**Petrotech 2003**
# Hydrocarbons Resources

## Forecast of oil and gas supply to 2050

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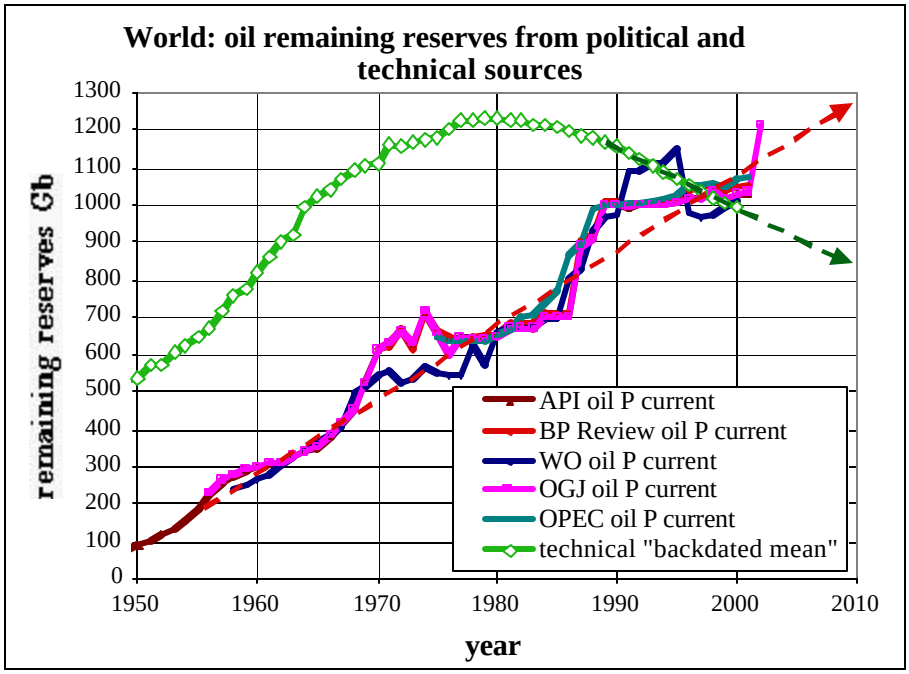
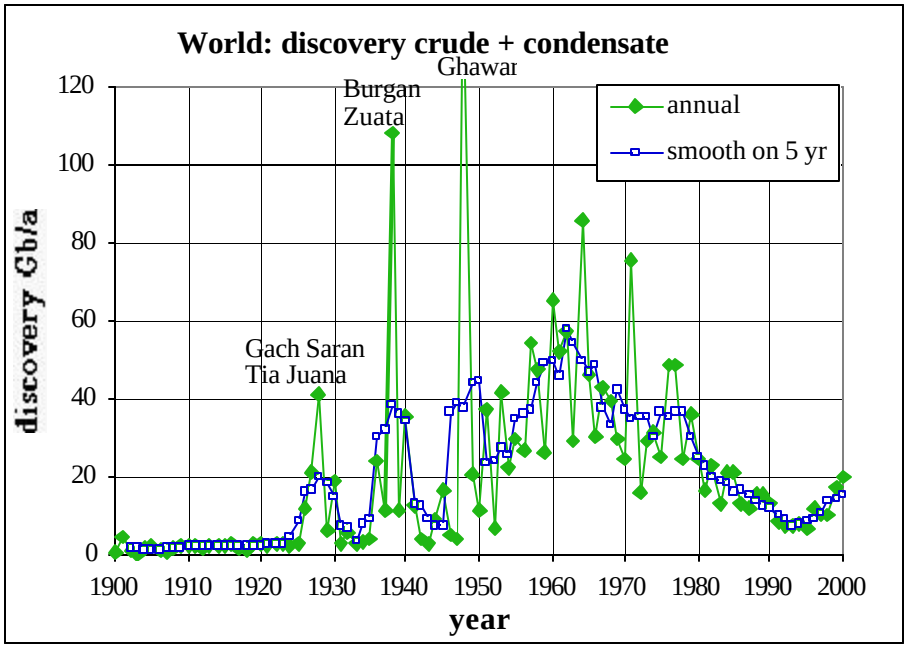
Overheads presented during the conference:
**Definitions:** They vary:
**Production**: "**Oil** "may refer to crude oil only 65 Mb/d), or include condensate, a liquid condensing naturally from gas, natural gas liquids (NGL) extracted in gas plants (NGPL), synthetic oil (from tarsands), and finally refinery gains (totalling 75 Mb/d).
**Natural gas** production may represent the gross volume, the marketed volume or the dry volume.
**Reserves**: Oil companies have usually several sets of reserve estimates, depending on the use or destination. Reserves can be the "proved" value to comply with SEC (Securities & Exchange Commission) rules, omitting the known probable reserves.
Proved reserves could be conservative estimates when the goal is to provide growth. But they could be optimistic when the goal is to establish quotas. In the late 1980s, OPEC countries added as much as 300 Gb to their reported "proved" reserves although only about 10 Gb were added from new discoveries.
Reserves can be the "mean" (expected value) estimate used by technicians to plan a development. These technical estimates are compiled in several industry databases.
"**Political**" data can be described as the current "proved" value, reporting the latest revised estimates. The last OGJ estimate at end 2002 includes tarsands (175 Gb) from Canada (Athabasca).
"**Technical**" data report the present "mean" estimates backdated to the year of discovery. They include extra heavy oils from Venezuela (Orinoco), but not tarsands.
-Figure 1 : **World remaining reserves from political and technical sources**



