"Modelling future liquids production from extrapolation of the past and from ultimates"

Jean Laherrere e-mail: jean.laherrere@wanadoo.fr

-1-1-What reserves and what production?

The word "reserves" may mean many things and is widely misunderstood. It may mean the estimated production from the beginning to the end of the field's life (ultimate reserves) or what is left to produce from a certain date. The estimates too may refer to what is "proved" so far, hence having a high degree of certainty (called also "reasonable certainty") or to what can be "expected" from the whole field over its full production life (called "mean" or "expected" value). Annual discovery can be the value at the year of discovery or the backdated value as estimated today.

World oil production is also badly defined, being 65 Mb/d for "conventional" crude oil or 75 Mb/d when including all liquids. Crude oil includes lease condensate in some countries. But there is no consensus on the definition of "conventional". Obviously, the goal should be to forecast the future production of all liquids since the demand is for all liquids. The starting point is to estimate "conventional oil", later adding NGL, "unconventional oil" and refinery gains, which together comprise supply. Only oils from coals and oil shales are excluded.

In most countries other than the USA and FSU, conventional oil depletion can be studied on the basis of estimated "mean" reserves, backdated to the year of discovery. We assume that the declared (in almost every country outside the US) 2P values (Proven + Probable) are close to the "mean" values (as defined by the State of Victoria in Australia) or being the median (P50) as defined by the DTI in the UK or by the SPE/WPC/AAPG rules (with the misunderstanding that for some P50 corresponds to the probable and for others to the proven+probable). "Mean reserve" growth will be close to zero, because some 2P values will grow but others will decrease, or disappear as in the case of fields that cannot be developed for whatever reason.

In fact the goal of the "proved reserves" is to provide growth to please the shareholders, and the goal of the "mean reserves" is to provide no statistical growth.

The US, following the Securities and Exchange Commission (SEC) rules, report only Proved Reserves, which are assumed to be estimated with a reasonable certainty (or high degree of confidence), omitting estimates of any Probable value, which later could acquire Proved status, leading to strong reserve growth.

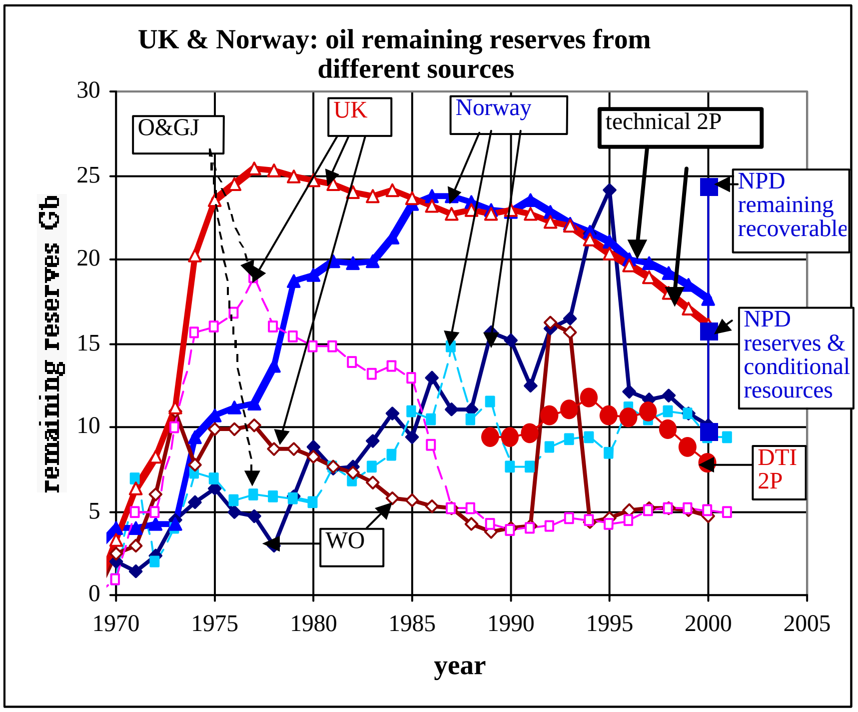
Proved reserve additions for the last 24 years as reported by the USDOE/EIA shows that the addition from new discoveries (average 0.15 Gb/a) is less than 7% of the total additions (average 2.1 Gb/a). Over 93% of the reserves addition come from changes in poor estimates of old fields. Furthermore the ratio positive revisions (51.5 Gb from 1977 to 2000) over positive+negative revisions (83.4 Gb, when production was 49 Gb) is 62%, meaning that the probability of these co-called proved reserves is close to the mode or most likely (and not a probability of 90% from the SPE/WPC/AAPG rules)

It is obvious that this US classification, being designed to please the bankers and shareholders by providing a large growth, does not represent the true pattern of discovery and cannot be modelled into the future. It is strange to see that this poor practice of proved reserves is applied by US media or US agencies to the rest of the world where good estimates exit as in the UK and Norway.

-1-1-1UK & Norway reserve reporting

The so called proved reserves for the UK and Norway as reported by USDOE (giving the different listings from World Oil (WO) and the Oil & Gas Journal (OGJ), but without stating its preference) display an erratic pattern as shown in the following graph when

compared to the technical 2P reserves, which are the sum of every discovery as estimated now and backdated to the discovery year.
Figure 1: Comparison oil reserves for UK and Norway from different sources

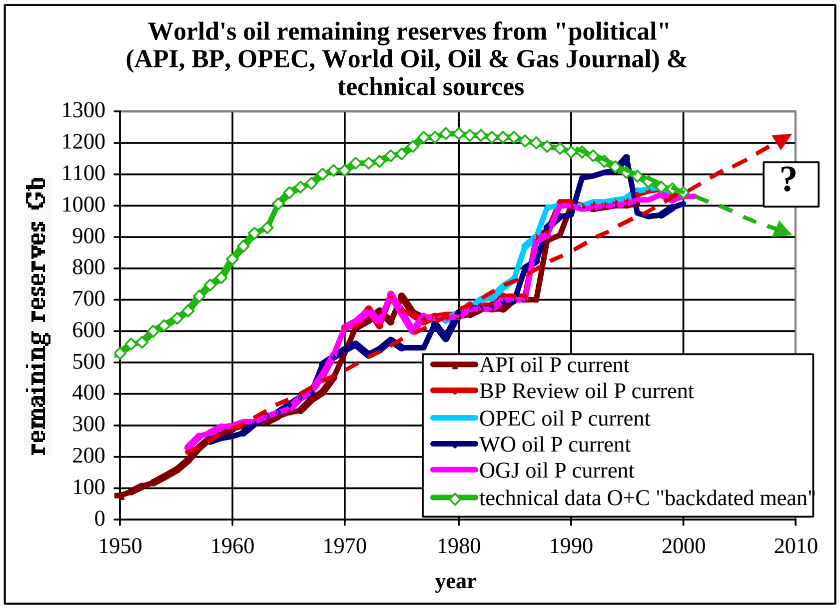


For 1996 WO reported Norway proven reserves at 26.9 Gb, but corrected this 1996 value down to 12.1 Gb the following year. It is hard to explain such variation except that WO wanted for few years to move from proven reserves to proven+probable to be more in line with what is done in the world outside the US. In Norway, the NPD distinguishes fields (original reserves and resources at 25.2 Gb oil and 28.2 Gb with condensate and NGL) and discoveries (resources 1.7 Gb oil and 3.2 Gb with condensate and NGL). Since July 2001 NPD has changed its classification to be closer to 1999 SPE/WPC/AAPG definitions by including recoverable resources.

In the UKOCS there are about 300 undeveloped fields (55% of the total number of discoveries), with 4 Gb oil + condensate (12% of the total discoveries). If there could be some positive revisions of the estimates of present oilfields, it is also likely to have a large write-off in the undeveloped discoveries when the North Sea will be depleted. For Norway the undeveloped discoveries represent 70% in number (150) and 17% in reserves (5 Gb)

The comparison of the world remaining oil reserves from political or financial sources (BP Review, OGJ, WO, API, OPEC) and technical sources displays completely different trends (Laherrere 2001) and explains the misunderstanding between economists using political data and the geologists using technical data. But every oilman knows that the present world's annual discovery is less than the annual production and that remaining reserves are consequently decreasing.

Many oil companies, being unable to grow their own reserves and production with new discoveries, are obliged to merge to show some growth. It is strange to see that Shell use in their 2001 oil scenarios the very unlikely and optimistic USGS-IPCC ultimates, but instead of trying to grow through exploration for these huge claimed undiscovered reserves, prefer to grow by buying existing oil companies as Pennzoil and Enterprise.
Figure 2: World's remaining oil reserves from political and technical sources:



In the rest of the paper we use "mean" reserves, considering proved reserves as useless for forecasting, the goal being to forecast the future production of all liquids. But the worst approach is to combine under the same term proved reserves and mean reserves as it is done by many and in particular the USGS. It is as if temperatures were in terms of the sum of Fahrenheit and Celsius values.

