 or $10 per barrel. Paradoxically, these two 'crises', which were the manifestation of price wars, revealed that OPEC was indeed a cartel for the simple reason that only cartels or oligopolists can engage in price wars. They may emerge badly bruised or deeply wounded from the battle but they can be truly identified as a cartel if they do emerge still alive.

For long periods of its chequered history, OPEC failed to prevent falls in the real price of oil, most notably between 1960 and 1967, and between 1987 and 1997. Yet, it managed recently to shift the market subjective view of the 'comfortable' price level from $18 per barrel to $25 per barrel; but it is too early to assess whether this is an ephemeral or fairly durable achievement.

Our judgement is that OPEC's existence has kept oil prices above marginal production costs, even when prices fell down to historically low levels. Oil producing entities (be it countries or companies) were thus able to obtain a rent from the exploitation of oil resources. This feature of OPEC's performance, to our mind, is more significant than the occasional price shocks, which have never proved durable.

Looking at the years ahead, it is reasonable to infer from this long history that OPEC will attempt (a) to prevent prices from falling when the world market suffers from a glut, (b) to reverse a price fall which it previously failed to prevent, and (c) to shift the price target from one level to a higher one in an episode fashion when the oil supply/demand balance seems to be tightening, or when member countries happen to place more value on revenues than on market share.

There will be instances between today and the beginning of the next decade when significant increases in capacity in places such as Russia, Iraq, Nigeria, the Caspian or Venezuela coinciding with economic recession will put a strong downward pressure on prices. And OPEC may not then be able to prevent some temporary fall but will attempt to reverse them as soon as market imbalances begin to recede.

One or two political crises are likely to occur at some unpredictable date causing prices to rise sharply albeit temporarily. Shocks, however, elicit responses in the form of both supply and demand adjustments. Severe shocks cause governments to adopt energy conservation policies and to provide incentives for fuel substitution and for R & D for new fuels. Severe shocks also push the world economy into recession, which in turn reduces demand for oil and energy in general. Demand for oil is more strongly influenced by drops in income than by price rises at least in the short term.

Price shocks may not cause a permanent upward shift in the oil price curve. They usually take the form of a spike on a shift of relatively short duration of that curve. The more likely consequence of a shock of great intensity or long duration is the ushering in of a subsequent low-price episode.

A gradual tightening of the oil supply/demand balance which could begin some time during the second decade of this century would enable OPEC to ‘sail with the wind’ and steer prices on a higher path. This will not require the spending of very great effort because market conditions will be doing most of the work. A wise OPEC should then disband since its members would continue to reap rewards without incurring blame. But human nature being what it is the member countries would be reluctant to leave the stage and the limelight. OPEC is at greater risk of collapse when the market remains affected for a long time by excess supplies than when the supply/demand balance underpins price stability, or a slow and gradual rising trend.

3.3 Economic Factors

A cross-section analysis of oil production by country does not show a strong correlation with the size of countries' reserves. Put differently, R/P ratios vary considerably from one country to another. R/P is as low as 6 or 8, offshore UK and Norway, as high as 80 or 100 in some of the Gulf countries. The intensity of resource exploitation differs remarkably from one place to another.

Production is a function of installed extraction, processing and lifting capacity; a function, in other words of investments made in the past and investments currently carried on to explore, develop fields and maintain wells and other plants. An investment drive in attempts to discover new oil or for maintaining or developing further existing fields will either shift the oil supply curve to the right or at worse put the brake on a shift to the left.

A failure to invest at the rate required by the growth of demand eventually gives rise to a situation of excess demand. The supply/demand balances tightens and prices – whether OPEC exists or not – inevitably rise. Of course such a tightening and price rises induce in turn adjustments either on the supply or the demand side or on both but time lags may be involved. If the adjustments are delayed and *ex ante* demand continues to expand against a temporarily inelastic supply curve a price shock will occur. A careful analysis of the market conditions that prevailed in the few years preceding the 1973 shock shows that the rate of investment in capacity in the late 1960s, early 1970s, although very high, was nevertheless insufficient relatively to the growth in world oil demand. Capacity was not keeping pace. And by 1972 or 1973 shrewd observers realized that something had to give in and the something could only be the price. With or without OPEC the oil price would have exploded. The important difference that OPEC made is that it succeeded in holding the new price level during five years following 1973 (1974 to 1978 inclusive) despite the demand stagnation caused by the price shock. The prices of other primary commodities that had risen four to five fold in 1972-3 collapsed immediately after because they were not supported by a cartel however weak or strong.

Failure to invest at a required rate is therefore a critical factor. This failure can arise for a variety of reasons.

- In countries where the oil sector is largely or exclusively in the hands of a national oil corporation, the failure to invest is generally due to lack of funds and poor managerial resources.
- Access to countries with huge reserves is denied to private oil companies who have the resources to invest. In some countries such as Mexico access is denied because oil nationalism is a fundamental element of the political and historical culture. Oil nationalism plays also an important role in Kuwait, Saudi Arabia, Iran and despite recent (widespread) views to the contrary it will play a role in liberated Iraq. In some cases (Iran for example) access is not denied but the terms the country is prepared to concede to foreign investors are not attractive to profit-motivated commercial entities. In other cases (e.g. Kuwait) negotiations for access have been dragging inconclusively for many years.
- Sanctions and embargoes have hindered oil investments in Libya, Iran and Iraq. In punishing an oil-exporting country for some political misdeed, the superpowers may be inflicting costs onto themselves if not immediately at least in the longer term.
- Domestic political unrest, failure of economic development policies, guerrilla operations and the like, restrict the ability to invest of either the national on the private foreign company operating in the affected country. This is the case of Colombia, Venezuela and to some extent Nigeria among others.
- Private oil companies under shareholders' pressure to deliver value have been buying back their own shares (an easier way to give shareholders money than trying to achieve ambitious growth targets). In doing so, however, they end up having fewer funds for allocation to their capex budgets.

Shocks due to political crises such as wars or revolutions are spectacular and attract attention. Failure to increase capacity to meet demand requirements in a future that is inevitably hazy when considered today is rarely noticed. There will be times however, when this failure will have a significant impact on supplies.

3.4 Technical Factors

3.4.1 The impact of depletion on conventional oil supply

Ever since oil was first produced in significant quantities over 140 years ago, debate has taken place on whether the oil will run out within the foreseeable future. Historically, near-term supply concerns arose when the relative rate of production capacity growth fell short of expected rates of demand growth. However, over time changing attitudes to oil supply and demand led to varying perceptions of whether the resource is in short supply or not. Changes in perception have switched around over very short periods of time depending on any particular event on either the supply side or the demand side. The only certainty on the supply side is the volume of oil that has actually been produced.

The introduction of new exploration techniques to boost recovery rates, the revolution in computers which transformed seismic acquisition and processing, the technical innovations that enabled deepwater development and the opening up of new petroleum provinces that were previously closed due to political constraints have all led to a period of optimism that has weakened near term concerns about the exhaustibility of reserves. The fact that the private oil companies are struggling to replace reserves and are lowering targeted rates of production growth is giving rise to supply side concerns again which are probably unfounded at least in the near and medium term

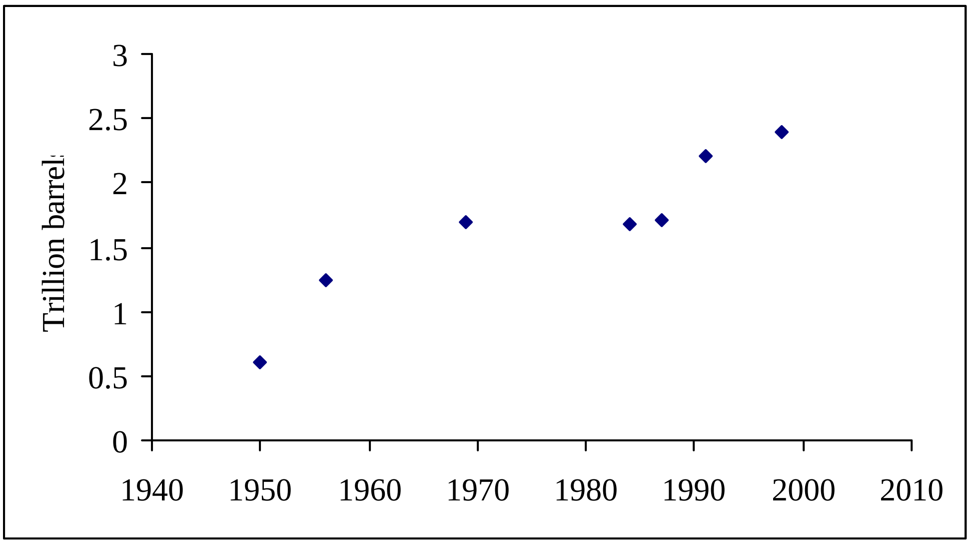
3.4.2 The entry of substitutes will mitigate supply constraints

The issue as to how long oil supply can keep on rising to meet demand forecasts must ultimately take into account potential substitutes. On the one hand, if the variety of oil substitutes is limited, then depletion could result in significant problems for supply especially over the longer term. However, if new oil substitutes are developed and can be supplied at costs that are ultimately competitive with the existing oil supplies, then concerns over depletion would be alleviated. There are many examples of how the energy industry has managed the transition from one fuel source to another without major supply side constraints. For example, coal substituted for firewood and petroleum substituted whale oil for illumination purposes. Furthermore, coal substituted for transportation and gas substituted for coal in domestic heating. Gas and coal are currently competing in the electrical generation sector with gas likely to be the winner.

3.4.3 Oil reserves tend to be understated

With any finite resource there will come a time when unfavourable economics will not permit further extraction. At present the global reserves life is 43 years based on current proven reserves and current levels of supply. However, this reserve life is based on proven conventional reserves alone and reserves can be labelled under a wide variety of physical, chemical and geological circumstances. There are also issues of definition as to what to include or exclude from a particular production forecast, as there are often constraints as to what oil reserves can and cannot be reported because of legal and political considerations. In addition, because there is no uniformity or stated policy as to the time period over which the existing technology and present economic conditions are anticipated to prevail reserve estimates are often inherently conservative.

Table 6: Historic estimations of ultimate recoverable reserves



The distribution of oil reserves can also be viewed as a pyramid with a small amount of higher quality reserves at the top but with an increasingly large amount of lower grade oil lower down. Naturally the cost of retrieving the resource increases lower in the pyramid making larger amounts or oil available at higher prices. The issue as to the total oil resource depends on where the pyramid is sliced and that this is a very subjective decision. There is a danger of circular reasoning if one divides the oil resource estimate by estimates of annual consumption since once the identified oil reserves have been depleted, there will always be a vast amount of oil reserves lower down the pyramid that may become economically viable to recover.

Reserves definitions are by their very nature defined on a probabilistic approach rather than a deterministic approach. An initial declaration of recoverable oil that can, with reasonable certainty, be recovered in the future under existing economic and operating conditions is usually defined as the 'proven' reserves. However, all fields will also be declared as having additional volumes of 'probable' and 'possible' reserves. The definition of 'proven', 'probable' and 'possible' reserves varies across the literature and from country to country. 'Proven' reserves are usually defined as being P90 reserves, indicating that there is a greater than 90 per cent chance that the actual proven reserves base will be higher and a 10 per cent chance that it will be less. Similarly, probable and possible reserves can be defined as P50 and P10 reserves respectively. The important point here is that when oil reserve numbers are quoted in the literature, it must be realised that the numbers are probabilistic and in the case of proven reserves they are more than likely to be exceeded.

In fact, there is a 90 per cent chance that initial reserves estimates of proven reserves will be exceeded. In addition, when such information is summed, eventually, to the regional and national level the simple arithmetic addition of a large number of independent values each representing the 90 per cent probability of a specified volume in a specific reservoir produces a higher joint probability of the total. It is for this reason that field growth and rates of field growth are well documented and are likely continue to be a major influence on additions to oil reserve numbers reported in the future.

Nearly every forecast of reserves since 1992 has been too low and that forecasts for different geographic regions are almost identical despite different fiscal systems, drilling levels and maturity. Recoverable resources are often assumed to be fixed, when in fact the amount of oil that can be recovered depends not only on the total amount of oil, but also dynamic variables like price, infrastructure and technology. If the amount of oil increases, as it has done in the past, then the level predicted for peak production must also increase and the date pushed further into the future. The methodology of deriving estimates of ultimate recoverable reserves from curves showing declining discovery size, moving towards the asymptote, does not take into account the fact that estimates of field size tend to increase through time.

3.4.4 Upward revisions a consistent feature

Upward revisions to reserves over the last five-year period have exceeded 150 billion barrels, 30 per cent more than actual consumption. Indeed, over the past fifteen years alone, reserve growth from existing fields has accounted for nearly 85 per cent of the additions of US reserves, and detailed studies show that additions to reserves from field growth are at least comparable to reserves derived from undiscovered resources. In addition, the total estimate of recoverable reserves is now 10 per cent higher than the total predicted some five years ago and as indicated above, further upward revisions can be expected. The United States Geological Survey (USGS) assessment of the development of field sizes also shows that reserves growth from existing fields is substantial. In fact in 2001, the USGS published a mean estimate of 612 billion barrels from revisions to previously booked oil reserves, significantly increasing their estimate of the world's ultimate recoverable reserves of oil. This is not simply due to the booking of deepwater reserves in West Africa and the Gulf of Mexico, but is also due significant revisions to existing reserves as a result of improvement in recovery factors. Such changes are a demonstration that oil reserve lives estimates are by definition conservative.

3.4.5 Forecasts of a global oil supply peak have been pessimistic

In any analysis of the potential disruptions to the supply of oil, the key technical issue is identifying the time when global production reaches a peak. Many pessimists argue that that the likely peak of oil production would be between 2005 and 2010. However, economic factors could speed or delay the point at which oil production begins to decline. Such economic factors would include the level of investment in new developments and the potential for new technology to defer the timing of depletion. The fact that many commentators have consistently underestimated the volume of oil resources and that predictions for the peak of world oil production have always been some 10 years (on average) ahead of the current year gives ground for optimism that depletion issue are not a problem on the supply side in the near term and medium term. Oil supply constraints are more likely arise from lack of investment rather than a lack of opportunities. In addition, new production methods have always been discovered, and the ultimate constraint upon our capacity to enjoy unlimited supply of oil at acceptable prices is knowledge. As technology advances and costs are lowered, the proportion of reserves in a field that can be recovered economically rises and the size of fields that can be developed falls.

