Factors influencing the International Price of Oil in the Medium to Long-Term

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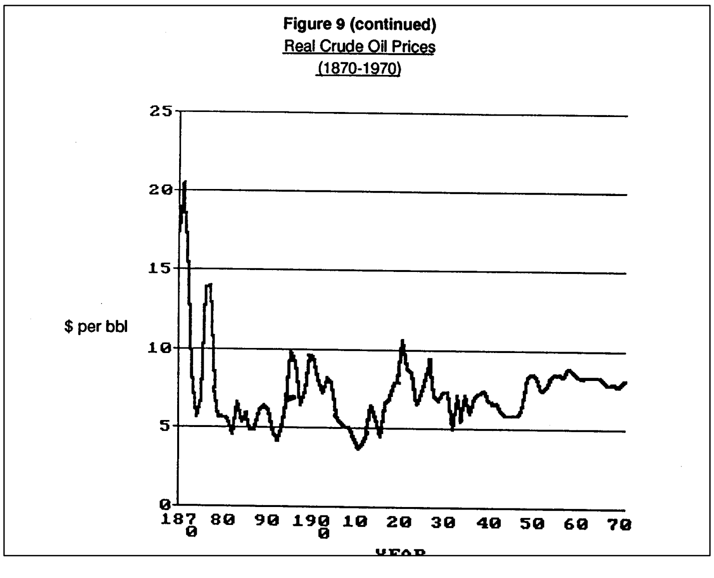
1. The historical long-term Trend in Oil Prices

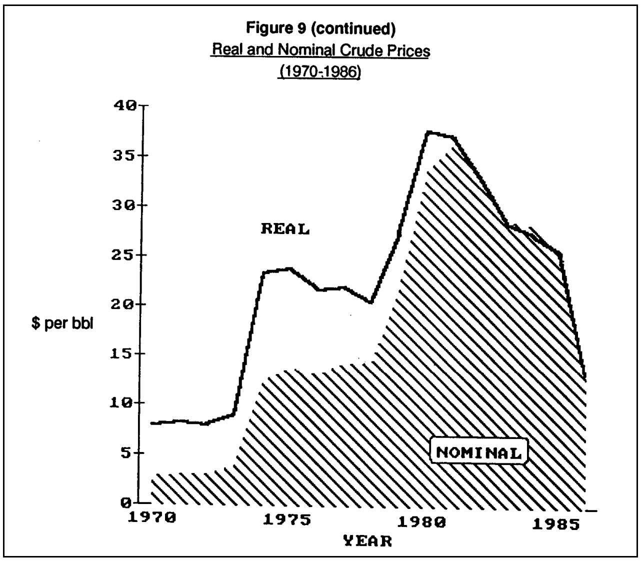
The historical long-term price movements on the international market for crude oil were analysed by Petroleum Finance Company in the report "World Petroleum Markets. A Framework for reliable Petroleum Projections", published as World Bank Technical Papers 92, Industry and Energy Series, 1988. The two charts shown below, taken from the report, trace the trend in the real price of crude oil between 1870 and 1985. The movement of the price of crude oil during that period allows four key observations to be made about the behaviour of real price of crude oil over time:

1. Price cycles are an integral aspect of petroleum economics. The yearly average crude oil prices fluctuate systematically around the long-term average price.

2. The average real price of crude oil from 1880 to 1972 was around US$14 a barrel in year 2004 prices (US$8 in the 1985-prices used in the chart). From 1880 to 1972 the yearly average price stayed within a band of US$9-17 in year 2004-prices (US$5-10 in 1985-prices); except in 1910 and 1921.[1]

3. The oil price from 1973 and 1985 was each year far above the previous price ceiling of US$17 in 2004-prices, indicating that OPEC's policy from 1973 of production ceilings imposed a structural shift on the oil market.



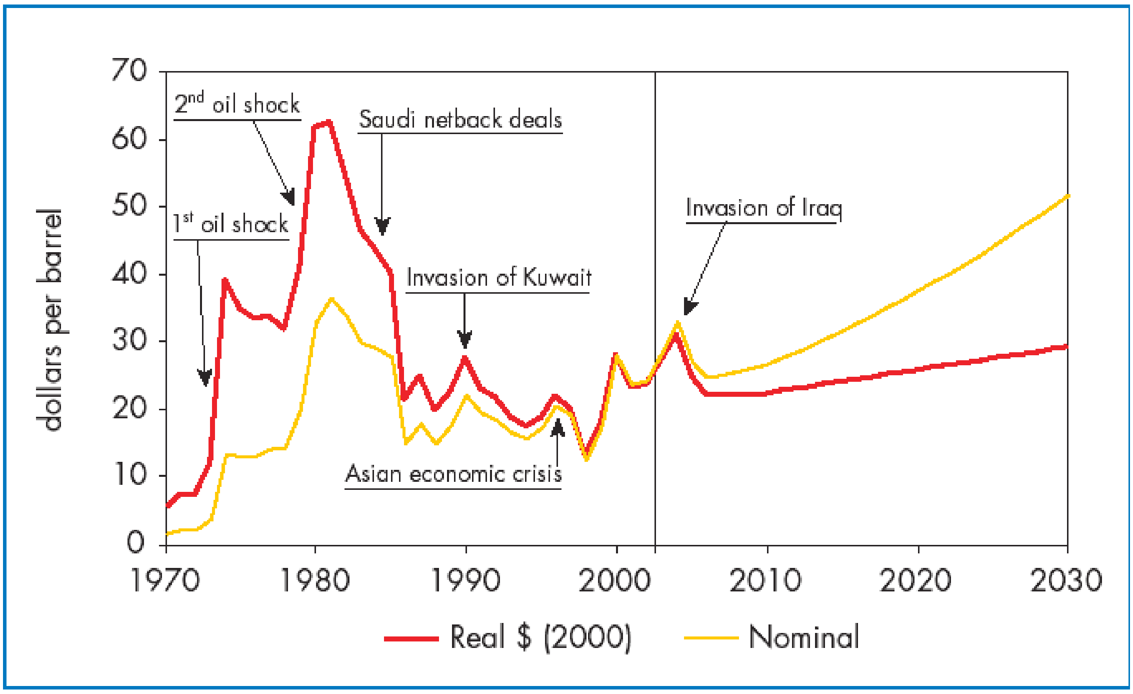


The next chart, copied from IEA's WEO2004, shows the evolution between 1970 and 2004 of the nominal and the real prices of oil, expressed in year 2000 price level. After the oil price increase in 1973, supply interruptions caused by the Iranian revolution in 1979 made the oil price overshoot to US$70/bl (year 2004-price level). The demand reaction it triggered made the oil price from 1981

[1] All nominal prices in this article are deflated using the US consumer price index.

fall in real and nominal terms. During the 1990s the price averaged around US$20 a barrel[2], from 2000 to 2004 more than US$25/bl. Thus, the average price also from 1986 to 2004 was far higher than the pre-1973 price-ceiling of US$17.

Figure 1.3: **Average IEA Crude Oil Import Price**



Source: IEA WEO2004

When discussing forecasts for the price of oil, a word of caution: the price depends on the price of the crude, which is used as benchmark. Due to differences in viscosity, sulphur content and acidity, different crudes have different market prices. The most widely used crude oil price benchmarks are:

- **West Texas Intermediate (WTI),** used primarily in the U.S; WTI is very light and very sweet. This makes it ideal for producing products like low-sulfur gasoline and low-sulfur diesel.
- **Brent**, used primarily in Europe; Brent is not as light or as sweet as WTI but it is still a high-grade crude.
- The **OPEC market basket**, used around the world. The OPEC basket is slightly heavier and sourer than Brent.
- Other benchmarks, like **Dubai**, are used in Asia.

As a result of these gravity and sulphur differences, **WTI** typically trades at a >3 dollar premium to the **OPEC basket** and **Brent** at a >1.5 dollar premium. In this paper, following the example of IEA's WEOs, the quoted crude oil prices refer to the average import price of IEA-countries.

[2] The low during the decade was US$10 in 1998 (that years price level), when two factors drove prices down. In 1997, a deeply divided Organisation of Petroleum Exporting Countries decided at its meeting in Jakarta to increase oil production by 10 per cent, just as the lift in oil demand from the Asian tigers imploded as a result of the currency crisis in the region.

2. Structural shift caused by OPEC's entry as active market manipulator and its limitations

The replacement of the price fixing cartel of the "seven sisters"[3] by OPEC as an active cartel from 1973 led to a permanent upward shift in the average price of crude oil: the 70 year average price up to 1972 was about US$14; from 1973 to 1984 the average price was 56 dollar; although it fell to an average of 24 dollars between 1985 and 2004, this price was still much higher than the pre-1973 price ceiling of US$17.

Long-term demand and supply factors set the framework conditions for the oil market, but the oil price here and now is defined by the "month-to-month" balance between demand and supply. Within the constraints imposed by market fundamentals other than OPEC-power, OPEC, a cartel of 11 oil exporting countries[4], tries to manipulate the short-term market to its advantage. While non-OPEC producers produce at full capacity for the market, OPEC tries to influence the final market price via decisions on the size of OPEC's oil output. Due to the very low short-term price elasticities of oil demand and of non-OPEC supply, the short term oil market reacts hysterically to changes in the balance between demand and supply: a 1% change can lead to a 30-50% jump in prices. This gives OPEC's policy of production ceiling substantial clout. OPEC looks at the balance between demand and supply on the market and tries to fix OPEC production (and hence OPEC's supply to the international oil market) at a level, which results in a price of crude within OPEC's officially announced target price range. In 2000 OPEC adopted a price target of US$22-28; the price range was suspended in January 2005; a decision on a new and higher price-band is to be taken later. Also in 2000, OPEC adopted a policy of fine tuning its supply in a way that prevents a large build-up of stocks in consumer countries; making sure that refineries have few barrels in stock to cope with a reduction in supplies.

In pursuing its policy of production restraints, OPEC faces two problems of economic self-interest. The first is that all oil producers in the world benefit from the higher oil price achieved by a production cut, but only OPEC carries the burden in terms of reduced physical sales of crude. Since OPEC acts as the marginal producer, higher oil prices hit OPEC with a double hammer in the medium term: total oil demand goes down and non-OPEC supply increases leaving OPEC with a sharply reduced market. This is the collective member issue: is a high price policy in OPEC's interest? The second problem is that all OPEC members in case of a decided cut-back in production end up with surplus production capacity. This tempts individual members to cheat by "secretly" producing above the allocated quota and "secretly" selling the extra output on the market. The higher the surplus capacity, the more difficult it is to agree on production cuts and the higher is the temptation to cheat. The reverse is equally true: the lower the surplus capacity of OPEC, the stronger is the cartel's ability through production cuts to impose its target price on the market.