-1-2-**What modelling?**

Statistical behaviour needs to cover a natural Petroleum system or many PS with a large number (thousand) of fields without any economical or political drastic constraints

-creaming curve = cumulative mean discovery versus cumulative NFW = one of several hyperbolas giving the ultimate

-annual/cumulative percentage production and discovery versus cumulative giving the ultimate

-future annual production versus time from ultimate: one or several Hubbert curves = normal curve (CTL) or derivative of logistic

-future annual production versus time fitted with shifted annual production

-future cumulative production versus time from ultimate: logistic curve

-future cumulative production versus time fitted with shifted cumulative production

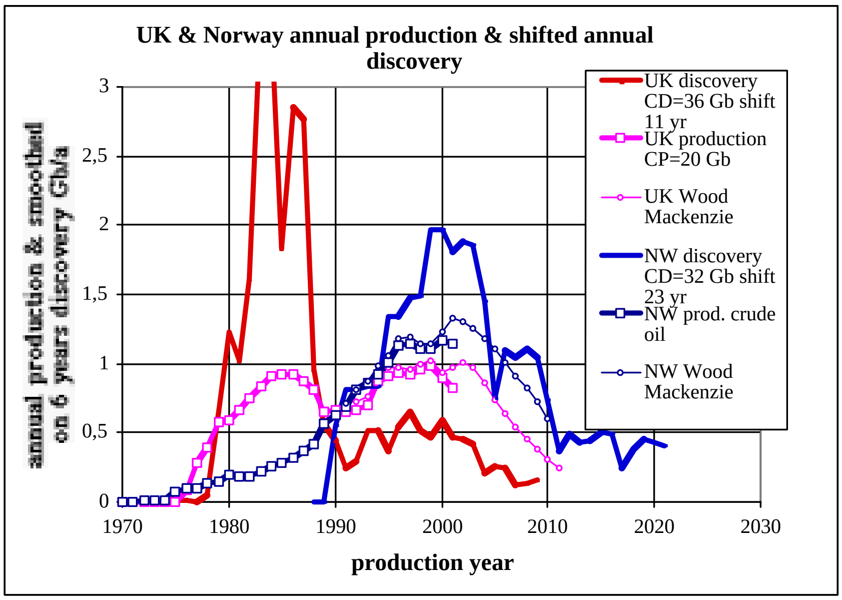
-future production of a basin from the aggregation of all known projects

It is well known that oil exploration is conducted in cycle. When a new play is found in a particular Petroleum System, many company come in and concentrate on this play, and turn to a new play only when the first has been exhausted. New legislation can also prompt a new cycle of exploration.

When there are a large number of Petroleum Systems, fields and producing companies, the laws of random distribution apply, and following the Central Limit Theorem, the annual discovery curve is close to a normal (bell-shaped) curve. King Hubbert used a bell-shaped curve that he later indicated being the derivative of the logistic curve (introduced by Verhulst for population growth). This curve is very close to a normal curve. But many object with some good reasons to the concept of a single Hubbert peak. In fact it is rare that the discovery or production pattern of a large country displays a single bell-shaped pattern. Normally there are several peaks, some being minor. Most of discovery patterns display several peaks as for example the two peaks for the UK (or France Laherrere OPEC 2001), or three for Netherlands. US oil production has a minor peak in 1929 at 1 Gb/a (due to demand), a major peak in 1970 at 3.5 Gb/a (due to supply), and a third peak in 1985 at 3.3 Gb/a (due to supply), representing the Alaska cycle. The most important of King Hubbert findings were that oil must be discovered before being produced and production follows a similar pattern to discovery after a certain time lag. One of the best ways to show this relationship is to display the annual production with the annual discovery shifted by a certain lag (it varies from 5 to 40 years (depending of the oil wealth and oil needs of the country concerned)? This method gives the best forecast for future production.

The best forecast in a mature basin, such as the North Sea is to add all the known projects as does Wood Mackenzie. The fit between mean shifted discovery and production (11 years shift for the UK and 23 years for Norway) shows a future production decline for the next 10 years, based on the corresponding decline of the discovery. This visual trend is in good agreement with Wood Mackenzie forecast. The good time fit is not matched in terms of volume, due to the fact that the life of the fields is longer than the variation of the discovery pattern. The agreement by this detailed forecast, although not possible in many places, with the shifted discovery is a good confirmation in general of the value of this approach.

Figure 3: UK & Norway annual production and shifted discovery with Wood Mackenzie forecasts



However, it is difficult to know if a new cycle could occur, and it is necessary to rely on the analysis by experienced geologists of the potential of the Petroleum Systems from the study of the source rocks. As before oil is discovered, it has to be generated by a source rock, migrate towards a reservoir, accumulate and be preserved in a trap until present times. Extrapolating future production with bell-shaped curve from ultimate reserves is a convenient way to forecast but there are other models assuming a certain plateau and a decline. The volume below the curve has to be equal to the reserves. The first step is to estimate ultimate recovery and the best way is the creaming curve, which is the plot of the cumulative discovery versus the cumulative number of New Field Wildcats (NFW). Most creaming curves display a pattern of diminishing returns, which is a well-known law of mineral exploration, and is very well modelled with one or several hyperbolas. The asymptote of the hyperbola is never reached and in mature basins, the maximum of future exploratory activities is assumed to reach twice the present cumulative of NFW.

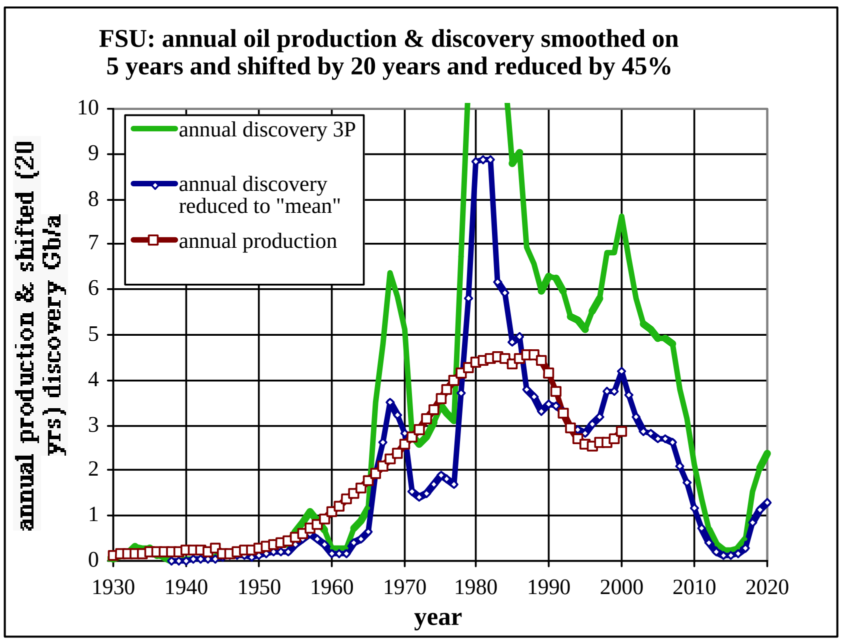
The display of cumulative discovery against time is usually disturbed by the stop and go nature of exploration, but when exploration is regular, the most convenient model is a logistic curve.

Another way to estimate the ultimate is to extrapolate the percentage of annual to cumulative production (and discovery) versus cumulative production (and discovery) towards a zero value. When the production (or discovery) pattern is a normal curve, the plot is at first curved but becomes soon a straight line. When the production is the derivative of the logistic (Hubbert curve) the plot is a straight line.

-2-NOPEC crude oil

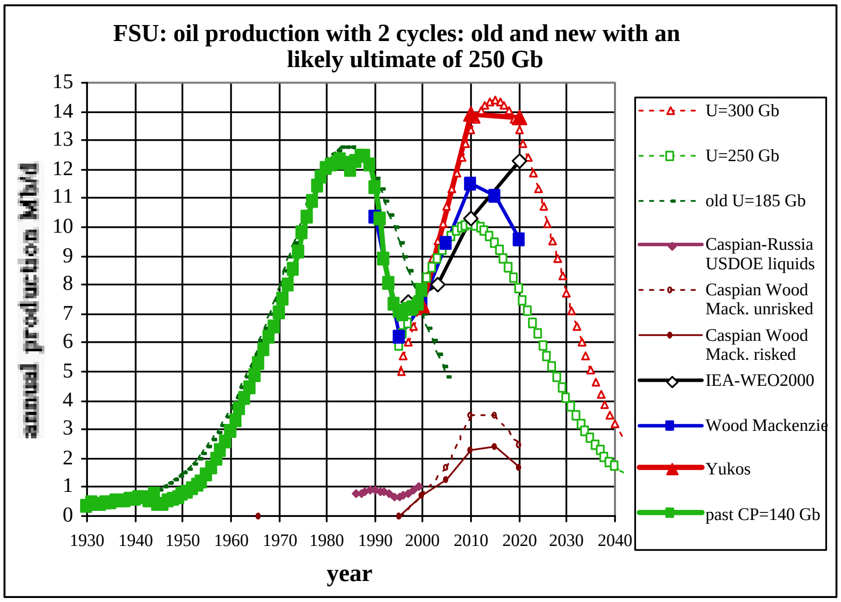
-2-1-FSU

The reserves as reported under the Russian classification (presented in 1979 at the WPC by Khalimow) are stated by Khalimow in 1993 to be strongly exaggerated. Gochenour (1997) has compared the A+B+C1 reserves of five Russian companies, giving a total of 49.4 Gb, but this equate to only 26.4 Gb (53%) when treated as "proved reserves" in a US sense.
The oil decline of the giant fields, such as Samotlor gives an ultimate estimate around 20 Gb when the official value is 28 Gb, confirming this overestimation. Lastly, the best fit between the shifted (by 20 years) discovery and the production is achieved by reducing the reported reserves by at least one third to obtain mean reserves.
Figure 4: FSU: Correlation annual oil production and shifted discovery



