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Limits to growth updated

In World Energy vol.10 n°2 2007 p 56 I.B.Mishari, VP Aramco, wrote:

« Public writer Laura Jones made a cautionary argument for reason in a 1997 essay: In 1798, Thomas Malthus predicted in An Essay on Population that the world would run out of food. In 1972 The Limits to Growth, published by the Club of Rome, predicted that the world be run out of gold in 1981, mercury in 1985, tin by 1987, zinc by 1990, petriolieum by 1992, and copper, lead and natural h gas by 1993... These predictions were irresponsible today as they were in 1798 (and 1972). Why ? Because the authors ignore the powerful incentives that markets provide. »

Laura Jones is giving an irresponsible quote without reporting what is exactly written. The *Limits to Growth* did not report that the world will run of petroleum in 1992: it wrote exactly for petroleum pages 58 & 59

- known global reserves	455 Gb
-R/P (static index)	31 years
-projected rate of growth average	3,9 % (range 2.9-4.9%)
-R/P grown with 3.9% (exponential index)	20 years
-5*R/P(exponential index to grown reserves)	50 years
-R/P grown with 3.9% (exponential index) -5*R/P(exponential index to grown reserves)	20 years 50 years

It means that

-if production is projected to grow exponentially at 3,9%/a, the known reserves will be depleted by 20 years or 1992

-if known reserves were grown by 5 times with exponential production, the reserves will be depleted by 50 years or 2022

Laura Jones was using only one of the several scenarios displayed by the Club of Rome, in fact the one mentioned as being wrong using exponential growth.

The message of Malthus and Club of Rome is that exponential growth is unsustainable (impossible) in a limited earth. A bacteria doubling every half an hour will fill (if not constrained by the resources) the volume of the solar system in a week and the Universe in 11 days ! Growth cannot keep steady for long.

The oil production growth (USDOE table 1.4 oil supply) has been varying for the last 50 years and everyone knows that the growth will stop at peak oil.



Every explorer knows that proved reserves are financial (SEC rules) or political (OPEC dispute on quotas based on non-audited reserves) reporting.

King Hubbert, in his famous 1956 forecast, did not use the USL48 proved reserves (at the time 30 Gb with 52 Gb already produced) but the ultimate being the range of 150-200 Gb. It is obvious that ultimate has to be used and not known reserves given by the Club of Rome at end 1972 at 445 Gb (or 745 Gb discovered).

In fact the Club of Rome was wrong on this proved data, because, for end 1972, OGJ reported proved remaining reserves at 667 Gb, when World Oil reported 562 Gb, plotted as average 630 Gb in the next graph (USDOE since 1980), where the estimate for proven + probable remaining reserves is about 1020 Gb. Some crazy estimates were reported before 1972 for the US as on Sept 2, 1963 OGJ wrote : US reserves put at 600 Gb.

The world cumulative oil production was at end 1972 about 300 Gb.

The Club of Rome was not wrong on its approach because its message was that exponential growth is impossible, it was wrong of using bad estimate without giving a range.



Hubbert in 1956 was using an world ultimate of 1250 Gb against a total discovery of 340 Gb= 90 Gb produced plus 250 Gb proven reserves to forecast a peak around 2000 but for a low peak production of 12 Gb/a (33 Mb/d) but extending up to 2200.





earth » p60-70 Hubbert wisely gives world oil ultimate a range 1350-2100 Gb, forecasting an oil peak between 1990 and 2000 at a value of 24 to 37 Gb/a (66 to 100 Mb/d)



As Hubbert was found right in 1970 on his US oil peak forecast, The Club of Rome should have used in 1972 at least Hubbert's estimate showing a peak in 2000 and with a production extending until 2100 and not 1992.