3.4.6 Unconventional Oil Reserves

Of course, all of the arguments outlined above refer to conventional oil reserves and ignore the potential from unconventional oil. Oil is considered to be unconventional if it is not produced from underground hydrocarbon reservoirs by means of production wells or if it need additional processing to produce a synthetic crude. More specifically, unconventional oil production usually includes the following sources:

- Oil shale
- Oil sands-based synthetic crude
- Coal-based liquid supplies
- Biomass liquid supplies
- Gas to liquid (GTL) supplies

Most projections of future supplies of unconventional oil are based upon production from oil sand synthetic crude. At present this type of unconventional oil is projected to grow from 1.3 million barrels per day today to over 4.2 million barrels per day by 2020 assuming that the economics remain at the same level as today. As a result, projects are expected to develop in anticipation of market needs with the gains coming primarily from oil sands in the Canadian province of Alberta, and from the Orinoco extra-heavy crude oil belt in Venezuela.

Although natural bitumen and extra-heavy oil are worldwide in occurrence, a single extraordinary deposit in each category is dominant. The Alberta, Canada natural bitumen deposits comprise at least 85% of the world total bitumen in place but are so concentrated as to be virtually the only such deposits that are economically recoverable for conversion to oil. Similarly, the extra-heavy crude oil deposit of the Orinoco Oil Belt, a part of the Eastern Venezuela basin, represents nearly 90% of the known extra-heavy oil in place.

In Canada, the National Energy Board estimates that about 300 billion barrels of the 2.5 trillion barrels of crude bitumen in the country may be ultimately recoverable. This is almost equivalent to the remaining reserves of conventional oil in Saudi Arabia. In Venezuela, Bitumines Orinoco, S.A. (BITOR) estimates that 1.2 trillion barrels of bitumen exsist in the Orinoco belt, of which about 270 billion barrels, are thought to be recoverable with current technology. Of course, the potential for future oil supply from unconventional oil supplies will in a large part be determined by the production costs. What is not in doubt though is the vast potential of this resource base, which has to date largely remained untapped.

3.4.7 Canadian Oil Sands

The major deposits in Canada are in four geographic regions of Alberta at Athabasca, Wabasca, Cold Lake and Peace River. Although the existence of the tar sand was known in the 18^{th} century it was not until the first development plans for the Great Canadian Oil Sands (GCOS) was not conceived until 1962 and the ownership of the project passed on to Suncor.

Suncor's area of operation, 40 km north of Fort McMurray, is within the Athabasca deposits. The processing capability of the original Oil Sands Plant has been steadily increased and the expansion of the Steepbank Mine (on the opposite side of the Athabasca River) resulted in record production of 105 600 b/d in 1999. At the beginning of 1999 the company announced its "Project Millennium", a phased series of expansions to the Steepbank mine, adding bitumen extraction plants and increasing upgrader capacity. The first phase is expected to increase production to 130 000 b/d by 2001; the second phase to 225 000 b/d in 2003. In 2000, the establishment of an in-situ project at Firebag (40 km north-east of the Oil Sands Plant) was announced. It is planned that Firebag, in conjunction with the open pit mining operation, will result in production reaching 260 000 b/d in 2004. Through a combination of mining and in-situ development Suncor envisages an oil sands production of 400 000-450 000 b/d in 2008.

Syncrude, a joint venture with ten participants (Imperial Oil, a subsidiary of Exxon, is the majority shareholder with 25%) operates the Lake Mildred plant, also 40 km north of Fort McMurray. Production began in 1978 and, using open-pit mining methods, the shallow deposits are recovered for bitumen extraction and the production of upgraded crude oil. Gross production was 223 000 b/d in 1999. A new project – the Aurora mine - a 35 km extension from Lake Mildred, opened in August 2000. The mine's output is partially processed on-site and then pipelined to the upgrader for further treatment. In 1999 the federal government approved a major expansion to Syncrude's upgrading capacity and construction began in 2001. It is planned that the work under development will result in a capacity in the region of 350 000 b/d by 2004.

Imperial Oil operates the Cold Lake oil sands deposits area. The company began commercial development in 1983 and has since gradually expanded facilities – total production of bitumen in 1999 was 132 000 b/d. Imperial plans to bring further expansion on stream so that by late 2002, bitumen production could be increased by 30 000 b/d.

Commercial production of Shell Canada's Peace River in-situ deposits (north-western Alberta) began in 1986. Bitumen production capacity is set at approximately 12 000 b/d although during 2000 the actual production from existing wells was considerably lower. In an attempt to boost declining bitumen production, Shell announced in late 2000 a major expansion of production capacity.

Albian Sands Energy, a joint venture, was created to build and operate the Muskeg River Mine on behalf of its owners: Shell Canada (majority shareholder, with 60%), Chevron Canada and Western Oil Sands (with 20% each). The mine, already under construction, is located 75 km north of Fort McMurray (Athabasca). In addition, a pipeline is to be constructed to link the mine to an upgrader to be built next to Shell's Scotford refinery. The start-up of the project is scheduled for late-2002, with production of 155 000 b/d of bitumen.

Taking into account all operations, total output from Canadian oil sands in 1999 was 323 000 b/d of synthetic crude and 244 000 b/d of crude bitumen from the in-situ plants; together these represented 22% of Canada's total production of crude oil and NGL.

Supply costs cited by the Canadian National Energy Board include all costs associated with exploration, development and production. They also include capital costs, operating costs, taxes, royalties and a 10% real rate of return to the producer. The exploration costs to the producer are minimal as the location and the aerial extent of the oil sands have been well defined.

Between the early 1980s and the late 1990s, operating costs fell from $22 to $10 per barrel through a continuous process of improvements and major recent improvements in truck-and-shovel mining and hydro transport. Industry analysts anticipate that further improvements in technology and operating methods may reduce operating costs to $7 per barrel by 2004 and to $6 per barrel by 2015. A table showing the current supply costs for oil-sand operations in Canada is shown below.

Oil sands in-situ	**Operating cost**	**Supply cost**
Primary recovery - Wabasca	$2 to $5	$5 to $8
Primary recovery – Cold Lake	$5 to $7	$8 to $10
Cyclic steam stimulation	$5 to $8	$8 to $12
Oil sands - mining		
Integrated mining/upgrading	$8 to $9	$11 to $14
Stand-alone upgraders	$8 to $9	$14 to $17
Mining – no upgrading	$4 to $6	$8 to $10

The indication of the increasing cost-competitiveness of Canadian unconventional oil sand production in the global oil market, and expectations that this will continue in the future, is provided by current investment in future projects. Publicly announced development plans for the period 1996 to 2010 amount to nearly $25 billion, of which about $5 billion was spent up to the second half of 2000. According the Canadian National Energy Board, production of synthetic crude and bitumen is forecast to almost triple to about 1.7 million barrels per day by 2015, which could represent over 50% of Canada's projected production at that time. With further cost reductions expected, likely projections of oil production from unconventional sources have the potential to surprise on the upside.

3.4.8 Venezuelan Orinoco Heavy Oil and Bitumen

The exploitation of the Orinoco Oil Belt is a matter of great concern to Venezuela and the subject of intense research relative to improved recovery. An interim technology, which permits recovery in the form of an emulsion, has proved successful. This emulsion, called Orimulsion, solves the production-transportation problem and eliminates refining by permitting the emulsion to be burned directly. Orinoco currently has a production capacity of 270,000 barrels per day of heavy crude, or about 14% of the country's total production capacity.

The long-term desire is to upgrade the extra-heavy oil to refinery feed, which will be economically advantageous. At present, there are four syncrude projects in different stages of development. Petróleos de Venezuela (PDVSA), the state oil company, has a minority interest in all four and all are at different stages of development:

- The Hamaca project (a joint venture between Phillips Petroleum, Texaco and PDVSA) has been delayed owing to financing problems. However, development is currently underway and it is planned to produce 190 000 b/d by 2003.
- The Sincor project, (a joint venture between TotalFinaElf, Statoil and PDVSA) started bitumen production in December 2000. Its upgrading plant came on stream in March 2002 and the project is expected to produce an average of 180 000 b/d this year.

- Production from the Petrozuata project, a joint venture between Conoco and PDVSA, has begun and had reached its target of 120 000 b/d by February 2001. Work to enable production to increase to 150 000 b/d by 2003 is under way. An upgrader will process the 120 000 b/d of 9° API oil, turning it into 103 000 b/d of lighter, synthetic crude, some of which will be used as refinery feedstock to obtain gasoline and diesel for the domestic and export markets. The remainder will be shipped to the US for processing into higher-value products.

- The Cerro Negro is a joint venture project between ExxonMobil, Veba and PDVSA. Output rose from 60 000 b/d in 2000 to 120 000 b/d by March 2001, following the completion of a new coking unit.

Total investments of about $12.8 billion are expected to produce 569,000 of synthetic crude capacity during the next three years, as production of light crude oil declines in the maturing fields in western Venezuela. The thick heavy oil from the Orinoco region must be diluted with lighter oil before it can be pumped through pipelines to the coast, where it is processed further.

Operating costs for heavy oil form the Orinoco region are about $8 per barrel, including extraction and the cost of upgrading it into lighter oil at a refinery. The actual operating cost of extracting the oil is not much different from that of conventional oil (about $3 per barrel in 2000), but the oil is so heavy that it has to be upgraded to a higher quality so it is saleable.

However, the heavy oil projects are attractive because they also incur a lower income tax rate. Heavy oil production is taxed at 34%, rather than the normal rate of 62% incurred by traditional oil projects. All oil operations are however subject to royalty payments of 16.67% of the value of production.

3.4.9 Depletion implications in the short, medium and long term

The evidence outlined above suggest that:

- *In the near term*, supply side disruptions due to depletion are unlikely on a global basis either on the 'Low Growth' or 'High Growth' scenarios, but might become an issue on a localised basis. Disruptions are more likely to be due to a lack of investment in new developments than any lack of opportunities and technology continues to drive down costs this will enable marginal oil reserves to be developed in the near term.

- *In the medium term* (2020), supply side disruptions due to depletion are unlikely on a global basis on either the 'Low Growth' or 'High Growth' scenarios. Once again we believe that disruptions are more likely to be due to a lack of investment in new developments than any lack of opportunities. New investment will increasingly be required to replace capacity lost due to depletion effects. Estimates of the rate of depletion have in the past been greatly overestimated but given that over 70 per cent of current world oil supply comes from oilfields that were discovered prior to 1970 (fourteen of these fields produce over 20 per cent of the world's total supply) management of the decline rates is likely to become of increasing importance in the future. The continued importance of technology will continue to drive down costs enabling marginal oil reserves to be developed.

- *In the long term*, there is a moderate probability that supply crisis would emerge under the conditions of the 'Low Growth' scenario by 2040. On the demand side, it is probably wrong to project current rates of growth well into the future. Therefore the current reserves life of oil is deemed to be irrelevant especially in the context of a global reserves life that has risen to around forty-three years despite the significant increase in global production. In addition, oil supply constraints could also be mitigated by the potential substitution of oil by gas (or even renewables). There have been 46 estimates made in the last 35 years. Of those, 25 have ultimate oil reserves at 2000 Gb or more, including three, which are either at or just below the 3000 Gb level, and one at almost

> 3500 Gb. Ten are at 1800 Gb and eight at between 1500Gb and 1800 Gb. However, although this reserves base is sufficient to meet even the most optimistic demand assumptions it is doubtful whether companies would be able to invest sufficient capital to meet such demand expectations. Therefore, under the conditions of 'High Growth' scenario by 2040 there is every possibility that there could be a supply constraint.

Ultimately, oil is a finite resource, but the real debate is not so much whether we are likely to significantly diminish the resource base within the next few decades but whether prices will fluctuate sufficiently to enable energy substitution. Clearly, volatility in the price of oil will sharpen the debate but this could actually cause unjustified near-term changes in investment patterns by industry and governments alike which will affect the long-term.

4. Supply Disturbances and Supply Shifts

4.1 Short-term (up to 2005)

4.1.1 Scenario 1

Under both the 'High Growth' and 'Low Growth' scenarios, the most probable disturbance that may occur in the near future will be due to a war in Iraq. The probability of a war is as high as 80 per cent. The immediate impact will be a loss of 2 million b/d of Iraqi oil in the world petroleum market. Should Iraq succeed in retaliating on oil installations in Saudi Arabia or Kuwait (probability 10 per cent) oil prices will quickly rise to the $40 per barrel level. If major damage is caused to these installations (probability less than 1.0 per cent) prices may well move higher, that is close to $45 or $50 per barrel and depending on the damage the duration of the price rise will be of the order of several months. If Iraq fails to attack its neighbours, the military operation ends quickly and Saddam Hussein does not set the oil wells on fire, oil prices will quickly fall from the current $25 per barrel level to $20 or even $18 d/b.

If the oil wells are set on fire and Saudi Arabia refuses to compensate for the lost output oil prices will hold for about a year at around $30 per barrel (probability 50 per cent).

4.1.2 Scenario 2

Under both the ‘Low Growth’ and ‘High Growth’ scenarios, terrorist action against oil instillations or tankers is possible (probability 30 per cent for oil fields, 60 per cent for pipelines, tankers and other isolated plants) but the probability of major disruptions is low (less than 5 per cent).

4.1.3 Scenario 3

Under both ‘Low Growth’ and ‘High Growth’ scenarios, a revolution in Saudi Arabia between now and 2005 is unlikely (probably 5 per cent). Political disturbances in Iran have a higher probability (20 – 25 per cent). This may also be the case for Kuwait. Instability in Venezuela could well cause a production disruption in the next few months (probability 25 – 30 per cent). The impact on oil price will be significant if the crisis occurs in Saudi Arabia. In that case, however, the USA will intervene militarily to secure the oil fields.

Problems elsewhere (Iran, Kuwait, Venezuela, etc) would have a greater impact because military intervention, save perhaps in Kuwait, is not a realistic prospect. Thus the disturbance could last for a while and its impact aggravated if it coincided in time with a problem in Iraq or if two or three disturbances occurred at the same time in different places. Probability of coincidence is less than 15 per cent but then prices could move up to $35 - $45 per barrel bracket.