It is surprising to see that, with a shift of 20 years between discovery and production, the production peak of the 1980s can be explained by the discovery peak of the 1960s and the decline of the 1990s (also explained by the breakdown of the FSU) by a discovery trough in the 70s and the present production rebound (also explained by new technology) by a new discovery peak of the 1980s. The decline should come quickly, but the old shift of 20 years can be shorter for the new discovery as Kashagan (planned for 2007).

The following graph is the result of a study (Laherrere 2002) published in Petroleum Review of April 2002. The ultimate is estimated to be around 250 Gb, being the sum of two cycles: an old one with 185 Gb extrapolated from past production and a new cycle totalling 65 Gb. This new cycle is made up of 25 Gb, representing the addition of the underproduction during 1990 to 1990, the new Caspian (mainly improvement of Tengiz and the future Kashagan), and 40 Gb for the undeveloped past discoveries and the undiscovered.
Figure 5: FSU: forecasting future oil production

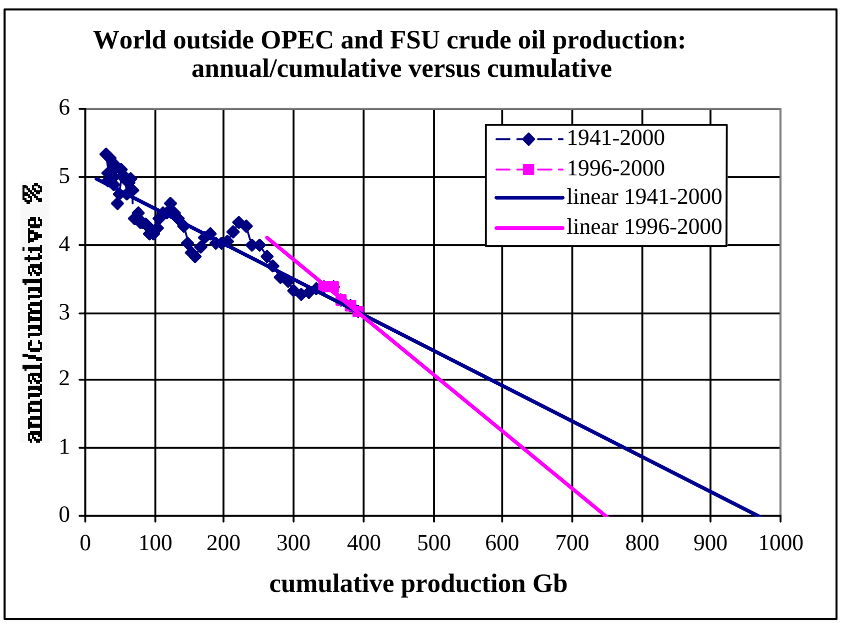


Our forecast (green squares) gives a second peak around 2010 at about 10 Mb/d and a sharp decline beyond. Yukos forecasts (Leonard 2002) a peak in 2015 over 14 Mb/d. Wood Mackenzie forecast peaks over 11 Mb/d in 2010, when as usual IEA forecasts a growing trend to 12 Mb/d in 2020 without admitting to a peak.

-2-2-world outside OPEC & FSU

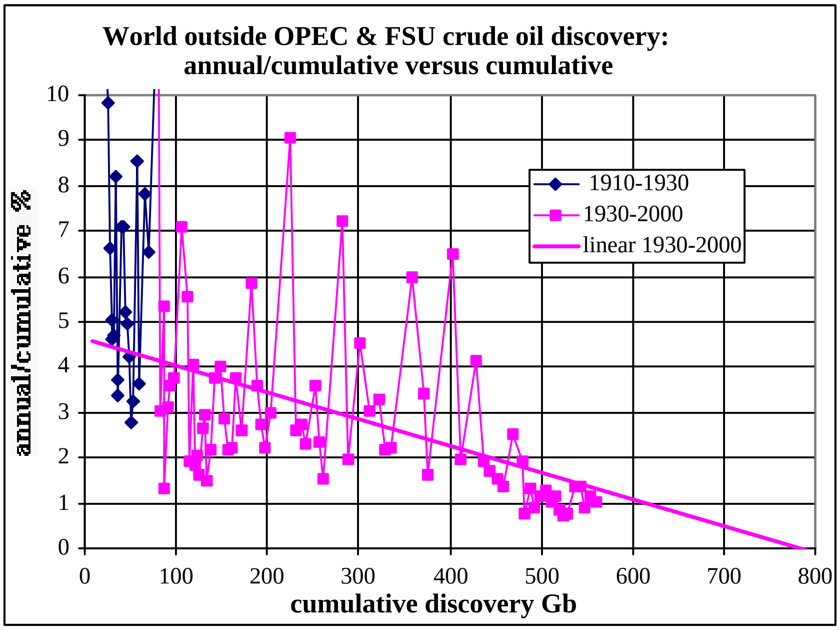
The production pattern for the world outside FSU and OPEC is almost undisturbed by politics. The percentage of annual to cumulative production versus the cumulative production (400 Gb in 2000) is unclear, but gives an extrapolation ranging from 750 to 950 Gb.

Figure 6: World outside OPEC & FSU: annual/cumulative versus cumulative production



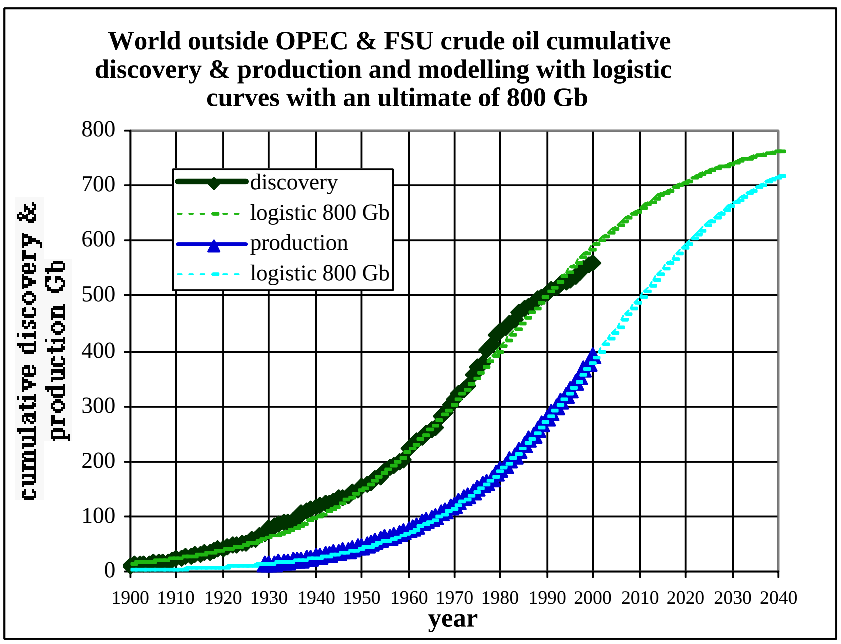
But the same display for discovery trends towards 800 Gb

Figure 7: World outside OPEC & FSU: annual/cumulative versus cumulative discovery



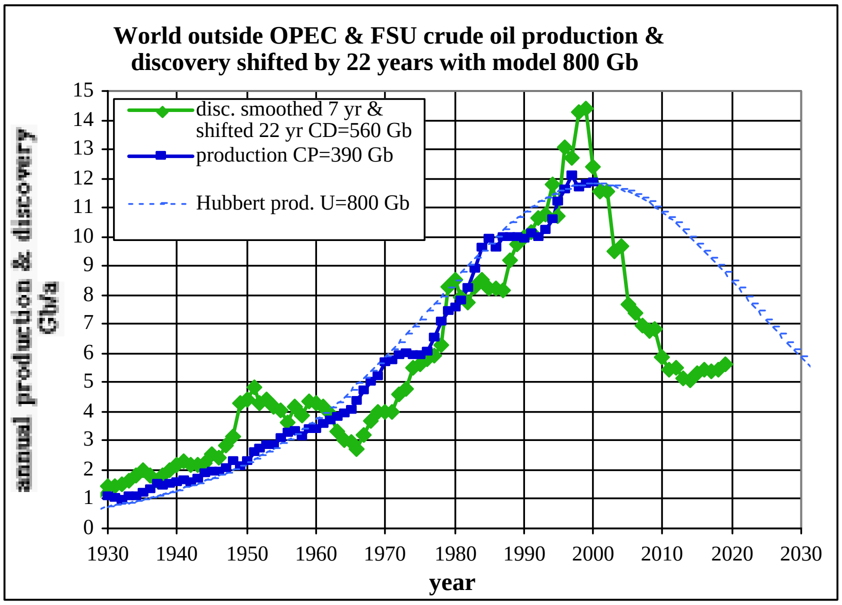
From this range, we have chosen the ultimate of 800 Gb for the world outside OPEC and FSU conventional oil as cumulative discovery and cumulative production display a good fit with a logistic curve having such an ultimate.