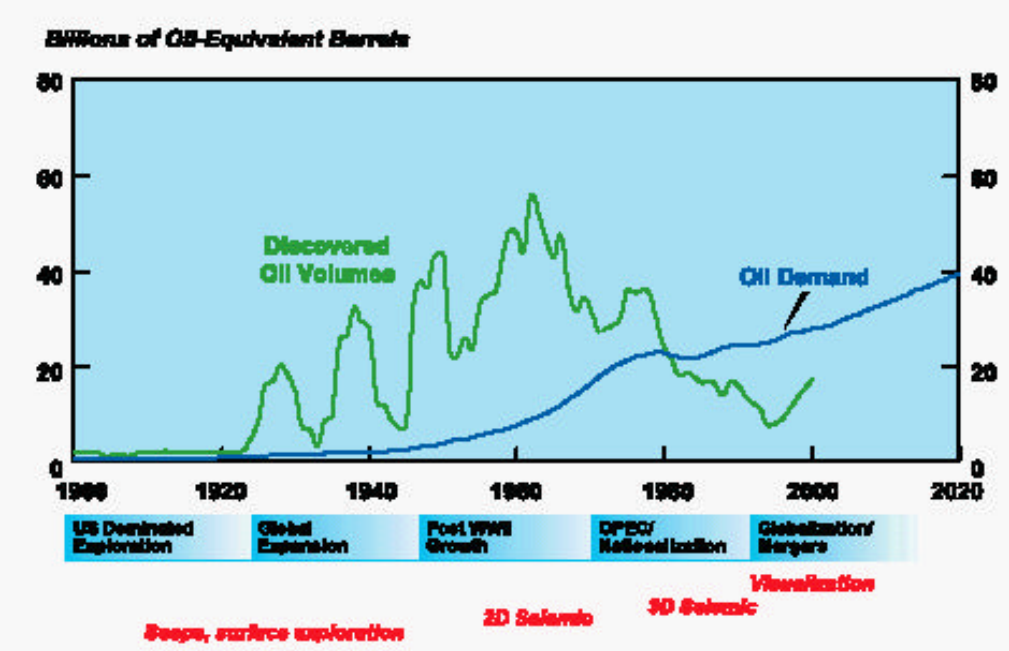
The technical world annual mean discovery from my file displays several cycles when smoothed, but are exceptional discoveries in Middle East and Venezuela

Figure 2: **World annual mean discovery for crude and condensate from my file**

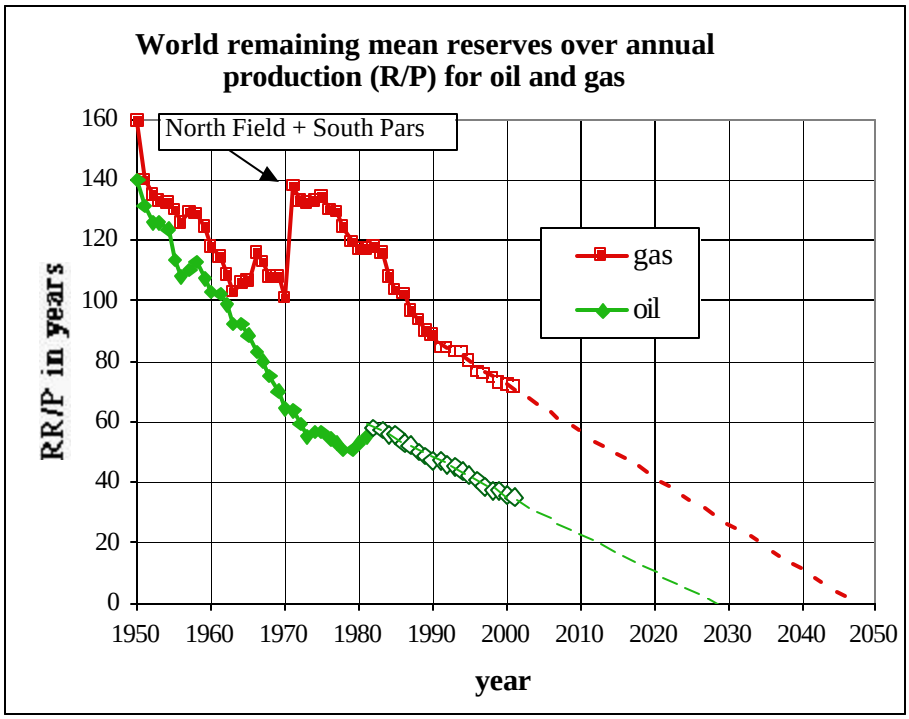



My file is in very good agreement with Exxon-Mobil plot by Longwell 2002: "The future of the oil and gas industry: past approaches, new challenges". The peak of the technical remaining reserves in 1980 results of the negative balance since that date between discovery and production as shown in the following graph.