4.2 Medium-term (up to 2010)

Under both the ‘Low Growth’ and ‘High Growth’ scenarios, the probability of a crisis in Saudi Arabia and indeed in other major Gulf countries (including Iran) increases with the passage of time. But the period from 2005 to 2010 is one during which additional supplies may be reaching the market from the Caspian, the West African offshore and perhaps from a pacified Iraq. Russian output would have built up in the immediately preceding years. While the probability of a crisis increases the magnitude of the impact on prices may be mitigated by the increase in supply.

Terrorism will continue to represent a threat (similar probability as for the short term) but the risk of serious damage is likely to diminish because of improved security measures.

In the medium term, however, certain political forces relating to human rights, environmental issues, or an anti-corruption drive may have gained momentum. Other things being equal these may restrict investments in capacity and restrict supplies. Economic difficulties in certain countries, not only in Latin America, Africa or Indonesia but also in Russia or the Caspian could restrict investment. The overall supply situation will thus depend on the magnitude of the positive shifts due to new capacity compared with the negative shifts due to insufficient investment in new capacity or in workovers needed to fight natural decline in old fields.

And as in all cases, the price impact of a supply shift depends also on the state of demand, which means that of the world economy at the time. Prices may fall instead of rising when supply is falling if demand is reduced by a greater magnitude.
Our view of the medium-term is one of fairly weak oil prices with the possibility of a price spike resulting from a political incident in Saudi Arabia. During that incident whose probability is in the order of 20-25 per cent prices could well climb to $50 per barrel. The risk of a political incident in Saudi Arabia is more likely under the 'Low Growth' scenario, which envisages flat real oil prices

4.3 Long-term (up to 2040)

The very long-term problem is one of oil depletion and the rate at which fuel substitutes and new fuel-using types of engines are developed and enter the market. But this is a problem that will begin to be felt around 2020 or a bit later. The period between 2015 and 2020 or 2025 could witness the beginnings of a tighter supply situation because the big increases from Iraq, Russia, West Africa and Venezuela would have occurred in earlier years. Oil prices will then rise and stimulate R & D substitutes, actual substitution and reduction in demand. In other words this would be a period leading to major adjustments in the longer term (2025 – 2040). The risk of supply disruption in the longer term due to depletion is much more likely under the 'High Growth' scenario than under the 'Low Growth' scenario.

5. Policy Responses of Importing Countries

In the past 30 years, following the 1973 and 1979-80 oil price shocks, governments of importing countries have adopted energy policies aimed at reducing their dependence on oil imports. A lower degree of dependence can be achieved either by reducing the level of oil consumption (and if this is impossible at least its expected rate of growth) or by increasing the volume of domestic production, an action which naturally is only available to countries with oil resources. Reducing the level, or the rate of growth of oil consumption, can in turn be achieved by either inter-fuel substitution or increased efficiency in the use of oil. Host governments, the USA remaining the major exception however, used excise taxes to curb consumption of gasoline and other automotive fuels and subsidies to encourage the development and the use of non-oil fuels such as coal or nuclear. In some cases, they provided incentives to improve the efficiency of oil or more generally energy using structures, engines or appliances. The determination with which governments designed and implemented energy policies varies significantly from country to country and from time to time.

In our view, the issue of supply security has been given exaggerated importance by both the USA and the EU. There are of course risks as in any area of human activity. Dependence on imports is a feature of a world where nations trade, and increased globalisation believed by economists and politicians to enhance the welfare of all societies will increase import dependence all round.

The oil issue is complicated immensely by political factors, the emotions that some of them elicit, the memory of the 1973 embargo which hurt the pride of industrialised countries because they were aggressed by developing nations.

It is difficult to disentangle the subjective elements from the positive factors that underlie the perceptions of risks. It is up to governments to decide on the cost/benefit of measures that mitigate risks. This assessment is bound to differ from one government or country to another. Japan, for example has a high degree of risk aversion for its considerable dependence on oil imports from the Middle East. Diversification of import sources is no solution, as it would only reduce the degree of dependence by a few percentage points. So Japan opted for (a) energy conservation, (b) diversification of the energy mix with increased reliance on coal, nuclear and natural gas and (c) on building up a huge precautionary stockpile of oil.

Energy conservation if implemented rationally is a win-win situation but diminishing returns will set in at some point. You can increase energy efficiency but cannot do without energy. Fuel substitution has run into problems because of small nuclear accidents, and because of the lack of a good domestic infrastructure for gas. Coal is not environmentally friendly. The Japanese stockpile is much too big and therefore involves unjustifiable costs.

The US policy includes a strategic stock. The US government favours a supply as against a demand solution to the security problem. But how to develop nuclear against public opinion objections? The US wants to reduce dependence on oil imports from the Middle East. A switch to Mexico, Venezuela and Canada in the Western Hemisphere will not lead to much increase in the volume of oil imported from these sources in the short run. These countries do not have surplus capacity and their ability to switch export destinations in favour of the USA is very limited because they already export most of their tradable oil to the USA. Switching to Nigeria, Russia or Iraq is akin to trading one set of risks for another, albeit to slightly lesser ones.
The EU is in favour of conservation and energy efficiency.

It is important to distinguish two different situations and adopt measures that are appropriate to each case.

- The first situation is a significant supply disruption as in 1973. The appropriate measure in this case is a strategic stock but it is essential to also have a clear and credible system of release in an emergency.

- The second case is one in which oil supplies begin to decline in the long run. The policy measure that is most appropriate in this case is subsidies for the development of non-conventional oil and liquids from gas plus subsidies for R&D in such fields as car engines and hydrogen, and policy measures to improve energy efficiency. Other solutions such as development of solar or wind energy will not solve radically the energy problem.

There is, of course, a major difference between what constitutes the appropriate policies and those that are likely to be actually applied. The importing countries' actual response to future oil shocks and to a possible long term supply tightening will depend on the nature of the event, perceptions about the expected length of the risks, the likelihood of repetitions and, in many instances, on a host of domestic and international political, economic and public opinion factors.

Policy responses would probably be close to the appropriate ones defined above, if they were only related to the exact nature of a crisis, and based on an objective appreciation of its expected duration and the chances of the crisis being a one-off event or the first in a future sequence of events.

Governments, however, may over-react to a temporary crisis, which may well turn-out to be one-off, and introduce costly policies that favour inter-fuel substitution in favour of coal and nuclear for example, because a new oil crisis would have confirmed political public opinion on its view that oil is an insecure energy source and that the Middle East is an insecure region of the world.

Some US lobbies are arguing already in favour of a switch in the sources of US oil imports away from the Middle East and towards Russia, the Caspian, Latin America and or West Africa. A crisis may cause the US government to adopt such a policy. The drawback is that by reducing its dependence on oil imports from the Middle East the US will inevitably increase the dependence of other countries, notably its European allies. Furthermore, the switch will cause some 'frictions' until full adjustments in supply take place and therefore a further temporary rise in oil price.

Governments are always inclined to favour fiscal policies as a means to limit the demand for oil and, other things being equal, to reduce imports. The first reaction to a crisis is likely to be an increase in excise taxes on automotive fuels. This is preferred to subsidies to alternative fuels or research and development since taxes bring in revenues whereas subsidies are an expense. There are instances, however, where encouraging new supplies is more effective than discouraging demand.

Government's responses will be more drastic should the crisis cause physical shortages in the consumer's markets. Long queues at petrol stations, electricity blackouts are much more explosive politically than price rises that take the barrel to the $40 to $45 level. One should recall that governments, again with the exception of the US, could easily mitigate the impact on consumers of a price rise by lowering the excise tax rate. Many can mitigate physical shortages by releasing oil from strategic stocks. The paradox of emergency stocks is that they are rarely used in an emergency because governments fear that an unfolding crisis may involve even greater emergencies in the near future. The development and the severity of a crisis is only fully known when it ends.

A situation can arise where several OECD governments decide to hasten the decline of oil from the energy slate with ambitious programmes to develop substitutes. Such a plan was introduced in the US in the 1970s but was abandoned when oil prices began to fall. Well, almost by definition prices fall after a shock, and money conscious governments beset by other calls on budgets would abandon expensive schemes, as has happened in the past. Serious and sustained attempts to free a country from oil will only be made if the trauma, political and economic, of a crisis is extensive and very deep. In our judgement this is an unlikely occurrence.

4 EXPLORATION OF FUTURE RISKS FOR GLOBAL ENERGY MARKETS OF COAL

1. Summary

On a global scale, coal is still significant with a contribution to primary energy demand that is at present only exceeded by oil. Although coal reserves are vast and are widely dispersed, consumption is increasingly concentrating in a small number of countries and in a few main uses. As a result, concerns over coal supply security are likely to remain minimal especially as almost half of current reserves are located in OECD countries.

The continuing use of coal in all its markets is threatened by environmental concerns reflected in tightening regulations and international agreements. Coal is particularly vulnerable as it contributes 38 per cent of the world's total carbon emissions from commercial fuels, and is also a major source of sulphur dioxide and nitrous oxides emissions as well as particulates and other environmental hazards. [1]

2. The Key Exporting Countries

2.1 Coal Resource Base

Coal reserves are vast and are widely dispersed (Table 1). Nearly 50 per cent of proved world coal reserves are found in the leading three countries (United States, Russia and China). In turn, at 2001 rates of production, the reserve to production ratio is over 200 years, particularly in the case of the Russian Federation. Even if one assumed the most optimistic growth estimates for the demand for coal the reserves to production ratio is still expected to remain above 100 years by 2040. The IEA currently estimates coal demand to rise by 1.7% annually such that 117 billion tonnes will be consumed in the period up to and including 2020, compared to current reserve estimates in excess of one trillion tonnes. This reserves base has also grown by 50 per cent over the past 22 years.

Of course, these numbers hide large variations in terms of accessibility, quality and cost. The quality and geological characteristics of coal production are more important than the actual size of the deposits. For example, Australia, Canada and the United States all have high quality coking coal. Table 1 shows that coal reserves are far more evenly distributed around the world than oil or gas. This is the first key point in terms of security of supply.

Another key point is that, as Table 2 shows, 45 per cent of world proved coal reserves are located in politically mature and stable OECD countries with OECD North America accounting for 26 per cent of the world's proven reserves base. Russia and China hold a further 27.5% of world reserves. In view of their increasing integration into the global economy it can be reasonably concluded that approximately three-quarters of total world coal reserves are located in reliable countries.

Table 1: World Coal Reserves (Major Countries)

Country	**Reserves (mn tonnes)**	**% Share of world**	**R/P Ratio (years)**
United States	250.0	25.4	246
Russian Federation	157.0	15.9	> 500
China	114.5	11.6	105
India	84.4	8.6	246
Australia	82.1	8.3	261
Germany	66.0	6.7	326
South Africa	49.5	5.0	220
Ukraine	34.2	3.5	407
Kazakhstan	34.0	3.5	431
Poland	22.2	2.3	136
Brazil	11.9	1.2	> 500
Others	78.7	8.0	
TOTAL WORLD	**984.5**	**100.0**	**216**

Source: BP Statistical Review of World Energy June 2002.

Table 2: World Coal Reserves – Major Regions

Region	Reserves (mn tonnes)	% Share of world
OECD Europe	104.5	10.6
OECD North America	258.0	26.2
OECD Asia/Pacific	83.5	8.5
OECD Total	**445.9**	**45.3**
Russian Federation	157.0	15.9
China	114.5	11.6
India	84.4	8.3
Latin America	21.8	2.2
Africa	55.4	5.6
Middle East	1.7	0.2
Others	20.3	2.1
Total World	**984.5**	**100.0**

Source: International Energy Agency, Coal Information 2001.

2.2 Historical and Current Supply of Coal

Total world coal production increased sharply from 1979 to 1989 but the dissolution of the Soviet Union set off a sharp decline in total coal production resulting in a steady decline in world coal production from 1990 to 1993. Global production recovered slowly from 1994 to 1997, but declined in the next three years. Recent declines in world production can be attributed to the following factors:

- China has been rationalising its hard-coal production by closing small uncompetitive mines and reducing coal consumption in some urban industrial, household and commercial markets.

- France, Germany, Poland and Spain have programmes to reduce heavily subsidised coal production.

- Low world and domestic coal prices dampened incentives to increase coal production in some of the major producing and exporting countries, including the United States.

The major coal producers in 2001 are shown in Table 3 along with their share of total world production.

Table 3 - Major 10 Coal Producers (m tonnes)

Country	**1991**	**1996**	**2001**	**2001 %**
China	1084.3	1374.1	1089.7	23.9
United States	903.5	965.2	974.0	21.3
India	239.9	311.0	343.5	7.5
Australia	219.6	256.1	315.0	6.9
Russia	353.3	256.7	269.0	5.9
South Africa	178.4	206.3	224.1	4.9
Germany	345.9	235.1	203.5	4.5
Poland	209.8	201.7	163.4	3.6
Indonesia	13.8	50.4	92.6	2.1
Ukraine	135.6	75.7	83.9	1.8
Total World	**4586.3**	**4718.8**	**4563.7**	**100.0**

The major coal exporters are shown in Table 4 below. This highlights the fact that over 60% of world exports are derived from OECD countries where the risks of supply disruptions are likely to be minimal. The top five exporters of coal accounted for 92 per cent of global exports and comments on each of these countries are made below.

Table 4: Major Coal Exporters (m tonnes)

Country	**1991**	**1996**	**2001**	**2001 %**
Australia	113.2	138.6	194.4	28.4
China	20.0	36.5	87.1	21.8
South Africa	47.4	60.2	69.8	17.5
Indonesia	7.6	36.4	64.5	16.2
United States	98.8	82.1	44.1	11.1
Colombia	16.4	24.8	38.0	9.5
Russia	37.4	25.3	22.1	5.8
Canada	34.1	34.4	30.1	7.5
Poland	19.5	28.9	24.6	6.2
Total World	**398.9**	**513.2**	**615.9**	**100.0**

Australia is the world's largest coal exporter and increased its exports by 5% in 2000 to 163.7 million tonnes of coal equivalent (mtce). Australia's share of the world's seaborne trade was 32% in 2000. High quality, low sulphur coking and thermal coals are shipped to major markets in Asia (Japan, South Korea and Taiwan) and to Europe. Sales to Asian markets were 143.8 mtce. In 2000 Australia increased its exports of coking coal by 6.9&% over 1999 to 99.6 mtce. Thermal coal exports in 2000 increased by 9.7% to 87.1 mtce.

