Do the last 6 years of production confirm the USGS forecast for the period 1996-2025 ?

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The USGS 2000 report entitled «USGS geological survey world petroleum assessment 2000-Description and results » estimates, from the data as of end of 1995, that the world total endowment, at the end of the period 1996-2025, is 3012 Gb for oil and 15 402 Tcf for gas. This endowment is given with an unrealistic accuracy of four significant digits, but it has been variously reported over time (3003 Gb for USDoE (Wood USDoE/EIA 2000) and IEA (WEO 2001), 3012 Gb in DDS-60 and 3021 Gb in Ahlbrandt 2002.

The USGS estimates are given under a probabilistic approach. The value F95 indicates that there is a 95% probability that the estimate will be exceeded, while the F5 value indicates that there is a 5% of it being exceeded. The "mean" is the average of the full probability curve. In the probabilistic approach only the "mean" may be aggregated. The F 5 and F 95 cases need a Monte Carlo simulation to aggregate the individual values. The undiscovered oil for the non-US is given for F95 at 334 Gb when the aggregation (adding all F95) of the 8 regions gives only 179 Gb, the difference is quite large !

The total endowment in the US was estimated at 362 Gb for oil (range 345-383) and 1908 Tcf for gas (range 1776-2100).

For the world as a whole, Wood(USDoE/EIA) uses the USGS total endowment of 2248-3003-3896 to draw scenarios, assuming that oil demand will grow at 2 % a year. With such a growth rate, cumulative production of oil and NGL will increase from 975 Gb in 2001 to pass 2000 Gb in 2030 and 3000 Gb in 2045. Taking an ultimate of 3000 Gb, Wood forecasts a peak in 2016, assuming that the subsequent decline is also at 2 % a year

The production data for the past six years (1996-2001) provides a good test by which to check the validity of the USGS forecast. Production data can be unreliable in some countries, but the most reliable source is the database available on the web by the USDoE/EIA. And the best country to check the USGS study is the US itself as they should know it the best, despite the fact that that the data are distorted by the financial rules from the SEC (Securities and Exchange Commission).

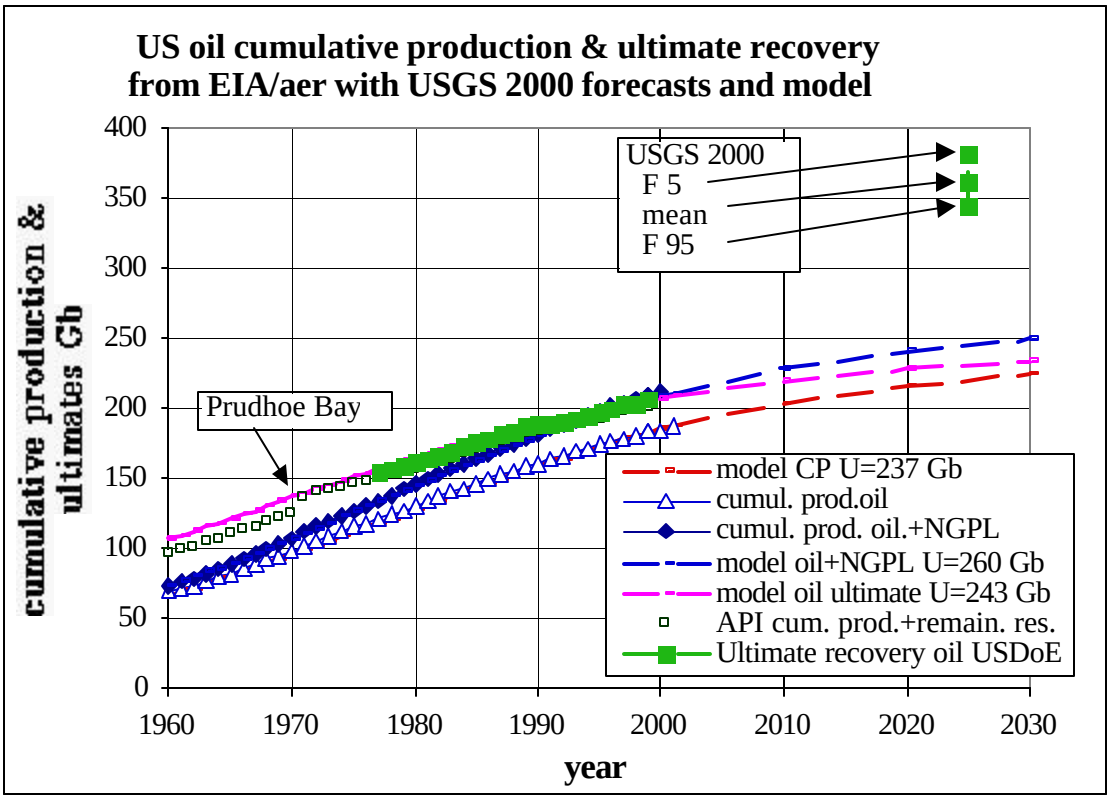
-US : from the cumulative current proved discoveries and the cumulative production