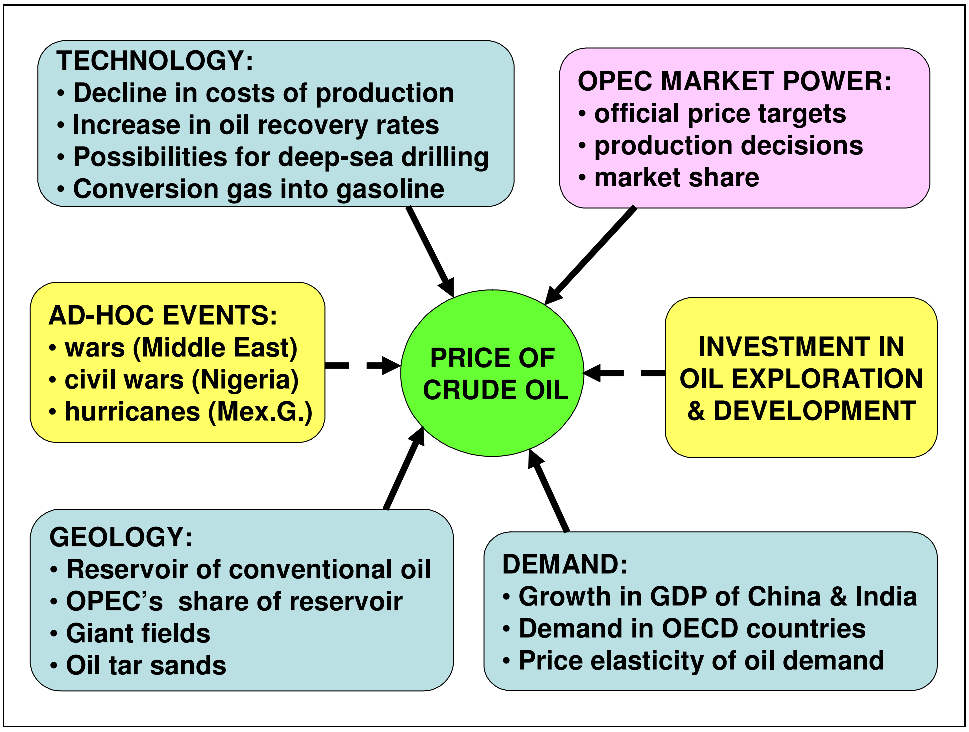
The evolution in the real price of crude oil and in OPEC supply of oil from 1970 to 2005 illustrates the limits which the two problems posed to OPEC's exercise of market power. OPEC reached its high–point of influence in 1973, when the Arab oil embargo started off OPEC's policy of production constraints at a time when OPEC supplied 53% of world oil supply. After 1973, expanding non-OPEC supply cut down OPEC's market share to 38% in 1985 and reduced OPEC supply also in absolute terms. Until 2004 OPEC supply did not grow beyond the level achieved in 1978! As OPEC weakened, it lost the ability to take decisions that shaped events, rather the new

[3] The seven largest oil companies in the world at that time: Exxon, Shell, BP, Mobil, Texaco, Chevron,
[4] Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela.

situation was that OPEC reacted to events. All major price jumps, beginning with the 1979-Iran crisis were caused by political events outside the control of OPEC. In 1985 the oil-price collapsed because falling oil demand and increased non-OPEC supply had lead to an OPEC surplus production capacity of 13 million barrels a day. This put too much strain on OPEC's policy of production constraints; Saudi-Arabia's production had dropped from 10m to 3.5m b/d and could not continue to take the major brunch of cut-backs in OPEC supply. Both then and later in 1999, Saudi Arabia used its large reserve production capacity to throw a higher supply on the market to depress the oil price and thereby re-impose market discipline on "cheating" OPEC members.

3. Are we in 2004 witnessing the start of a permanent upward shift in the real price of oil?

What makes forecasts for short-run and long-term prices for crude oil so difficult, is that a number of factors impact on the price of oil. The chart below summarises the impacts, distinguishing between factors that influence the price in the short-term (dashed arrows) and factors that influence the price in the long-term and determine whether a permanent shift in the price of oil takes place.



It is obvious from the number of factors shown in the chart above, that forecasters must be cautious when drawing strong conclusions about a paradigm shift on the oil market. Once oil prices increase, fuel substitution effects and energy savings keep down the demand for oil, while higher returns on tertiary oil recovery methods and on the development of marginal oil fields and oil-shale reserves increase the supply of oil. This puts a lid on the scale of the potential oil price rises in the medium to long term.

Fluctuations in the price of oil in the short term are caused by "*ad-hoc events*" that change the short-term demand and supply balance. Examples are political events, extreme weather, fluctuations in the level of investment in oil exploration and development and fluctuations in the macro-economic growth rate of the international economy.

In 2004 a number of factors converged to push the price of crude oil substantially beyond the 100-year average price level. (i) A world economic growth of close to 5% pushed global oil demand up by 3.2 percent, equal to 2.5 million barrels a day, the highest increase in oil demand for 16 years. (ii) The supply side was negatively affected by the threat from Shia's in Iraq to blow up the Southern export pipeline, civil war threats in Nigeria, a sharp increase in duties on foreign oil companies in Venezuela, political problems surrounding the Yukos oil company in Russia, hurricane damage to oil installations in the Gulf of Mexico, and the psychological impact of the admittance by Royal Dutch/Shell, the world's third-largest oil company, in early 2004, that it had overstated its oil and gas reserves by 22 percent. (iii) A significant part of the increase in the Chinese demand for oil came from diesel consumption for new diesel power plants build to prevent power shortages. (iv) Spare oil production capacity that could be tapped instantly to offset a temporary loss of supply dropped in 2004 to 1 million barrels a day of, the bulk of it in Saudi Arabia. That's a low reserve for an 82 million barrel per day supply system and well below the 10-year average of 5.0 million barrels per day. In the past, the larger surplus of capacity could temper the blow that geopolitical fears had on oil markets; but when oil supply and demand get close, almost any factor and uncertainty is magnified in the price structure.

The sharp increase in the price of oil in 2004 can, thus, be explained fully with reference to short-term factors. To conclude that the price increase from 2002 to 2004 is also a harbinger of a permanent upward shift in the price of oil, one must be able to identify structural factors that lead to significant changes in *the interaction between (i) the impact of the geology of oil resources and of OPEC production policy on annual oil supply, (ii) the impact of world economic growth and of energy-environmental policy on world oil demand, and (iii) the impact of technological progress on the supply of and the demand for oil.*

In the following sections, we will analyze the interplay of the factors through a two-step procedure. First, we look at the "*long-term market fundamentals*": technology, oil demand and oil geology to draw conclusion about the *potential demand-supply balance* during the next 25 years. Then we add the "*OPEC-factor*" to the equation. We analyze the implications of the emerging demand-supply balance for OPEC's market power and determine, which "oil-price oil-production policy" is in OPEC's economic self-interest. This provides a justified estimate of the future oil price.

4. Impact of Technology on Oil Supply and Demand

Since technological progress impacts the demand as well as the supply of oil, we begin with this.

Technological progress increases the *supply of crude oil* and reduces the cost of marginal oil supply through four mechanisms:

1. New technology, such as horizontal drilling, reduces the *cost of production* in exploration, development and extraction, enabling marginal fields to become commercially viable.
2. New technology enables *previously inaccessible oil deposits* to become accessible, e.g. deep-sea offshore oil.
3. New technology for secondary and tertiary *production enhancement* increases the recovery rates of oil;
4. New technology reduces the cost of extracting and processing *un-conventional oil resources*.

Technological progress reduces the demand for conventional crude oil and puts a ceiling over the medium-to-long term increase in the price of crude oil by lowering the cost of production and *increasing the supply of substitute fuels*:

1. New technology for converting natural gas and coal into gasoline and diesel fuels.
2. New technology for bio-fuels.

The impact of new technology on *the demand for oil products* is two-edged. Technological progress increases the energy efficiency of oil-using equipment and of transport. But new technologies can also increase the demand for oil. The increase in the energy efficiency of car motors over the last 10 to 15 years, for example, was off-set by by an increase in average car size and motors and by the almost universal use of air-conditioning in new cars. The latter was made possible by the reduction in the cost of air conditioning, which turned air conditioning from being a feature of luxury cars into a feature of standard cars.

New technology will continue to bring impressive *cost reductions in the exploration-development-production-pipeline transport chain*. Through the 1980s, exploration costs per barrel for new oil fields fell from US$20 to US$5-7 per barrel thanks to breakthrough technologies such as 3D-imaging. Therefore, despite the decrease in the quality of new exploration areas, the costs of exploration and development per barrel remained flat during the 1990s. Since 2001, however, the cost per barrel found has increased.[5]

The point of this for oil scenario analysis is, that supply curves showing the cost of new oil supply as a function of the specific source of marginal oil supply usually over-estimate the future costs of production because they do not take into account the cost-reducing impact of technological progress up to then. The overestimation of the future cost of production per barrel in such charts tends to be large because the annual rate of cost reduction is, on average, always higher in new technologies that expand the production frontier (e.g horizontal drilling) than in mature technologies, which reduce the cost of ongoing operations (e.g. vertical drilling).

[5] Quoted in Economist, October 30· 2004. “Oil companies profits. Not exactly what they seem to be”.

Improvements in methods for enhanced oil recovery are responsible for most of the increase in proven reserves since the 1970s: new technologies increase the fraction of oil that can be recovered from an oil field - the so-called recovery factor. [6] In the 1960s oil companies assumed as a rule of thumb that only 30 percent of the oil in a field was typically recoverable. The recovery rate for 'conventional' oil (i.e., excluding tar sands, shale oil, etc.), is now on average 40% (volume-weighted) of the oil in-place; with recovery factors in individual fields ranging from 1% to over 90%.[7] Looking forward, oil companies now bank on an average of 40 or 50 percent to be achieved during the lifetime of the field.

With a total amount of "conventional" oil in-place of about 5,000 billion bls, the gains from increases in recovery rates are huge:

- A 10% percentage point increase in the average recovery factor adds about 500 billion bls to the world's reserve endowment.
- Increasing the global average recovery factor by 0.6% percentage points per year generates incremental annual supply equal in size to the world's oil consumption in the year 2004.

Another area, where technological progress can make a large impact on supply, is in the development of lower cost and environmentally more friendly production methods for extracting and processing *non-conventional oil*[8]: oil shales, tar sands and bitumen, and extra heavy oil.

Total, the French energy group, began in the 1990s to investigate the task of extracting *extra-heavy crude oil from central Venezuela's Orinoco belt; whose extractable reserves are estimated at 270 billion bls*. Thanks to rapid advances in bringing down the cost of extraction, production started in 1998.[9]

ExxonMobil, Royal Dutch/Shell and ChevronTexaco are the largest of the oil companies involved in extracting the sticky, tar-like bitumen from the massive *Athabasca oil sands in the Province of Alberta in Canada*. Extractable reserves in Alberta are presently estimated at 27 billion cubic meters or roughly 200 billion bls. These reserves are mined by open surface mining, where roughly two tonnes of the sands must be dug to produce one barrel of oil,[10] or by the in situ technique where super-heated steam is injected into the wells to get the bitumen flowing. The mined crude bitumen is converted into socalled synthetic oil in a production process, which involves use of substantial amounts of gas as energy feed-stock. Synthetic oil has a higher sulphur content than normal crude oil and must, therefore, be refined by refineries that have the equipment to handle high-sulphur oil. The two major technological challenges – in addition to the general work on reducing the cost of

[6] The most impressive increases in recovery rates since the 1970s occurred in the "difficult" reservoirs. The off-shore Dan-field in the Danish North Sea, for example, was originally, upon entering production in 1973 expected to yield a recovery rate of 5%, due to being trapped in limestone, but inter alia horizontal drilling techniques, enabled the recovery rate to reach more than 25% by 2004.

7 The most important determinant for the recovery rate is the geology of the reservoir: a 3% recovery rate occurs in fractured tight reservoirs, 80% can be achieved in very porous reefs. Another is the fluid: whether it is onephase oil, oil with dissolved gas drive, oil with gas cap, or oil with aquifer."Jean Laherrère: Future of oil supplies. Seminar Centre on Energy Conservation, Zürich, May 7 2003, quoted from Teknologirådet, 2004.

[8] The classification refers to bitumen-like oil, which, unlike conventional oil, will not flow to a well under natural conditions.

[9] Total had 10 years of technical co-operation with PDVSA, Venezuela's state oil company, before being allowed to invest in Venezuela

[10] Source: Carola Hoyos: "Oil industry faces a stark choice", Financial Times, 21 Sept 2004

production – are to replace the use of gas by crude bitumen itself in the production of synthetic oil, and to reduce the amount of water in situ production.

The EU, US and other countries are actively promoting the *introduction of bio-fuels,* the production of transport fuels from agricultural wastes and surplus products. Supply from this will have a minor effect on the demand for conventional diesel used in transport.

The expected increase in the price of oil can be expected to increase interest in the development of projects using either *"gas-to-liquids" (GTL) technology* to produce diesel and gasoline from natural gas, or technology that can produce *liquid transport fuels out of coal*. That both technologies are becoming commercially viable is shown by the large investments in the gas-to-liquid plant being made in Quatar by ExxonMobil, and by the announcement end-2004 of plans by a Chinese private investor for coal-to liquid fuel manufacturing plant. The commercial viability of GTL-technology depends on whether the cost of the conversion process, including the inevitable energy losses in the conversion process, is lower than the price difference between the netback value of LNG (liquefied natural gas) for the gas producing country and the price cif of diesel in the consumer country. Since the international prices of gas and LNG are linked to the price of crude oil, whereas the price of coal is more independent, the economic attractiveness of the more expensive coal liquefaction process will increase over time.