Japan is Australia's main market and in 2000 86.6 mtce were shipped to Japan, an increase of 9% compared to 1999. South Korea remained Australia's second largest coal market in 2000. However, exports fell by 5% in 2000 to 21.8 mtce mainly due to competition in the thermal coal market from China and Indonesia. Taiwan was Australia's third largest market with exports increasing 16% to 16.3 mtce.

China is the second largest exporter of coal with a large range of coal types being produced for both domestic and export markets. Coal is the most important energy source for the domestic market supplying 70 per cent of China's basic energy needs. In 2000, China exported 10 per cent of its production, well above official targets with most being directed to the north Asian markets. Only minor volumes were sold to European markets.

South Africa is the third largest exported of coal with most being sent to utilities and industrial customers in Europe, because of the freight advantage that it has to that market. Since sanctions were lifted in 1993, there has been a steady increase in export volume. In 2000, Europe accounted for 63 per cent of South African thermal coal exports.

Exports of coal from Indonesia have been growing steadily despite the continuing political and economic crises in the country. By 2000 over 75 per cent of coal produced was exported. Japan, Malaysia and Taiwan were the most important destinations for Indonesian coal exports.

The USA is estimated to contain over 29 per cent of the world's coal resources. It has a well-developed modern infrastructure, strong domestic demand and excess export capacity available. It is therefore no surprise that the USA is known as the 'swing supplier' in the international coal trade, with export volumes fluctuating by as much as 25 per cent as was the case in 1993. The majority of USA coal exports are of high quality, and are exported, to major markets in Europe, Brazil, Japan and Korea.

2.3 Near term coal supply

Under both the 'Low Growth' and the 'High Growth' scenarios that near term supply of coal is not considered to be an issue. The resource base is such that prices are expected to remain under pressure in the short, medium and long term. Substantial cost-cutting efforts through industry concentration and productivity gains have served to add to the already vast reserves base. In addition, the role of the US in world markets as the short-run swing producer is expected to continue for many years. Although exports from the USA represent just 10 per cent of the country's total production, mines can be quickly brought back into operation and production increased when exports seem likely to earn more money than the local market, and vice versa. The importance of North America in world markets is expected to encourage capital investment in coal production for at least the next two decades.

2.4 Medium- and long-term supply of coal

Under both the ‘Low Growth’ and the ‘High Growth’ scenarios that medium term supply of coal is not considered to be an issue. The importance of North America in world markets is expected to encourage capital investment in coal production for at least the next two decades. Supply costs are forecast to remain lowest in those OECD countries where new technology has been adopted in order to lower extraction costs and increase productivity.

3. Potential supply disruptions

The key exporting countries in 2001 were Australia, China, South Africa, Indonesia and the USA. Together these countries made up over 90 per cent of 2001 exports. In this section we focus on the potential supply disruptions that could occur paying particular attention to these five exporting countries.

3.1 Economic impacts

The potential supply disruptions due to economic factors relate mainly to price. In this respect the international coal market plays a crucial role in price setting. Because domestic coal industry performance is increasingly assessed against the standards of the international market, prices set by buyers and sellers in the international market will affect domestic energy production and consumption decisions. In addition, prices in the two key regional markets, Europe-Atlantic and Asia-Pacific, move in close relationship. With the increasing importance of the global coal market it seems likely that the current system of long-term supply contracts will decline in importance in coming years.

In the absence of any cartel in the coal industry, the impact of a developing spot market in coal will tend to drive down prices. As a result it is likely that the industry will continue to concentrate on those areas where the supply costs are lowest and where productivity is highest. Not surprising the major exporters with these attributes are the OECD exporters, including the USA. It is therefore very unlikely that the development of a more dynamic pricing mechanism will result in any near or long term supply disruptions in the global coal market.

3.2 Geopolitical impacts

The substantial resource base combined with the wide variety of producers from mainly OECD countries means that potential supply disruptions from geopolitical factors are likely to remain minimal. The fact that the USA is likely to remain the coal 'swing producer' in the short-, medium-, and long-terms means that potential disruptions could be made up in relative quickly without any long lasting effect on prices.

3.3 Institutional impacts

The key uncertainty affecting future coal uses is the impact of environmental policies on demand. Governments are imposing increasingly strict requirements on the coal supply chain, from mining to transport, and on the use of coal in power generation and steel making. Therefore, the coal-supply and price outlook hinges on the effect of new environmental and climate change policies on demand prospects. Investors may show a reluctance to commit to the large resources necessary to ensure a sufficient coal supply in the current landscape if long term demand is placed at risk by the possible introduction of environmental and climate change policies.

Environmental pressures are unlikely to result in any near term disruptions, as it will have more of any effect on demand than on supply. However, lower demand for coal will ultimately have an impact on coal prices, which in turn could affect long-term investments. However, the development of new technology to reduce emissions could mitigate many of the environmental arguments.

Another institutional impact relates to subsidies in both OECD and non-OECD countries. A number of OECD countries provide subsidies in order to sustain domestic production, particularly within Europe. Although plans exist to reduce subsidies in many OECD countries by 2005, they will not be completely eliminated and may actually be used to maintain access to coal reserves in order to maintain security of supply. Reduction in subsidies might lead to a further round of mine closures in OECD countries but this is unlikely to be of major importance in the global context.

3.4 Technical impacts

The rate at which clean-coal technologies are adopted and the scope at which they are put into place will both be critical for future coal use. The cost of environmental protection for new supply projects or retrofitting existing plants is a causing a growing level of uncertainty. Clean coal technologies can result in significant gains in efficiency and reductions in emission levels but these gains come at a price. However, it is likely that environmental pressures to reduce emissions are likely to force the industry into accelerating efforts to implement new technologies in order to meet carbon-emission targets. Such measures are likely to partially mitigate the impact of institutional pressures to reduce coal supplies.

3.5 Extreme combinations

Given the rich resource base of coal and diversity of the resource base, it is considered that supply disruptions will occur only in the most exceptional circumstances. Such circumstance could occur if two or more of the factors discussed above combine. Such a combination could include an embargo on coal exports from China, at the same time as political instability in South Africa stops coal production and a strike by train drivers in the USA (the main mode of transporting coal from mines) prevents that country from making up any supply deficit. However, such a combination is only is considered extremely unlikely.

4. Affect on prices of supply disturbances

There is an impression given that coal use is rapidly fading into history. The reality, in recent years, is that its overall consumption has remained robust. Although the geographical pattern of consumption and the pattern of end use have changed nearly two-thirds of total world coal consumption is accounted for in just four countries namely China, United States, India and Russia. However, as we have shown the potential for supply disruptions is very minimal as the volume of remaining reserves remains high with OECD countries accounting for over 60 per cent of exporting countries. In addition, the USA is expected to remain the swing producer for coal in the longer-term.

The key potential supply disturbance that we have identified relates to environmental pressure and the impact that this could have on demand. The greater the environmental pressure on the industry the greater the likelihood that this could lead to downward pressure on prices in the medium-term. In the longer-term this could affect investment decisions and put upward pressure on prices. However, this upward pressure could be fully mitigated by improvements in technology, the constant pressure to reduce costs combined with the vast resource base available.

5. Terminology

The term "coal" is normally divided into four categories

- Anthracite
- Bituminous Coal
- Sub-Bituminous Coal
- Lignite/Brown Coal

In turn the International Coal Classification of the Economic Commission for Europe (UN/ECE) recognises two broad categories of coal:

Hard Coal

Coal of gross calorific value greater than 5,700 kcal/kg (23.9 GJ/t) on an ash-free but moist basis and with a mean random reflectance of vitrinite of at least 0.6. It is the sum of coking coal and steam coal.

Brown Coal

Non-agglomerating coal with a gross calorific value less than 5,700 kcal/kg (23.9 GJ/t) containing more than 31 per cent volatile matter on a dry mineral matter free basis. It is the sum of sub-bituminous coal and lignite.

5 EXPLORATION OF FUTURE RISKS FOR GLOBAL ENERGY MARKETS OF COAL

Introduction

The current demand for uranium can be met by primary production of uranium and by secondary sources from stockpiles and inventories. The uranium resource base is large enough to support even the most optimistic of demand assumptions and the reserves are located mainly in OECD countries. In the near-term, primary and secondary uranium resources will be able to meet both optimistic and pessimistic demand forecasts. In the medium-term, secondary sources will be depleted but current production and current developments of primary uranium should be sufficient to supply both optimistic and pessimistic demand forecasts. In the long-term, significant new sources of uranium will need to be developed to meet rising demand. This will require significantly higher prices to justify new investment.

In the near term, the real risks to supply could come from disruptions in secondary supplies of uranium. Such disruptions are likely to be short-lived and cause spikes in the uranium price. In the longer term, economic factors are more likely to cause supply disruptions if prices do not recover to levels that justify new investment decisions. However, political factors and the introduction of new technology could suppress demand for uranium if the nuclear industry goes into decline.

2. The key exporting countries

2.1 Uranium resource base

The uranium resource base can be divided into primary and secondary supplies. Primary uranium resources consist of deposits that are produced by conventional techniques, 40 per cent by open pit mining, 33 per cent by underground mining and the rest through modern techniques, including in situ leaching. Secondary uranium resources consist of inventories, stockpiles and recycled materials.

2.1.2 Primary uranium resource base

Estimates of remaining reserves of uranium have been divided into several categories reflecting the different levels of confidence in the quantities reported to the Nuclear Energy Agency (NEA). The resources are broadly classified as either conventional or

Figure 1: Reasonably assured resources (RAR) (in 1000 tonnes U, as of 1 January 2001)

COUNTRY	Cost Ranges				
	<USD 40/kgU	USD 40-80/kgU	< USD 80/kgU	USD 80-130/kgU	< 130/kgU
Algeria			26.00	0.00	26.00
Argentina	2.64	2.44	5.08	2.00	7.08
Australia	654.00	13.00	667.00	30.00	697.00
Brazil	56.10	105.90	162.00	0.00	162.00
Bulgaria	2.22	5.61	7.83	0.00	7.83
Canada	277.99	36.57	314.56	0.00	314.56
Central Africa Republic	0.00	0.00	8.00	8.00	16.00
Chile	NA	NA	NA	NA	NA
Congo, Democratic Republic of			1.80	0.00	1.80
Czech Republic	0.00	2.37	2.37	0.00	2.37
Denmark	0.00	0.00	0.00	27.00	27.00
Finland	0.00	0.00	0.00	1.50	1.50
France	0.19	0.00	0.19	0.00	0.19
Gabon	4.83	0.00	4.83	0.00	4.83
Germany	0.00	0.00	0.00	3.00	3.00
Greece	1.00	0.00	1.00	0.00	1.00
Hungary	0.00	0.00	0.00	0.00	0.00
India	NA	NA	NA	NA	NA
Indonesia	0.00	0.47	0.47	6.33	6.80
Italy			4.80	0.00	4.80
Islamic Republic of Iran	0.00	0.00	0.00	0.49	0.49
Japan	0.00	0.00	0.00	6.60	6.60
Kazakhstan	317.23	115.56	432.76	162.04	594.83
Malawi			11.70	0.00	11.70
Mexico				1.70	1.70
Mongolia	10.60	51.00	61.60	0.00	61.60
Namibia	61.83	82.04	143.87	31.24	175.10
Niger	10.91	18.69	29.60	0.00	29.60
Peru			1.79	0.00	1.79
Portugal			7.45	0.00	7.45
Romania					4.55
Russian Federation	63.00	75.00	138.00	0.00	138.00
Slovenia	0.00	2.20	2.20	0.00	2.20
Somalia				6.60	6.60
South Africa	119.20	111.90	231.10	59.90	291.00
Spain	0.00	2.46	2.46	2.46	4.92
Sweden	0.00	0.00	0.00	4.00	4.00
Thailand					0.01
Turkey	0.00	9.13	9.13	0.00	9.13
Ukraine	19.25	23.35	42.60	38.40	81.00
United States	NA		104.00	244.00	348.00
Uzbekistan	90.08	0.00	90.08	25.27	115.35
Viet Nam	0.00	0.00	0.00	1.34	1.34
Zimbabwe	NA	NA	1.80	0.00	1.80
Total	**1691.07**	**657.69**	**2516.07**	**661.87**	**3182.52**

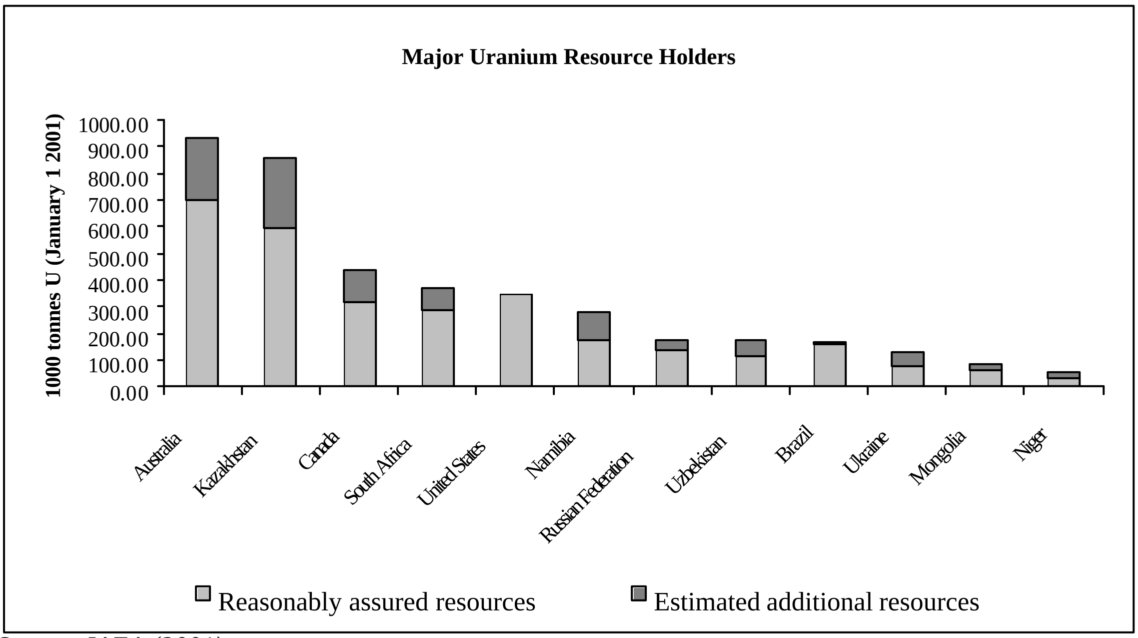
Source: IAEA (2002)