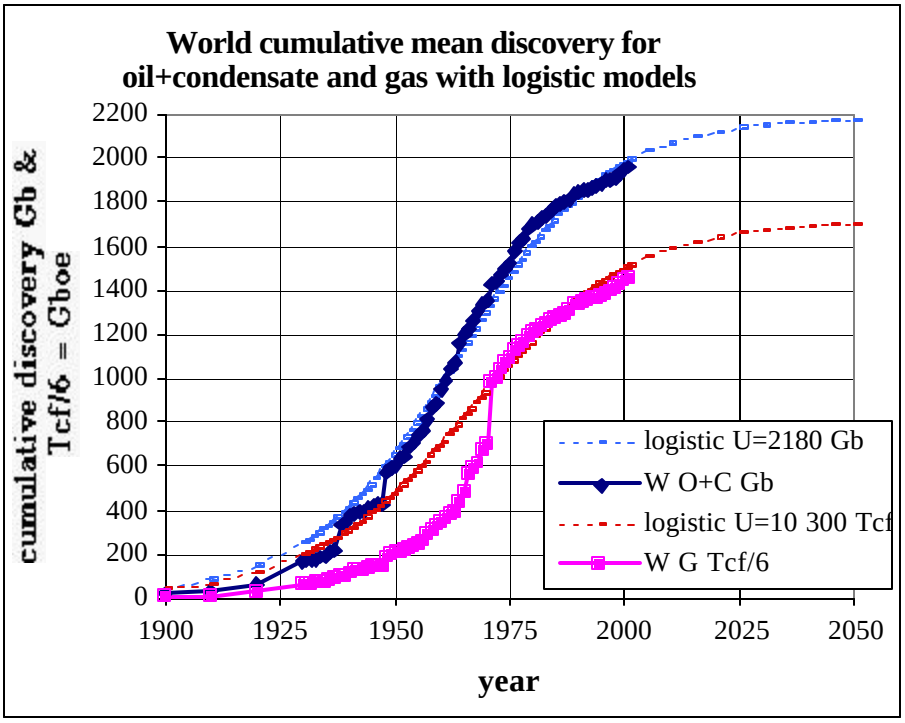
Figure 3: **Exxon-Mobil annual oil discovery**



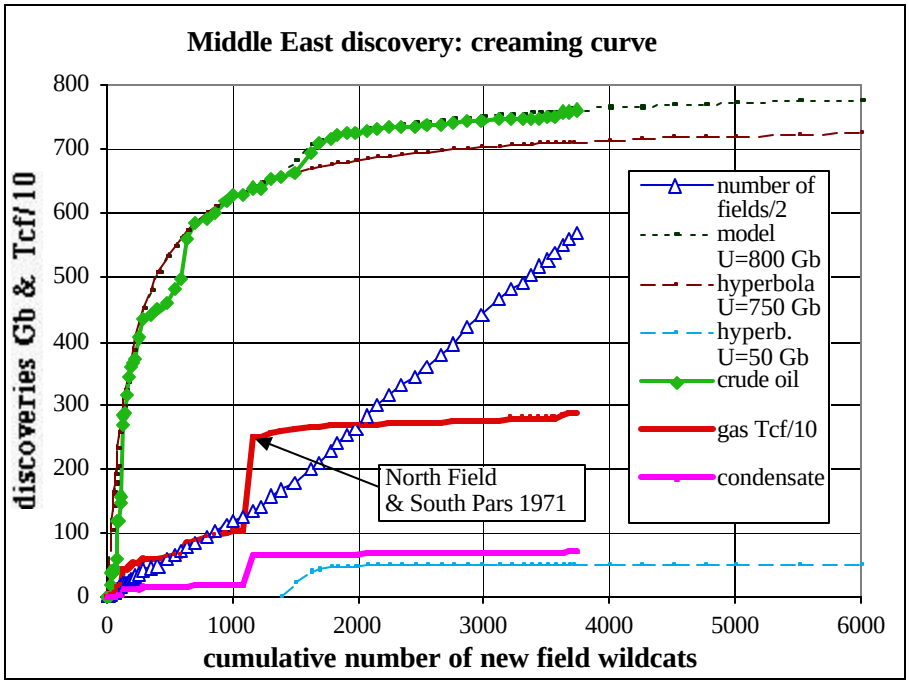
It is common practice to report security of supply in terms of **remaining reserves to annual production ratio (R/P) quoted in years**, claiming that current reserves of 1000 Gb could support current production at 25 Gb/a for 40 years.
R/P is a poor indicator and should be ignored, as the real value when extrapolated gives different value, as less than 30 years for oil.
-Figure 4 : **World R/P for oil and gas**




