The Countdown for the Peak of Oil Production has Begun – but what are the Views of the Most Important International Energy Agencies

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1. Preface

Conditions of the world's oil supply have entered into a new phase: increasing demand pressure, worries about the security of supply in important oil producing countries, speculative factors, but particularly, clear indications that limitations on the supply side have caused unexpected and high price increases. In view of the fact that an increase of oil production is obviously becoming more and more difficult, it is now almost irrelevant, whether the peak of oil production has already been reached or whether growth of production “only” can't keep pace anymore with rising demand.

With accumulating evidence we will soon be able to decide between the conflicting views held by “optimists” and “pessimists”. According to the doctrine of the “optimists” (mostly pronounced by economists), rising prices will induce a fast increase of oil exploration and production, which in turn will lead to a relaxation in the oil market in the near future. In contrast, the “pessimists” (mostly influenced by geological considerations) expect that it will become increasingly difficult to balance the increase in demand by a sufficient rise in supply. As a consequence production will not be able to follow demand and, after a short phase of stagnation, will decline inescapably.

Many indications during the last four years vindicate the theses of the “pessimists” and not of the “optimists”. But it would be much more appropriate to leave these misleading categories behind and to speak in future only about “realistic” and “unrealistic” views. This topic is not a matter of belief anymore.

At first the present state of the world's oil supply will be outlined. Then follows a detailed discussion of the arguments of the “optimists”. We attach particular importance to this, as in most publications there is a reference to the main original papers which are often quoted with their central messages, but this is rarely accompanied by a critical analysis. In most cases the conclusiveness of the cited arguments is not questioned since they originate from institutions to which a high authority is attributed.

2. The present state of oil supply

2.1. Fundamental aspects

The different phases of oil production can be described schematically by the following pattern: In the early phase of the search for oil, the easily accessible oil fields are found and developed. With increasing experience the locations of new oil fields are detected in a more systematic way. This leads to a boom in which more and more new fields are developed, initially in the primary regions, later on all over the world. Those regions which are more difficult to access, are explored and developed only when sufficient new oil can't be found anymore in the easily accessible regions. As nobody will look for oil without also wanting to produce it, in general shortly after the finding of new fields their development will follow.

With increasing production the pressure of an oil field diminishes and the water levels rise,

and after some time the production rate begins to decline. This trend can be controlled to a certain extent so that the decline in production rate is delayed or reduced: by injecting gas or water into the reservoir in order to increase the pressure, by heating the oil or by injecting chemicals in order to reduce the viscosity of the oil.

In every oil province the big fields will be developed first and only afterwards the smaller ones. As soon as the first big fields of a region have passed their production peak, an increasing number of new and generally smaller fields have to be developed in order to compensate the decline of the production base. From there on, it becomes increasingly difficult to sustain the rate of the production growth. A race begins which can be described as follows: More and more large oil fields show declining production rates. The resulting gap has to be filled by bringing into production a larger number of smaller fields. However, these smaller fields reach their peak much faster and then contribute to the overall production decline. As a consequence, the region's production profile which results from the aggregation of the production profiles of the individual fields, becomes more and more “skewed”, the aggregate decline of the producing fields becomes steeper and steeper. This decline has to be compensated for by the ever faster connection of more and more ever smaller fields.

So, the production pattern over time of an oil province can be characterised as follows: To increase the supply of oil will become more and more difficult, the growth rate will slow down and costs will increase until the point is reached where industry is not anymore able to bring into production a sufficient number of new fields quick enough. At that point, production will stagnate temporarily and then eventually start to decline.

This pattern can be observed very well in many oil provinces. However, sometimes this general pattern was not followed: either because the timely development of a “favourable” region was not possible for political reasons, or because of the existence of huge surplus capacities so that production was held back for a longer period of time. However, the more existing surplus capacities were reduced, the closer the production profile follows the described pattern.

In the history of oil production, which is now extending over more than 150 years, we can identify some fundamental trends:

- The world's largest oil fields were all discovered more than 50 years ago.
- Since the 1960’s, annual oil discoveries have decreased tendentially.
- Since 1980, annual consumption has exceeded annual new discoveries.
- Till this day more than 42,000 oil fields have been found, but the 400 largest oil fields (1 per cent) contain more than 75 per cent of all oil ever discovered.
- The historical maximum of oil discoveries has to be followed after some time by a maximum of oil production (the “peak”).

How close have we already got to the peak? This is the only exciting question remaining.

2.2. Countries outside OPEC and Former Soviet Union (FSU)

On the global level, the development of different oil regions took place at different times

and at varying speeds. Therefore, today we are able to identify production regions being in different development stages and with this empirical evidence we can validate with many examples the simple considerations which were described in the previous chapter.

Looking at the countries outside of the Former Soviet Union and OPEC, it can be noticed that their total production increased until about the year 2000, but since then total production has been declining. A detailed analysis of the individual countries within this group shows that most of them have already reached their production peaks and that only a very limited number of countries will still be able to expand production, particularly Brazil and Angola.