We have compared US cumulative production, given by the USDoE, using what they call "ultimate recovery" (being the cumulative production plus the remaining proved reserves) for the period 1960-2001 with the USGS endowment at 2025. The API values (USDoE data start at 1977) are slightly lower than the EIA values for "ultimate recovery" (as API data for reserves were lower). The problem is that oil is assumed to include condensate, but the NGL (in fact NGPL: natural gas plant liquids) are not included in the oil production in the USDoE data for what is termed "petroleum". The USGS data indicate that NGL is included in what is termed "oil", but the value of cumulative production as of end 1995 is given as 171 Gb, which is close to the cumulative value of the USDoE for "petroleum", being 174 Gb. We have plotted the cumulative production of "petroleum" and NGL (in fact NGPL, but the cumulative production as end 1995 is 195 Gb, far from the USGS value, which includes NGL.

-US "oil"

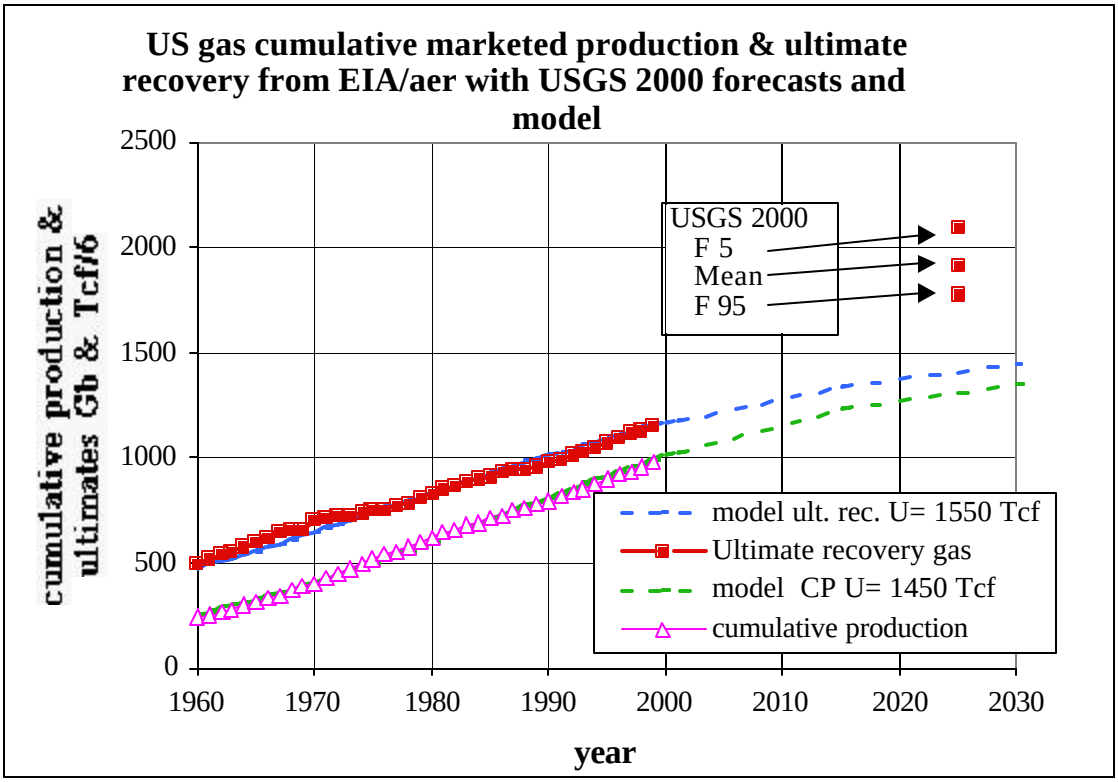
For "oil", the extrapolation of the past (with a simple logistic curve) gives a value in 2025 for cumulative production; around 220 Gb for "petroleum"; 245 Gb for petroleum+NGL; and 230 Gb for the "ultimate recovery". This is far from the USGS range 345-362-383 Gb, which is incidentally, a surprisingly narrow range of only plus or minus 5%. The EIA ultimate

recovery represents the current estimate of the known fields, but in the future it will include the future discoveries and the extrapolation in the end may be matched with the more usual definition of the term “ultimate” which includes the undiscovered.
It is obvious that US oil production up to, and during, the first six years of the USGS study period is not in trend with the USGS estimate.
Figure 1: US “oil” cumulative production from EIA annual energy reports