The world cumulative "mean" discovery trend may be extrapolated using a simple logistic curve **versus time** .
The fit is good for oil giving an ultimate recovery of around **2200 Gb** and fair for gas giving **8700 Tcf**.
-Figure 5 : **World cumulative discovery of oil and gas with logistic model**



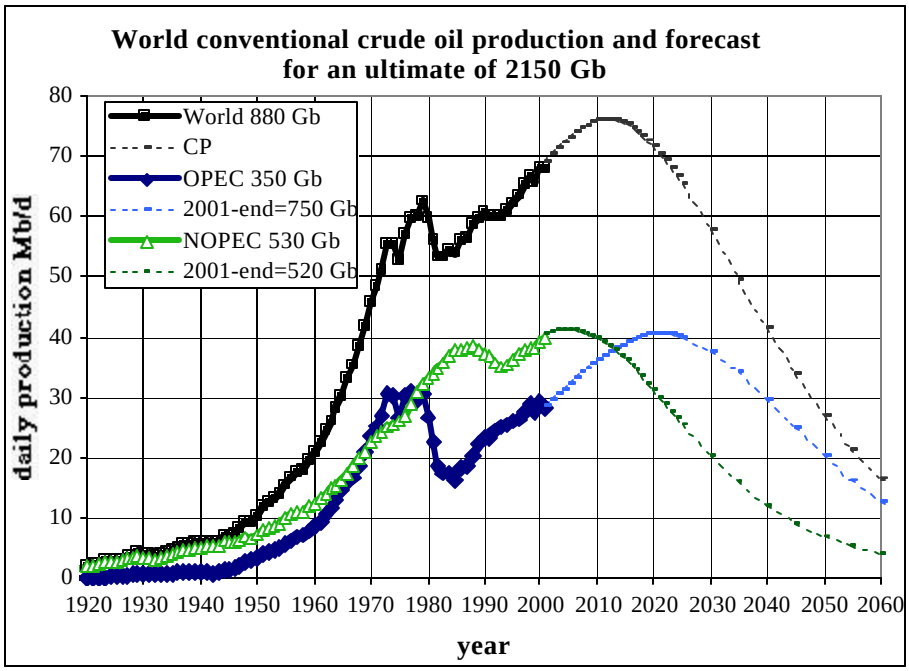

Plotting cumulative discovery versus time with a logistic curve is not a very satisfactory way to assess the ultimate.
A better approach is to use a creaming curve showing cumulative discovery **versus the cumulative number of New Field Wildcats** (NFW), and to model it with several hyperbolas
-Figure 6: **Middle East discovery : creaming curve from 1905 to 2001**




A study (Laherrere 2002 b) presented at the International Workshop on Oil Depletion at Uppsala, Sweden, subdivided the world into three zones: OPEC, FSU and the rest-of-the-

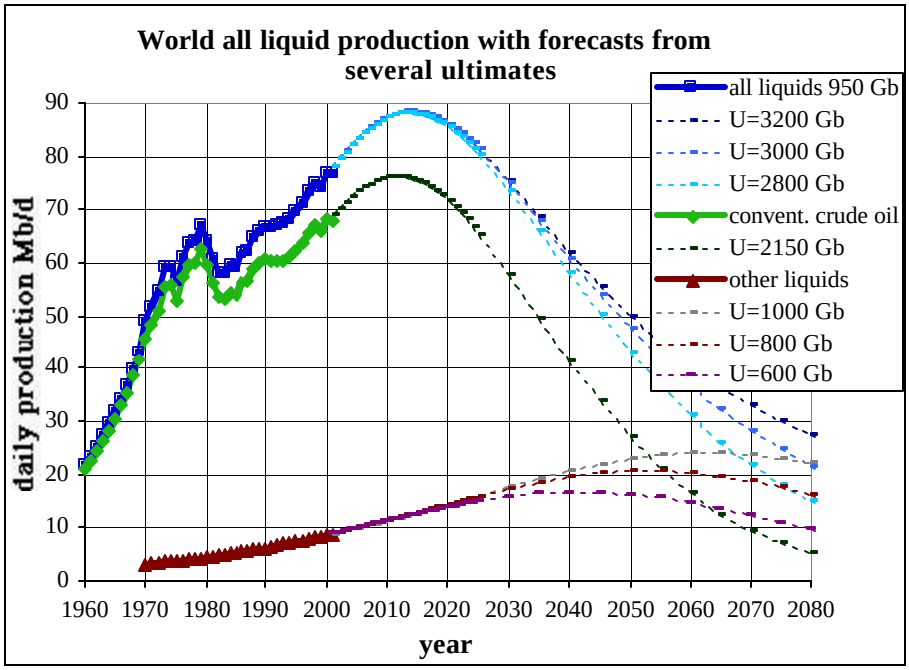
world. Production has been constrained by politics in the first two zones, but was at full capacity elsewhere. The ultimate recovery and future production for each zone were modelled with several normal curves (or Hubbert curve). The result based on an ultimate of **2150 Gb** (as in the previous graph) is shown in the next graph where OPEC (ultimate **1100 Gb**) and Non-OPEC (ultimate **1050 Gb**) are distinguished.