Figure 2: Estimated additional resources (EAR) –Category I (in 1000 tonnes U, as of 1 January 2001)

COUNTRY	Cost Ranges				
	<USD 40/kgU	USD 40-80/kgU	< USD 80/kgU	USD 80-130/kgU	< 130/kgU
Algeria	0.00	0.00	0.00	0.00	0.00
Argentina	2.03	0.35	2.38	6.18	8.56
Australia	185.00	11.00	196.00	37.00	233.00
Brazil			100.20	0.00	8.40
Bulgaria	2.20	6.20	8.40	0.00	8.40
Canada	102.81	19.58	122.39	0.00	122.39
Central Africa Republic	0.00	0.00	0.00	0.00	0.00
Chile	0.00	0.00	0.00	0.00	0.00
Congo, Democratic Republic of			1.70	0.00	1.70
Czech Republic	0.00	0.31	0.31	0.00	0.31
Denmark			0.00	16.00	16.00
Finland	0.00	0.00	0.00	0.00	0.00
France	0.00	0.00	0.00	11.74	11.74
Gabon	1.00	0.00	1.00	0.00	1.00
Germany	0.00	0.00	0.00	4.00	4.00
Greece			6.00	0.00	6.00
Hungary	0.00	0.00	0.00	18.40	18.40
India	0.00	0.00	0.00	0.00	0.00
Indonesia	0.00	0.00	0.00	1.70	1.70
Italy	0.00	0.00	0.00	0.00	0.00
Islamic Republic of Iran	0.00	0.00	0.00	0.88	0.88
Japan	0.00	0.00	0.00	1.30	1.30
Kazakhstan	113.20	82.70	195.90	63.40	259.30
Malawi	0.00	0.00	0.00	0.00	0.00
Mexico	0.00	0.00	0.00	0.70	0.70
Mongolia	11.00	10.00	21.00	0.00	21.00
Namibia	70.55	20.27	90.82	16.70	107.51
Niger	11.17	14.36	25.53	0.00	25.53
Peru			1.86	0.00	1.86
Portugal	0.00	0.00	0.00	1.45	1.45
Romania					4.69
Russian Federation	17.20	19.30	36.50	0.00	36.50
Slovenia			5.00	5.00	10.00
Somalia			0.00	3.40	3.40
South Africa	48.10	18.70	66.80	9.60	76.40
Spain	0.00	0.00	0.00	6.38	6.38
Sweden	0.00	0.00	0.00	6.00	6.00
Thailand					0.01
Turkey	0.00	0.00	0.00	0.00	0.00
Ukraine		20.00	20.00	30.00	50.00
United States	0.00	0.00	0.00	0.00	0.00
Uzbekistan	46.80	0.00	46.80	9.97	56.71
Viet Nam	NA	NA	1.10	5.64	6.74
Zimbabwe	0.00	0.00	0.00	0.00	0.00
Total	**611.06**	**222.77**	**949.69**	**255.44**	**1117.96**

Source: IAEA (2002)

Figure 3: Major Uranium Resource Holders (January 1, 2001)



Source: IAEA (2001)

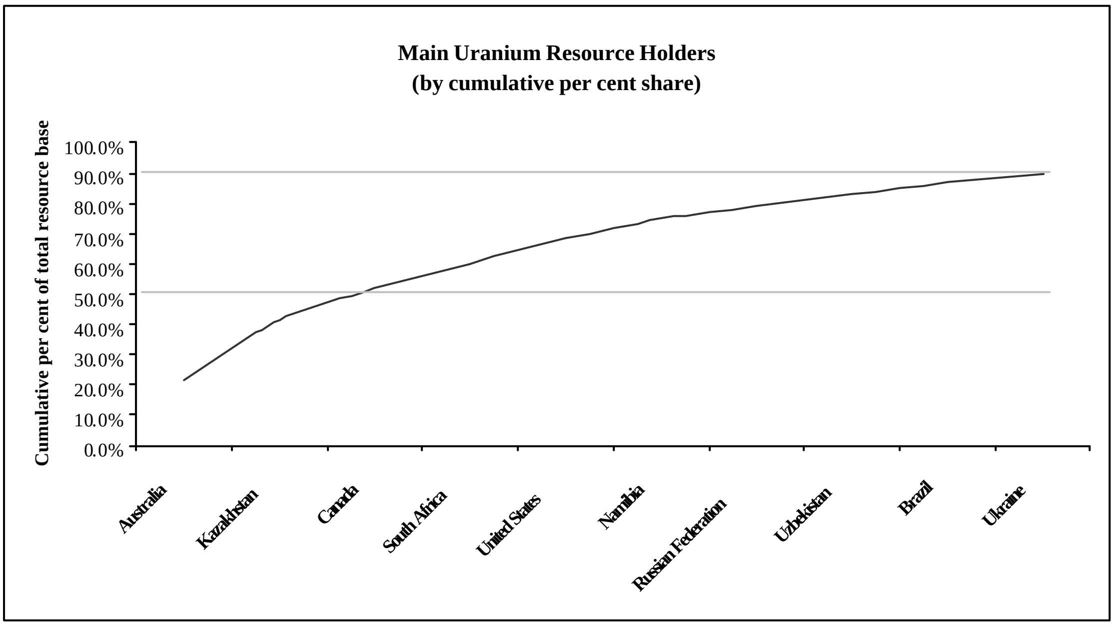
unconventional. Conventional resources are those resources that have an established history of production where uranium is either a primary product or and important by-product. Very low-grade resources or those from which uranium is only recovered as a minor by-product are considered to be unconventional resources.

The NEA also subdivides conventional resources into four different confidence levels of occurrence. These include reasonably assured reserves (RAR) which have a high assurance of existence, estimated additional resources (EAR-I) that are inferred to occur in extensions to well-explored deposits, estimated additional resources (EAR-II) that are believed to exist on trend and finally speculative reserves (SR) which are thought to exist on the basis of extrapolation rather than any direct evidence.

The NEA further divides the uranium resource base into categories based on the cost of production. These categories are defined as: USD 40kg/kgU or less, USD 80kg/kgU or less, and USD 130/kgU or less. The costs include all direct and indirect costs associated with mining, processing and transportation.

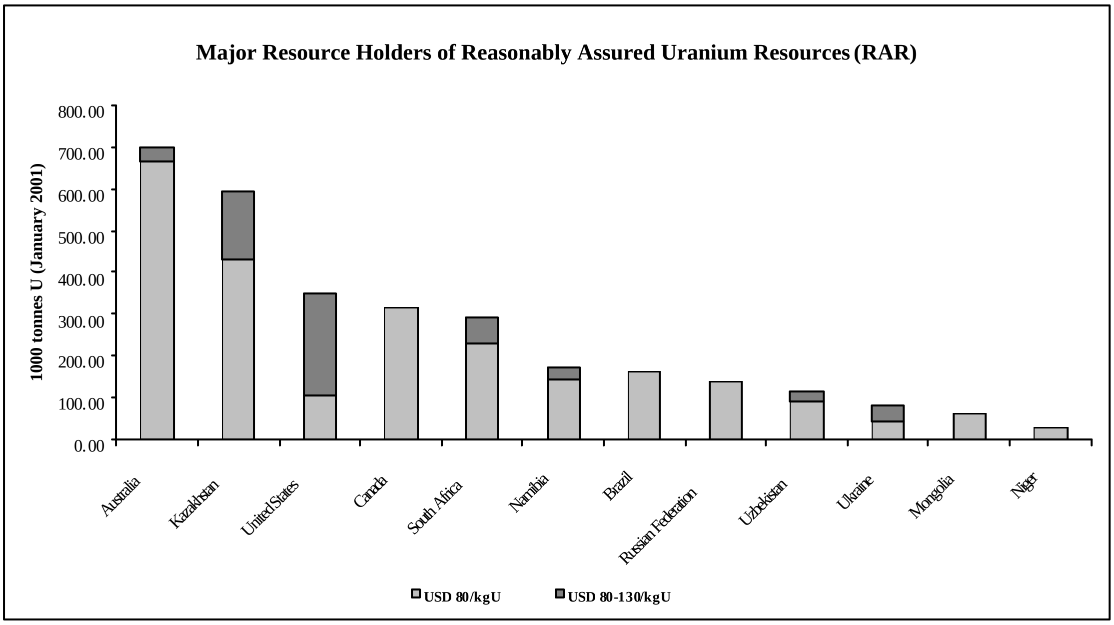
For the purposes of this report we have focused on the reasonably assured resources (RAR) and the estimated additional resources (EAR-I). These resources are tabulated

Figure 4: Main uranium resource holders by cumulative interest



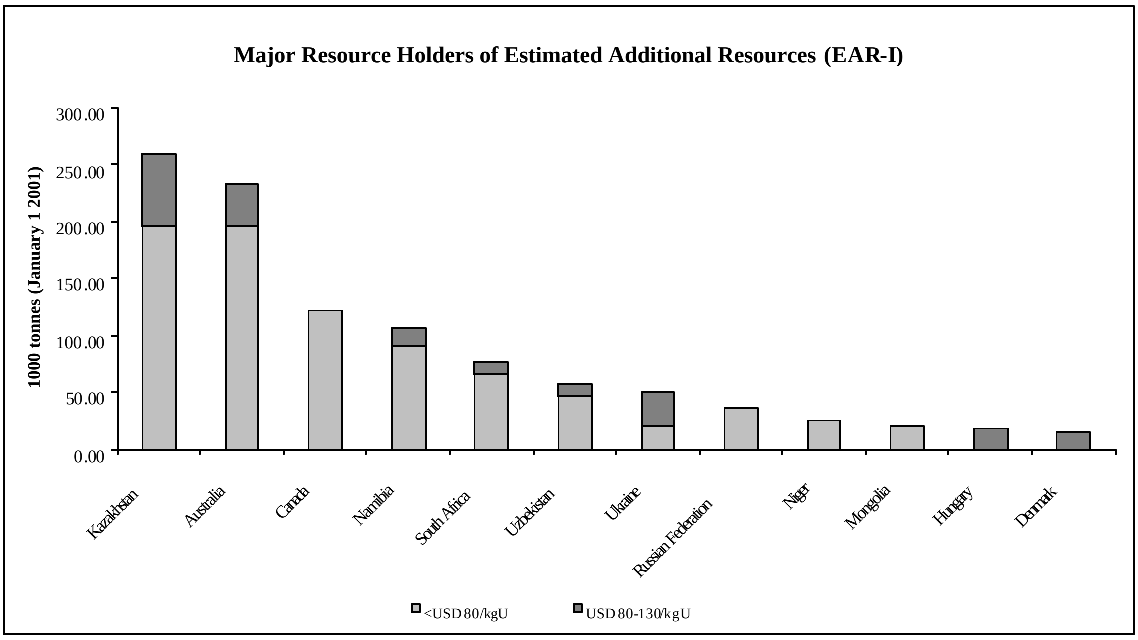
Source: IAEA 2002

Figure 5: Main Uranium Resource Holders of Reasonably Assured Reserves



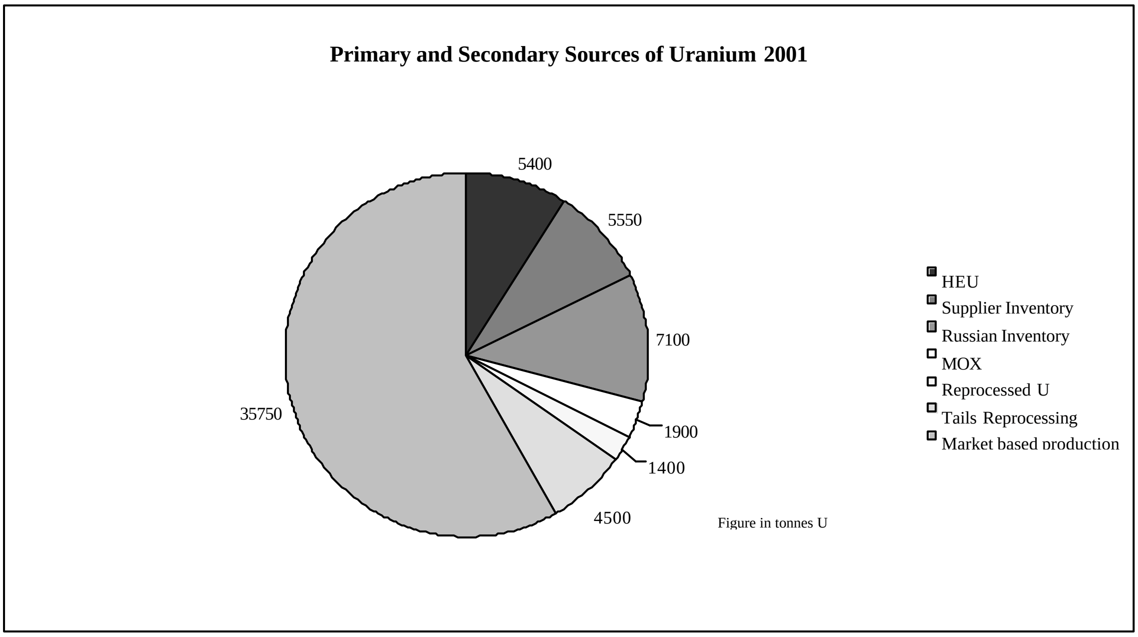
Source: IAEA 2002

Figure 6: Main Uranium Resource Holders of Estimated Additional Reserves (EAR-I)



Source: IAEA 2002

Figure 7: Primary and Secondary Sources of Uranium 2001



Source: IAEA 2002

in Figures 1 and 2, which show that the most significant resource holders at the end of 2001 were Australia and Kazakhstan, which together accounted for nearly 50 per cent of known remaining resources (Figure 3). Canada is the third largest resource holder and is followed closely by South Africa. The US is also an important resource holder although the data suggests that its resources are limited to reasonably assured reserves. Other major resource holders include Namibia, Brazil, the Russian Federation, Uzbekistan, Ukraine, Mongolia and Niger. Figure 4 plots the resource holders' cumulative interest in the total estimated uranium resource base at the end of 2001. This chart shows that uranium deposits in Australia, Kazakhstan and Canada account for over 50% of remaining reserves and that the top ten resource holders account for over 90% of the resource base. Figures 5 and 6 separate the uranium resource into the RAR and EAR-I categories. As one would expect the countries with the largest RAR resource are also the ones with the largest EAR-I resources.