Figure 8: World outside UPEC & FSU: cumulative production & discovery with logistic model



The correlation of annual production to annual discovery displays a good fit with a shift of 22 years and the best fit of a single Hubbert curve is for 800 Gb, as shown in the next graph. It gives a peak around 2000, in line with the decline of the discovery after 2000.

Figure 9: World outside OPEC & FSU production and shifted discovery & forecast with an ultimate of 800 Gb



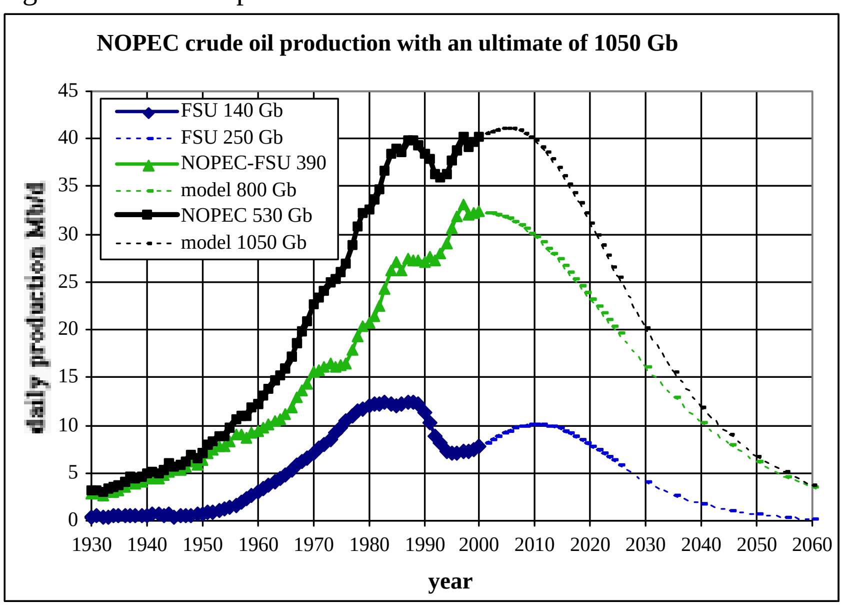
The sharp increase of production during the 1990s shown on this graph is due mainly to new production from the deepwater. It might be useful to distinguish the deepwater, as is done by some authors, who treat it as unconventional oil, or alternatively to consider it as a different cycle. As the definition of deepwater varies, being from 200 m to 500 m waterdepth and as the ultimate of deepwater is around 100 Gb (with more than half already discovered), which is less than the accuracy of the world discovery, I prefer in this paper not to distinguish deepwater.

-2-3-NOPEC

Adding FSU with an ultimate of 250 Gb and world outside OPEC and FSU with an ultimate of 800 Gb gives NOPEC an ultimate of 1050 Gb.

On this graph it is obvious that the deep trough of the NOPEC curve around 1993 was entirely due to the trough of the FSU.

Figure 10: NOPEC production & forecast with an ultimate of 1050 Gb

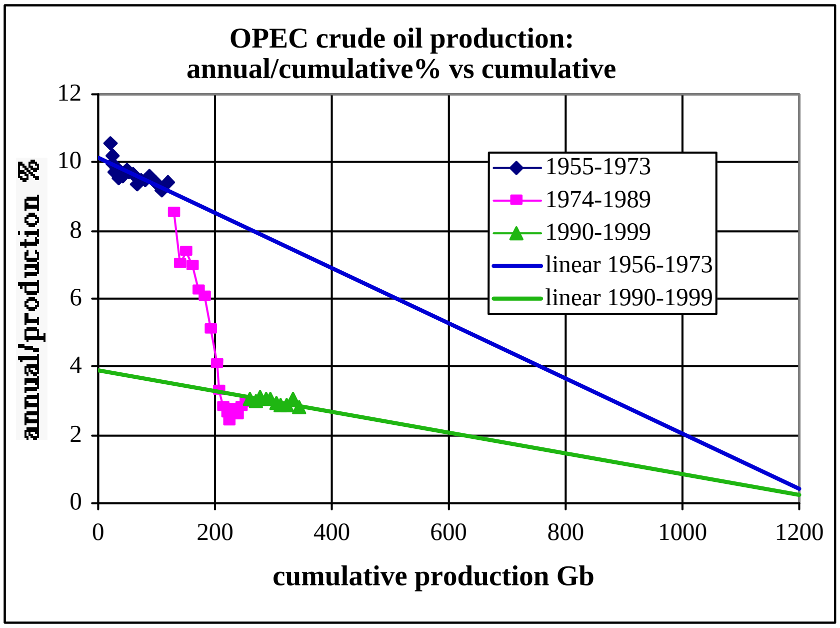


NOPEC will peak around 2005, but broadly the peak is a bumpy plateau from 1986 to 2005.

-3-OPEC crude oil

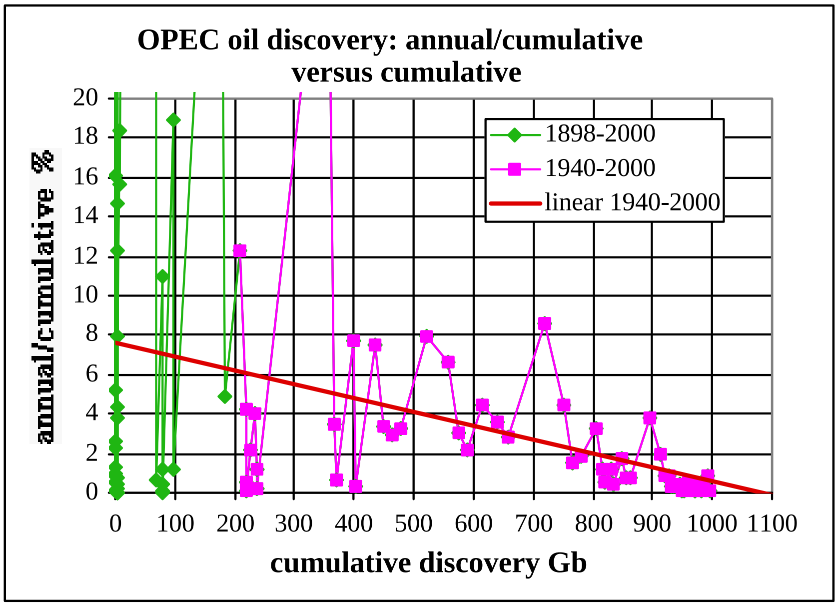
It is obvious that the OPEC oil production pattern has been disturbed by politics and is therefore very difficult to extrapolate. Some parts of the plot an annual/cumulative versus cumulative indicates a range around 1200 Gb for production.