-Figure 7 : **World conventional oil future production for an ultimate of 2.2 Tb**

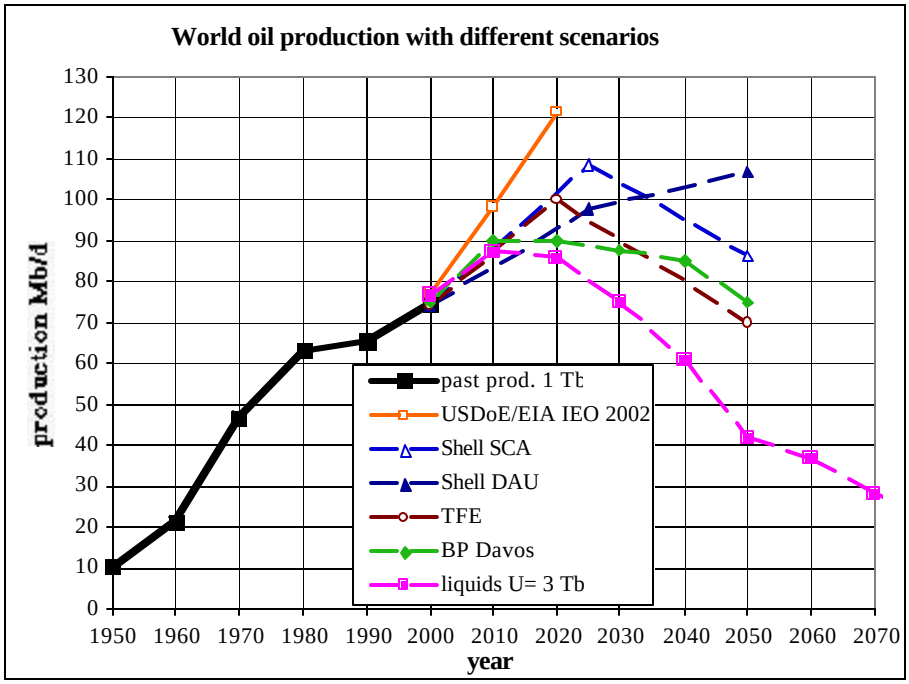



Liquids other than conventional oil are the Orinoco extra-heavy oils, Athabasca tarsands, NGL and refinery gains and may be modelled also by estimating the ultimate from past production. Such a plot shows that the future production of all liquids could peak around 2015 at 90 Mb/d, far from the official forecast from USDoE and IEA (about 120 Mb/d in 2020).

-Figure 8 : **World liquids production for an ultimate of 3 Tb**



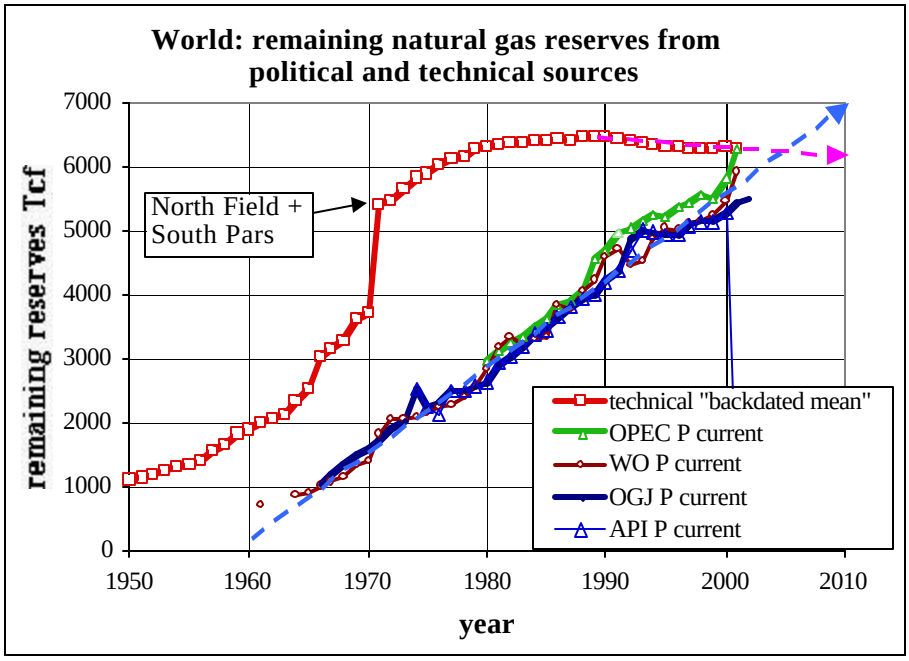

This model assumes that the only constraint is from the supply. But demand also plays a part as demonstrated in 1979 when oil production declined from an early peak because the demand fell as a result of high oil prices.
If the present economic recession is protracted, demand could stay level for the next ten years, giving a bumpy production plateau of around 80 Mb/d. If supply is constrained by demand in this way, then the decline need not start before 2020.
The next graph compares our scenario, assuming no demand constraint, with the scenarios Shell, BP, TFE (Bauquis 2001), and USDoE-EIA IEO 2002
-Figure 9: **comparison of oil production scenarios**