-US natural gas
For natural gas, the problem is that the production values vary greatly between gross production, marketed production and dry production. In 2001, dry production was 79 % of the gross, and 95 % of the marketed (90 % and 96 % in 1973). The ratio of dry to gross has decreased significantly since 1986 with the increased recovery of NGPL. The USGS gives 854 TCF as cumulative production as of end 1995, whereas the USDoE value is 897 Tcf, which in fact is the marketed production. Most of the production data are given for dry production, and the cumulative seems to be for marketed (83 % of the gross in 2001). But it seems that the reserves are estimated in gross volume and not in marketed or dry volume, although it is never indicated. The reinjected volume should be excluded, but not the flared and vented, to compare production and reserves.

The extrapolation of the past data 1960-2001 with a logistic curve gives, for 2025, a cumulative production of 1320 Tcf and an ultimate recovery of 1400 Tcf, which is far from the USGS range of 1775-1908-2100 Tcf. It is also strange to see such a narrow range for the USGS estimate of only plus or minus 10 %. The high probability case (F95) of the USGS is as much as 25 % higher than our likely estimate from the past.
Figure 2: US gas cumulative marketed production



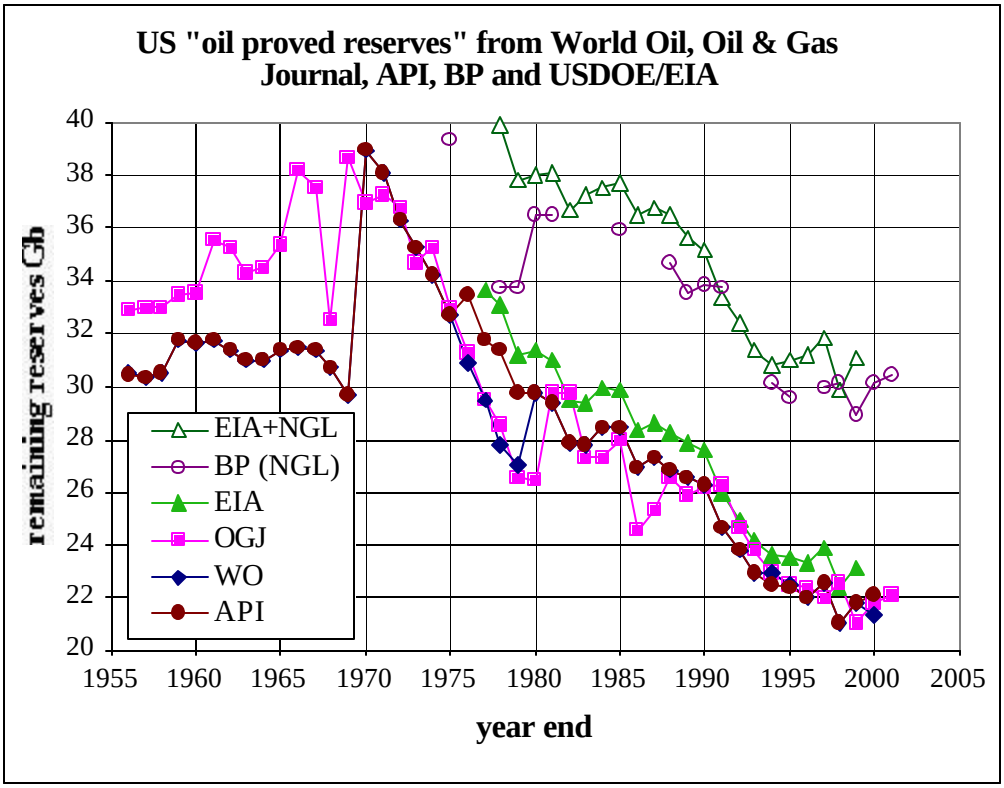
US reserves are reported as “proved reserves” to comply with SEC rules (“proved reserves” are defined as having a reasonable certainty of being present), obliging the oil companies to omit the “probable reserves”. This practice can be justified for financial reporting by oil companies, but it is a poor practice by which to evaluate the real potential of a country. The rest of the world reports reserves as “proven+probable” (UK accounting procedures). The US practice leads to a significant upward reserve revisions. For the period 1977-2000 the annual average of positive revisions was more ten times the new discovery and the percentage of these positive revisions versus the total of all revisions was about 64% for oil and 55 % for gas and NGL.