Figure 11: OPEC annual/cumulative versus cumulative production



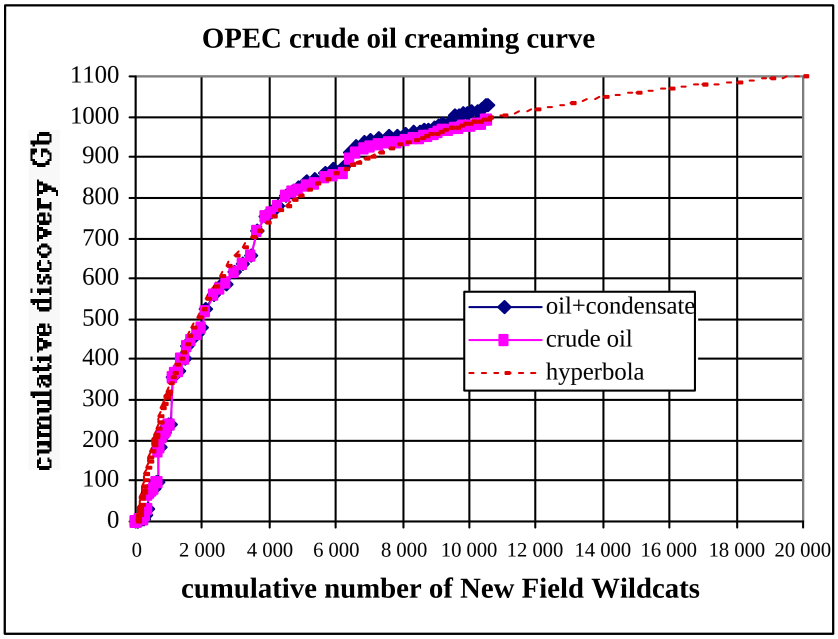
But the same plot for discovery less disturbed by politics indicates an ultimate around 1100 Gb

Figure 12: OPEC annual/cumulative versus cumulative discovery



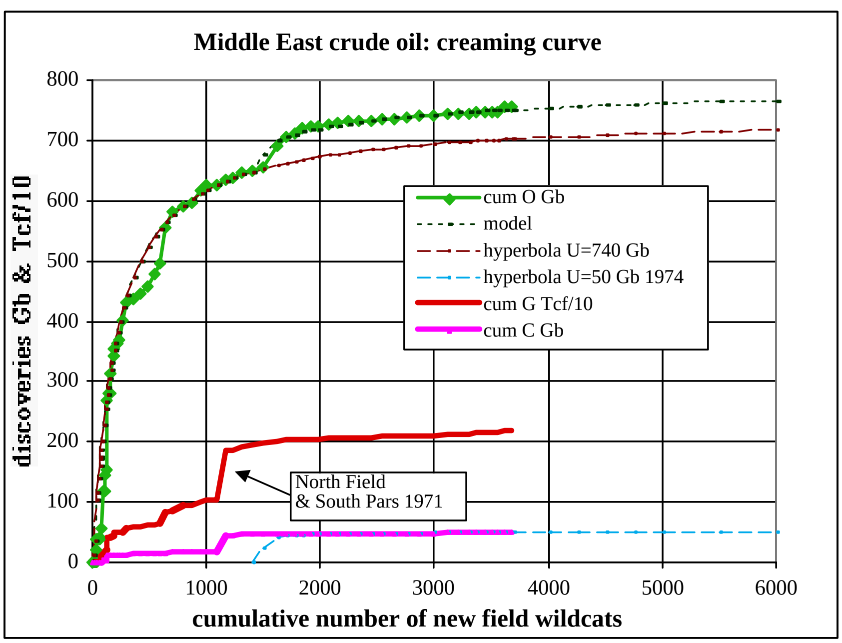
The cumulative discovery trend fits well with a logistic curve based on an ultimate of 1100 Gb up to 1980, but less so after, as exploration stopped when the revenues started to decline. A creaming curve is a much better check. The OPEC creaming curve can be modelled with a hyperbola, which shows that the result of doubling the amount of New Field Wildcats will bring only a cumulative discovery of 1100 Gb, which we consider as the OPEC ultimate.

Figure 13: OPEC creaming curve



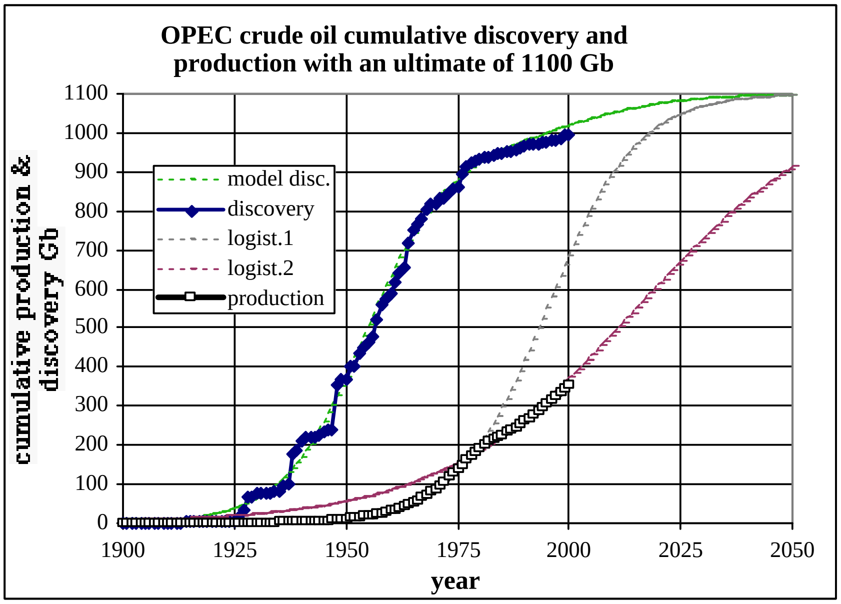
OPEC's cumulative discovery up to 2000, which is about 1000 Gb for more than 10 000 NFW, comes mainly form the Middle East. We can see from the creaming curve that the Middle East cumulative discovery is around 750 Gb from only 3 500 wildcats and reaching less than 800 Gb for doubling the number of wildcats. This graph shows clearly that the belief by some economists that the Middle East has a great potential left is wrong. In 1980 total discovery was 723 Gb for 1920 wildcats and in 2000 total discovery was 755 Gb for 3680 wildcats, meaning that for the last 20 years it has found only 18 Mb per wildcat compared to 380 Mb for the period 1905-1980 and 580 Mb for the period 1905-1970. The Middle East evidently follows the same trend as the rest of the world of diminishing returns.

Figure 14: Middle East creaming curve



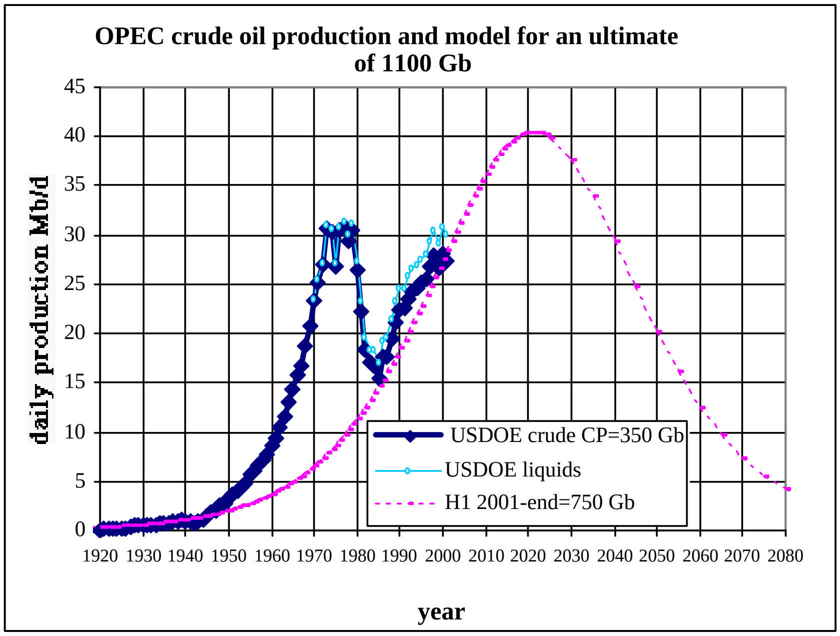
The modelling of the OPEC cumulative discovery versus time by a logistic curve, as given in the next graph for an ultimate of 1100 Gb is good until 1980, but deteriorates afterwards because the fall in oil price decreased the exploration. Cumulative production gives also a good fit for a logistic at 1100 Gb, but a poor fit with a shifted discovery after 1985, date of the countershock. Another logistic with a lower slope can be fitted since 1980, but OPEC production will resume a higher level soon.

Figure 15: OPEC cumulative production & discovery with logistic models



A simple cycle with an ultimate of 1100 Gb is taken to model OPEC's future oil production, as shown on the next graph, extrapolating as well as possible the last past production. In fact the fit is not bad since 1985. This model is a possible if the future is in line with the demand growth of the past. But it seems that because the present recession, demand growth will be less than expected and the supply will be constrained by reduced demand, decreasing this scenario and delaying the peak. For most of the past 40 years the erratic changes of world demand were only felt in the production of the swing producers (the five countries of the Middle East), the rest of the world were producing at full capacity. But if the overcapacity narrows, the swing producers will not work anymore and the balance between demand and supply will be more difficult than in the past.