**-Natural gas**

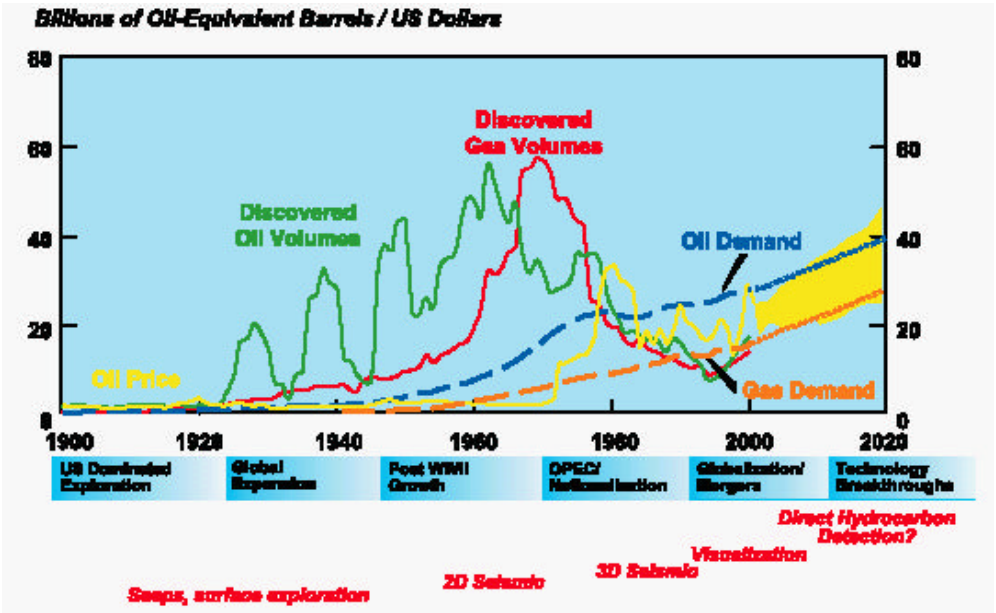
As for oil political remaining reserves are completely different from technical sources

-Figure 10 : **World natural gas remaining reserves from political and technical sources**




The small decline of the technical remaining reserves since 1990 is well explained in the Exxon-Mobil plot of annual gas discovery (in red) being slighlty lower than production since taht date.

Figure 11: **Exxon-Mobil annual gas discovery**




That plot shows that the introduction of the 3D during the 80s did not decrease the decline of discovery for oil and gas.

One of the best ways to forecast future production is to compare **annual production** with **mean annual discovery shifted** by a certain number of years. For gas production in North

America (US + Canada + Mexico) the shift is 20 years, providing a good means of forecasting gas production for at least the next 10 years.

-Figure 12 : **North America natural gas annual production and shifted discovery**

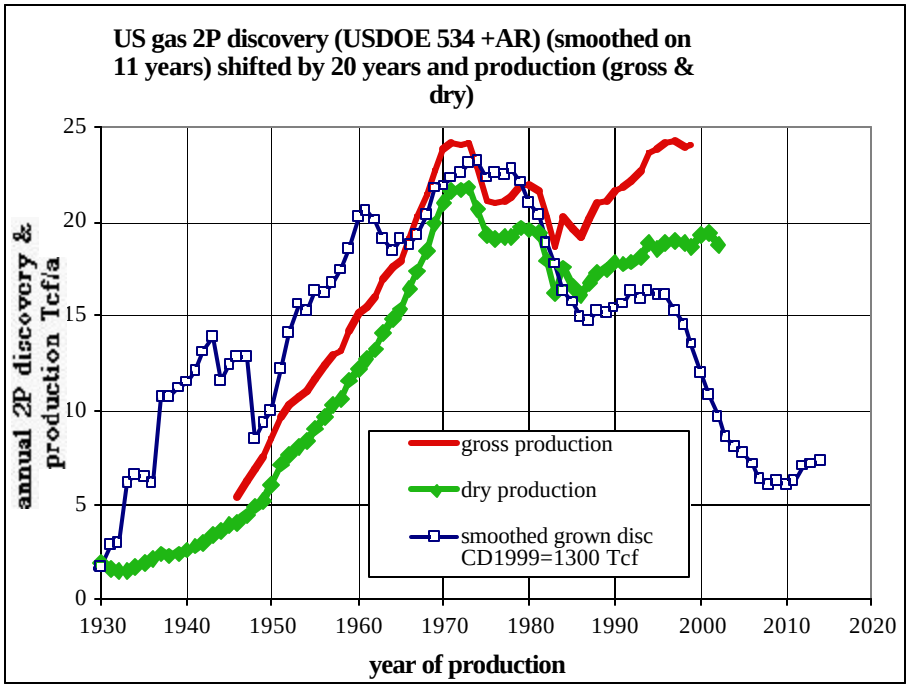
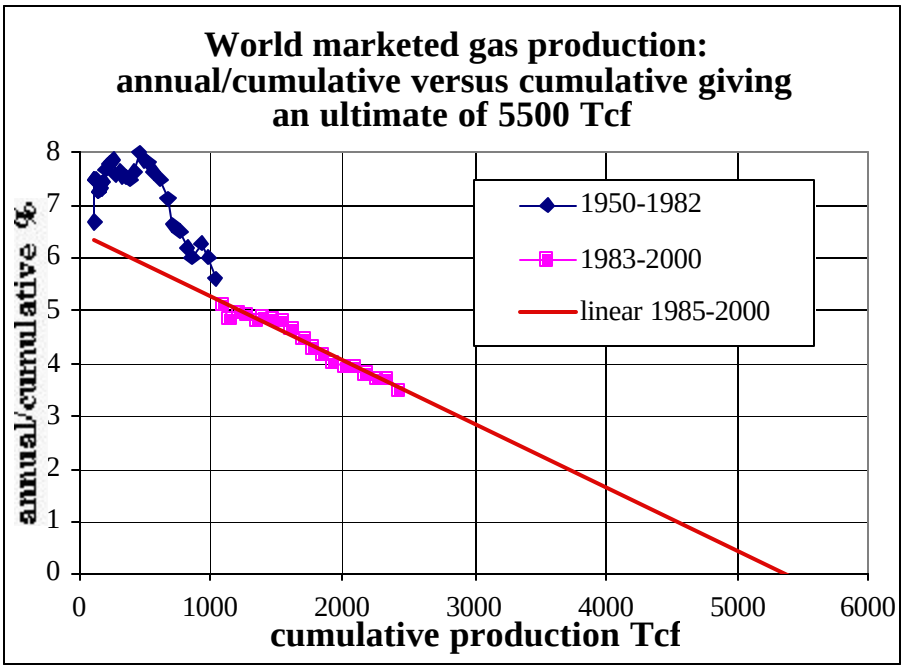