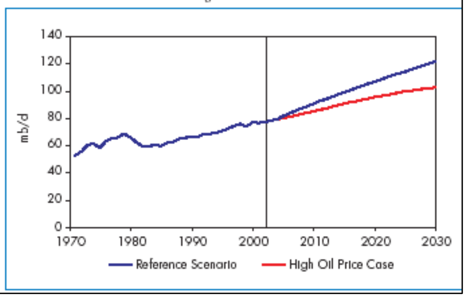
Overall, it is safe to conclude that technological progress will continue as usual, meaning that the most striking cost-reducing improvements will be made with regard to “marginal oil supply”. Thus, it is not possible on the technology side to identify developments that lead to a parameter shift on the oil market.

5. Factors leading to shifts in the demand for oil

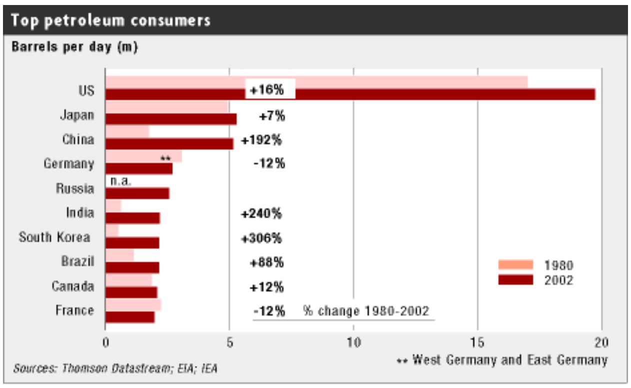
Structural changes on the oil market can on the demand side be triggered by changes in *the rate of growth in world GDP*; and by changes in *the elasticity of oil demand* with regard to changes in income (GDP) [11] and the price of oil[12]:

- *A* longer-term change in the rate of growth in world GDP changes the relative strength of oil demand vis-à-vis the "autonomous" development in oil supply. The changing balance on the oil market affects the price of oil as witnessed by the large difference in the average yearly price of oil during the world economic depression of the 1930s and during the economic boom period from 1950 to 1970.
- Changes in the elasticity of oil demand result from (a) new technology, (b) the regional composition of world GDP growth, (c) the composition of oil demand by sector and (d) the energy and environmental policy in major consumer countries.

Figure 3.27: World Oil Demand in the Reference Scenario and High Oil Price Case



The complex interactions result in strong fluctuations in annual growth rates in demand, see the evolution in demand from 1970 to 2003 in the "world demand chart" copied from WEO2004. From 1973 to 2003, world GDP growth averaged 3.3 percent per year and growth in world oil demand 0.9 percent per year (from 2867 mty/60mbd to 3712 mt/77mbd); resulting in a "change in oil demand / change in GDP" ratio of 0.3. If year 1971 is starting point, the growth rate in demand jumps to 1.4%, yielding a ratio of 0.4[13]. A break-down by sub-periods, shows a 0.9 ratio during the 1970s, whereas the 1980 to 1991 period results in zero growth in oil demand and a negative ratio. The pattern is confusing because the ratio shows both the income elasticity of oil demand to the growth in GDP and the demand reaction to the price hikes triggered by the two supply chocks of the 1970s. The demand reaction to the 1973 tripling of the oil price was mood; the additional doubling of the price in 1979 - and the forward looking "group-think effect" in terms of expectations of continued future oil price increases which it triggered - then unleashed a fall in oil demand up to 1985, which depressed the price of oil. Yet, the average price of US$24 from 1986 to 2002 was still 42% higher than the pre-1973 average of US$14.



The next chart, tracing the change in national oil demand of the top oil consumers from 1980 to 2002 shows huge national differences. Germany and France cut annual oil consumption despite increases in GDP; US demand (fuelled by higher GDP and population growth) increased 16%. South Korea increased its oil consumption by a staggering 306%, or by more than 6% per year. China oil demand grew 3% per year, yet China

[11] The income elasticity is the percentage increase in world oil demand per percentage increase in world GDP.

[12] The price elasticity is the percentage decrease in world oil demand per percentage increase in the price of crude oil. The effect of price changes on the demand for oil is asymmetric: the positive elasticity of demand to a price decrease is lower than the negative elasticity to a price increase. One cannot, therefore, speak of a single price elasticity.

[13] Source: IEA: "Key World Energy Statistics, 2005 pp.10 for year 1973 and 2003 figures, and WEO2004, table 2.1 for the year 1971 consumption figure of 2413 mty.

had the largest absolute increase in oil demand and is since 2003 the world's second largest oil consumer. India will soon overtake Russia and Germany, Brazil is not far behind.

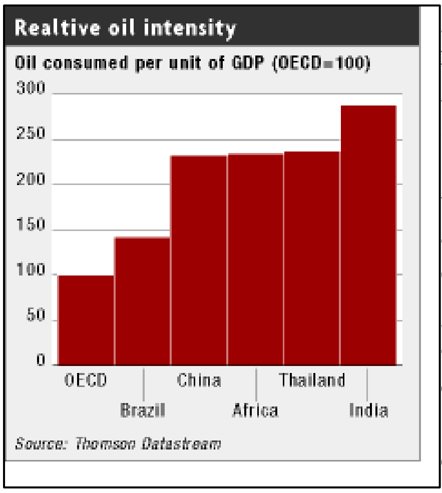
Looking forward towards 2030, the interactions become yet more complicated. GDP-growth and oil demand elasticity are affected by important shifts in the regional shares of the world economy - China accounted for 30% of world GDP growth between 1998-2003. Oil demand is in addition affected by the "autonomous" energy saving impact of "post-Kyoto" policy.

The *growth rate in world GDP from 2005-2030* is affected by two contradictory tendencies. The aging of the populations in EU and in Japan reduces the growth of world GDP; whereas the growing economic strength of China and India, having 40 percent of the world population and a huge catching up potential, points to an increase in the growth rate of world GDP. In WEO2004's reference scenario, the two tendencies affecting world GDP cancel each other: it *projects a 3.2% annual growth in GDP*, the same as the previous 25 years. This is a plausible assumption. But it assumes that China's average GDP growth rate of 9.5 percent from 1980 to 2004 drops to 5 percent during 2005-2030.

Based on the 3.2% GDP growth rate, WEO2004's reference scenario for 2005-2030 projects the *demand for oil growing 1.6% per year* from 83 mb/d in 2004 to 90 mb/d in 2010 and to 121 mb/d in 2030. The projected annual increase in demand and the "*change in oil demand / change in GDP" ratio of 0.5* is higher than during the previous 30 years.

One reason for the higher oil demand – but not listed by IEA as a determinant - is that WEO2004's reference scenario projects a increase in the price of oil, which is lower than the past: it increases 24 percent from US$ 24 in 2005 to US$31 in 2030.

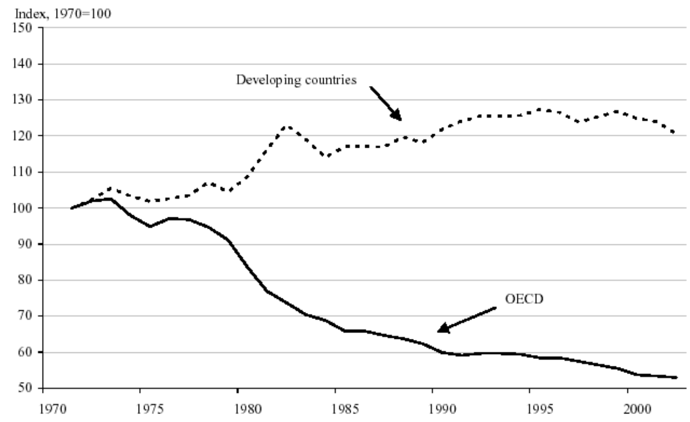
Another is that *changes in the regional composition of annual growth in GDP* lead to shifts in the global GDP-oil demand oil ratio because of differences in the regional GDP and price elasticities of oil demand. China and Africa are more than twice as oil-intensive as the OECD average, and India almost three times per unit of GDP (see chart).[14] Up to a certain level of GDP per capita, around US$5000 per capita, the energy and oil intensity of GDP increase. The GDP-elasticity of oil demand is higher in the emerging giant economies of China and India than in OCED-countries because economic growth in emerging economies prompts widespread increase of oil in all sectors; while in OECD countries growth in oil demand comes mainly from transport.[15] Beyond US$5000 per capita, sectoral shifts in the composition of GDP lead to a decline in the energy intensity of GDP.



[14] The charts on energy intensity and on top oil consumers are reproduced from Financial Times, 2004.
[15] OECD Economic Outlook 76 estimates that the long-run income elasticities of demand are 0.4 for the OECD, 0.7 for China and 0.6 for rest of the world; whereas the long-run price elasticities of demand are -0.6 for the OECD and -0.2 for both China and rest of the world.

These factors explain the difference in the *evolution of the oil intensity of GDP* between OECD countries and the developing world. In the latter oil intensity increased, while it fell in the OECD area, see the chart.[16] As the share of the world economy tips towards China and India, the "oil demand/GDP ratio" increases. Oil demand in both countries has substantial catching up to do before they are "mature economies": per capita oil consumption in 2004 in China was 1.45 and in India 1.2 barrels per year, versus 25 in the USA, 10.7 in France, and 12.5 in Italy.[17] Therefore, although energy savings is one of the six policy priorities adopted by the People's Congress in March 2005, one must for the 2005-2030 period expect that China's "change in oil demand / change in GDP" ratio will be higher than the amazingly low 0.3 ratio from 1980-2002. An indication of this is given by the high growth rates in Chinese oil demand from 2002 to 2004 – yielding ratios larger than 1! China generated 36 per cent of the jump in global oil consumption between 2002 and 2004, North America 24 per cent, the rest of developing Asia 16 per cent and Europe 11 per cent. In 2004 world GDP growth of close to 5% triggered an increase in global oil demand of 2.5 million barrels a day to 83 m b/d (=3.2 percent), which is the largest increase in demand since 1980 and yields a "world oil demand/GDP ratio" of 0.6.[18]

Figure IV.2. Oil intensity of production has fallen in the OECD area



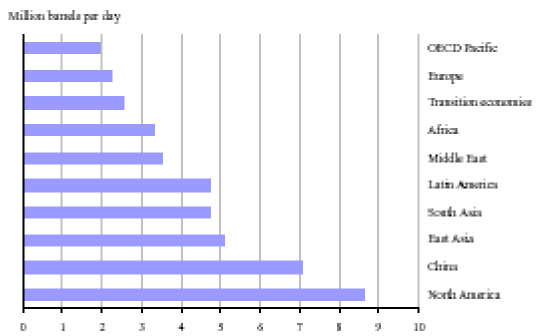
Note: Oil intensity is defined as total primary oil use per unit of output (GDP).

Source: OECD Economic Outlook 76 database and International Energy Agency.

A third factor is that the substitution of oil consumption by gas in the household and industrial sectors has led to an *increasing concentration of oil demand in the transport sector*, where few substitution possibilities exist. From 1971 to 2004, the transport sector's share of world oil use increased from 33% to 47%. In WEO2004's reference scenario, it increases to 54% in 2030, accounting for two-thirds of the increase in total oil use during the 2005-2030 period. The demand for transport fuels (like the demand for electricity) - and due to low substitutability, the demand for oil in transport - remains closely aligned with GDP. This is why the oil demand/GDP ratio for OECD countries, despite the continued advance in the productivity of energy use, will – ceteris paribus - be higher in the future than during the last 30 years.

Figure IV.3. Oil demand is projected to increase most in North America and China

Absolute increase in regional oil demand, 2000-30

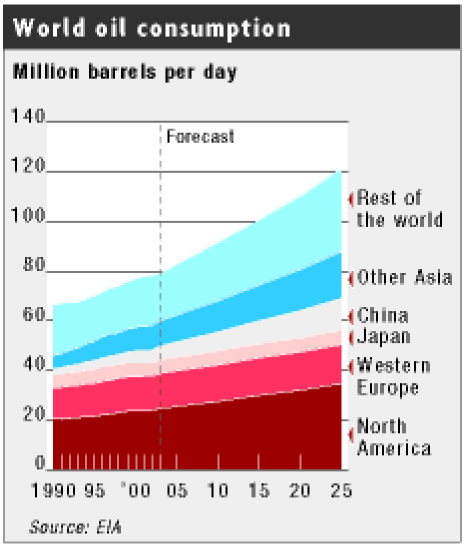


Source: International Energy Agency.