Critical for the stagnation of oil production in this group of countries was the peaking of oil production in the North Sea which occurred in 2000 (1999 in Great Britain, 2001 in Norway [1]). Oil production onshore stagnated much earlier and has been declining since the mid 90's. This decline could be balanced by the quick development of offshore fields which now account for almost 50% of the production of all countries in this group. The North Sea alone has a share of almost 40% of the total offshore production within this group. For this reason the peaking of the the North Sea was decisive. This production decline couldn't be overcompensated anymore by the quicker connection of new fields in the remaining regions – it could only be balanced for a few years [2].

Decisive for the further development will be, when the production of Cantarell in Mexico, the world's biggest offshore field, will start to decline. This field, discovered in1978, even today contributes half to the Mexican oil production. It has reached a plateau for some years now. The present production rate can only be maintained by the massive injection of nitrogen. The yearly amount of nitrogen injected into the field has doubled the world's annual consumption of nitrogen. Optimistic observers assume that this field will continue to produce at current levels up to the year 2010, others expect the decline to start much earlier. Just recently, PEMEX itself has warned that it expects Cantarell to start decline in 2006 at an annual rate of 14% per year [3]. Apart from that, the quality of the oil produced in Mexico has degraded steadily. Today, the share of light oil has halved since 1997 [4].

This steady degradation of the quality of the oil produced can be observed in almost all regions having passed the peak and poses an additional challenge for the existing downstream infrastructures: refineries have to be run with oil of increasingly lower quality. The supply share of lesser oil qualities is steadily increasing – this causes additional pressure on the price for the remaining good oil grades.

Particularly interesting is the example of Indonesia, which is the only OPEC member state which is included in this group of countries as it will probably soon leave the OPEC – because in march 2004 for the first time more oil was imported than exported [5].

Oil production in regions having passed their peak can be forecasted with some certainty for the next 10 years. If it is assumed that the remaining regions with growth potential (Angola, Brazil and the Gulf of Mexico) will considerably expand their production by the year 2010 (in accordance with the optimistic forecasts of the companies operating in these regions), total oil production of this group of countries, however, will decline by 7-8 Mb/day (Mb = million barrels) by 2010. Not accounted for in this forecast is the fact that (contrary to the assumptions made above) in Brazil production has been declining for 8 month in series and is now back to the level of 2002, as the connection of new fields was delayed for economic and technological reasons [6].

As the production of conventional oil is declining, this group of countries will be able to supply additional amounts only from non-conventional sources. Non-conventional oil

sands in Canada and Venezuela will contribute 1-1.5 Mb/day, provided that the already announced expansion plans will be realised without any further delay.

Figure: Oil production of countries outside OPEC and FSU

2.3. Former Soviet Union (FSU)

The oil production of the Former Soviet Union peaked reaching a production rate of more than 12 Mb/day at the end of the 80's. Soon afterwards production collapsed by almost 50% within 5 years. The production peak at the end of the 80's had been forecasted by western geologists based on the depletion patterns of the largest oil fields [7]. However, the following production collapse during the economic break down turned out to be much steeper than expected. For this reason, Russian companies were able to stop this decline after the liberalisation of the oil market and to increase production levels again – in some years at double-digit rates during the last 5 years - with the help of international cooperations and investments. However, this fast recovery now comes to an end as the easily accessible fields have been developed and the financial and technological backlog is widely closed.

Recently the director of the Russian energy agency, Sergej Oganesyan, conceded for the first time that the growth rates of the past few years can't be repeated anymore and that in 2005 production will probably stagnate or even decline [8].

But despite this strong revival of Russian production, the oil price has remained under

pressure and has been rising slowly but continuously and even exceeded the $40 line, a fourfold increase compared with 1999. The double-digit growth rates in Russia contributed to compensate for the inescapable production decline in other regions of the world, and to counter the rising demand pressure.

The two other important oil regions of the Former Soviet Union are Azerbaijan and Kazakhstan.

At world level, Azerbaijan is the oldest modern oil region. Its highest production rates were reached already fourty years ago. Today, we can expect production expansions only in the offshore areas. In this context, especially the field complex Azeri-Chirag-Guneshli has to be mentioned. Once fully developed, Azeri-Chirag-Guneshliy probably will reach its maximum in 2008 or 2009 at a production rate of 1 Mb/day. Soon thereafter the production rate will decline very fast to almost negligible amounts within 10-15 years. The total production of this region, however, will increase by a much smaller amount as 150.000 b/day are already produced from Azeri-Chirag-Guneshli today and as in future the production from other fields will drop noticeably [9].

For some years Kazakhstan was considered to be a potential counterbalance for Saudi Arabia. Today we know that these hopes were exaggerated. They were nurtured by speculations of the US federal authority “EIA” which expected oil and gas reserves in the region around the Caspian Sea amounting up to 300 Gb of oil equivalent. Realistically, only about 45 Gb of oil are likely to be recoverable, about half of this amount is located in already developed fields [10].