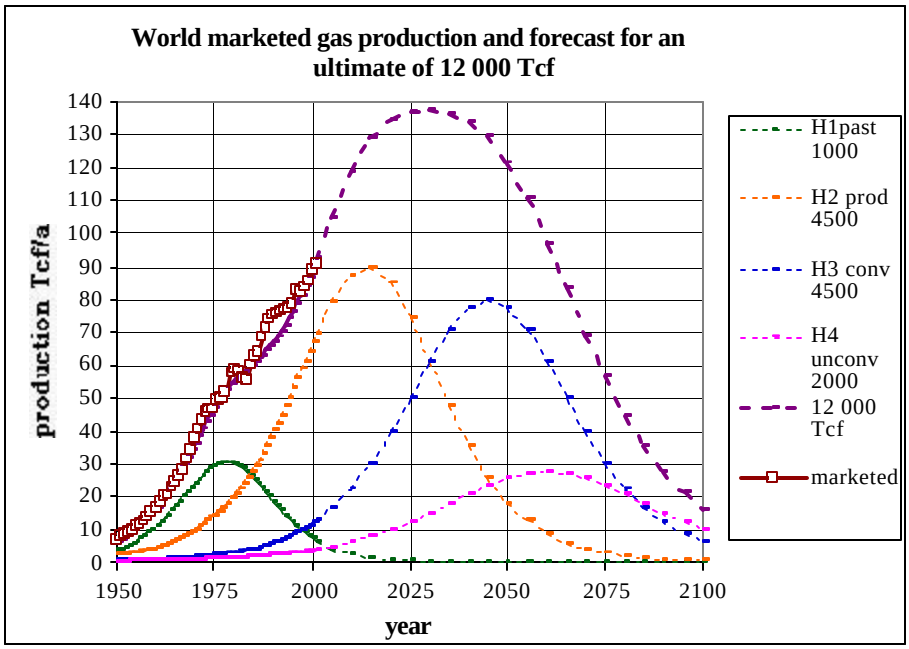

Figure 5 forecasts an ultimate recovery of around **10 000 Tcf** of gas, based on the past discovery trend, whereas the extrapolation of the past production gives on figure 13 an ultimate of only around **5500 Tcf**.

This discrepancy indicates that a large proportion of the gas reserves is stranded in remote locations far from market.