Figure 16: OPEC production & forecast with an ultimate of 1100 Gb



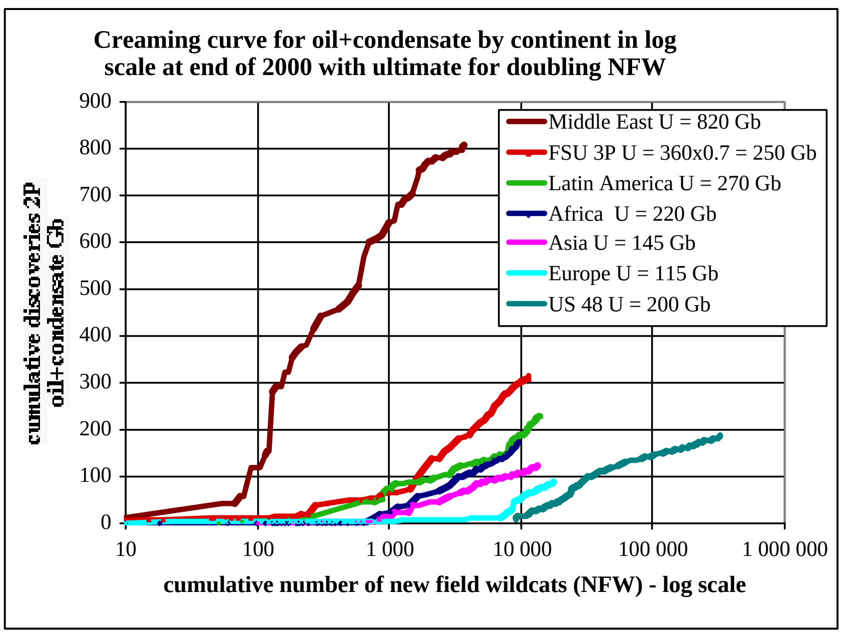
The peak for OPEC production should be around 2020 about 40 Mb/d, being in line with Bakhtiari (2001) (National Iranian Oil Co) statements, but in complete disagreement with USDOE 2001 which forecasts 62.4 Mb/d for 2020 without mentionning any peak.

-4-World

-4-1-conventional crude oil

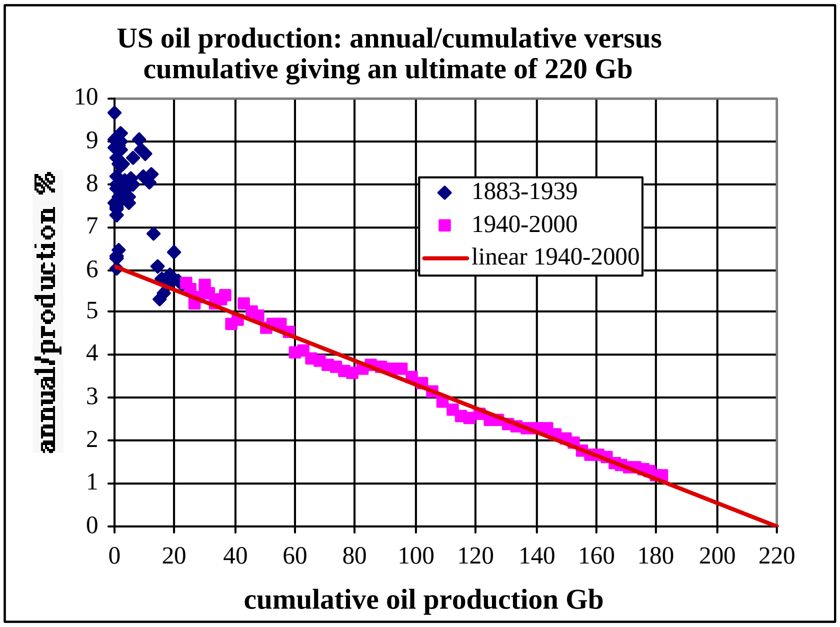
The world oil + condensate ultimate is about 2 Tb, as estimated from the creaming curves by continent using the mean reserves.

Figure 17: Creaming curves by continent



For the US, estimates of "mean" reserves come from a 1990 study which evaluated at this time the real reserves by discovery year, supplemented by a MMS curve to grow reserves to mean values (multiplying by 4.5 after 50 years). However the last report by MMS on the 1999 estimates shows that the revision from 1998 value was negative. It seems that the offshore estimates have been somewhat overestimated (no doubt to deliver a good impact for the stock market). The estimate of the ultimate from past production displays a fair straight line since 1940, giving a fairly reliable 220 Gb value for the full US.

Figure 18: US annual/cumulative versus cumulative production

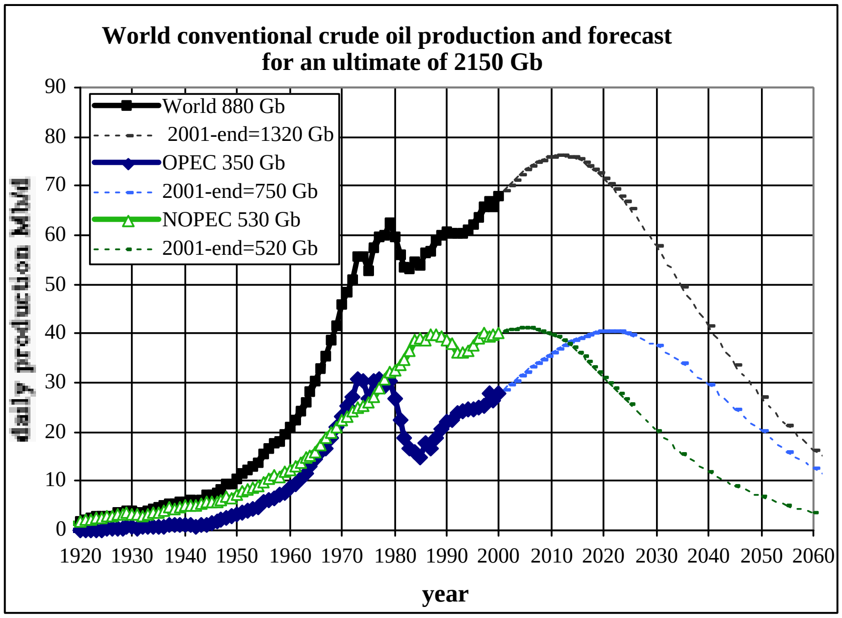


The total oil+ condensate (excluding NGL) by continents is 2050 Gb, rounded to 2 Tb, for conventional oil + condensat, excluding the natural gas plant liquids. We have increased the values in order to obtain 2150 Gb, but we believe that the accuracy is so poor that the rounded ultimate should stay as 2 Tb, plus or minus 20% (or plus 20% and minus 10%).

From creaming curves	ultimate	to obtain 2150 Gb
Middle East	820	840
Latin America	270	290
FSU	250	260
US+Canada	230	250
Africa	220	240
Asia	145	150
Europe	115	120

Adding the two curves on OPEC and NOPEC gives the curve for world conventional crude oil, peaking around 2012 at less than 80 Mb/d

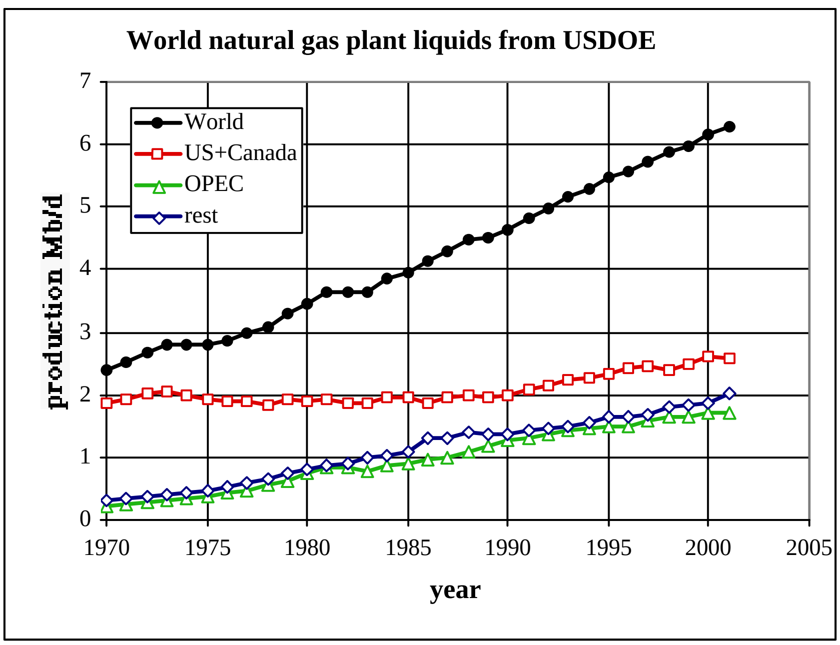
Figure 19: World conventional crude oil production & forecast with an ultimate of 2150 Gb



-4-2- natural gas liquids, other liquids and refinery gains

The natural gas plant liquids have increased from 2.3 Mb/d in 1970 to 6.2 Mb/d in 2000, giving a constant increase of 0.15 Mb/d per year. The US and Canada were the main producers in 1970 and stay flat until 1990, but during this period OPEC has increased sharply and could catch them up in 2010.