average 1977-2000	positive revisions	negative revisions	% positive vs all revisions	proved reserves	new discovery	new reservoirs in old fields
oil	2.6 Gb	1.5 Gb	64 %	26 Gb	0.17 Gb	0.14 Gb
gas	20 Tcf	18 Tcf	54 %	182 Tcf	1.9 Tcf	2.6 Tcf
NGL	1 Gb	0.8 Gb	56 %	7.6 Gb	0.06 Gb	0.08 Gb

The SPE/WPC/AAPG rule for defining “proved reserves” it that they shall correspond with a probability of 90%, far from the US practice, which in fact is close to the practice of reporting the “median” value (50%), as in the UK for “proven+probable”. The most recent annual MMS reports for the GoM OCS give a global negative revision for the 1000 fields, meaning that the probability is less than 50%.

The reserve growth was large in the past and is still important for very old fields as for example Midway-Sunset heavy oil, which is the present largest oil producer in the US Lower 48. It was discovered in 1894, and its production has not yet declined, growing with the number of producing wells (over 10 000). The reserve growth of the past onshore fields should not be applied to the recent offshore fields. It is well known that present technology has increased drastically the initial production of new wells, but the depletion rate has increased correspondingly (now about 50 %/a).

If the USGS seems to lack reliability, it should be noted that most of the databases used by economists are also very unreliable. One of the most widely used database is the BP Statistical Review, which in fact simply reproduces Oil & Gas Journal data (OGJ). This journal is the first, each year, to publish production and reserves by country estimated for December 31 of the year. OGJ publishes them one week before this date, long before the operating companies have make their assessments on reserves, and it does not correct the estimates the following year (when World Oil does it) as it is assumed to report the national official view. In fact USDoE publishes US reserves about one year later than OGJ.
The data are termed "oil and gas proved reserves", but for OGJ it is crude oil and condensate, when for BP it is oil+NGL. The comparison of the published data to the USDoE data, which is assumed to be the reference, is striking, showing that reserves cannot be trusted, having an accuracy of less than 20 %
Figure 3: US proved reserves from different sources



-**World outside US & Canada** : from the cumulative mean (2002) backdated discoveries and production
The database by field is more reliable for the world outside US & Canada as it is estimated as "proven+probable", which is close to the "mean" value, which statistically provides no field growth in contrast to the "proved" value which does "grow".
The main problems are, as for the USA, in knowing, first, how condensate and NGL (usually classified as other liquids in contrary to condensate) are treated, and second, how gas is defined. In the UK, the DTI reports only condensate, whereas in Norway the NPD reports separately condensate in M.m3 and NGL in Mt. It is also rarely specified if the reported natural gas is gross, marketed or dry. For the world as a whole, the percentage in 1998 of the gross volume is 4% for flared and vented, 11 % for reinjected, 85 % for marketed and 81 % for dry production. The percentage of dry versus marketed is 96 % for the world but it varies from 82 % for Venezuela to 100% for Russia. The combined vented and flared percentage of

gross production in 1998 can be as high as 75 % in Ecuador, 66 % in Nigeria, 62 % in Angola, still 18 % in Mexico and 19 % in Brazil, both of which import gas. The world average is 4 %.

Most public data do not provide the status of the reported gas reserves, but for production, the data refer to dry gas, although in some cases to marketed gas (BP). Very often, the ratio R/P is used (quoted in years) to provide an optimistic impression despite the fact that often R and P do not apply for the same definition. BP, for example, includes oil sands in production but not in reserves.