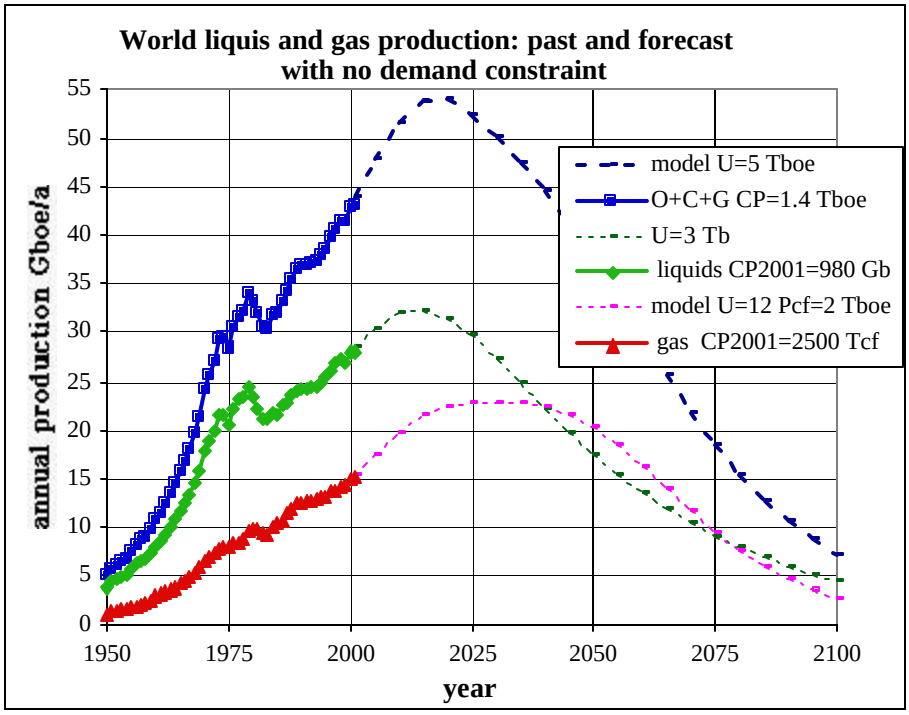
-Figure 13 : **World marketed gas production : annual/cumulative versus cumulative**



The assessment of unconventional gas is difficult (Perrodon et al 1998) but it is estimated at around 2500 Tcf compared to the 10 000 Tcf for conventional gas. The expectations for oceanic hydrate resources seem very exaggerated and any production unlikely (Laherrere 2002 d).
The global ultimate for all gas is then around **12 000 Tcf** (12 Pcf).
-Figure 14 :**World conventional gas production for an ultimate of 12 Pcf**

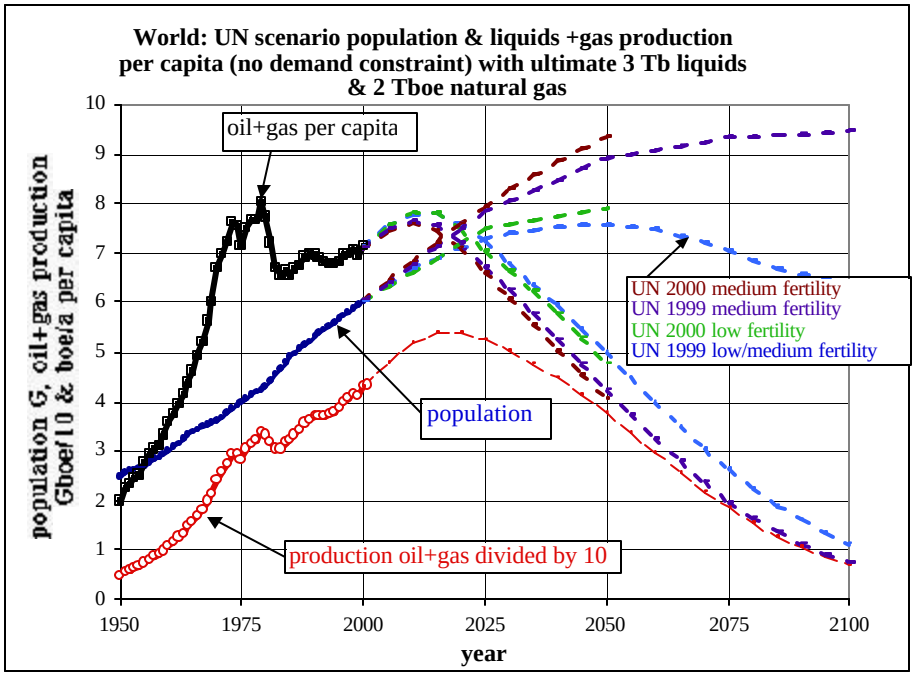



The forecast for all hydrocarbons, adds the all liquids and all gas using the calorific equivalence (6 Tcf = 1 Gboe)
–Figure 15: **World all hydrocarbons production and forecast**




The production of oil and gas per capita shows that it peaked in 1979 and that the next peak around 2015 will be lower. The following decline does not vary much from the different population scenario (fertility rate) from the United Nations forecasts.

-Figure 16**: World's oil and gas consumption per capita and forecast of possible supply**




**-Conclusion**

There are several ways to model oil and gas supply, the main problem is not from the model, but from the data which are flawed by bad reporting (for confidential, financial or political

reasons). The shock of 1979 was caused by bad data (Yergin 1991), as the collapse down to 10 $/b of 1998 was caused by the IEA missing barrels (Simmons 2001).
Good supply forecasting will be achieved when good data will be delivered and openly published.
But forecasting the demand is another problem, as it depends upon the economic growth (official forecast 3.5%/a for the next 20 years).
Another important question: to morrow, is oil going to be priced in dollar or euro, barrel or tonne?

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