High expectations regarding future production potentials concentrate on three fields: Tengiz, Kamchagarak and Kashagan. All three fields contain oil with a high sulphur content the development of which jeopardises the environment and is very expensive. Tengiz and Kamchagarak produce oil since some years; in Tengiz alone, more than 4,500 tons of sulphur are separated from the produced oil each day and stored in the surrounding area polluting the environment [11]. Plans for a production extension are delayed due to high development costs and difficult geological conditions. In 2000, the third big oil field, Kashagan, was found. It is supposed that production can be increased considerably from 2006 on. But there are big doubts whether this will be possible. High sulphur content, high deposit pressure of more than 1000 bar and an unfavourable geographical location far away from any infrastructure make it expensive and difficult to develop. It is certainly no coincidence that two of the big companies being involved in the discovery of the field (BP and Statoil) have withdrawn from the group of companies developing the field. After an analysis of the first exploration drilling, it was communicated that the companies' internal criteria for a development weren't fulfilled [12]. British Gas already has announced its withdrawal.

Azerbaijan and Kazakhstan will probably be able to double their production rate by 2010 – from 1.3 million barrels to 2.5-2.6 Mb/day – but to hope for more seems unrealistic.

According to this assessment, the whole region may be able to increase its production in the coming years, but the very big expansion expected by many people will not occur. A total production increase of 2-3 million barrels/day is probably already on the high side.

2.4. OPEC member countries

The conclusion of the previous analyses is: the expected production decline in the group of countries described initially is partly offset by a possible expansion in Russia and in the

Caspian Sea. But there still remains a gap of 3-5 Mb/day to keep world oil production constant until 2010. This gap has to be filled by the OPEC member countries. If the world demands additional oil, this amount would have to come from the OPEC member countries as well.

Conventional wisdom has it that this will be possible for OPEC without any problems. However, a production growth of 3-5 Mb/day within a few years does constitute a problem. Particularly as it is widely accepted that – apart from Iraq which can't be considered to be a reliable oil producer for the time being – only Saudi Arabia is supposed to be able to increase its oil production significantly. This would require an expansion of almost 40% of the Saudi Arabian oil production within very few years. This is a very ambitious goal, even for a country with an abundance of oil.

Moreover, in recent years the suspicion has grown that the conditions for oil production in Saudi Arabia are not as favourable anymore as is commonly assumed, but are becoming more and more difficult. In assessing the future production potential of Saudi Arabia, Ghawar, the world's biggest oil field, plays a key role. This field was discovered in 1948 and has now been producing oil for more than 50 years. It is a fact that meanwhile more water is pumped into the field than oil is extracted, and it seems quite possible that the production rate will decline soon. Anyway, it is certain that Ghawar can not anymore contribute to an expansion of Saudi Arabian production [13].

There is now a debate going on about the wider question, whether Saudi Arabia will at all be able to increase its production significantly. This debate was initiated early in 2004 by Matthew Simmons, an American investment banker. His doubts are based on a comprehensive in-depth analysis of technical papers in the public domain addressing the problems of oil production in Saudi Arabia, and on a great number of interviews with engineers working on site and also a visit of the oil fields in Saudi Arabia.

Simmons has provoked comments by senior executives of the state-owned company Saudi Aramco. But their comments have rather fueled existing fears instead of assuring the world. First, it was admitted by Saudi Aramco that the big old oil fields show decline rates, and that by now Abqaiq is depleted by 73%, and Ghawar by 48% [14]. Moreover it was indirectly confirmed by Abdul-Baqi and Nansen Saleri, that proven reserves do not amount to 262 Gb - as is commonly assumed - but are only 130 Gb and that another 130 Gb had already been counted as reserves because it is regarded probable that they can be developed eventually [14]. If one would apply the same criteria which are common practice in western companies, then Saudi Aramco's allegation for proven reserves should be devalued by 50%. This devaluation is confirmed indirectly by another Saudi Aramco executive [15].

Furthermore, Saudi Aramco executives tried to counter the fears of Simmons by stating that a production of 10 Mb/day could be upheld until 2042. In doing this they had to assume that the above mentioned reserves of 260 Gb are proved reserves (which they are definitely not). Saudi Aramco went on to state that in case of a more aggressive development of remaining reserves, production could be increased to 12 Mb/day by 2016 and then could be maintained constant until 2033 [14]. But even this scenario put forward by the Saudis is hardly assuring in view of the projections of the International Energy Agency (IEA) which assume that in the long term additionally more than 20 Mb/day are supposed to come from those regions.

The analyses of Simmons [16] and others (e.g. Bakhtiari [17]) make the point that Saudi Arabia's potential to increase production will soon reach its limits.

2.5. The world is nearing the moment of truth

The recent rise of crude prices to more than $40 per barrel could for a short while be slightly reversed by the announcement of OPEC member states to increase their production. This shows that in the short term prices can be influenced by rhetoric - but eventually everybody wants to see OPEC delivering. However, it will soon turn out whether the “pessimistic pessimists” are right who believe that also OPEC has no more spare capacity left or whether the world will sit back for a few more years.

In case world oil production can be increased again, this will be taken by many as a refutation of the claims of the “Cassandras” and as evidence that oil production can therefore be increased for many more years to come. More appropriate would be the perception (1) that the remaining oil will be consumed this much faster and (2) that an increase of production in the short term will in effect further increase the level of oil dependency - until from this higher level a steeper decline than otherwise necessary will be enforced.

Recent developments are in obvious contrast to the assertions of the optimists which don’t foresee any problems in the availability of oil for the next 20-30 years. But they now acknowledge that price increases might be possible.