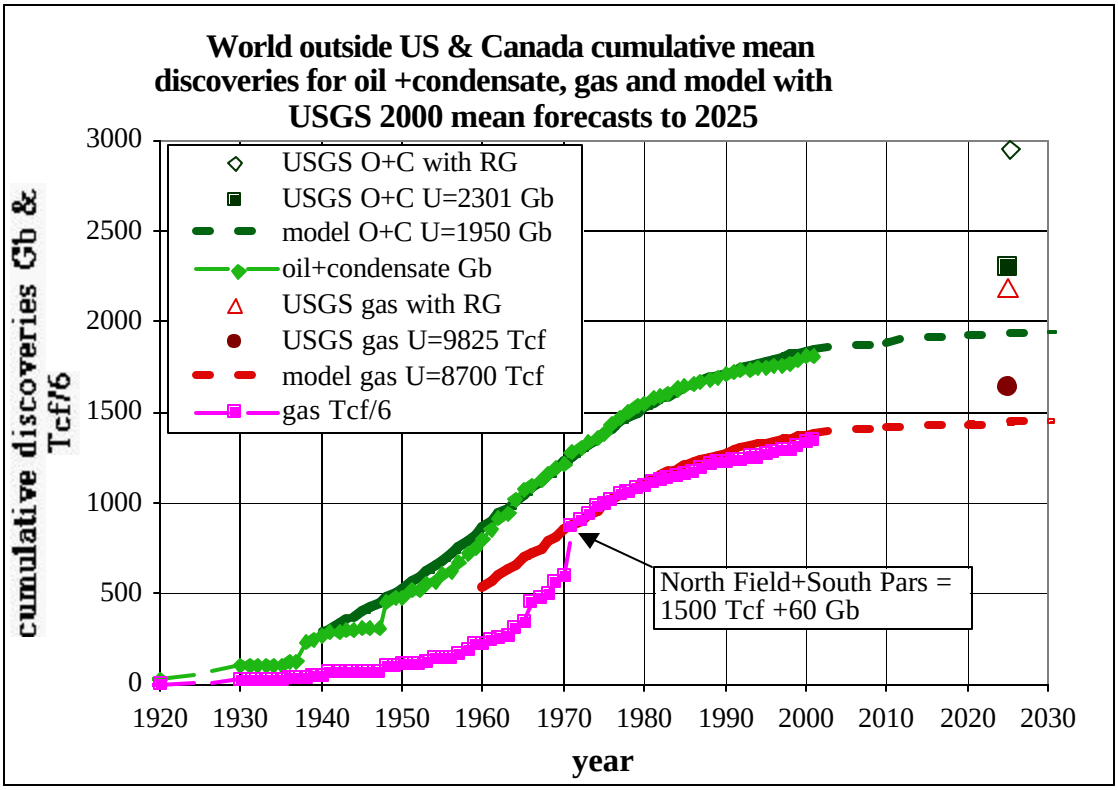
The USGS did not define which kind of gas they refer to, and the best way to find out is to check their world cumulative production. The USGS cumulative US gas production, as of end 1995, is reported at 854 Tcf, which matches well with the cumulative marketed gas estimated as 897 Tcf by USDoE and 859 by the Industry database. But its value for cumulative gas production in the world outside the US at 898 Tcf, as of end 1995, is almost certainly wrong, as the value from the industry database is 1340 Tcf (=2200-859). USGS estimate is evidently off by 450 Tcf or by about 50 %.

Such an error on an established fact raises doubts about the value of the study as a whole.

We have used the 2002 industry estimates for the world outside US & Canada to draw the trend of backdated "mean" cumulative discoveries, extrapolated with a logistic curve. The extrapolation gives a value in 2025 of 1930 Gb for oil+condensate, and 8640 Tcf for gas. This contrasts with the USGS "mean" estimate for 2025 of 2301 Gb with no reserve growth and 2955 Gb with reserve growth for oil +NGL, and 9828 Tcf for gas with no reserve growth and 13 128 Tcf with reserve growth

The USGS estimates are 20% higher than the likely extrapolation of past cumulative discoveries for oil+NGL (34 % for remaining ultimate) and 12 % (14 % for remaining ultimate) for natural gas.

Figure 4: World outside US & Canada cumulative discoveries



It is not surprising to see such a discrepancy on the past discoveries considering the methodology that was employed by the USGS. The undiscovered was estimated on a simple one page sheet (called the seventh approximation) but in fact it was no more than wishful thinking as the assessor had only to estimate the number and sizes of undiscovered fields (minimum, median and maximum) and a geologic probability (being the probability of oil to be present, completely different from the probability of the distribution of the reserves when oil is present), without any relationship with past discoveries. These estimates were made without the benefit of confidential information from the oil companies

The example of East Greenland with an estimate of 47 Gb of oil with a geologic probability of 70 % is striking.

Applying a reserve growth estimated in the US on old onshore fields where reserves are "proved" to the rest of the world which use "proven+probable" is not at all justified as they are a different kind of estimates. It is like comparing the temperatures in the US and Europe without bothering to check that one set of values is in Fahrenheit when the other set is in Celsius. Even US reserves growth offshore is different from that onshore. The reserve growth used by the MMS is about half of that used by the USGS.