The tables demonstrate that uranium resources are abundant and that most (45%) lie within OECD countries with the exception of Kazakhstan. In addition, the figures illustrate that most resources can be extracted at a cost of less than USD 80 per kg

2.1.2 Secondary sources of uranium

Secondary sources of uranium include inventories, stockpiles and recycled materials. Utility companies, fuel-cycle companies and government bodies own most uranium inventories. Secondary sources of uranium are relatively cheap to store and they are held for a variety of reasons, the most important being to enhance security of nuclear power supply, to guarantee delivery schedules, and to hedge against variations in the price of uranium. The World Nuclear Association has evaluated inventories and estimates that there are over 215,000 tonnes of uranium held in stockpile globally, excluding any military stockpiles.

Disarmament agreements between the FSU and the US rendered large quantities of high-enriched uranium (HEU) surplus to requirements. At the end of 2001 the FSU was estimated to have produced 1400 tonnes of HEU, one third of which is currently being delivered to the US in a low-enriched form. In total the volume of HEU in the market is equivalent to some 40,000 tonnes of uranium.

There are also large stockpiles of depleted uranium, known as 'enrichment tails'. Depleted uranium is a by-product of the uranium enrichment process and at the end of 2000, it was estimated that there were some 1.2 million tonnes of depleted uranium stocks with over 80 per cent held by the US and the FSU.

2.2 Historical and current supply of uranium

Global production of uranium in recent years has consistently fallen over the past 20 years as falling demand and a significant supply of secondary uranium have combined to depress prices. By 2001 primary uranium was produced in 23 countries with OECD countries accounting for over 56 per cent of global production. Primary uranium supply accounted for nearly 60 per cent of total supply with the various sources of secondary supplies making up 40 per cent (Figure 7)

The leading producers of primary uranium in 2001 were Canada and Australia (Figure 8). Together these two countries produced over 70% of global primary uranium supply. Each of these countries produced over three times the annual volume of Niger, the FSU, Namibia, Uzbekistan and Kazakhstan. A detailed breakdown of annual production is provided in Figure 9. The US is also a major producer but many of its mills and mines have been mothballed and are operating on a standby basis only.

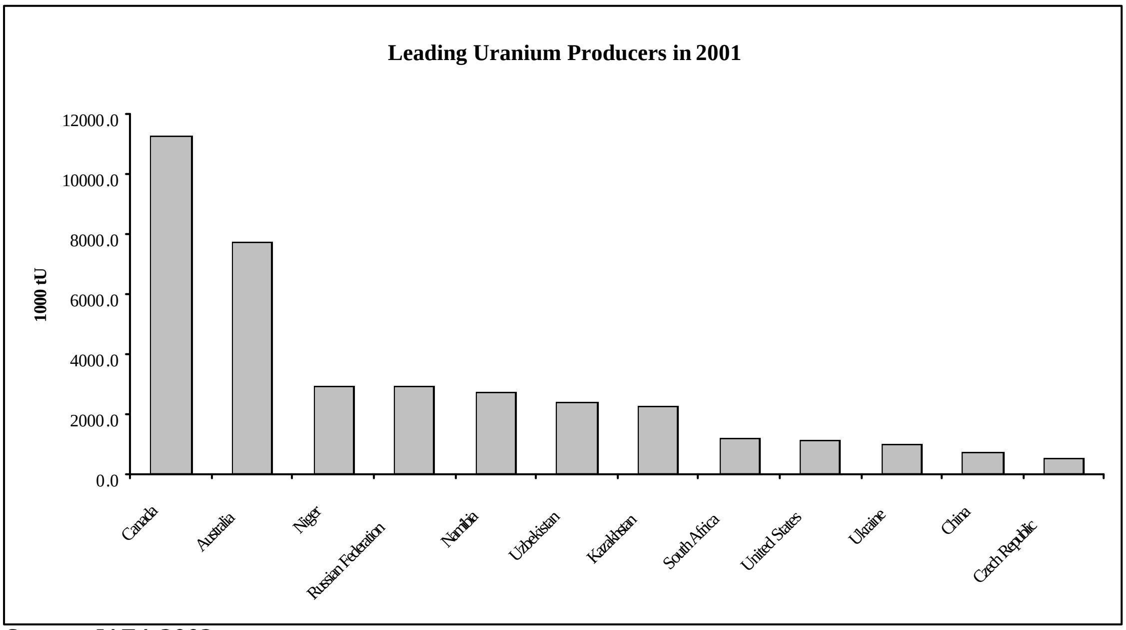
The four uranium-producing countries of the FSU, Russia, Uzbekistan, Kazakhstan and Ukraine, contributed nearly 20% of global production in 2001. Although production in the Ukraine and Russia is mainly for domestic use, much of the production from Kazakhstan and the Uzbekistan is for export as it provides an important source of currency for export. The four main producers in Africa, Niger, Namibia, South Africa and Gabon contributed less than 105 of supply in 2001.

2.3 Near term uranium supply

2.3.1 'Low Growth' scenario

Under the 'Low Growth' scenario demand for uranium is forecast to remain flat in the near term until 2005 at around 61,000 tonnes per year (Figure 10). Primary uranium supply is expected to supply up to 65% of total demand with secondary sources supplying 35% (Figure 11). The decline in the relative proportion on secondary supplies reflects

Figure 8: Leading Uranium Producers in 2001



Source: IAEA 2002

the expected gradual drawdown of stocks, which have to be made up with higher levels of primary production.

Under such benign circumstances there are not expected to be any supply constraints. With no increase in demand, the 9000 tonnes of capacity that is currently mothballed is unlikely to be brought back into production especially as several new projects under development are nearing completion in Canada (at McArthur River) and Australia (at Beverly, Honeymoon and Jalibuka). As these projects come into production, there is likely to be small surplus of supply.

2.3.2 'High Growth' scenario

Under the 'High Growth' scenario demand for uranium is expected to rise to around 65,000 tonnes per year by 2005 (Figure 12). The 4000 tonnes per year increase can easily be met by increasing production from the Australian projects referred to above as well as the potential re-opening of capacity that is currently mothballed. Mothballed production can take as little a 12 months to be brought back on stream and at present there is global spare capacity capable of producing up to 9000 tonnes per year (Figure 13). Nearly 75 per cent of this spare capacity lies in Canada, the United States and Australia (Figure 14).

Figure 9: Historical Production and IAEA Estimates of Future Production (1000 tonnes U per year).

COUNTRY	1998	1999	2000	2001	2005e	2020e	2040e
Argentina	7.0	4.0	0.0	0.0	0.0	0.0	0.0
Australia	4894.0	5984.0	7579.0	7700.0	9000.0	21600.0	19600.0
Belgium	15.0	0.0	0.0	0.0	0.0	0.0	0.0
Brazil	0.0	0.0	80.0	250.0	250.0	250.0	100.0
Bulgaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Canada	10922.0	8214.0	10683.0	11250.0	12500.0	11300.0	8800.0
China	590.0	700.0	380.0	380.0	1380.0	1380.0	1380.0
Congo	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	610.0	612.0	507.0	501.0	450.0	200.0	0.0
Finland	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	452.0	416.0	296.0	120.0	100.0	50.0	0.0
Gabon	725.0	0.0	0.0	0.0	0.0	0.0	0.0
Germany	30.0	29.0	28.0	20.0	10.0	0.0	0.0
Hungary	10.0	10.0	10.0	10.0	0.0	0.0	0.0
India	207.0	207.0	207.0	207.0	207.0	150.0	100.0
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kazakhstan	1270.0	1560.0	1870.0	2250.0	2300.0	2600.0	9400.0
Mexico	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mongolia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Namibia	2780.0	2690.0	2715.0	2702.0	3000.0	4000.0	5600.0
Niger	3714.0	2907.0	2911.0	2910.0	3000.0	3300.0	4100.0
Pakistan	23.0	23.0	23.0	23.0	0.0	0.0	0.0
Poland	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Portugal	19.0	10.0	14.0	10.0	8.0	0.0	0.0
Romania	132.0	89.0	86.0	85.0	0.0	0.0	0.0
Russian Federation	2530.0	2610.0	2760.0	2910.0	3200.0	3800.0	3800.0
Slovenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Africa	965.0	927.0	838.0	1160.0	1300.0	1800.0	7700.0
Spain	255.0	255.0	255.0	30.0	0.0	0.0	0.0
Sweden	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ukraine	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	2500.0
United States	1810.0	1773.0	1522.0	1077.0	2200.0	9400.0	7200.0
Uzbekistan	1926.0	2159.0	2028.0	2350.0	2500.0	3800.0	3800.0
Yugoslavia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**34886**	**32179**	**35792**	**36945**	**42405**	**64630**	**74080**

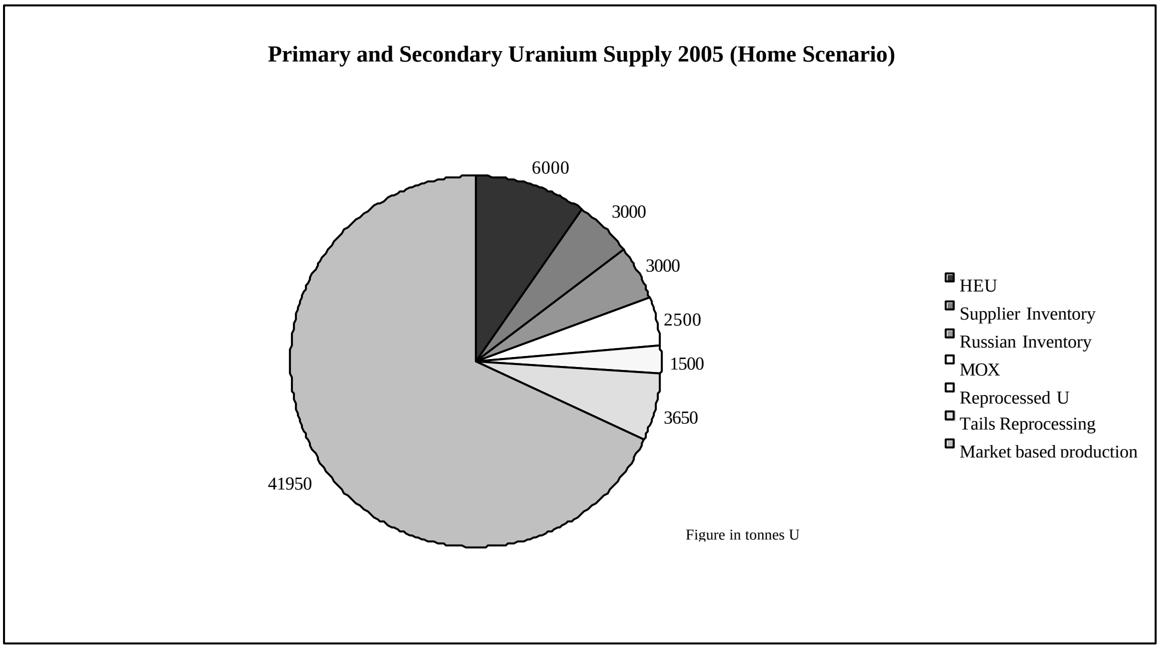
Source: IAEA 2002

Figure 10: Supply Demand Forecast under the 'Low Growth' Scenario (1000 tonnes per year)

	2000	2005	2010	2015	2020	2025	2030	2035	2040
Demand	61600	61600	61600	61600	61600	58520	55594	52814	50174
HEU	5400	6000	6000	6000	6000	6000	6000	6000	0
Supplier Inventory	5550	3000	3000	3000	1500	0	0	0	0
Russian Inventory	7100	3000	900	0	0	0	0	0	0
MOX	1900	2500	3000	3600	3600	3600	3600	3600	3600
Reprocessed U	1400	1500	2000	2000	2500	2500	2500	2500	2500
Tails Reprocessing	4500	3650	2350	0	0	0	0	0	0
Market based production	35750	41950	44350	47000	48000	46420	43494	40714	44074

Source: IAEA 2002 and OIES Estimates

Figure 11: Primary and Secondary Uranium Supply under the 'Low Growth' Scenario



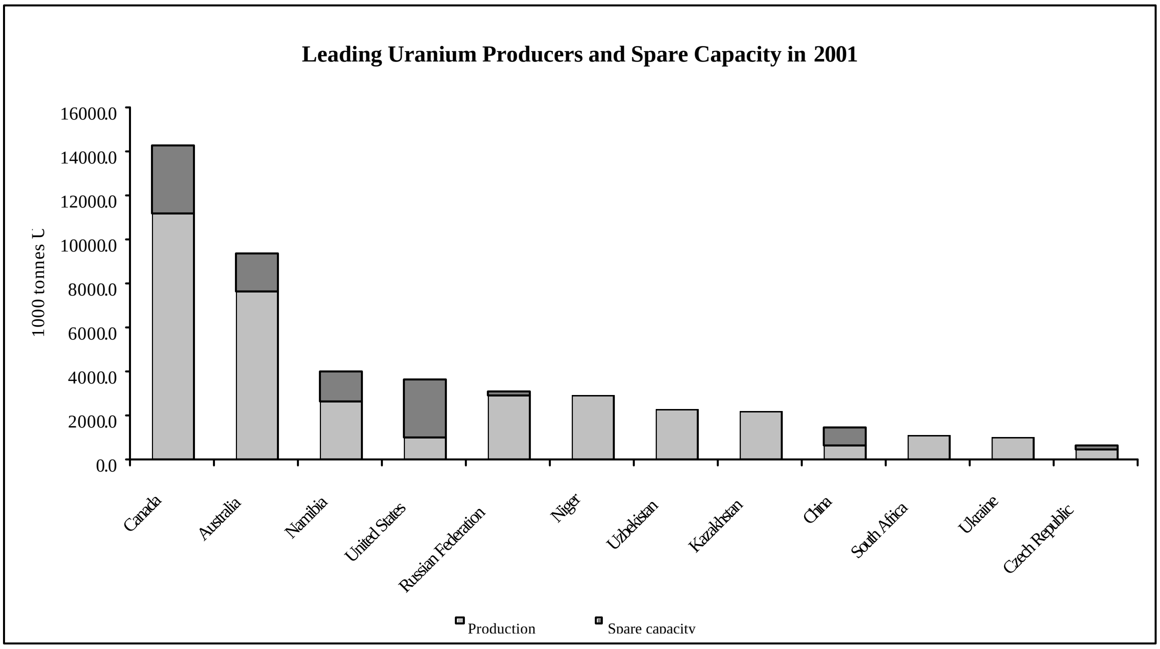
Source: IAEA 2002 and OIES Estimates

Figure 12: Supply Demand Forecast under the 'High Growth' Scenario (1000 tonnes per year)