3. Critique of forecasts by USGS, US-EIA and IEA

The analyses and forecasts of the US Geological Survey (USGS), of the Energy Information Administration (EIA) being the statistical arm of the US Department of Energy, but particularly also of the International Energy Agency (IEA) in Paris, are frequently quoted because they enjoy high credibility and are considered to be a reliable orientation regarding future developments.

From time to time the US Geological Survey, an American federal authority, publishes assessments about the global availability of hydrocarbons. It has to be noted that these studies don’t provide any explicit information about future production potentials.

Often these studies are quoted in a very abbreviated form, while all references to uncertainties and boundary conditions contained in the studies are omitted. The energy agencies EIA and IEA proceed in a similar way and use selected statements of the USGS studies as basis for their optimistic assessments of future production potentials.

Common to all these analyses is a confident perspective which is in stark contrast to the analyses described in the previous chapters of this paper. Therefore recent influential publications of these institutions will be analysed in greater detail at this stage.

3.1. US Geological Survey (USGS)

The latest survey of resources is the “US Geological Survey World Petroleum Assessment 2000” and was published in june 2000 [18]. Apart from the content of the study, also the way the results of the study were published is of interest. Main results were released to the press at the end of march 2000, before the publication of the full report, delivering the message that up to now the potential for future oil discoveries had been grossly underestimated and that there was still much oil left to be found [19]. By coincidence this

press release appeared on the eve of a critical OPEC meeting at which an expansion of production quotas was to be negotiated at a time when oil prices started rising dramatically for the first time since Gulf War I.

Also unusual and coinciding with the publication of the survey, one of the authors - Les Magoon - published a poster on the USGS web page (using the official logo) which warns of the imminent big “rollover”. This is the moment when the oil market changes from a buyers’ market – in which oil price is governed by consumer demand with no supply restrictions - to a sellers’ market in which supply constraints determine prices [20]. This moment will be reached when global oil production can’t be expanded anymore and begins to decline. According to Magoon, the examination of many analyses leads to the conclusion that the exact moment can’t be determined with certainty by anyone, but production peak will be reached in all probability somewhere between 2003 and 2020: “Nobody is sure, but those willing to forecast say somewhere between 2003 and 2020. Most everybody seems to agree that it will most likely be within our lifetime, and possibly quite soon!”

For the illustration of this statement the production curve published by the “pessimists” Colin Campbell and Jean Laherrere in Scientific American [21] showing a maximum in 2003 is used and by doing this he gave prominent support to their view. Only after protests of the oil industry, a small annotation was added that this does not present the official opinion of the USGS. But albeit, this illustration has been visible until today on the USGS web page with the logo of the federal authority. Therefore, a certain identification with the content can’t be denied.

In the executive summary of the resource survey 2000 the following phrases deserve attention: purpose of the study is “... to assess resources ... which have the potential to be added to reserves within a 30-year timeframe (1995-2025)...” [18]. It is stated explicitly that those oil findings can be expected in the time between 1995 and 2025. Until today almost one third of this period of time has elapsed, so that already now we are able to compare the estimates of the study with reality.

Moreover the wording “to assess resources... which have the potential to be added to reserves” is so vague that its exact interpretation is left to the reader.

In brief the results of the survey can be summed up as follows:

- Outside of the USA up to 334 Gb of oil can be found between 1995 and 2025 at a probability of 95%, and 1107 Gb at a probability of 5%. By using extensive Monte-Carlo simulations a “mean” value of 649 Gb is calculated.
- Furthermore between 95 Gb (5% probability) and 378 Gb (95% probability) of natural gas liquids (NGLs) can be found.
- In contrast to previous analyses a new factor - called “reserve growth” - is introduced. The factor for the reserve growth is calculated from the experience in the USA during the last decades, extrapolated for the next 30 years and then applied on the rest of the world.

This method of adjusting reserves by a growth factor must be criticised in two respects:

The upward revision of reserves in the past is caused in most cases by an initial underestimation of the content of the old and large fields. These fields were so large that it wasn’t necessary for their efficient development to determine their exact size. And some of these fields are so old (up to 100 years and more) so that the methods of reserve estimation at the time of discovery were very simple and unprecise.

Today the growth of reserves tends to be much smaller, partly because newly found fields are so small that a precise estimate is needed, but also because modern exploration methods are much more precise than in the past. Nowadays it happens quite often that reserves also have to be adjusted downwards instead of upwards (as lately the example of Shell has shown).

The second point of critique refers to the fact that – as is known to all experts - the growth of reserves in the USA in the past was much higher than elsewhere. This is a direct consequence of the regulations by the Securities Exchange Commission (SEC), which for financial reasons call for very conservative evaluations at the beginning of the development of an oil field. This American practice leads to systematic underestimations.

For these reasons this marked reserve growth in the past was only observed in the USA and can not be extrapolated into the next 30 years, nor even less can this pattern be applied to the whole world.

But apart from this important aspect, it seems very strange that a scientific geological institute makes estimates of the geological potential of oil findings and then additionally applies a growth factor which only reflects the economic rules of “reserve reporting”. It is obvious that the reporting of reserves can only extend within the boundaries of the geologically possible. The USGS study mixes different categories of reserve evaluation which are not compatible. The results can not be regarded as scientifically sound and are all but reliable.