Looking forward to the year 2030, the EIA and IEA in WEO2004, therefore both expect the USA, not China, to be the main driver of the absolute growth in world oil demand, see the chart[19]. In WEO2004's projections China's " GDP/oil demand ratio" increases to 0.7, but as the GDP-growth rate falls to 5%, the growth rate in China's oil demand increases only by 0.4% to 3.4%. China's oil consumption in year 2030 would be 7 mbd

[16] Source: OECD World Economic Outlook 76, 2004
[17] Andrew McKillop: "Demographic oil demand and peak oil", September 20, 2004. VHeadline.com
[18] IEA's March 2005 forecast expects a demand increase in 2005 of 1.8 mb/d to 84.3 mb/d, a growth of 2.2 percent.
[19] Copied from OECD Economic Outlook 76.

higher than year 2004 consumption of 6.2 mbd; accounting for 19% of the world's incremental oil demand. The projected growth in China's oil demand and GDP seems low; but the forecast for total world demand looks realistic.



The *share of oil in world primary energy demand* fell from 45 percent in 1973 to 36 per cent in 2002, when coal accounted for 23 per cent, natural gas for 21 per cent, nuclear for 7 percent, hydro-power for 2 per cent and other renewable energy for 11 percent. Due to the reduced possibilities for the further substitution of oil use, the downward trend will not continue: WEO2004 expects oil to cover 35 percent of primary energy demand in 2030.

The *price elasticity of oil demand during 2005-2030 will be lower* than during the previous 25 years for two reasons.[20] (i) The increase in the transport sector's share of world oil consumption reduces the substitution potential in oil consumption. OECD2004 assumes that the price elasticity of oil demand in transport is half the elasticity of non-transportation oil. (ii) The reduced oil intensity of GDP has reduced the oil saving necessity triggered by an increase in the price of oil.

Yet, WEO2004 expects in its *high oil price scenario of US$38 per barrel*, that demand growth is reduced to 0.8% per year instead of the 1.6% under the reference scenario's price of *US*$29. Global oil demand in 2030 would be 19 mb/d, or 16%, lower than in the base case.

Green-house-gas policy will act as a counteracting force to the strong demand push coming from the free market. Oil demand will be lower than indicated by the reference scenario (projecting the situation without implementation of post-Kyoto policy measures) due to the introduction of post-Kyoto green house gas measures that – unlike the energy saving measures introduced by OECD Governments in the immediate years after 1979 – are not linked to or triggered by increases in the price of oil. On the contrary, the lower the international oil price, and thus, the lower the level of self-correcting forces to reduce the demand for oil, the stronger will the new "Kyoto policy measures" be. If oil demand develops as projected under the reference scenario, Governments will have to introduce new *energy saving measures in order to reach officially adopted Kyoto and post-Kyoto targets for reductions in greenhouse gas emissions.*[21] Although not presented as such, WEO2004's "World Alternative Policy scenario" can be said to show the Kyoto-effect. In it, the growth rate for *oil demand is reduced to 1%* per year leading to an oil consumption in 2030, which is 13 mb/d lower than in the reference scenario, with two-thirds of the reduction in oil consumption coming from the transport sector.

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[20] OECD 2004 lists the following assumptions for its elasticities of oil demand. OECD assumes the *price elasticity* of transportation oil demand with respect to the price of crude oil to have a long-run elasticity for price increases between -0.2 and -0.4; the price elasticity for non-transportation oil is twice as large. In Non-OECD regions the price elasticities are one-third as large as in the OECD. The *income elasticity* of oil demand in the OECD regions is assumed to be normally distributed with mean of 0.55, and in the Non-OECD regions having a mean of 1.0. The autonomous Kyoto-effect is not taken into account in these price and income elasticities of OECD. De facto demand elasticities, will, therefore, be lower during 2005-2030.
[21] WEO2004's reference scenario takes into account only policies and measures adopted by mid-2004.

The oil demand reducing effects of "Kyoto-demand-side measures" and of an "OPEC high oil price policy", if implemented simultaneously, are not cumulative but largely overlapping, as they affect the same "easy oil saving potential". Energy efficiency norms for new vehicles and airplanes, road pricing and city tolls to transfer individual traffic to collective transport will take away most of the oil saving effect that would be triggered by a long-term increase in the price of crude oil. The Kyoto-effect, therefore, reduces the impact of OPEC pricing policy on world oil demand, as Kyoto policy measures will suck up most of the demand reduction potential in any case.

Summing up the trend on the demand side, we can conclude that *free market forces* acting on the demand side will exert a strong upward pressure on the price of oil during the 2005-2030 period: the GDP elasticity of oil demand will be higher and the price elasticity of oil demand be lower than during the preceding 25 years.

6. Factors on the Supply Side: Oil geology, Level of Discoveries and Recovery Rates

Oil geology can during a forecast period "raise its head", pushing up the price of oil in three ways:

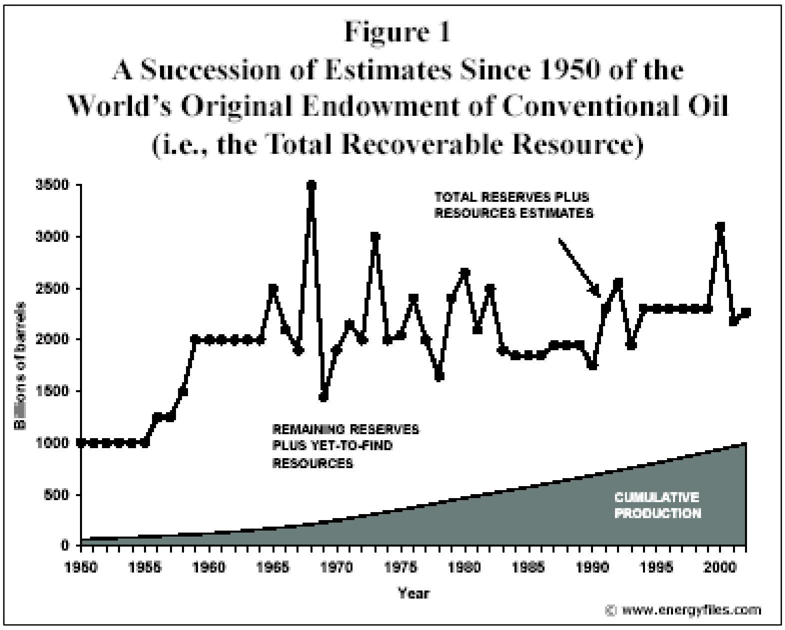
(i) The *cost of production of marginal oil supply* increases because the depletion of low-cost oil resources makes it necessary to develop high cost oil fields to satisfy future demand. Technological progress however reduces the cost increase.

(ii) OPEC members have the majority of oil reserves and oil resources, but a minority share of world oil supply. Non-OPEC supply is, therefore, depleting faster than OPEC supply and will peak long before OPEC production. This means that *OPEC's market power* is destined to increase.

(iii) Steady growth in annual oil depletion leads to the day where absolute resource constraints make it impossible to increase world oil production: world oil supply will then *peak*, after which it falls within very few years. The price increase that market participants will expect from the peaking situation, is certain to trigger a steady "hotelling price increase" at least a decade before the peak.

What is the strength of the three factors during the 2005-2030 forecast period compared with the previous 25 years period?

There is general agreement that the *world's original endowment of conventional oil resources* in ground amounts to about 5-6 billion barrels. The term "*ultimately recoverable resources/reserves*" refers to the total geological deposits of oil in the world that can be extracted from these. The USGS (US Geological Service) estimates these to be in the range of 2.2 billion barrels (probability of 95%) to 3.9 billion barrels (probability of 5%) with a mean of 3 billion barrels. This mean figure includes (i) cumulative production to date of about 1 billion barrels, (ii) remaining proven reserves from discovered fields of about 1.2 billion, (iii) undiscovered recoverable resources and (iv) estimates of "reserves growth" in existing fields partly due to expected technological improvements in the recovery rate, partly due to the increase in reserves in oilfields that typically occurs through improved knowledge about the field's productive potential, as "probable" and "potential" reserves become "proven". *Reserves growth* accounts for around 28% of *remaining ultimately recoverable resources*, whereas *undiscovered resources* account for about 36% in the USGS mean case.[22] The estimate as can be seen from the chart [23] is very much in line with the prevailing view of forecasts made by geologists since the mid-1950s. The variation in estimates is mainly a function of differences in the estimates of recovery rates.



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[22] Reference: WEO2004

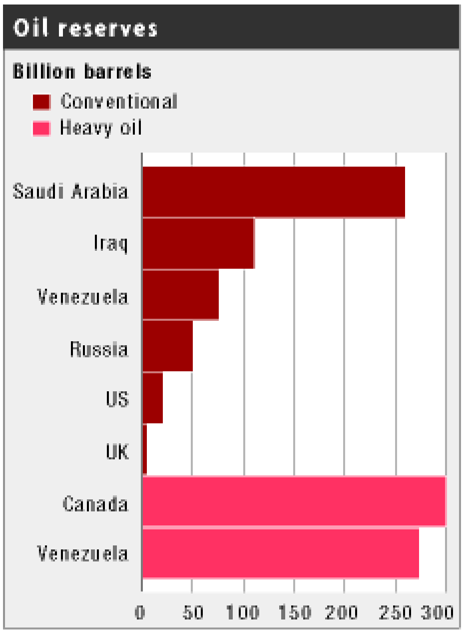
[23] Source of chart: Roger W. Bentley and Michael R. Smith :"World Oil Production Peak - A Supply-Side Perspective"

The chart shows that roughly 1 billion barrels of the resource base have been consumed so far, and that we are nearing us the year when the world has consumed 50% of the lower estimate of the recoverable resource endowment of conventional oil. The 1.6% yearly increase in consumption, projected in WEO2004's reference scenario, leads to a global oil consumption of 1.1 trillion barrels

In addition, the world is endowed with an estimated *7 trillion barrels of un-conventional oil resources* of which oil shales make up 38%, tar sands and bitumen 39%, and extra heavy oil 23%. Extra-heavy oil in Venezuela, tar sands in Canada and shale oil in the United States, account for more than 80% of these resources.[24] The amount of oil that can be recovered from these resources is uncertain. The WEO2004-report reports a figure of 330 billion bbls of extractable unconventional oil reserves. Experts believe that continued advances in technology will enable 1.2 bls of unconventional oil to be extracted over the next 60 years.

To what extend is this gradual erosion of the resource base reflected in a tightening oil market?

One indicator is the *ratio between the world's proven reserves and current production, (R/P-ratio).* The existence of oil and gas in fields controlled by the companies does not make a proven reserve; reserves of a field are reported as proven only if they can be recovered with current technology and are economically viable. Definitions of these vary; the rule of thumb is that estimates of "*proven reserves*" for a specific oil field must have a production probability of 90%, additional amounts called "*probable reserves*" a probability of 50% and the additional "*potential reserves*" a probability of 10%.[25] During operating time the proven reserves of a field tend to increase. Partly, because production increases the knowledge about the reserves of a given reservoir, turining some or all "probable and potential reserves" turn into "proven". Partly, because new technology increases the recovery rates. With proven reserves of 1300 billion bls and a consumption of 84 million bls/day(=30.6 billion bls/year), the year 2004 "proven reserves to current production ratio" stands at a record high of 40 years. This is a major reason why the IEA and the Energy Information Agency (EIA) of the US Department of Energy remain optimistic about the supply-demand balance.



Another indicator of future production potential, is the ratio of *remaining ultimately recoverable resources* to the *expected average production level over the projection period.* Based on USGS's mean resource estimates and WEO2004's demand projections, remaining resources are sufficient to meet the projected average annual production, between 2005 and 2030, 63 times over.

A second factor for optimism is that the R/P ratio refers to conventional oil resources only. Adding the potential oil supply from non-conventional oil resources changes the picture: the reserves of *extra-heavy crude oil* from central Venezuela's Orinoco belt and the massive *Athabasca oil sands of Canada* are larger than the conventional oil fields of the Gulf states.