Figure 20: World natural gas plant liquids production



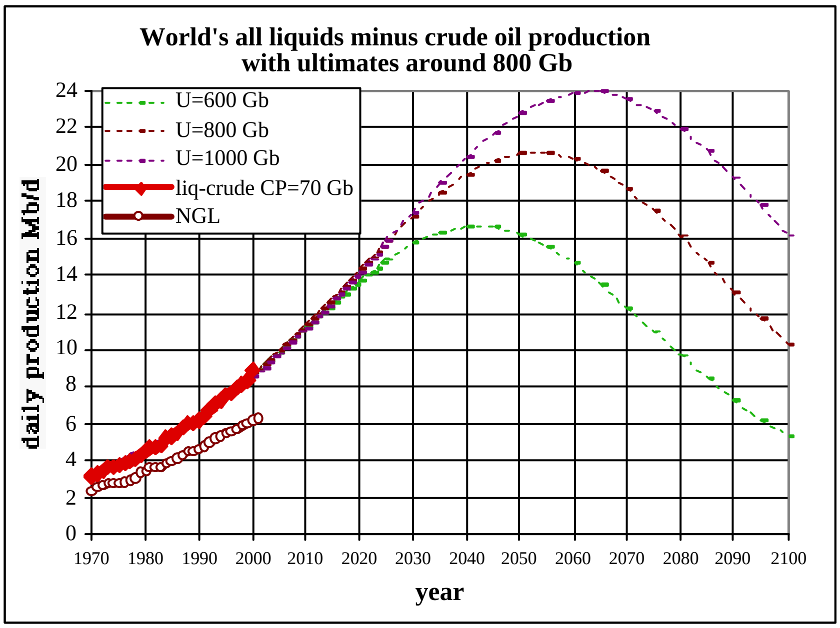
These additional liquids gathering mainly the NGL, synthetic oil and refinery gains display a smoothed increase over the last 20 years, despite the oil countershock of 1986. They will likely continue to rise smoothly up to a certain peak, which is difficult to estimate. This peak depends on both the peak of the natural gas and the peak of the unconventional oil. Because of the unknown, it is simpler to model it with a single curve depending on the ultimate. In the past (Perrodon et al 1998), our estimate of the ultimate of the unconventional oil (mainly Athabaska and Orinoco) was 750 Gb, but now with the start of the Orinoco production we feel that 500 Gb is a better value. The present production of unconventional oil is around 1 Mb/d less than the refinery gain (1.7 Mb/d). It will accordingly take a long time to peak.

Present NGL production is 6 Mb/d, which is about equal to the North Sea oil production and about 9% of the crude oil production. On average about 25 Mb of liquids are extracted per Tcf of gas production. As the natural gas ultimate is about 10 Pcf, NGL ultimate should be about 250 Gb.

Refinery gain for 2000 at 1.7 Mb/d is 2.6 % of the crude production (ultimate 2000 Gb). Its ultimate should be about 50 Gb.

So the ultimate of the liquids other than conventional crude should be around 500+250+50= 800 Gb

Figure 21: World all liquids other than crude oil production & forecast with ultimates around 800 Gb

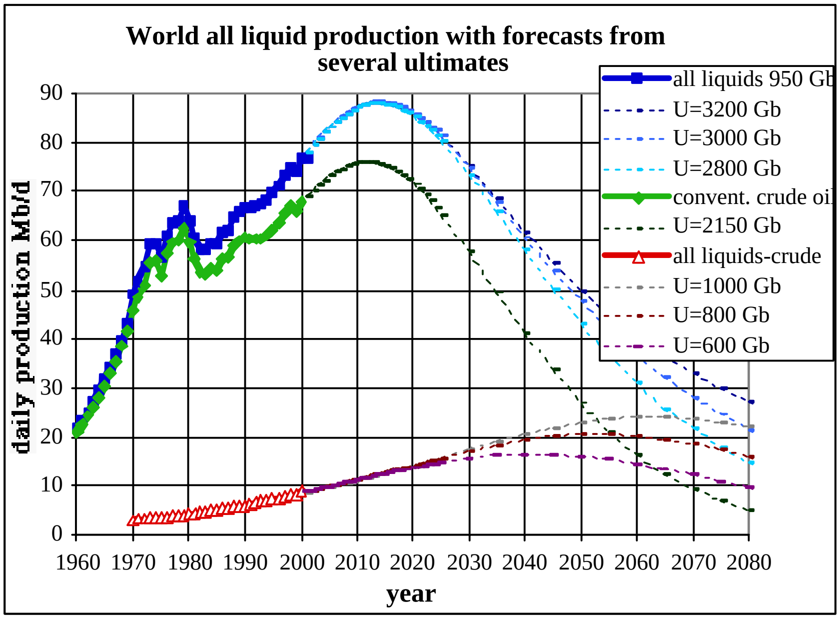


Three curves with ultimates from 600, 800 and 1000 Gb are plotted fitting the past data. The most likely ultimate of 800 Gb peaks around the 2050s at over 20 Mb/d.

-4-3- all liquids

Adding the other liquids to conventional crude oil gives the all liquids curve.
It will likely peak around 2015 at about 90 Mb/d. This peak production is exactly what is forecasted by the BP CEO J. Browne (Davos 2001), “a level he believes might be close to the industry's maximum production capacity.” Contrary to Shell which believes that the demand will constrain supply (scenarios 2001), BP believes that the supply will constrain demand

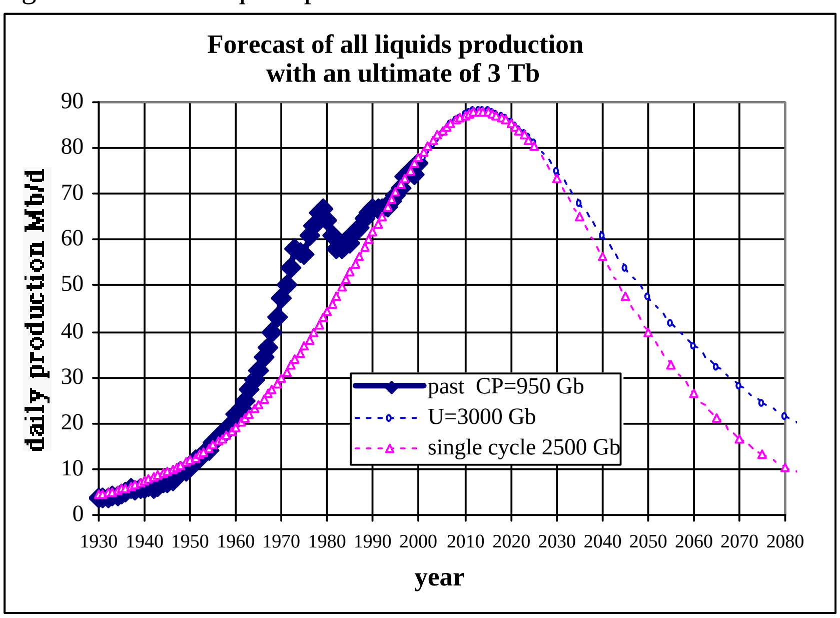
Figure 22: World all liquids production & forecasts



The above forecast for all liquids is the addition of many curves giving a total ultimate of 3 Tb. A simpler alternative, modelling past data with a single cycle (ultimate of 2.5 Tb) gives a very similar curve as shown in the following graph up to 2040, but the ultimate (past and future) of this single cycle is only 2.65 Tb.

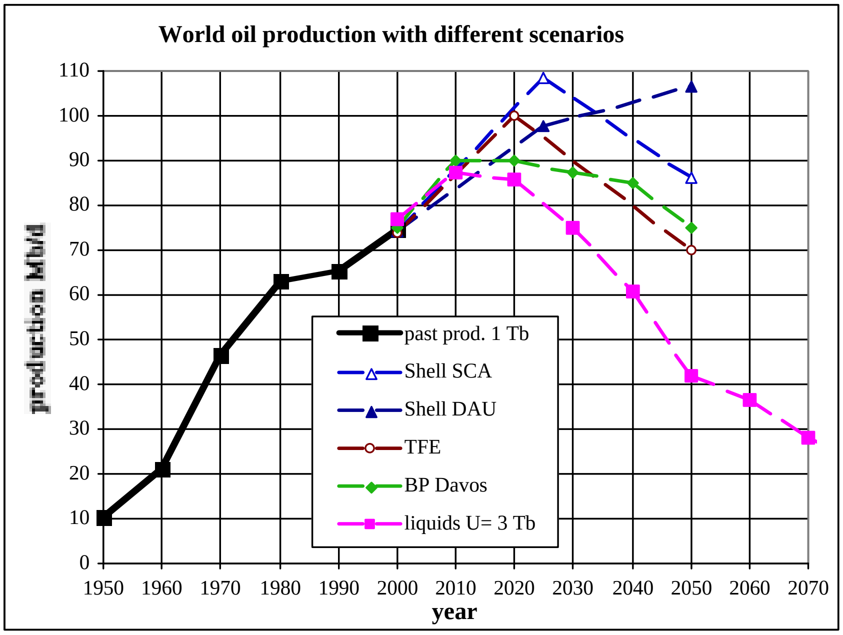
This single cycle fits well the past production except during the period 1950-1980, when there was an exuberant rise (called in France “les trente glorieuses”). Will the future be in line with this model? Nobody can tell, but it is a robust model. Only long recession can decreases sharply the demand (as in 1979), adding another cycle, delaying the peak and the unavoidable decline.