To arrive at a global picture, US data have to be added to the world’s oil resources outside the US. For this purpose the USGS draws on its own analysis of the US from 1996 [22]. The total results of the USGS study are shown in the following table.

Table: USGS estimate of potential oil findings between 1995 and 2025 and reserve growth in already found fields [18].

Discoveries	5% Probability	„Mean“	95% Probability
crude oil (outside USA)	1107	649	334
NGL (outside USA)	378	207	95
crude+NGL (USA)	104	83	66
total	1589	939	495
Reserve growth			
crude oil (outside USA)	1031	612	192
NGL (outside USA)	71	42	13
crude+NGL (USA)	k.A. (76)	k.A. (76)	76
total	1178	730	281

Moreover, the study quotes figures of proven reserves and cumulative production from other statistics. It is particularly interesting that the USGS takes the values for non-US countries from the industry database (formerly Petroconsultants, today IHS-Energy). This very database, however, is used by Campbell and others for their analyses.

Table: Cumulative production by 01/01/1996 and proved reserves, as quoted in the USGS study [18].

	Crude+NGL (USA)	Crude (outside USA)	NGL (outside USA)	Total
Cum. production	171 Gb	539 Gb	7 Gb	717 Gb
Reserves	32 Gb	859 Gb	68 Gb	959 Gb

Using these figures the USGS calculates the total potential of past and future world oil production (Estimated Ultimate Recovery – EUR): 3,012 Gb being the mean value, 2,269 Gb with a probability of 95% and 3,919 Gb with a probability of 5%. In addition the total amount of liquified natural gas outside of the US is estimated to be in the range of 183 to 324 Gb. For the US the NGLs are already accounted for in the table above.

To give an insight into the methodology of the analysis, two regions will be examined in greater detail: the Falkland Islands and the basin of the Greenlandic Sea.

The USGS study identifies as the region with the largest potential of oil discovery the sea area east of Greenland which is estimated to contain as much oil as the North Sea. In this region certain geological analogies exist to the shelf ridge off Middle Norway, but only certain analogies... With a probability of 95% no oil at all will be found, according to the USGS, with a probability of 5% 117 Gb will be found. Based on these estimates, it is calculated via complex mathematical models that probably 47 Gb of oil could be found in the region. (Incidentally in the shelf off Middle Norway 10 Gb have yet been found after many years of intensive exploration – with the significant contribution of Colin Campbell.)

Until today there hasn't been any single exploration drilling in the Greenlandic Sea. It will be interesting to see which oil company will take the risk to drill in an area where oil is expected to be found with a probability of 5%.

For to the Falkland Islands, the potential for “undiscovered” oil is estimated to be 5,8 Gb. This number was calculated as the mean value assuming that at 95% probability no oil at all will be found and with a probability of 5% about 17 Gb will be found.

In contrast to this estimate, the sobering reality is described in the following quotation of Marshall DeLuca in OFFSHORE, one year before the completion of the USGS study [23]:

“The most recent frontier project was the offshore Falkland Islands area. This exploration project has turned out to be a disappointment – thus far. The operators have tried six wells in the area ... and have encountered some oil shows, but did not strike anything close to commercial levels. It has been estimated that the group will need a discovery with at least 140 Mb of oil to justify development of the Falklands. With the harsh environment of the Falklands, well costs are currently estimated at between $25 and $30 million per well. The FOSA drilling program is now complete, and the operators are evaluating well data. No plans for the future have been announced.”

So far no single oil field containing approximately 140 million barrels has been found. Where to look for the 5,800 million barrels of which the USGS assumes that they can be found?

As the study indicates the time frame 1995 to 2025 for the new discoveries of oil, one can easily calculate how much oil per year on average should be found.

Table: Calculation of average discoveries per year until 2025 based on USGS

assumptions.

Probability	Discoveries (crude+NGL)		Reserve growth		Total
	1995-2025	Gb/yr	1995-2025	Gb/yr	Gb/yr
95%	495 Gb	16,5	281 Gb	9,4	25,9
Mean	939 Gb	31,3	730 Gb	24,3	55,6
5%	1589 Gb	53	1178 Gb	39,3	92,3

Just taking this table, the lack of realism of the study becomes apparent. If we take seriously the values indicated as “mean”, this would mean that every year 55 Gb of new oil would have to be added to the reserves, originating either from new discoveries or from reassessments of existing fields. In fact, however, reported reserves have been staying roughly constant. Currently discoveries and reassessments correspond approximately with annual consumption - which amounted to about 27 Gb in 2002. Hence, the USGS study assumes that in future on average this value will be at least twice as high than in the past.

As a matter of fact, between 1995 and 2002 in total only 107 Gb were discovered and 110 Gb were added by reassessing existing fields [24]. According to the USGS projections (“mean”), however, in this period 219 Gb should have been found and 170 Gb should have been added due to reassessments, whereas the amounts to be expected with a probability of 95% did materialize. After one quarter of the forecasting period has now passed, the real development lags far behind the USGS projections. In order to achieve the “mean” projections even roughly, in future much more oil than ever before has to be found. This seems to be the most unlikely of all possible future developments! There is not a single indication that the USGS estimates, apart from the 95% probability values, have anything to do with reality.