Of course, there are many fields in the rest of the world showing some growth, in particular when there is no incentive to report the real value, as for example is the case in the gasfields in the Middle East where OPEC quotas do not apply. An example arose in 2002 in the largest field in the world in terms of oil equivalent, namely the combined North Field of Qatar and South Pars in Iran. The Qatar part of the field was found in 1971 but the Iranian extension was not confirmed until 1991. The field is now estimated to have 1500 Tcf of gas and 60 Gb of condensate, making it almost twice as large as Ghawar in Saudi Arabia. It was only when Iran invited the international companies to develop its part of the field that Qatar decided to multiply by three its previous very conservative estimate.

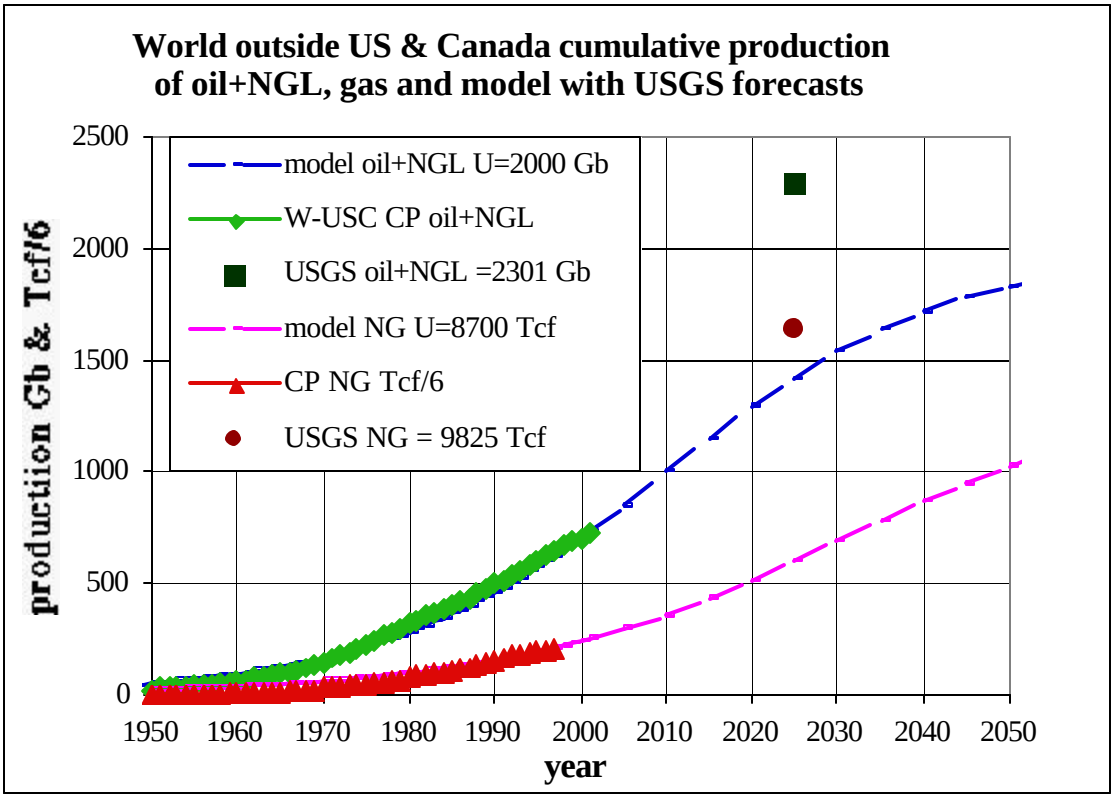
In general, positive revisions tend to attract attention whereas negative revisions and the undeveloped marginal discoveries are ignored. In the 1995 database used by USGS, which was already obsolete in 2000, there are 300 undeveloped discoveries in the UK offshore and most of them will never be developed, but the USGS failed to take this into account.

In the database used by the USGS for the world outside the US & Canada, it is likely that the positive reserve growth of some fields will be matched by the negative reserve growth of many poor discoveries. Statistically, the global final revision, which will be known only when the producing basin will be depleted, will be close to zero, or even negative. Furthermore, in this database, all the reserve estimates of the FSU, which were made under the Russian classification of A+B+C1, are now considered to be about 30 % higher than "proved" reserves under the Western classification.

For all of these reasons, we consider that the estimates given by USGS, including reserve growth for the world, are unjustified. The USGS "mean" estimates without reserve growth are also too high when compared with the extrapolation of past mean discoveries.