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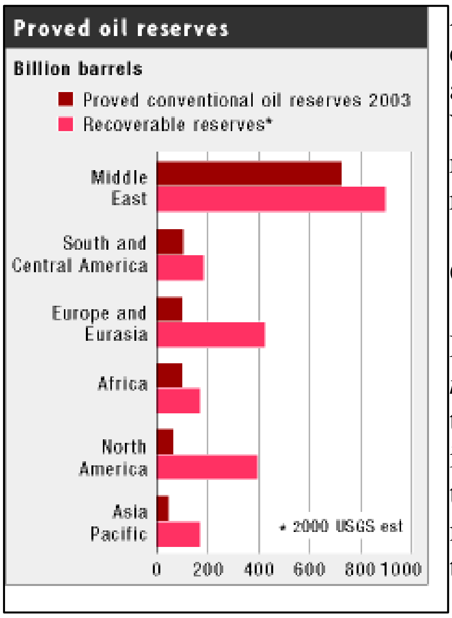
[24] Soure: WEO2004
[25] SEC reporting rules generally only allow the reporting of reserves "behind pipe" (i.e., produced by existing wells).



A third factor giving raise to medium term optimism is that the estimated recoverable reserves in regions outside the Gulf states, are much larger than their present proven reserves, see chart. Whereas the Gulf states have 70% of the world's proven reserves, they may have less than 50% of the world's recoverable reserves.

Other factors lead oil market specialists to be less optimistic.

First, *there is concern that the proven reserves of OPEC members may be inflated*. Members of OPEC have a temptation to inflate their reserves because OPEC's output quotas are based in part on national reserves; and the largest producers doubled their reserve estimates between 1986 and 1988. Outsiders have not had access to detailed production data from Saudi Aramco, the state-owned oil company, for more than 20 years.

Secondly, whereas historically, proven reserves and output have moved in tandem; *the relationship between reserves and production seems to be weakening*. Once a year, oil companies listed on the New York stock exchange announce their "*reserve replacement ratio*," telling investors whether they have found enough new oil and gas during the year to make up for their production.[26] For six consecutive years, ChevronTexaco announced that the company has found more oil and natural gas than it has produced. Over that time, ChevronTexaco's proven oil and gas reserves have risen 14 percent, more than one billion barrels. But near the bottom of ChevronTexaco's financial filings is a much less promising statistic. For each of those years, ChevronTexaco produced less oil and gas than the year before. Even as reserves have risen, the company's annual output has fallen by almost 15 percent, and the declines continued in 2004 despite a company promise to increase production in 2002.[27] ChevronTexaco is not the only big oil company whose production is falling despite rising reserves, though it has the largest gap.[28] That is a cause for concern, as in the long run, actual production is the most important proof that reserves exist.

Thirdly, the fact is that *the best oil reservoirs have been discovered* and that the *areas that have been long producing are starting to become very mature*[29]:

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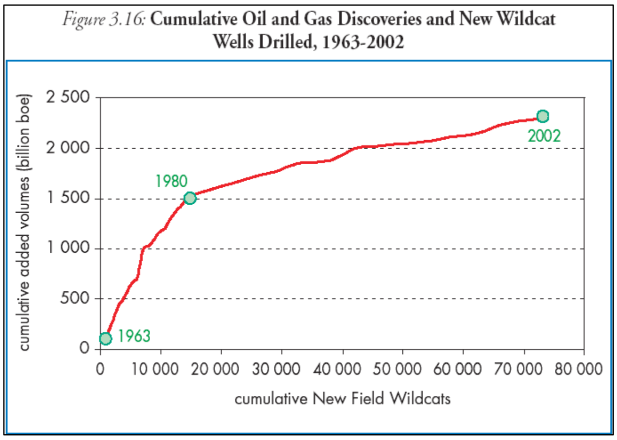
[26] The four biggest oil companies own only about 4 percent of the world's reserves, which are mostly government-held. . The four so-called supermajors produce only a small fraction of the world's oil; together, they extracted 3.2 billion barrels in 2003, about 10 percent of production worldwide. But they offer a unique glimpse of supply trends because they must disclose their reserves and production each year.

[27] Source: "An Oil Enigma: Production Falls Even as Reserves Rise", New York Times, 11 June 2004

[28] At *Exxon Mobil*, oil reserves rose from 9.6 billion barrels at the beginning of 1994 to 12.1 billion barrels at the start of this year, a 26 percent increase. But Exxon Mobil's production fell 2 percent, from 909 million barrels in 1994 to 893 million in 2003; during the first nine months of 2004, however, ExxonMobil's production increased 4%. At *ChevronTexaco*, oil reserves jumped from 6.9 billion barrels at the beginning of 1994 to 7.7 billion barrels in January 1998 to 8.6 billion barrels at the start of this year. But after surging from 644 million barrels in 1994 to 757 million in 1998, production plunged to 641 million barrels last year. At *BP*, the data is considerably more confusing, because the company has had so many acquisitions and sales over the last several years. Still, BP's production at its wholly owned fields has plunged to 562 million last year from 672 million barrels in 1998, while its reserves have risen to 7.5 billion from 6.5 billion over that span. Source: NYT 11.june 2004

[29] The maturity – and the associated decline in production – could explain the breakdown in the historic relationship between reserves and production.

- Global discovery peaked in the 1960s. Most of the existing oil reserves are in oil fields found more than 20 years ago. Most of the increase in proven reserves since 1980, is due to an upward revision of reserve estimates from fields existing prior to 1980.
- Since 1980, annual consumption has exceeded annual new discoveries. Discoveries in the 1990's were about 10 Gb per year as against an annual consumption of about 25 Gb per year.
- Global reserves found since 2000, when Kazakhstan's giant Kashagan oilfield was discovered, have fallen 40 per cent compared with the previous four-year period. The top-10 oil groups spent about $8bn combined on exploration in 2003, but this only led to commercial discoveries with a net present value of slightly less than $4bn.[30] The previous two years show similar, though less dramatic, shortfalls.
- About 80% of the oil produced today flows from fields that were found before 1973.[31] Some of these are reaching the phase of declining annual production.[32].
- Increasingly, the best prospects for new oil have proved to be in places that are off limits to major foreign oil companies.[33] Little is known about the medium to long-term investment plans of the national coil companies in key countries like Saudi-Arabia and Kuwait.
- Yet, more than 50 percent of oil and gas consumption in 2010 must come from new fields.[34]
- About half the oil discovered so far has been found in fewer than 150 giant fields, the other half in about 2 000 smaller fields, most of the discoveries made after 1980 were in small fields. If the world's future supply needs to result from new fields that are getting progressively smaller, it could require more than 3,000 new oilfields to be found and developed over the next ten years, compared to slightly more than over 400 named new oilfields that were discovered in the past decade.[35]



The higher success rates in drilling brought about by the introduction of 3-dimensional techniques, which lowered the number of wells drilled per oil field found, could not arrest the declining returns per barrel, because the average find is getting progressively smaller. The reserves found per well drilled are getting increasingly smaller, see the chart[36].

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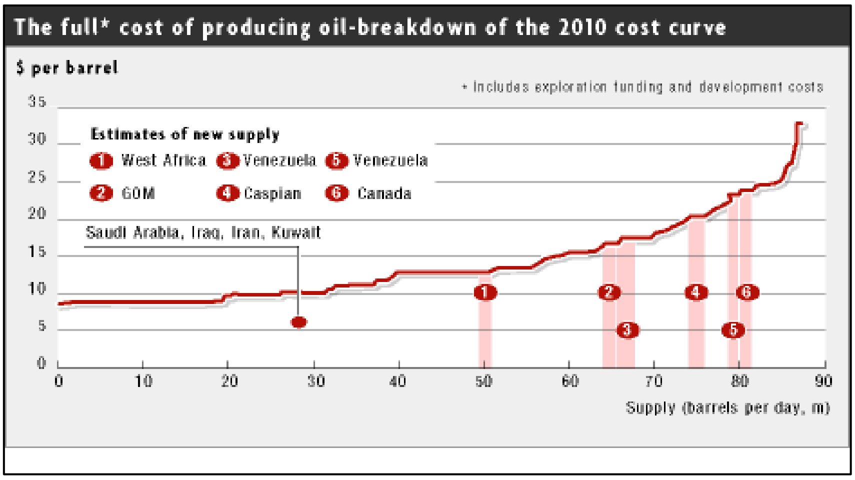
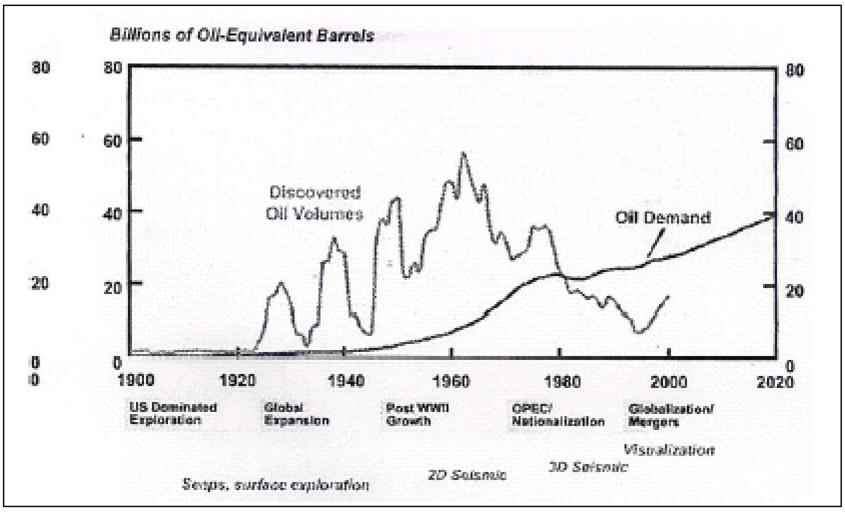
[30] Source: Wood Mackenzie quoted in James Boxell: "Top oil groups fail to recoup exploration costs", FT, 10.10.2004
[31] Source: Colin J. Campbell and Jean H. Laherrère: "The End of Cheap Oil". Scientific American, March 1998
[32] The annual global decline of older fields, such as those in the North Sea and US that came into production after the oil shocks of the 1970s, is 8-10 per cent. Saudi Arabia's reported proven reserves, more than 250 billion barrels, are one-fourth of the world's total. The most significant field is Ghawar. Discovered in 1948, the 300-mile-long sliver near the Persian Gulf is the world's largest oil field and accounts for more than half of the kingdom's production. In Saudi Arabia, seawater is injected into the giant fields to help move the oil toward the top of the reservoir. But over time, the volume of water that is lifted along with the oil increases, and the volume of oil declines proportionally.
[33] Analysts at Deutsche Bank believe that, after 2008, almost half the opportunities for oil companies will be in LNG, GTL, and Venezuelan & Canadian oil sands, with deep water projects making up another quarter of expected openings.
[34] Estimate by Harry Longwell, Director and Executive Vice-President, Exxon-Mobile Corporation:"The future of the oil and gas industry. Past approaches and new challenges." World Energy Vol. 5, nr. 3, 2002
[35] Matthew R. Simmons: *The World's Giant Oil Fields*. Hubbert Center Newsletter #2002/1. M. King Hubbert Center, Colorado School of Mines. January 2002, quoted in "Teknologirådet, 2004".
[36] Source of chart: EIA World Energy Outlook 2004

The LRMC of incremental oil supply is thus going to increase, as indicated in the next chart.[37] The chart draws up the supply curve of oil by showing the full cost of producing a barrel of oil, meaning the price covering the cost of exploration, development and extraction in the regions of supply, whose cumulative output provides the supply needed to cover demand. The chart sees marginal supply at present coming from Venezuelan and Canadian tar sands (points 5 and 6 on the curve). According to the chart this production is economically viable at roughly US$25 per bbl; whereas WEO2004 shows the cost of production to be around US$15 only. The year 2004 average price of over US$40/bbl, gives in any case even the marginal oil fields an economic resource rent of over 100% over the cost of production.



Fourthly, *discoveries since 1980 have consistently lagged behind the growth in demand*, see the chart below. The introduction of 2D seismic exploration techniques in the 1960s, of 3D seismic exploration techniques in the 1980's, and of other new technology pushed the frontiers ever deeper off-shore and into arctic territory. Yet, these techniques, however, did not reverse the decline in discoveries. The increase in discoveries beginning in the 1990's, when computer visualisation of deep structures was introduced, reversed the trend only temporarily, see the chart.[38] That discoveries reached almost 20 billion bls in 2000 was partly due to the single large Kashagan oil field; since then reported discoveries averaged 12 billion bls/year only.