Figure 23: World liquids production with forecast for 3 Tb and for a single model



The comparison of the above forecast with the scenarios from Shell (2001), BP (2001) and TotalFinaElf (TFE) (Bauquis 2001) shows that it is close to BP, in line for the peak timing (but not the level) with TFE and Shell (Spirit of the Coming Age or the hydrogen era) and far from Shell DAU (Dynamics As Usual)

Figure 24: World oil production with different scenarios

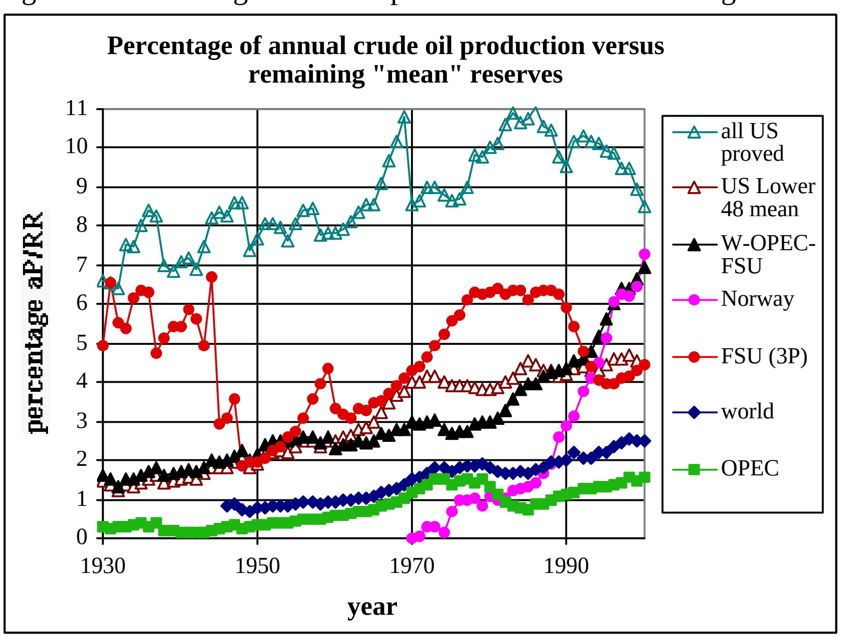


-5-1-**Future discovery needed to fill the demand?**

The very optimistic forecast on demand being over 115 Mb/d in 2020 by USDOE and IEA when estimate from technical data is less than 90 Mb/d, prompt the question of how much new discovery is needed to fill the gap of 25 Mb/d (9 Gb/a)?

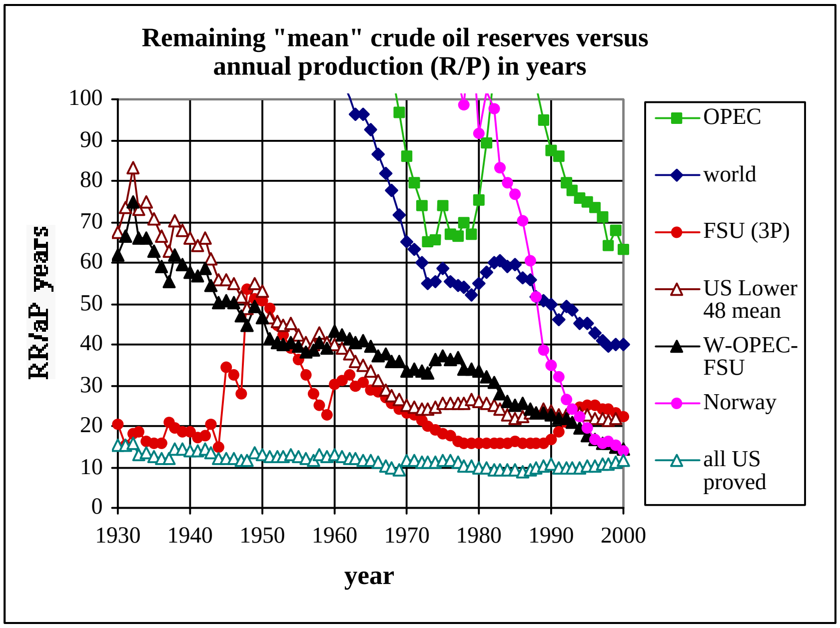
The percentage of annual production versus remaining reserves is displayed on the following graph. In 1970 it was between 1% for OPEC and 4% for FSU (using the official 3P estimate), the world average being 1.5%. In 2000 the percentage is 2.5% for the world, but 7% for the world outside OPEC and FSU. To fill the gap of 25 Mb/d would need an additional 9/0.025= 360 Gb for the world, but if it comes only from the world outside OPEC and the FSU, it is 9/0.07= 130 Gb would be needed, which is well above what is in deepwater.

Figure 25: Percentage of annual production versus remaining mean reserves



Most of the optimists rely on the R/P ratio, quoted in years, to forecast a 40 year period before there is any need to worry about the world oil production, ignoring that the present production is assumed to grow at a significant rate and that oil production cannot sustain a level production during 40 years to drop to zero overnight at the end of the period. Furthermore they argue on the basis of proved reserves, when the real R/P should be based on “mean” reserves, which displays a drastic decline. The world R/P ratio was 140 years in 1950, 100 years in 1960, 50 in 1980 and 40 in 2000. For Norway R/P was 100 years in 1980 and 14 years in 2000. For the US lower 48 the R/P with “mean” reserves has declined from 70 to 20 years, but with proved reserves it has been constantly around 10 years for the last 70 years.

Figure 26:R/P: remaining mean reserves versus annual production



In fact, R/P ratio is a very poor indicator, when the reverse is a good indicator of depletion. If world discovery stops to day and if the world is produced to keep this 40 R/P ratio, the world oil production will decline at 2.5%/a

-Conclusion

Production modelling seems to be more reliable than data. The main problem is the poor quality of the data, both for production as for reserves and the definitions. Condensate is included with oil in some countries but in others not, and the distinction with NGL is difficult. Dealing with proved estimates is the worst approach for forecasting future production.
The world outside US deals with proven+probable reserves.

The best recommendation is to promote that every country provides the real “mean” reserves, but the most changes should come from the US and FSU.
In the US the new Public Act 106-554, which asks for reliable data from federal agencies, should push the USDoE to approach the SEC to changes their rules. The SEC should require the companies to provide, in addition to the financial estimates of proved reserves, the recognised SPE/WPC/AAPG proven+probable reserves to estimate their technical potential.
It appears that the world’s production of all liquids can be modelled fairly well with simple bell-shaped curves first for conventional crude oil in the FSU, Non-OPEC, OPEC and second the NGL, unconventional oil and refinery gains. Such modelling forecasts that as much as 3 Tb of all liquids will be ultimately produced, reaching a peak around 2010 at about 90 Mb/d. This forecast is much less than the forecasts by USDOE and IEA but in line with BP’s prediction and not far from that of TFE.

But demand is likely to be constrained by a combination of high prices, recession, and political action.

-References

-Bakhtiari A.M. 2001 “OPEC capacity potential needed to meet projected demand not likely to materialize” OGJ July 9, p66-70
-Bauquis P-R. 2001 “Quelles energies pour un developpement durable” Journees de l’energie au Palais de la decouverte 18 Mai
-BP Davos 2001 BP press release “Browne predicts 30 years of growth for oil sector” Jeremy Warner. 29 January 2001 http://www.bpamoco.org.uk/environment/01-01-29ind.htm
-Gochenour D.T. 1997 “Practical difficulties of valuing Russian oil reserves” SPE 37958
-Khalimov E.M., 1993, "Classification of oil reserves and resources in the Former Soviet Union" AAPG 77/9 Sept. p.1636
-Khalimov E.M., M.V.Feign 1979 "The principles of classification and oil resources estimation" WPC Bucharest, Heyden London 1980 p263-268
-Laherrère J.H. 2001 “Estimates of Oil Reserves ” IIASA International Energy Workshop June 19-21 2001 Laxenburg http://www.iiasa.ac.at/Research/ECS/IEW2001/pdffiles/Papers/Laherrere-long.pdf
-Laherrère J.H. 2001 “Forecasting future productioin with past discoveries“ OPEC seminar: «OPEC and the global energy balance: towards a sustainable energy future» Vienna, Sept. 28-29 http://www.hubbertpeak.com/laherrere/opec2001.pdf
-Laherrère J.H. 2002 "CIS future oil production" Petroleum Review, April
-Perrodon A., J.H. Laherrere, C.J.Campbell 1998 “The world’s non-conventional oil and gas” Petroleum Economist March report 113p see http://textor.com/cms/dPEWNC.html
-Shell 2001 “Energy Needs, Choices and Possibilities - Scenarios to 2050” http://www.shell.com/files/media-en/scenarios.pdf