From these comments it is evident that the USGS deals with resource assessments in a rather liberal manner. Nevertheless, one can draw some benefits from the USGS projections by “calibrating” them appropriately. As an example we can take the oil production in the US which is a rather mature region now.

Hubbert predicted that the peak of US oil production would be reached in 1969 and 1970 [25]. In fact the production maximum occurred in 1971 [26]. Hubbert based his forecast in 1956 on the fact that the maximum of new discoveries had already passed, therefore he could estimate the remaining amount of oil to be found with some accuracy. Combining this with an extrapolation of the oil production, he was able to predict the production peak. After about half of the recoverable oil had been produced, the maximum had been reached.

With a similar method, even though in detail more sophisticated, the study “Global 2000” (commissioned by the US President) predicted in 1980 the date for the global production peak to be somewhere near the end of the 20th century [27]. The biggest uncertainty was predicting oil consumption - not forecasting how much oil still can be found. In fact this study has assessed the total existing reserves amazingly precise (as we now know with much greater certainty) - just the development of demand was greatly overestimated.

Most scenarios trying to forecast the production peak see it at the time when about half of the recoverable oil has been produced.

This will be different when using USGS data because of their more generous reserve assessments. For the USA the USGS predicts a EUR (Estimated Ultimate Recovery) of

362 Gb (mean) [22]. At the time of production peak 106 Gb had already been produced [28]. If we calibrate the production peak with these values, we see that we reach the production peak at 30% depletion of EUR as estimated by USGS.

Assuming 3,345 Gb for the global estimated EUR according to USGS 2000 ("mean" for oil + NGL, the value for oil is 3012 Gb), the global production peak would be reached at a consumption of about 1,000 to 1,100 Gb. As until the end of 2003 about 920 Gb have been produced [28], the production peak may be expected in the coming years. This seems to be the only valuable information that can be extracted from the USGS figures.

3.2. The US "Energy Information Administration" (EIA)

The Energy Information Administration, which belongs to the US Department of Energy, publishes many energy statistics and analyses which draw worldwide attention.

The quality of some of their publications, however, gives cause to serious criticism. When one analyzes the statistics of the administration over many years then one will observe that figures for inventories and consumption initially nearly always are overstated and then after months and years - sometimes 10 years back - are adjusted, often quite significantly. This is especially noticable in the last two years. E.g. the US natural gas production figures were always overstated and were corrected only after many months. It is difficult not to suspect any purpose behind this practice (corrections were carried out only after public attention had moved to other topics). Even until today the EIA isn't prepared to concede that US natural gas production has peaked and is in decline now - in contrast to most industry observers who see a definite decline of production for some time now according to their databases ([29], [30]).

Particularly revealing was an episode in the winter of 2003, when the US Secretary of Energy replied to the question of a journalist asking for the reason for rising natural gas prices with a reference to the statistics of Raymond&James [31]. He didn't refer to data of his own administration but he quoted industry analyses which were totally contrary. So much (or so little) regard has the Secretary of Energy for the analyses of his own administration.

Even in its latest "US Annual Energy Outlook 2004" the administration forecasts a significant growth in natural gas consumption in the US for the coming 20 years for which, according to many industry observers, the resource base is completely lacking [32].

The publication of the USGS resource study discussed above was used as a basis by the EIA to forecast the world's oil production. As an example for many analyses of EIA the study "Long Term World Energy Supply" will be examined in greater detail [33].

Based on the resource data of the USGS study different supply scenarios until 2010 and beyond are outlined. In the summary it is pointed out that all 12 analyzed scenarios see the production peak, depending on different assumptions, between 2021 and 2112. Also included, but not mentioned in the text of the summary is the chart "Annual Production Scenarios with 2 Percent Growth Rates and Different Decline Methods" which shows the peak in the year 2016 based on 2% decline after peak and an EUR of 3003 Gb.

Moreover, the only realistic - from our point of view - scenario is not mentioned. This is a scenario based on the USGS resource figures at 95% probability (2,248 Gb) and assuming a production increase of 2% per year until the peak is reached and thereafter a production decline of 2% per year. In this scenario the peak would already be reached

before 2010, consistent with the claim of the “pessimists”. Instead of this the pessimistic scenario formulated in the EIA presentation is based on the USGS “mean” with a total oil production potential of 3,003 Gb.

Figure: “Published Estimates of World Oil Ultimate Recovery” [33]

The chart “Published Estimates of World Oil Ultimate Recovery” tells only half the truth again. The different underlying definitions of the individual authors are not pointed out. E.g. USGS includes in its analysis crude oil at a density higher than 15° API, as well as deep-water oil up to a depth of 4,000 metres. Campbell 1995 only includes crude oil at a density higher than 17.5° API and offshore regions with water depth up to 500 metres. Also polar oil in regions north of 66° latitude is not considered (Alaska, Siberia). These categories are not conventional oil according to the common definitions among explorers, but are shown separately by Campbell. If we add these categories of oil to the results published by Campbell in 1995 and compare them with the figures of USGS 2000 at 95% probability then the figures are practically identical and differ only by a few per cent [34].