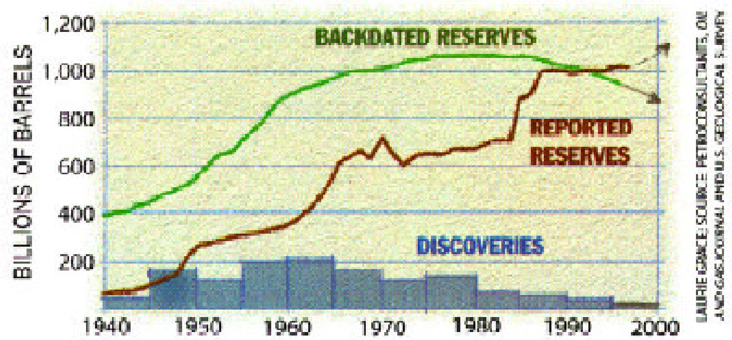


The year 2003 upstream performance review by energy research firm John S. Herold, based on a sampling of some 194 companies from around the world, shows that *drillbit reserve replacement* — which measures a company's own exploration efforts and excludes additions resulting from acquisitions — fell to 109% last year from 140% back in 1999.[39] Oil discoveries by the companies covered in the Herold study have been running at an annual pace of slightly less than seven billion bbl for the last five years while production has been running at over 10 billion barrels per year. *Gains from technical revisions of existing reservoirs lift the overall total*, enabling companies to grind out an average annual increase in oil reserves of around 1%. Reserve

[37] Copied from Martin Wolf: "Oil and Geology", Financial Times, May 1, 2004.
[38] Source of chart: Harry J.Longwell: The Future of the Oil and Gas Industry, 2002
[39] Source: Quoted in Petroleum Intelligence Weekly, October 4, 2004

replacement costs through exploration investment and through mergers and acquisitions jumped 20% to $6.36 per barrel of oil equivalent in 2003, rising about 15% per year since 1999. Finding and development costs have been escalating in mature areas like North America and Europe since 1999. Lately, frontier areas such as Africa, the Middle East and South and Central America also began to experience significant cost pressures.

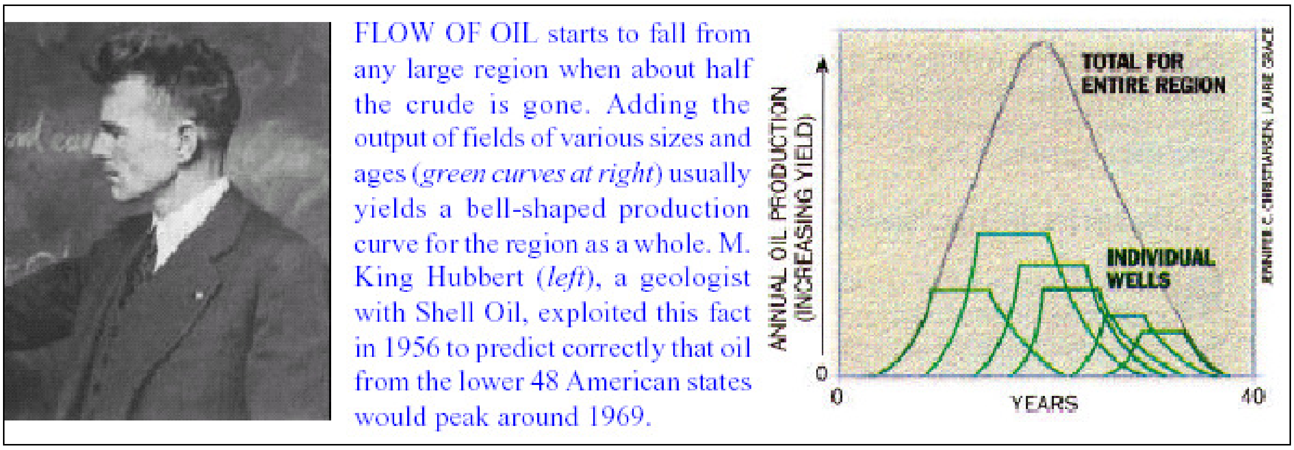
Most of the increase in proven reserves during the last 30 years is due to upward revisions of reserve estimates of fields discovered before 1980. This is shown in the next chart.[40] The lower curve shows the proven reserves as reported officially in a given year, while the upper curve shows the de facto reserves of that year according to the revised estimates made by the year 2000. The difference between the two shows the reserves added at later revisions of the original reserve estimates. For example, in the year 1950 proven reserves were estimated at about 250 billion bls. In the following years the reserves in the fields were revised upwards to 550 billion bls. Whether reserves will continue to grow relative to demand is a question of whether future reserve revisions and/or the finding of new oil fields will result in reserve additions in excess of consumption. Proven reserves found after 1990 will be revised upwards over time, although one should note that reported proven reserves of a year 2004 discovery already incorporate the upward lift of higher recovery rates compared with a year 1980 production technologies.



GROWTH IN OIL RESERVES since 1980 is an illusion caused by belated corrections to oil-field estimates. Backdating the revisions to the year in which the fields were discovered reveals that reserves have been falling because of a steady decline in newfound oil (*blue*).

Fifth, although the R/P ratio of 40 years is high by historical standards, *it does not mean that the year of peak production is far away*. Production will peak and begin declining long before the last barrel has been produced. The question is, when the peak is likely to occur? The decline of oil was most famously predicted by M. King Hubbert of the US, who was largely correct when he forecast, 14 years before the event, that oil production in the contiguous US (excluding Alaska and Hawaii) would peak around 1970. Central to Hubbert's prognosis is the hypothesis that oil demand in a region will peak when roughly half of the recoverable oil in a major oil region has been consumed. He, therefore, also predicted (based on an over-estimation of the growth in world oil demand) that the peak for world oil would come around year 2000.

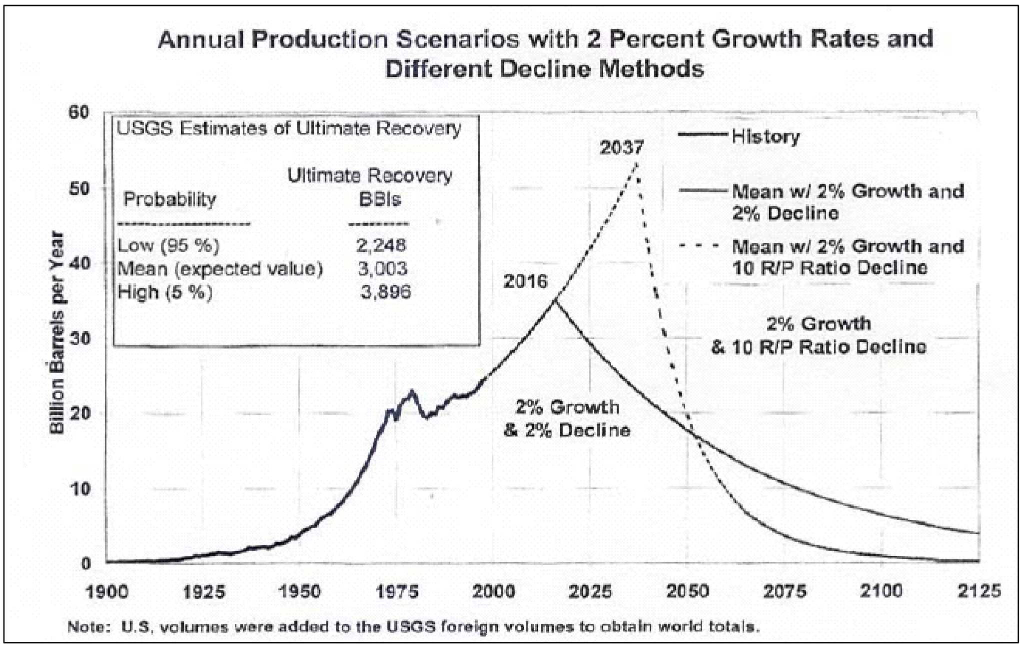
[40] Source of chart: www.oildepletion.org



Source: www.oildepletion.org

Assuming that the world has about 3000 billion bls of recoverable reserves of conventional oil; and using IEA's forecast of an annual 1.6% increase in world oil demand and assuming zero production of non-conventional oil, the world will by 2016 have consumed half of the conventional reserves. According to Hubbert's theory, world oil production would reach its plateau that year, except for the fact that supply from non-conventional oil postpones the peak in both total and conventional oil production.[41]

Researchers in the United States Geological Survey (USGS), which is the governmental body responsible for oil and gas research in the US, refute the validity of Hubbert's theory, claiming that



the predictions of an imminent peak in conventional oil production are unrealistic. Based on different assumptions as to ultimate reserves, future growth in demand, and decline rates after the peak, the EIA has computed a series of scenarios for the future development in conventional oil production. Two

[41] The development for natural gas is similar. Global discovery of conventional gas in new fields peaked in the late-1960s and has been in decline since. Global gas discovery in new fields is now running at around 65 Tcf/year, about three-quarters of the current consumption rate. The likely maximum resource, including present ones, to be discovered, at least within any reasonable time-scale, is about 10000 Tcf. About 7750 Tcf of conventional gas has been found so far, of which about 2400 Tcf has been burnt, leaving 5400 Tcf or so as industry-data (proved + probable) reserves. A simple mid-point peaking model of production would predict that global production of conventional gas will peak when roughly 5000 Tcf had been used, i.e., about the year 2025 at the present trend growth rate in oil demand.

of these are shown in the EIA-chart.[42] The first scenario is similar to "Hubbert-peak-hypothesis". It assumes that an exponential growth in demand of 2% per year can be sustained until production peaks in 2016. In the other scenario, this demand growth is sustained until 2037, whereupon production drops almost vertically.

On the basis of the US Geological Survey's assessments of conventional oil reserve, the EIA assumes that investments in exploration and development of about $75 billion/year (= 2 trillion USdollar) will ensure continued exponential growth in conventional oil production to a level of 45 billion bls/year in 2030 as against 30.6 billion bls/year in 2004. The IEA in WEO2004 concludes that supply can meet demand, growing 1.6% per year, at least until 2030 when demand is 121 mb/d, provided that 3 trillion of investments are made in the total supply chain. Of this, 70% would be in exploration and the development of production capacity and pipelines. Similar supply projections are presented by the European Commission.[43] Thus, global production of conventional oil need not peak before 2030 if the necessary investments are made. The level of investment of US$115 billion per year is feasible in principle: according to BP calculations, the top 30 oil firms increased their spending on exploration and development from US$70 million in 2000 to $100 billion in 2003.[44]

Increased supply from *non-conventional oil production* is a means to cover shortfalls in oil supply from conventional oil production, which can postpone the peaking year. In WEO2004's reference scenario, supply from unconventional oil production is projected to grow from 1.6 mb/d in 2003 to 3.8 mb/d in 2010 and 10.1 mb/d in 2030, making up 8% of oil supply that year: *non-conventional oil from Venezuela and Canada* would provide just under 6 mb/d; *gas-to-liquids plants* 2.4 mb/d; and 1.6m b/d would come from *biofuels* derived from agricultural products and from *coal-to-liquids*. WEO2004 expects supply from unconventional production to be rather inelastic: in its "high-price scenario", production from unconventional production would expand 15% to 11.6 mb/d.

But although production need not be limited by absolute resource constraints, the question remains whether in practice, private oil companies will invest enough and OPEC will to expand production to the extent warranted by increasing oil demand. We will discuss this in turn.

Taking net losses of world oil supply capacity through depletion at around 1.25-1.5 Mbd each year, present demand growth of about 2.5 mb/d per year requires new production, or increased existing capacities of well above 3.5 mb/d each year. The WEO2004 's reference scenario expects Non-OPEC countries to meet most of the increase in global demand up to 2010, after which Non-OPEC supply drops from 51 mb/d in 2010 to 48 mb/d in 2020 and 43 mb/d in 2030. EIA in its forecast up, sees non-OPEC oil supply increasing from 48m to 65m b/d to 2025, the annual increment - which during the past two decades was in excess of 2 mb/d - being 0.75 m b/d.[45] Acording to some experts, it is an optimistic assumption, as after 2010, a rise in supplies from Russia, Central Asia and deep-ocean off Africa will be offset by declines in other areas.[46]

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[42] Source of chart: US Department of Energy, Energy Information Administration (EIA), 2000

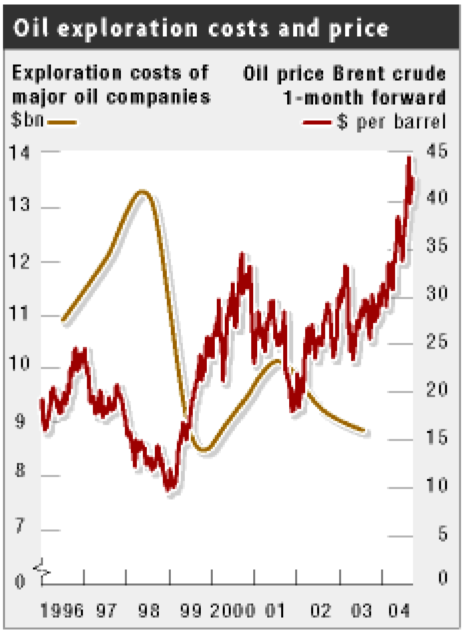
[43] In World energy, technology and climate policy outlook (WETO, 2003), according to "Oil based Technology and Economy. Prospects for the Future", Danish Board of Technology, December 2003.