Up to 1972 the world oil ultimates (EUR) were already reported (J.D.Parent 1979 Institute of Gas Technology p39-42, 57-58) by experts as :

	year	Tb
Pratt, Weeks & Stebinger	1942	0,6
Duce	1946	0,4
Pogue	1946	0,55
Weeks	1948	0,61
Leversen	1949	1,5
Weeks	1949	1,01
Mac Naughton	1953	1
Hubbert	1956	1,25
Weeks	1958	1,5
Weeks	1959	2
Hendricks USGS	1965	2,48
Ryman Exxon	1967	2,09
Shell	1968	1,8
Weeks	1968	2,8
Hubbert	1969	1,25
Hubbert	1969	2,1
Moody	1970	1,8
Warman	1971	1,2
Warman	1971	2
Weeks	1971	2,29
Hubbert	1971	2
Warman	1972	1,9
Moody	1972	1,8
Bauquis, Brasseur & Masseron IFP	1972	1,95

The discovered value of 750 Gb used by the Club of Rome was really too low and should have been at least doubled by including yet to find.

The oil supply (all liquids) linearization designed by Hubbert as the percentage annual over cumulative production versus cumulative production displays a linear trend only when the annual production follows an Hubbert curve (derivative of the logistic function), which can be extrapolated towards the ultimate. But most plots display several partial linear parts, meaning that it could change in the future. It is the case for world oil supply as reported by USDOE/EIA (table 1.4) the linearization is erratic but the forecast for U=3 Tb using a Hubbert curve is in line with the last 4 years 2003-2006



The plot shows clearly that the oil supply does not follow a simple Hubbert curve but can be modelled with several because the plot is composed of several linear parts trendoing towards 900 Gb from 1973 to 1984, 2250 Gb from 1985 to 2002 and the period 2003-2006 is extrapolated towards an ultimate of 3 Tb.

The past production is not the best data to evaluate ultimate, creaming curves (cumulative discoveries versus cumulative number of New Field Wildcats is a much better approach, but needs confidential data and it is why it is used by few.

The Saudi Arabia creaming curve from IHS data shows that the first 20 NFW (1935-1964) found 300 Gb with 12 fields when the last 20 NFW (1998-2006) found 3 Gb with 18 fields, meaning that yet to find should be small in volume despite being large in number of fields, obviously much smaller than the uncertainty of the known discoveries. IHS has increased in the last two years 90 Gb to Saudi reserves to match Aramco values released after the debate in 2005 between Baqi-Saleri of Aramco and Simmons in Washington. It is the big problems of public data, as in particular for BP Statistical Review, that they cannot report data in contradiction to the official national values. But BP is wrong to write that proved reserves are estimated from geological and engineering informations when they are obviouly political because they very often stay the same for many years !



The ultimate for crude oil less extra-heavy oil is estimated at 2000 Gb. Only one significant number is used because the uncertainty due to the bad quality of data. More precise ultimate will be used only when better data is obtained in particular for Middle East. The ultimate is reached with several cycles (first cycle with surface exploration, second with seismic and third with deepwater), leading that the mid-point is different from the peak.



But oil supply must match the oil demand which includes every oil which can burned including biofuels and coal to liquids.For such ultimates we feel that the ultimates is 3Tb (2 Tb for crude less extra-heavy, 0,5 Tb for extra-heavy, 0,25 Tb for natural gas liquids and 0,25 for other liquids including refinery gains and biofuels). Of course biofuels are renewables and will follow not the derivative of the logistic function but the logistic function (S curve). For 3 Tb the peak is about 2015 and less than 100 Mb/d, but adding another Tb to the expensive oil (red curve) will not change the peak but the slope after the peak.



To conclude the Limits to growth in 1972 was right by writing that exponential growth is impossible, but the Club of Rome was wrong on the reserves value and for petroleum should have mentionned Hubbert's forecasts.

Hubbert's world oil peak forecasts were too pessimistic because he did not anticipate the 1973 and 1979 oil shocks, he was too short on the low estimate but about right for the high value of 2 Tb for crude oil (as for the US with his range 150-200 Gb).

I feel obliged to correct wrong comments on important papers as those of Club of Rome or Hubbert, despite they are far of being perfect. Their approach were right believing that constant growth is unsustainable, but their data were wrong, because the confidentiality of field data.

The most important goal is to push operators to release field data as it is done in the UK (DTI) Norway(NPD) and US federal lands (MMS). Everybody should support Matt Simmons's proposal to oblige every nation in the world to relinquish annual production of every significant producing field (>50 000 b/d or even > 10 000 b/d), because oil belongs to every nation except in onshore US.