However, it is much more important to note that the USGS survey is totally in line with other studies once the figures at 95% probability are taken as reference. But the figures for the “mean” case and even more so the values at 5% probability are far higher than other estimates. As a consequence, the chart can rather be read as a confirmation of the fact that the oil endowment of the world most likely amounts to 2,000 or 2,300 Gb and not to 3,000 Gb or even 4,000 Gb.

Figure: "Different Interpretations of a Hypothetical 6,000 Billion World Original Oil-in-Place Resource Base" [33]

The chart "Different Interpretations of a Hypothetical 6,000 Billion World Original Oil-in-Place Resource Base" is misleading. Campbell and Laherrere analyzed the 200 largest oil fields (which cover the bulk of the total amount of oil) with regard to their oil recovery factors. These oil fields have already reached an average recovery factor of more than 40% (and not 30%, as it is suggested in the chart). This is already documented in the IEA World Energy Outlook 1998 [35]. If we extrapolate this value to a recovery factor of 50%, this would amount to 1,800 Gb/0.4*0.5 = 2,250 Gb instead of the 3,000 Gb stated by the USGS! This number would be consistent with the USGS value at 95% probability. Therefore this chart by the EIA is a deliberate deception.

Moreover the small amount of "undiscovered" oil in the analysis of Campbell and Laherrere is explicitely based on their different methodology: Campbell and Laherrere extrapolate the discovery rate based on the historical trends of the past 70 years and show that this extrapolation approaches an asymptotic limit at about 1,800 Gb of crude oil. In their "Mean" case the USGS completely ignore these historical trends: instead of declining further, the USGS analysis assumes that the trend of annual discoveries will reverse. Present and past discoveries, however, do not support such a view.

Figure: "Annual Production Scenarios for the Mean Resource Estimate and the Different Growth Rates (Decline R/P = 10)" [33]

The methodological approach for the construction of the "Annual Production Scenarios for the Mean Resource Estimate and the Different Growth Rates (Decline R/P = 10)" is strange. First of all: Why is there a production curve based on the "Mean" case of the USGS study and not also one for the "Low" case (with a probability of 95 %)? Later in the study for the most part only graphs are shown which are based on the USGS "High" values with a probability of 5%. However, as already mentioned, if we calculate the production profile with a growth rate of 2% before and a decline rate of 2% after the maximum based on the "Low" case, then production would peak before 2010 – fully consistent with the estimates of the "Pessimists".

Assuming the peak of production takes place very late in time obviously leads to very unrealistic "catastrophic scenarios": a long period of growth is necessarily followed by a steep decline, i.e. a total break down of oil production within a few years after the peak.

This steep production decline is generated by assuming a constant reserve/production ratio of 10 years (R/P = 10). It is argued that such a constant R/P–ratio was observed empirically in the US after production peaked in 1971.

In fact, production each year declined at an average rate of 2%, but reserves were also adjusted each year in such a way that the R/P-ratio was almost unchanged. (This is a consequence of the concept of "reserve growth": Even though reserves were adjusted downwards each year, they were adjusted by less than the actual production of the year in question.)

A consistent calculation would have to be in line with the observed 2% decline rate of the production. EIA, however, uses the constant R/P=10 ratio based on the final EUR as basis which results in a 10% annual decline rate. But the real praxis was to arrive at R/P=10 by annually upward revising EUR.

However, much more important is another criticism. How realistic are the future production

scenarios as described by EIA? These scenarios are quite implausible as already today most of the regions in the world have either reached or passed their production peak (see chapter 1). Once more and more regions experience a shift from growing to declining production it is getting increasingly difficult for the ever fewer remaining countries to compensate for this decline, let alone to add to total production. For instance, if we take the scenario with the peak in 2030 (based on a yearly production growth of 3%), this curve tells us the following: In the last 50 years the world has managed to increase global production per year from about 5 Gb by about 20 Gb to 25 Gb; in little more than half of this period it is thought to be possible to increase yearly production by about twice that amount from 25 Gb to 65 Gb – by another 40 Gb! This is incredible.

In view of the remaining production potentials it is much more likely that global oil production will never be able to exceed the 30 Gb level significantly, and not for longer than a few years.

3.3. The International Energy Agency (IEA)

The IEA was founded by the OECD nations after the oil shocks in the 70's as a counterweight to OPEC. Since that time the IEA is regarded as the “energy watchdog” of the western world and is supposed to help to avoid future crises. Every two years the IEA publishes the “International Energy Outlook” which forecasts the development of the coming two decades. These reports are considered by many people to be something like a “bible”. The IEA also publishes monthly reports covering the current situation of the oil markets.

The “IEA International Energy Outlook 1998” did forecast that world oil demand will increase by 50% to 120 million barrels/day by 2020. It was correctly seen that production outside of OPEC would reach its maximum in the year 2000 and soon after would start to decline. Almost 20% or 17 million barrels/day of the total consumption in 2020 was explicitly defined as “not yet identified unconventional oil” – a hidden warning which could be translated to “the IEA has no idea of where this oil is going to come from”. This study did also discuss the different views on the future production potential by dedicating 5 pages to a review of the “Pessimists'” position.

The following report „IEA International Energy Outlook 2000“ was already influenced by the USGS Resource Assessment 2000. This influence can also be seen in the latest report „IEA International Energy Outlook 2002“ [37]. While the 1998 report still discussed the different views later reports simply ignored differing views.