44 Quoted in Economist, October 30, 2004. "Oil companies profits. Not exactly what they seem to be". Total investment in world energy supply and infrastructure is much larger: Meeting projected energy demand will entail cumulative investment of some $16 trillion from 2003 to 2030, or $568 billion per year according to IEA World Energy Outlook 2004.

[45] The largest increment in Non-OPEC supply occurred in 1978 with 2.2 mbd.

[46] The production of members of OECD continues to fall: it was 21.9m barrels a day in 2002 and 21.6m in 2004. Production of other non-Opec oil producers is forecast to rise by 2.3m barrels a day between 2002 and 2004, with the

The four so-called oil super-majors produce only a small fraction of the world's oil - together, they extracted 3.2 billion barrels in 2003, about 10 percent of production worldwide – while their reserves of about 40 billion barrels of oil, represent 4 percent of the world's proven reserves.[47] Development spending on existing oil and gas fields by the ten largest listed oil companies rose from $34.6bn in 1998 to a record $49.5bn in 2003. As a result non-OPEC production from 2002 to 2004 is expected to rise by 3.5 per cent yearly between 2004 and 2008.[48] For the evolution in non-OPEC production beyond 2008, the investment in exploration is relevant. Here the picture is negative, see the chart. From 1998 to 2003, exploration spending among the group of 10 companies fell from $11bn to $8bn. The year 2003 upstream performance review by energy research firm John S. Herold, based on a sampling of some 194 companies from around the world, shows that upstream investment rose by a relatively modest 9% to $161 billion [49], with development spending, amounting to $100 billion, capturing almost two thirds of upstream expenditure while exploration activity with $24.5 billion, held steady its share of overall upstream spending at around 15%.[50] An OPEC report in 2004 shows a 6.5 per cent decrease in *well completions* in 2003 compared with the year before. Deutsche Bank estimates major oil companies have cut back their *exploration budgets* by 27 per cent and that between 2001 and 2003 only six of the world's 15 leading oil companies managed to replace all the reserves of oil they pumped. Even if the trend were to change during 2005, it would not have much of an impact on oil supply before 2010.



The above is in particular a problem for the prospects for supply from non-OPEC countries, as Chinese and Indian companies are becoming an increasingly important source of finance for exploration, development and production by making deals with OPEC countries against long-term supply contracts and through equity investment.

At present, OPEC, which has 70% of the world reserves of oil, produces 38% of world production of oil; the Gulf states provide 28% of world supply[51]. The EIA under the US Department of Energy forecasts OPEC production to rise 26m barrels a day, from 30m in 2002 to 56m in 2025. The reference scenario in WEO2004 sees production in OPEC countries, especially the Middle East, to increase from 28 mb/d in 2002 to 33 mb/d in 2010, to 50 mb/d in 2020 and to 65 mb/d in 2030.

former Soviet Union's output forecast to jump by 1.7m barrels a day. OPEC production rose by 3.3m barrels a day between 2002 and April 2004, almost enough on its own to meet the increase in world consumption.

[47] They also have about 150 trillion cubic feet of natural gas, enough to produce the energy of 25 billion barrels of oil.

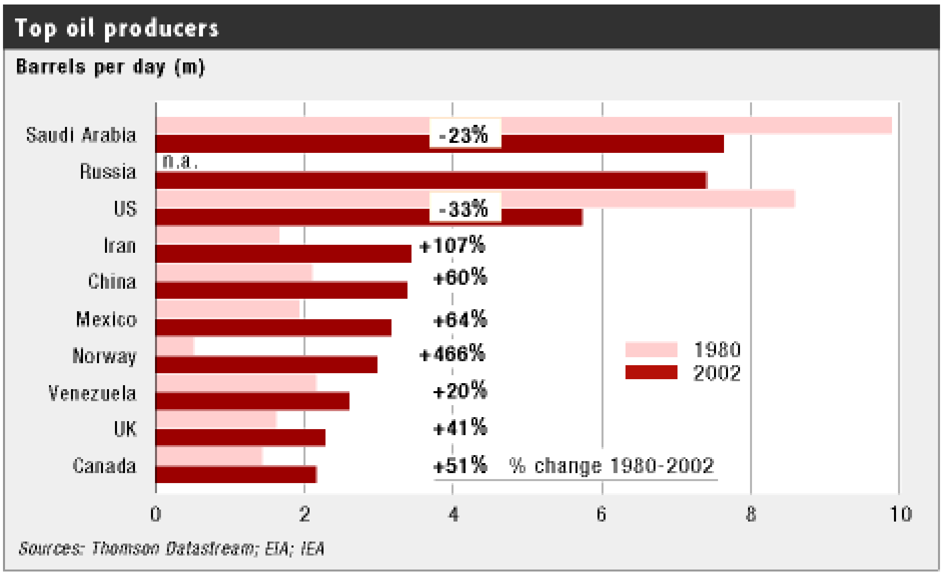
[48] Source: Wood Mackenzie quoted in James Boxell: "Top oil groups fail to recoup exploration costs", FT, October 10, 2004

[49] The oil and gas industry saw its cash flow climb 27% to $197 billion in 2003 versus 2002, as average net income rose 38% to $6.41 per barrel of oil equivalent in 2003. The difference between cash flow and spending was used by the oil firms to hand cash back to shareholders: BP is expected to purchase back shares of $7.25bn worth in 2004, Exxon some $9bn, while Shell has chosen to dole out the year 2004 windfall revenue as dividends to shareholders.

[50] Source: Quoted in Petroleum Intelligence Weekly, October 4, 2004

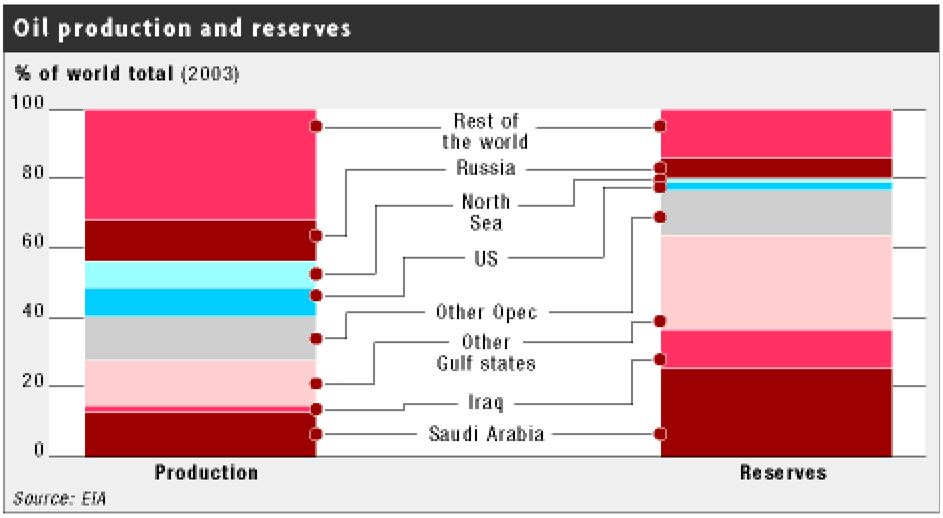
[51] Source for chart: IEA:"International Energy Outlook 2004", reproduced from Wolf, Financial Times, 2004

To meet expected world demand, the United States Department of Energy's research arm says Saudi Arabia will need to produce 13.6 million barrels a day by 2010 and 19.5 million barrels a day by 2020.[52]



This forecast appears not to be compatible with existing plans for supply. Saudi Aramco seems to have plans ready for expanding production capacity to 15 million barrels a day; but expects its production capacity in 2010 to be 10.5 m b/d only. [53]

Summing up the situation on the supply side, four fundamental changes exert a bigger pressure on the price of crude oil, than during the previous 25 years. (i) Whereas in the past most of incremental supply came from increased recovery rates of operating fields; in the future most incremental and total supply must come from new oil fields yet to be developed. (ii) Whereas incremental supply in the past came from non-OPEC countries, most of the increment in supply will have to come from OPEC supply and from unconventional oil. Incremental supply during (iii) The peaking of conventional oil production, which in the optimistic supply forecast happens in 2037, will trigger price expectations that will have repercussions on oil prices as early as 2025.



[52] Source: “Forecast of Rising Oil Demand Challenges Tired Saudi Fields”, Jeff Gerth, February 24, 2004, NYT

[53] Source: Jeff Gerth: “Forecast of Rising Oil Demand Challenges Tired Saudi Fields”, February 24, 2004, NYT

7. History of IEA Price Forecasts

IEA underlines in WEO2004 that "the assumed price paths, should not be interpreted as forecasts. They reflect our judgement of the prices that will be needed to encourage sufficient investment in supply to meet projected demand over the Outlook period." (page 47).

EIA's price projections have undergone substantial changes over the years. In 1980 IEA forecast a doubling in the (year 2004) price of oil price from US$74 in 1980 to US$148 by 2000. The real price in year 2000 turned out to be one sixth of IEA's forecast.[54] IEA's projected doubling of the real price of oil within 20 years both reflected and co-sponsored 1980/81 group-think. The demand contraction during the early 1980s was a response both to the 1979 oil price hike, and a forward looking reaction to the expected doubling in the future price of oil. The exaggerated price forecasts made in IEA's reports, therefore, played a role in reducing the demand for oil during the 1980s.

During the next 15 years, the price projections in IEA's publications kept the *resource-pessimistic"* mindset, that an upward price trend for oil is inevitable. Projections typically showed the oil price edging continuously upward 2-3% per year in fixed prices from the year-of-publication price before levelling off after 10 to 20 years. But since the real price of oil decreased after 1980, the start-off price in the year of publication kept falling and thereby also the projected future maximum price.

After calling for too many years "the price will rise" without seeing it happen, IEA decided to change the tune. With WEO1996 IEA adopted the *"market fundamentalist"* mode of thinking: the forecast shows a flat oil price in the medium term followed by a modest upward trend in the long-term. In this scenario, the marginal cost of production defines the average price of oil in the short to medium term, while the rise in real prices in the longer term is influenced by the post-2010 increase in the market share of production from the Gulf states. Yet, once more, the price projection in each successive WEO more was lower than the level projected in the previous WEO. WEO1996 projects a flat oil price until 2000 after which a steady price increase takes place. WEO1998, WEO2000, WEO2002 and WEO2004 project a flat price until 2010 before a steady price increase takes place. WEO2000 and WEO2002 in addition reduced the post-2010 rate of price increase assumed by the previous WEO.

The price forecasts of *the "resource pessimistic WEOs"* overestimate the realized prices up to 2005 – except WEO1994 – because they all underestimated the short to medium term supply of oil from non-OPEC sources. The supply made it difficult for OPEC to raise prices substantially above the marginal cost of non-OPEC supply. The *market fundamentalist WEOs"* all underestimate the average price up to 2005. IEA in WEO2004 attributes this to the appearance of sustained OPEC cohesion since 1999 and ongoing global tensions"[55]. To this one could add IEA's underestimation of the strength of China's demand for oil in particular and of world oil demand in general.