It can be readily demonstrated in many countries that production follows the same pattern as the discovery after a time lag. (Laherrere 2001). Accordingly, we have plotted the cumulative production for the world outside US & Canada, assuming an ultimate of 2000 Gb for oil+NGL and 8700 Tcf for gas. On this basis, the forecasted cumulative production in 2025 will be around 1420 Gb for oil+NGL and 3600 Tcf for gas. This is 900 Gb below the USGS estimate (without reserve growth) and 6000 Tcf below the USGS gas estimate without reserve growth.

Figure 5: World outside US & Canada cumulative production



-Norway

Norway is the best country to check the USGS study outside the US as the NPD (Norwegian Petroleum Directorate) has the best reserve classification in the world and reports on the web data from every field and discovery. The reserves and resources of Norway are reported as follows by NPD, which does not use the terms proven and probable.

NPD as end 2001		produced	remaining reserves	initial reserves	contingent discoveries	undiscovered.	potential resources
oil	M.m3	2368	1501	3869	811	1420	6100
gas	G.m3	730	2189	2919	1645	2510	7074
NGL	Mt	57	111	168	37	0	205
condensate	M.m3	50	131	181	89	0	270
liquids	Gb	15,9	11,6	27,5	6,1	8,9	42,5
gas	Tcf	26	77	103	58	89	250

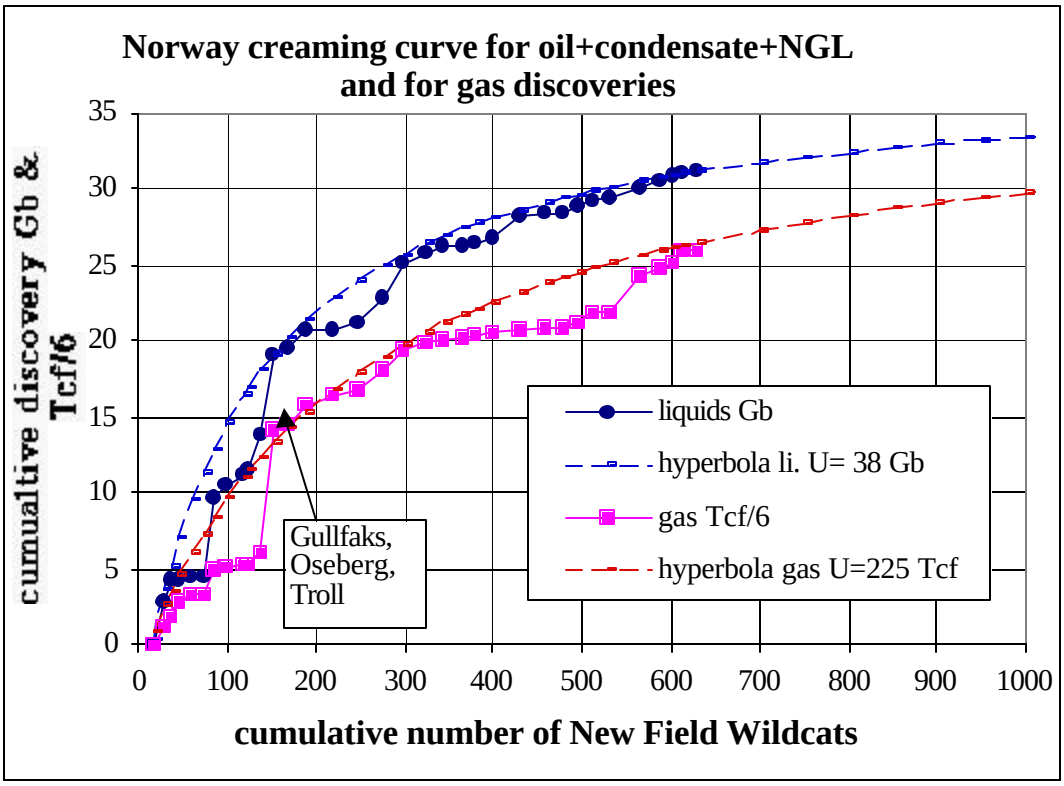
NPD reserves refer to producing fields and those under firm development, which presently amount to 52 fields. The total number of discoveries as end 2001 are 223, which according to the industry 2002 database hold 31Gb of so called “proven+probable” liquids and 156 Tcf of natural gas, which are not too far from NPD total of initial reserves + contingent discoveries (34 Gb and 161 Tcf). The addition of NGL (2.5 Gb) explains the difference.