The “IEA Annual Energy Outlook 2000” and “IEA Annual Energy Outlook 2002” have an almost opposite message compared with the report of 1998. According to the latest report world oil demand will reach the level of 120 million barrels/day by 2030 instead of 2020. But the hint at “yet unidentified sources” in the 1998 report has been dropped. Quite the reverse, based on the USGS study, now almost any production rate is considered to be possible. Even the production of non-OPEC states, which according to the 1998 report was supposed to decline to 27 million barrels/day by 2020, is expected to grow from 43 million barrels/day in 2000 to 46 million barrels/day in 2020.

Key statements of the study regarding future world oil supply will be discussed in more detail ([38]).

Table: Aggregate figures of table 3.5 in “The International Energy Outlook 2002” [38]

	Amount of Oil	IEA Comment
Remaining reserves	959 Gb	reserves are effective 1/1/96
Undiscovered resources	939 Gb	resources effective 1/1/2000 are mean estimates
Total production to date	718 Gb	
2001 Production	75,8 mb/day	

The stated sources are USGS (2000) and IEA databases.

In fact all figures except those for the current production are derived from the USGS (2000) study. However, in the USGS study all data refer to January 1st 1996 including still undiscovered resources and total production to date. This is a first methodical error. It would have been correct to adjust all figures in the IEA table to the new base year 2000, i.e. to extrapolate the remaining reserves to 2000, to reduce the findings still to be obtained and to adjust the historic production (after all 132 Gb have to be added in the period from 1996 to 2000).

Moreover, the figures are not consistent as the following examples show.

Table: Daily production in 2000 and 2030 as well as reserves and undiscovered in selected countries, according to the report “IEA Annual Energy Outlook 2002” [38], cumulative production between 1996 and 2030 calculated from these figures, and real discoveries between 1996 and 2002

	Production (mb/d)		Cum. Production 1996-2030 (Gb)	Reserves 1995 (Gb)	Undiscovered 1996-2025 (Gb)	Discoveries 1996-2002 (Gb)
	2000	2030				
Indonesia	1,4	1,7	19,5	10	10	2,3
China	3,2	2,1	35	25	17	7
Brasil	1,3	3,9	29	9	55	6,2
UK	3,3	1,1	27	13	7	1,3
Norway	3,4	1,4	32	16	23	2,2
Mexico	3,5	2,7	44	22	23	0,8

The first two columns show the daily production in 2000 and 2030 according to the assumptions in IEA [38]. The study gives also intermediate values which allow to calculate the total production over the period 1996 to 2030 (column “Cum. production 1996 – 2030”). In this calculation the year 1995 has to be taken as the base since the assumed reserve data in this study (column “Reserves 1995”) and expected discoveries (column “Undiscovered 1995-2025”) refer to this year. For comparison, the real discoveries made in these countries between 1996 and 2002 are listed in the last column “Discoveries 1996-2002”. These are the discoveries after almost a quarter of the forecasting period.

It is obvious that the production forecast by the IEA cannot be attained by Indonesia, UK and Mexico, even if we accept the optimistic assumptions regarding discoveries, since the assumed reserves are not sufficient.

When we compare the real discoveries between 1996 and 2002 with the expected discoveries between 1996 and 2025, the rate of expected discoveries for all these states except for Indonesia and China is in total contrast to the observed development. Particularly striking are the discrepancies for Brazil, Norway and Mexico – there after all more than 100 Gb were expected to be found until 2025, but in fact only 9 Gb were discovered between 1996 and 2002. These figures would have been available also for the authors of the IEA study.

If we assume that the present discovery rates can be held constant over the remaining forecasting period (which is very optimistic, because according to past experience discoveries decrease with time), then in every country (maybe except for China) production would be down to zero in 2030.

Also in Germany the Bundesanstalt für Geowissenschaften und Rohstoffe (i.e. the German federal agency for earth sciences and raw materials) has dealt critically with the scenarios of the IEA and comes to the conclusion [39]: “The forecasts of EIA and IEA assume a continuous growth in oil consumption, without assessing sufficiently the real supply of oil and the production potential.”

Lately, for the first time we hear more cautious statements from the IEA. To increase production until 2020 will be very very expensive, the IEA says, and the new director, Claude Mandil, warned that “a new oil shock is possible” [40].

4. Final remark

The projections presented by USGS, EIA and IEA regarding the future availability of oil give reason to grave concerns because the comforting messages of these studies unfortunately are not based on valid arguments. These studies ignore future limitations in the supply of oil which are meanwhile apparent, and by doing this they send misleading political signals.

This article describes how, as it were, a “building” has been erected by well-known institutions:

- The supporting ground floor has been built by the USGS 2000 study: it describes, how much oil the world has at its disposal - it just needs to be found.
- On this the EIA has built a first floor which describes the future production potential. The result is that in fact any conceivable future growth of production will be possible - with growth rates exceeding everything that could be observed in the past.
- On top of this the IEA constructs a second floor: the predicted growth in oil demand for the next decades will not be restricted by any limits of supply.

However, if only one brick is removed from the ground floor, the whole edifice collapses like a card house.

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