	2000	2005	2010	2015	2020	2025	2030	2035	2040
Demand	61600	64800	68100	71500	83300	95000	116000	130000	145000
HEU	5400	10600	12400	11900	11900	0	0	0	0
Supplier Inventory	5550	8210	1867	0	0	0	0	0	0
Russian Inventory	7100	3000	900	0	0	0	0	0	0
MOX	1900	2500	3000	3600	3600	3600	3600	3600	3600
Reprocessed U	1400	1500	2000	2000	2500	2500	2500	2500	2500
Tails Reprocessing	4500	3650	2350	0	0	0	0	0	0
Market based production	35792	42405	43200	56659	64630	72000	82900	77000	74080

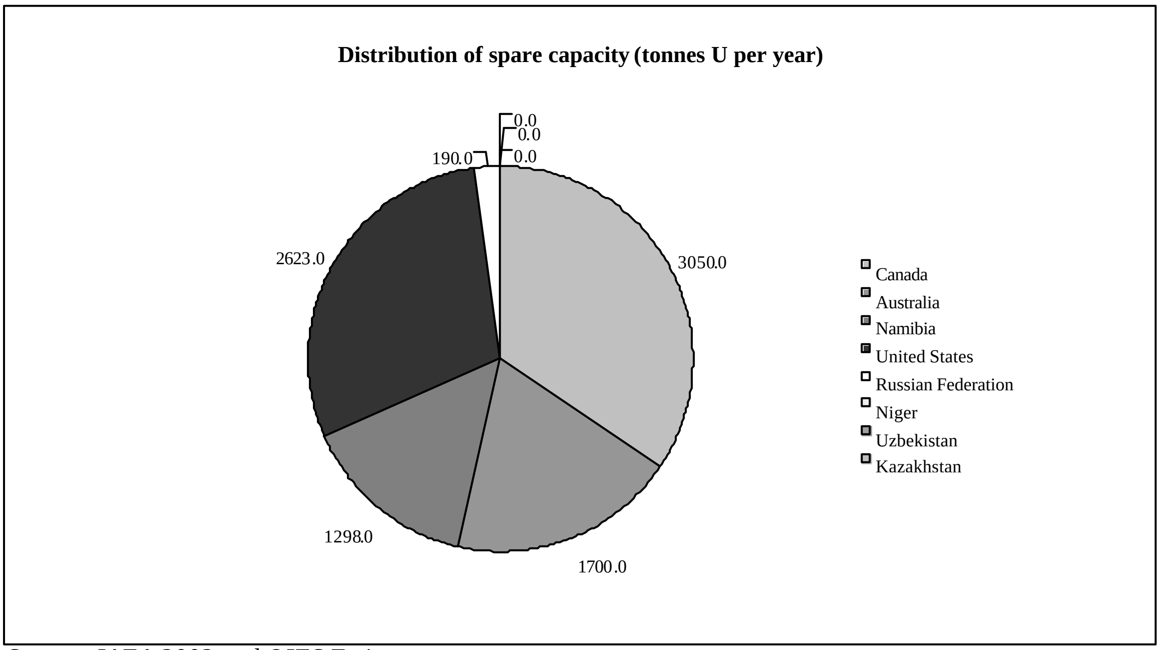
Source: IAEA 2002 and OIES Estimates

Figure 13: Leading Uranium Producers and Spare Capacity in 2001



Source: IAEA 2002

Figure 14: Distribution of Spare Capacity in 2001 (1000 tonnes per year)



Source: IAEA 2002 and OIES Estimates

2.4 Medium term supply of uranium

2.4.1 'Low Growth' scenario

Under then 'Low Growth' scenario demand for uranium is expected to remain flat until 2020 with no incremental demand for new nuclear generation. Under such a scenario, primary uranium is forecast to make up over 75 per cent of primary supply with secondary sources accounting for just 25 per cent (Figure 15). The reduction in secondary supplies by 2020 is due to the complete drawdown of Russian inventories by that time and exhaustion of 'tails ' reprocessing.

Under the 'Low Growth' scenario, primary uranium production would have to increase to around 48000 tonnes per year, a 10 per cent increase over primary production today (Figure 10). Such an increase can easily be met by current mothballed production as well as the new Canadian and Australian projects currently under development. Analysis of the resource base suggests that the expected primary production of around 65000 tonnes per year can be recoverable at costs of between $35 and $45 per kg.

2.4.2 'High Growth' scenario

We have adopted the International Atomic Energy Agency (IAEA) optimistic demand estimates for the 'High Growth' scenario. Such estimates assume that demand for nuclear
power will rise as greater efforts are made to reduce carbon dioxide emissions and there is greater concern over security of supply. Under such circumstances, the IAEA estimates that demand for uranium could rise to around 83300 tonnes per year by 2020, a 30 per cent increase over present day demand.

The IEA estimates suggest that the quantity of secondary uranium supplied from inventory held by utilities and commercial suppliers will decline sharply over the next 15 years. In part this decline can be partially offset by increasing use of Russian and US highly enriched uranium, but inevitably increases in primary capacity will be required.

Given that the lead times for the development of new projects can be between ten and fifteen years from discovery to the start of production capacity and investment decisions must be taken soon to ensure supply meets demand. Assuming that the industry will gradually adopt market-based principles and that increases in production will only take place in those countries where investment can be economically justified then it is likely that capacity increases will first take place in Australia, the United States and Canada where low cost supplies are plentiful. Estimates of supply by the International Atomic Energy Agency (IAEA) suggest that by 2020 Australia and Canada will contribute over half of the world uranium output with capacity in Australia set to rise to 21600 tonnes per year and to double in the US (Figure 9). Analysis of the resource base suggests that the expected primary production of around 83000 tonnes per year can be recoverable at costs of between $45 and $60 per kg.

2.5 Long term supply of uranium

2.5.1 'Low Growth' scenario

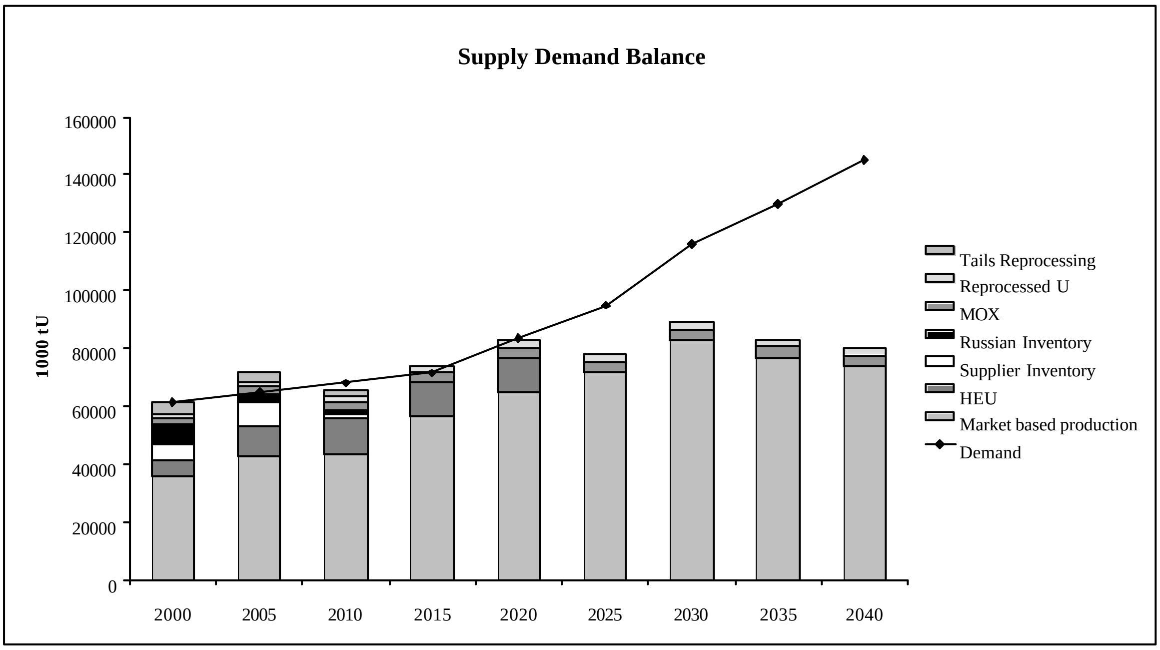
Under the 'Low Growth' scenario the long-term demand for uranium is set to decline after 2020 as nuclear power stations are decommissioned. Under such circumstances, primary supply of uranium would have to contract by some 10 per cent between 2020 and 2040 in order to prevent the market from becoming oversupplied. Under such circumstances it is unlikely that non-OECD supplies would increase in importance as the resource base in the Australia, Canada and the US could easily cope with the benign demand environment. Inventories of secondary uranium are forecast to have been completely drawn down with secondary supplies coming solely from MOX and reprocessed uranium.

2.5.2 'High Growth' scenario

We have adopted the International Atomic Energy Agency (IAEA) optimistic demand estimates for the 'High Growth' scenario. Such estimates assume that demand for nuclear power will rise as greater efforts are made to reduce carbon dioxide emissions, there is greater concern over security of supply and that dependence on oil will fall after 2025. Under such circumstances, the IAEA estimates that demand for uranium could rise to around 145000 tonnes per year by 2040, a 120 per cent increase over present day demand.

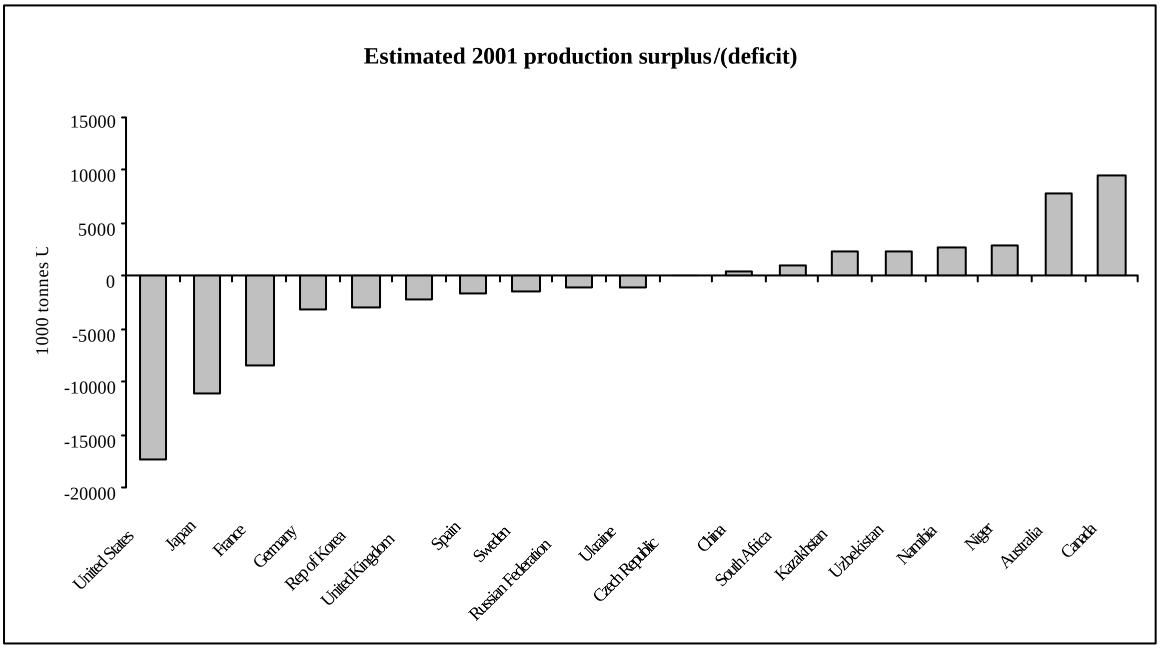
Analysis of the resource base suggests that primary production of up to 75000 tonnes per year can be recoverable at costs of between $80 and $130 per kg. Incremental uranium production between 2020 and 2040 is set to come from Kazakhstan, South Africa and the Ukraine with capacity in nearly all other countries remaining stable. Secondary sources of uranium are not expected to be of significance by 2040.

Figure 15: Supply Demand Balance under the 'High Growth' Scenario (1000 tonnes per year)



Source: IAEA 2002 and OIES Estimates

Figure 16: Supply Demand Balances Showing the Major Exporting and Importing Countries.



Source IAEA 2002

However, the significant increase in demand means that a supply gap will open up after 2025, which can only be filled with higher cost resources (Figure 15). Examination of the resource base suggests that these supplies are available in non-OECD countries such as Kazakhstan, Namibia, Brazil, Uzbekistan, Mongolia and Niger. However, the cost of developing these resources could in some cases be higher than $130 per kg.

3. Potential supply disruptions

In 2001, the key exporting countries for primary uranium were Canada, Australia, Niger, Namibia, Uzbekistan, Kazakhstan and South Africa (Figure 16). In this section, we focus our attention on the potential supply disruptions that could occur paying particular attention to these seven major exporting countries.

We have summarised the likelihood of supply disruptions on the 'Low Growth' and 'High Growth' scenarios on Figure 17.

Figure 17: Summary of the Risks of Supply Disruption

	Home			**Best**		
	Near	Medium	Long	Near	Medium	Long
Economic	Low	Low	Moderate	Low	Moderate	High
Political	Low	Moderate	Moderate	Low	Moderate	Moderate
Institutional	Low	Low	Low	Low	Low	Low
Technical	Low	Low	Low	Low	Low	Moderate

Source: OIES

3.1 Economic impacts

3.1.1 Potential size of disruption

There are two potential disruptions due to economic factors, the long term impact of low uranium prices on investment and the near term impact of potential supply disruptions to secondary sources of uranium.

At present, the decline in uranium prices to around $30 per kg has occurred because of the sale of secondary supplies of uranium. This has meant that the global imbalance between production and consumption of primary uranium has had little effect on prices. If there were to be a major disruption of supplies of secondary uranium this would lead to a shortfall in supply of 35 per cent by 2005. Such a shortfall would lead to a major increase in the uranium price.

Supplies of secondary uranium are expected to be depleted in 15 to 20 years but if prices remain at current levels there is little incentive for producers to undertake major exploration or development work. Prices must rise to ensure that ongoing exploration and development can take place. If not this could lead to severe supply disruption later in the long-term as the average lead-time to develop new resources is around 10 to 15 years from the time of discovery to first production.