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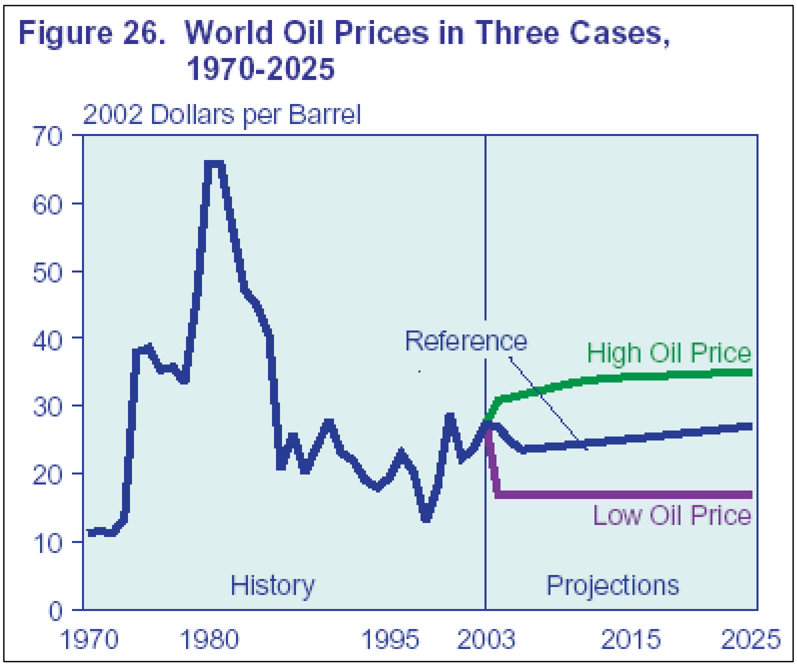
[54] The projection was based on an over-estimation of demand and underestimation of supply: IEA had based the oil production scenario on production from proven reserves only, while the oil demand forecast was based on GDP-projections of governments and the GDP-oil demand elasticities of the 1970s.
[55] WEO2004, pp. 524

The demand-supply scenarios of EIA and IEA differ slightly in their 2004 publications. EIA's reference scenario projects a 2% increase in *annual demand* up to 2025; WEO2004's"reference scenario" a demand growth of 1.6% per year up to 2030. EIA expects a continued expansion in non-OPEC supply after 2010, WEO2004 a fall.



Yet, EIA's and IEA's projections for the price of crude oil are rather similar.

EIA's base case assumption projects prices to moderate after 2004 and then rise slowly to reach $28 (expressed in year 2004-dollars) per barrel in 2025.[56] In the high price case, prices are projected to reach $35 per barrel in 2013 and $38 per barrel in 2025.[57] (see "figure 26").

IEA's reference scenario in WEO2004 sees oil prices in year 2006 to drop to US$24 per barrel (expressed in year 2004-dollars), staying at US$24 up to the year 2010, after which prices gradually increase to US$31 in year 2030. The average price throughout the period is US$29.[58]

None of the two organisations base their price projections on a direct analysis of the structural shifts in demand and supply and their likely implications for the operation of the international oil market. In the reference case projections, OPEC is a passive operator, expanding its production to supply whatever quantity the market needs.

8. Conclusions: The Supply-Demand Balance on the Oil Market and Price of Oil

According to WEO2004's the assumed price paths scenarios reflect IEA's "judgement of the prices that will be needed to encourage sufficient investment in supply to meet projected demand". Unfortunately, the prices of the reference scenario are incapable of generating the projected supply. The US$29 average price forecast is compatible neither with the reaction of the free market nor with optimal OPEC pricing policy, which makes the reference scenario irrelevant for policy discussions.

The projected "Alpine mountain peak" oil supply profile of growing annual supply up to 2037, replaced by a steep annual decline from 2038 onwards; may be technically-geologically feasible.

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[56] All quoted prices are in year 2004-dollars; EIA expresses its prices in year 2002 dollars, IEA in year 2000 dollars.
[57] Source: EIA, 2004
[58] IEA's sister organisation, OECD, is more price pessimistic. The baseline scenario of Economic Outlook 2004 generates a trend rise in the real oil price from US$29 per barrel in 2003 to US$38 a barrel by 2030, if initial OPEC/non- OPEC market shares are maintained over the projection horizon.

But it cannot happen in a free market economy because of the "Hotelling-price effect. If demand develops as projected in these scenarios, all market actors will by 2025 know that resource scarcity leads to a US$80-90 per barrel oil market 13 years later. Producers will not be willing to supply oil at IEA's/EIA's projected US$30 per barrel in 2025, if they have a strong expectation that they can get an additional US$50 for the product 13 years later. Several years before world oil production peaks, the future scarcity price will start having an effect on the market price of crude oil. A producer, who expects a US$80 price in 2038 and bases his production decisions on a 10% discount rate, will, as a minimum, ask for a US$42 price if he is to supply the market in 2025. The supply-price reaction of the free market will, therefore, ensure a flatter "hill-top" supply profile.

The developments in the supply-demand balance increase OPEC's ability to manipulate the market in its favour. In WEO2004's "reference case", OPEC's worldwide market share rises from 37% in 2002 to 53% in 2030 – regaining its historical peak in 1973 - with Middle East net exports rising from 17 mb/d in 2002 to 46 mb/d in 2030. In the "high oil price" scenario, OPEC production and share of world oil supply are lower, yet, OPEC still sees a 40% grows in the demand for its supply. A growth in demand and annual supply makes it easier to rally members around "tight" production quotas than the previous situation of stagnant supply!

IEA accepts that OPEC through its production quotas manipulate the market price to its advantage, but considers this to be irrelevant, as WEO2004 concludes that a higher average price for oil is not in OPEC's interest! The argument, put together from different sections of the text in 2004, is as follows: "In the High Oil Price Case, the average IEA crude oil import price is assumed to average $38[59] per barrel over the projection period. In this scenario world oil demand in 2030 would be 19 mb/d, or 15%, lower than in the Reference Scenario. (see the chart from WEO2004) Conventional and non-conventional oil production outside OPEC countries increases markedly at the $38 price, causing OPEC's market share to fall considerably. Production in OPEC countries would be 38% lower in 2030 and OPEC's cumulative oil revenues over the projection period 7%, or $750 billion, lower than in the Reference Scenario. They are also lower when discounted at a rate of 10% per year. The net loss of OPEC revenues would be even larger if the effects of higher oil prices on the global economy were taken into account.[60] Plainly, OPEC would not benefit from higher prices in the long term."

Table 3.9: **Oil Production in Reference Scenario and High Oil Price Case** (mb/d)

	2002	2030		
		Reference Scenario	High Oil price Case	Difference (%)
World	77.0	121.3	102.5	-15
OPEC	28.2	64.8	40.4	-38
OECD	21.1	12.7	13.1	4
Other non-OPEC*	25.9	33.7	37.4	11
Non-conventional	1.8	10.1	11.6	15

* Including processing gains.

[59] Expressed in year 2004-price level. WEO expresses its prices in year 2000 price levels: the price is US$35. IEA's forecast in year 2000 price level is: year 2003: US$27, 2010: US$22, 2020: US$26, 2030: US$29. Average price throughout the period of US$27 on = US$29 in year 2004-prices

[60] High world oil prices feed inflation in industrialized countries, driving up the cost of construction equipment and other capital goods oil exporters need to buy overseas.

IEA's analysis of OPEC's economic interest fails to take four factors into account.

1. *The assumed pricing policy of OPEC is not in agreement with the findings of behavioural finance: that in trading off present and future consumption, people apply higher discount rate in the short term than in the long term.*[61] Discounted by 10% the difference in revenue between the high and the reference scenario will be much lower than 7%; being close to insignificant. Yet, IEA assumes that OPEC's politicians will be sufficiently impressed by such a small difference, that they will forgo revenue in the short term to get a slightly higher revenue in the long term. That in itself is not plausible; use of a fixed 10% discount rate accentuates the mistake.

2. *OPEC's here-and-now economic interest is not defined by total revenue, but by net revenue*. The cost of expanded oil production must be deducted from the incremental oil revenue of expanded oil supply. OECD's Economic Outlook No. 76 from 2004 quotes a cost of production for new oil fields in the Gulf states of US$7 per barrel: US$5 for investment in exploration and development and US$2 for cost of operation.[62] WEO2004 assumes that its high price scenario of an average US$38 price would lead to a cumulative 28% decline in OPEC's supply of oil during the period compared with the production under the reference scenario's average US$29 price.[63] Multiplying the 39% increment in production under the reference price scenario by US$7 per barrel and deducting this amount from the gross revenue of the reference scenario, yields a cumulative net revenue equal to the net revenue of the high price scenario. The NPV of the net revenue for the US$38 price must, therefore, be higher than for the US$29 dollar price.

3. WEO2004 overlooks the *wealth-depletion effect of a low-price OPEC policy.* The NPV of the net-revenue from selling saved oil resources 15-20 years later on the market must be added to the net revenue of a high-price policy. If OPEC assumes pessimistically that the oil price after 2038 is US$38 and OPEC cost of production US$7 per barrel, then the NPV of the net revenue of a barrel saved between 2005 and 2030 and sold 20 years later is US$4.6 per barrel (discount rate of 10%). If the future oil price in real terms is US$80 per barrel, the wealth effect is US$10.9 per barrel left in the ground. If one assumes a shorter waiting period in terms of number of years until the oil is sold, the wealth effect is increased further.

4. WEO2004's scenario for the US$38 oil price *overestimates the de facto price elasticity of world oil demand* to an OPEC-induced price increase because it does not take into account the energy policy reactions to the higher greenhouse gas emissions that result from the low oil price scenario. The introduction of post-Kyoto green house gas measures are – unlike the energy saving measures introduced by OECD Governments in the immediate years after 1979 –not linked to or triggered by increases in the price of oil. On the contrary, the lower the international price of oil, and thus, the lower the strength of the self-correcting forces for reducing the demand for oil, the stronger the new demand measures will be to achieve the required cut down in CO_2-emissions. Because incremental Kyoto policy measures,

[61] A person being asked whether he/she prefers €1000 in year 2005 or €1100 in year 2006 and opts for the €1000, will most likely prefer €1100 in the year 2016 to €1000 in the year 1000!
62 Joîl Maurice: Prix du Pétrole, Conseil d'Analyse Économique, Paris, 2001.
[63] WEO2004 estimates that the 60% expansion in OPEC supply capacity from 40.4 to 64.8m b/d in the reference price scenario can be achieved by expanding investment in Middle East oil supply by US$116 billion, an increase of 31% over the US$380 billion investment in the high price scenario. The low increment in the investment is surprising: a priori one would expect the incremental cost of supply per barrel to increase and not to decrease.

introduced to counteract a high oil demand, suck up most of the demand reduction potential of a OPEC high price policy, the difference in world oil demand under a high and a low oil price is lower than estimated by WEO2004.

A reasonable price assumption for the 2005-2030 period is an average price of US$40-45; a higher price of US$45 and above cannot be excluded, yet, it would make a number of synthetic oil technologies too favourable.

EIA to be credible needs to rethink its approach to price projections. Until now they have been influenced too much by "past trend will continue" thinking.[64]

In 1980, influenced by the two oil chocks of the 1970s, IEA forecast a doubling in the (year 2004) price of oil from US$74 in 1980 to US$148 by 2000. The real price in year 2000 turned out to be one sixth of IEA's forecast. IEA's projected doubling of the real price of oil within 20 years reflected and co-sponsored 1980/81 group-think, thereby playing a role in the demand contraction of the early 1980s, which was a response both to the past 1979 oil price hike and to the expected doubling in the future price of oil.

During the next 15 years, the price projections in IEA's publications kept the *resource-pessimistic"* mindset, that an upward price trend for oil is inevitable. Projections typically showed the oil price edging continuously upward 2-3% per year in fixed prices from the year-of-publication price before levelling off after 10 to 20 years. But since the real price of oil decreased after 1980, the start-off price in the year of publication kept falling and thereby also the projected future maximum price.

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In WEO2005, IEA revised its price scenarios upwards, see the comparison in the chart below.

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[64] To quote the Danish philosopher Soeren Kirkegaard: "Life is lived forward and understood backwards".
[65] WEO2004, pp. 524

Oil Price Scenarios 2010-2030 WEO2004 and WEO2005

Period	**WEO 2004** Year 2004 price level	**WEO 2005** Year 2004 price level
2010	Reference Scenario: US$26	Reference Scenario: US$35
2020	R.S.: US$2	R.S.: US$37
2030	R.S.: US$34 (average 2005-2030 of US$27, H.P.S = US$38)	R.S.: US$39 High Price Scenario: US$52

Litterature:

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