production status end 2001	Number of fields	liquids	gas Tcf
producing	55	25,9	96
abandoned	13	0,4	4
developing	8	1,3	4

appraising	36	2,0	31
discovery	105	1,7	21
Total	223	31,3	156

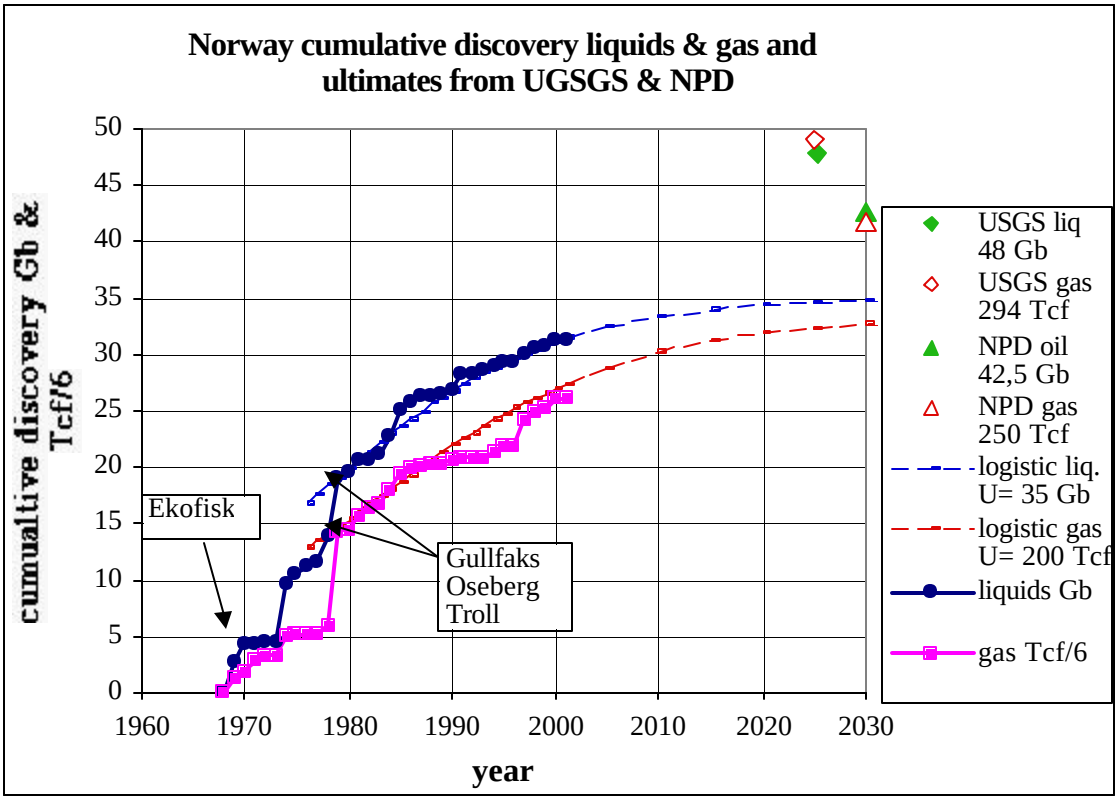
The plot of the creaming curve (cumulative discoveries versus cumulative number of New Field Wildcats) from the industry database shows that the curve can be fairly well modelled by a hyperbola with an asymptote at 38 Gb for oil and 225 Tcf for gas, at a point when a 1000 NFW had been drilled. This represents an addition of two-thirds to the present number of wildcats, drilled during the past 35 years. To-date, the model reaches only 33 Gb and 180 Tcf. Only new deepwater gas discovery can upset this curve.

Figure 6: Norway creaming curve for liquids and natural gas



Cumulative discoveries may be modelled with a logistic curve based on an ultimate of 35 Gb of oil and 210 Tcf of gas in order to fit with the creaming curve, assuming an end of exploratory drilling in 30 years' time). It compares with the ultimates from NPD of 42 Gb for oil and 250 Tcf for gas, assumed to be at 2030, and from USGS (without of course no reserve growth) of 48 Gb and 294 Tcf at 2025. It means that the USGS estimate is about 40 % higher for oil+NGL and 70 % higher for gas. NPD forecast is in between, but the fact that NPD includes NGL when it is not in the industry database data explains this discrepancy

Figure 7: Norway cumulative discoveries for oil+condensate and gas with USGS and NPD forecasts.



-Conclusion

The 2000 USGS study gives unrealistically precise estimates, with 4 or more significant digits. Its definition of reserves is weak and it fails to properly identify the various the categories of oil and gas

The USGS study is particularly flawed outside the US showing the wrong cumulative production for gas and an erroneous notion of reserve growth.

The extrapolation of the past with the first six years of the study period from 1996-2025 does not confirm the USGS forecasts, even when excluding the reserve growth, which raises serious doubts about the methodology of this study.

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