The potential impact of low uranium prices is not likely to be felt in the near or medium term as the amount of mothballed capacity in OECD countries such as Canada, the United States and Australia and is sufficient to meet demand without major new investment. The potential size of disruption in the long term very much depends of the level of future demand. In the 'Low Growth' scenario, demand will not require major new investment. However, in the 'High Growth' scenario the significant amount of new capacity required by 2040 to cover the growing gap between supply and demand will require major investment decisions to be taken. Non-OECD countries, such a Kazakhstan, are expected to provide most of the incremental production capacity after 2020.

The real impact of the low uranium prices has been felt in many of the non-OECD countries where the cost structure in the existing industry is relatively high. In Namibia, Niger and Kazakhstan the industry is now struggling to cut costs in relatively inefficient industries. In Namibia major new deposits have been discovered but development will require a sustained upturn in uranium prices. Similarly in Kazakhstan new with its vast uranium resource base the current uranium price makes most of the deposits uneconomic at the present time.

3.1.2 Potential likelihood of occurrence

The near term likelihood of a supply disruption to secondary supplies as a result of economic impacts is unlikely to occur as it is in the interest of the countries and companies to run down the very high inventories to much lower levels. Under both the 'Low Growth' and 'High Growth' scenarios the inventory draw down is likely to take between 10 and 15 years. If there is any supply disruption it is likely to be more temporary than permanent.

Of greater concern is the impact of low prices on future investment. Under the 'Low Growth' scenario the lack of investment is unlikely to lead to any major disruption to supplies and the demand can be met by increased capacity that is already under construction. However, under the 'High Growth' scenario there has to be real concern of a supply shortfall after 2025 if prices do not rise.

3.2 Geopolitical impacts

3.2.1 Potential size of disruption

In order to ensure regular and reliable supply, many countries have sought to avoid over dependence on any one single source of uranium, particularly as in the near term the world market is relying on secondary sources of uranium to satisfy demand. Any extended shortfall in secondary sources could destabilise the uranium market and lead to potential temporary shortfalls and significant upward pressure on prices.

The EU has encouraged users to maintain a portfolio of diversified, long-term contracts with primary producers and to limit reliance on secondary sources. Japan also ensures a stable supply of uranium through long-term contracts and by direct participation in foreign mining countries. The focus on primary resources is of great near term importance, as political decisions will strongly affect the market for secondary uranium over the next 20 years. These include the conversion of weapons grade highly enriched uranium (HEU) to civilian use, US and EU restrictions on the sale of uranium produced in countries of the FSU, and the sale of US stockpiles of uranium. In addition, although uranium production in the FSU is known tom have exceeded civilian and military requirements over the past 40 years, there is little information on the size of the remaining stockpiles.

Environmental issues are also gaining greater importance. This is very apparent from the number of countries that are now reporting environmental cost information and activities. Although most of these reports focus on decommissioning and reclamation of inactive sites, there is increasing awareness of ongoing environmental-related issues, particularly in OECD countries. For example in Australia, the Jalibuka project is currently under investigation as it lies close to a World Heritage site

In countries such as the US and Canada environmental awareness not only relates to ongoing reclamation but also to the whole nuclear energy debate. This could affect permission to re-open mothballed plant but more importantly permission to develop Greenfield sites. In its extreme, the anti-nuclear lobby could try and target the source of suppliers of uranium rather than the consumers of uranium in order to achieve their objective of closing the nuclear industry. If such a lobby group were to gain political acceptance in the US and Canada, this could pose a threat to the two of the larger suppliers of primary uranium.

Environmental problems in the non-OECD countries result in slightly different supply concerns. Kazakhstan has significant environmental problems as a result of previous ownership issues. Contamination of groundwater in the major production areas has led to the development of an exclusion zone around most sites where extraction of drinking water is prohibited. In addition, uranium and ore processing centres have left behind significant volumes of low-level radioactive waste. As no financial provisions were made to clear this waste the Republic of Kazakhstan must provide the funding. While these environmental problems remain foreign investors are reluctant to invest in new capacity, as they do not wish to be exposed to any historical environmental liabilities. The issue of liability for historical environmental liabilities is a major disincentive for foreign investment.

Geopolitical disruptions have had a greater impact in non-OECD countries. In Namibia, the effect of political uncertainty caused the rapid curtailment of exploration work by foreign investors in the early 1980s just when refinement of exploration techniques had led to the discovery of a major new deposit in Namib Desert.

3.2.2 Potential likelihood of occurrence

The likelihood of politically induced supply disruptions will vary according to whether it is politically or environmentally induced.

Political decisions concerning the release of secondary stockpiles of uranium could cause massive disruptions to supply but such decisions are unlikely as it is not in the interest of most producing countries to induce major price instability. Secondary sources of uranium are more likely to be disrupted by environmental groups who are seeking to disrupt supplies to the nuclear industry. In such cases, the supply disruption is only likely to be localised and temporary.

Of greater concern in the long-term is the increasing influence of anti-nuclear lobby groups. At its extreme these lobby groups could influence the development decisions for new sites, particularly in Canada, the USA and Australia, and this would have a serious impact on longer-term supply. The influence of such lobby groups in the near and medium term is not considered to be a major threat.

The reticence of private companies to invest in non-OECD countries is likely unless guarantees can be made that exclude them from any historical environmental liabilities. In the longer term such guarantees are likely to be forthcoming as mining can be a major source of foreign income. However, given the lead-time for new developments the likely impact on supply disruption is set to grow from being low in the near-term to relatively high in the longer term.

Given that most of the primary supply in the near and medium-term is set to come from OECD countries, the threat of supply disruption due political instability or civil war is low. However, in the longer term increasing reliance on non-OECD supplies, particularly after 2020 could increase the risk to supplies.

3.3 Institutional impacts

3.3.1 Potential size of disruption

There are no real cartels operating within the uranium industry. A number of supply restrictions have been in place to prevent dumping of cheap uranium. For example from 1991 to 1999 the US restricted imports of uranium from the former Soviet Union. However all such restrictions have now been lifted.

Elsewhere restrictions on production have been more a result of domestic policy than any cartelisation. Production was restricted in Australia up until 1996 as a result of a policy, which restricted uranium production ('three mines policy'). The removal of this policy means that new developments are now possible although they will still be subject to stringent environmental, heritage and nuclear safeguards.

Under the current two tier market structure it is not possible for any major cartel to form. Not only are there diverse sources of supply of primary uranium but also there are also diverse sources of secondary uranium. There have been discussions between various countries to explore the possibility of restricting the sale of secondary uranium into the market in order to support prices but such discussions have come to nothing.

3.3.2 Potential likelihood of occurrence

The likelihood of any supply disruption due to institutional impacts is very low. In the near and medium term the source of supply is just too diverse. In the longer term any cartel would have to be made up of non-OECD countries such as Namibia, Niger, Kazakhstan and Uzbekistan. This is an unlikely combination and would only occur under the 'High Growth' scenario with the forecast of high increase in demand.

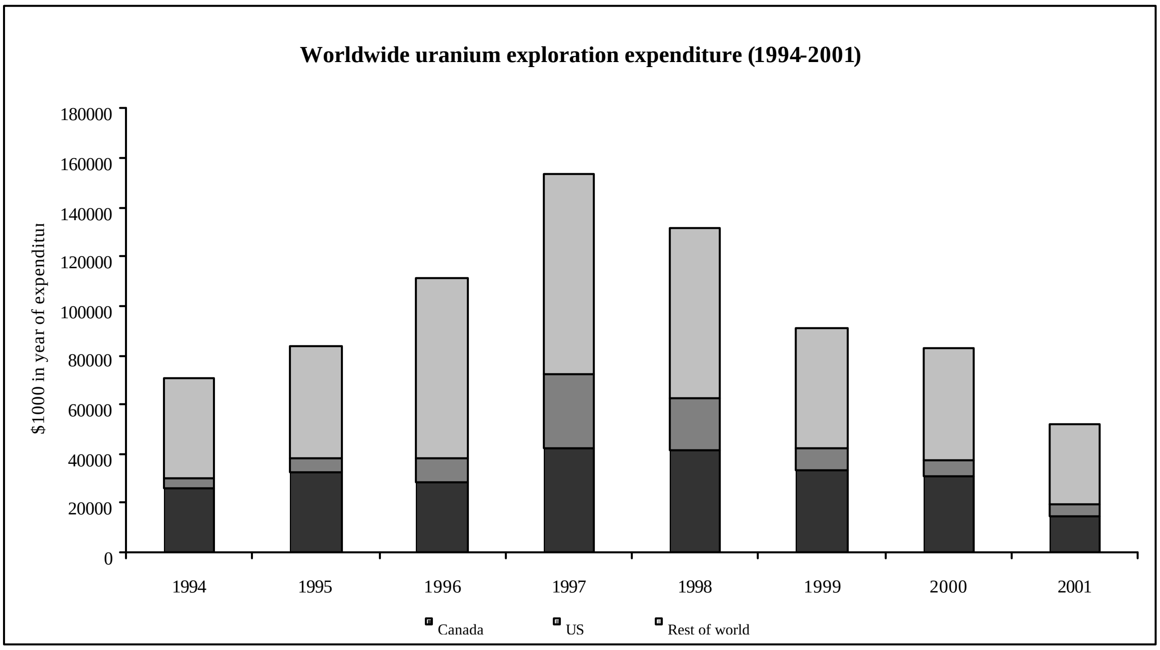
3.4 Technical impacts

3.4.1 Potential size of disruption

The fall in uranium prices over recent years combined with the surplus in supplies has meant that expenditures on total global uranium exploration have fallen sharply. Worldwide exploration expenditures in 2000 totalled just $87 million down from a high of $178 million in 1997 and the figure for 2001 was expected to fall to around $55 million (Figure 18). Increases in exploration budgets have been recorded in Canada, Australia, the US, Russia and India but in general expenditures on domestic exploration were some ten times higher than expenditure on exploration abroad. In addition, exploration in Canada and the US accounted for over 50 per cent of the total budget in 2001. Such a decrease in exploration could be of concern in the longer term.

In contrast, technological developments in the nuclear power industry could adversely affect demand for uranium. New reprocessing technologies could reduce demand for uranium by some 17% over the next 20 years (IAEA 2001). Other technologies under development could also make a difference. These include fast breeder reactors, high-

Figure 18: Worldwide Uranium Exploration Expenditure (1994-2002)



Source: IAEA 2002

temperature gas-cooled reactors and new enrichment technologies that could extend uranium resources for centuries (IAEA 2001).

3.4.2 Potential likelihood of occurrence

Supply disruptions due to technical factors are only expected to be of importance in the long-term. Sufficient new reserves have been discovered to meet near and medium-term demand forecasts under both the 'High Growth' and 'Low Growth' scenarios. However, there are insufficient low cost reserves to meet long-term demand forecasts under the 'High Growth' scenario and this could lead to supply disruptions unless new exploration is undertaken in the next few years.

However, the impacts of low-levels of exploration are likely to be mitigated by improvements in efficiency in the nuclear industry making the likelihood of supply disruptions as a result of technological factors low

4. Affect on prices of supply disturbances

The price assumptions for the ‘Low Growth’ and ‘High Growth’ scenarios are shown in Figure 19. In the ‘Low Growth’ scenario prices are expected to remain relatively depressed as demand for uranium remains benign. Even so we have assumed that the price will rise by around 2 per cent per annum until 2040 reflecting the high cost of production of new developments currently being brought on stream. In the ‘High Growth’ scenario we forecast prices to rise above $130 by 2040, representing a 5 per cent compound annual growth in prices. Such an increase will be necessary to justify the development of the more expensive non-OECD deposits required to fill the supply gap after 2025.

Figure 19: Price Scenarios

	Home	Best
Near	$30	$35
Medium	$35-45	$45-60
Long	$45-65	>$130

4.1 ‘Low Growth’ scenarios

Supply disruption in the ‘Low Growth’ scenario are considered to be low in the near term. If they do occur then they are likely to be short-lived causing near term price-spikes. Under such circumstance we would not foresee average prices rising substantially above our current price forecast.

Medium term supply disruptions are also considered to be low although there is a moderate chance that environmental factors could disrupt supplies. In such a case we would still consider the impact on prices to be relatively short lived as current production, developments in progress and secondary supplies are sufficient to meet demand. As a result we would not foresee average prices rising significantly above our forecast.

In the longer term political factors could put pressure on prices. If decisions are taken to prematurely close the nuclear industry then the risk to the price is more on the downside.

4.2 'High Growth' scenarios

Supply disruption in the 'High Growth' scenario are considered to be low in the near term. If they do occur then they are likely to be short-lived causing near term price-spikes. Under such circumstance we would not foresee average prices rising substantially above our current price forecast.

In the medium term, there are real economic supply risks if decisions to develop new reserves are not made in time given the long lead times in the industry. By 2020 the supply of secondary uranium is expected to be exhausted but if such supplies prove to be lower than anticipated there will be sustained upward pressure on the price. Current estimates of supply suggest that the price will have to rise to between $45 and $65 per kg to bring on new supply but if secondary sources run out earlier than forecast this would push this price band upwards.

In the long-term the risk of supply disruption duo to political and economic factors is estimated to be high to moderate simply because the supply demand gas that opens up after 2025 is so wide. The impact of technology on demand is unlikely to be able to bridge this gap therefore there is a real risk of upward pressure on prices if new developments are not brought on stream on time.

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7. Terminology

Metric units are used in all tabulations and statements. Resources and production quantities are expressed in terms of metric tons (t) and uranium (U) rather than uranium oxide (U3O8).

1 short ton U3O8	=	0.769 tU
USD/lb U3O8	=	USD 2.6/kgU
1 metric ton	=	1 tonne

HEU	Highly enriched uranium (used principally for nuclear weapons and fuel)
MOX	Mixed oxide fuel (fabricated from depleted or natural uranium oxide which can be used in standard light water reactors)

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[i] It is legitimate to ask, why should the focus be on price instead of quantities. A disruption of production or distribution means a reduction in availability. At first sight this is certainly true. But the severity and the many implications of a quantitative shift can only be gauged by considering the resulting price effect, its impact and the behavioural and policy adjustments to this effect. The true measure of a shortage (which is always relative to demand) is the extent of the price change. And in the very extreme case when a commodity entirely vanishes from the market one could still say that the price change is of infinite magnitude.