Jean Laherrere 2 October 2018

updated and corrected version of the August paper

Extrapolation of oil past production to forecast future production in barrels

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Method and modelling
List of examples:
-Pennsylvania anthracite
-France & Belgium coal
-oil production NOPEC: 21 countries fields
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- -Egypt
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- -India Mumbai High, Ankleshwar
- -Indonesia Handil
- -Kazakhstan
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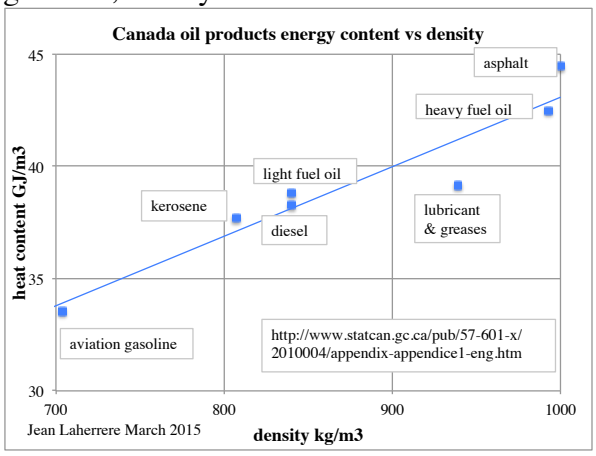
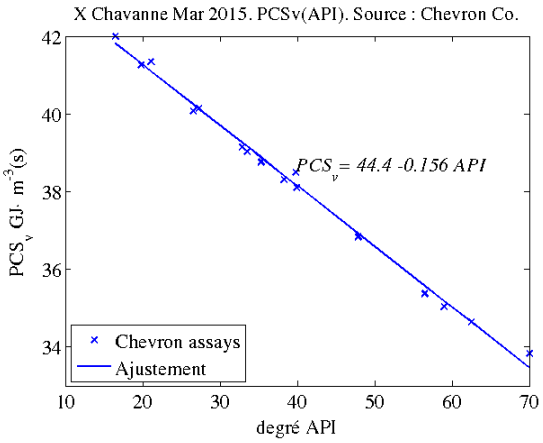
- -Venezuela El Furrial
- -OPEC ABS2018

Conclusions

-Introduction

Everyone speaks about oil production without adding a clear definition of which oil, and how it is measured
There are different oils
-crude oil: each field has a different crude oil (gravity, heat content, amount of sulphur and other products)
-condensate, which is badly defined by IEA either as crude if sold with crude or NGL if sold with NGL, but no consensus on world definition
-natural gas plant liquids =NGPL
-natural gas liquids = NGL
-extra-heavy oil = XH
-shale oil = light tight oil in the US
-oil shale = oil obtained by pyrolysis of immature source rock (kerogen)
-refinery gain = obtained in refinery in changing the volume, but not the weight of crude oil
-biofuels
The range is in 2016 of world oil production from USDOE/EIA is 80.6 Mb/d for crude and 97.2 Mb/d for all liquids or a range of 1 to 1.2 = 20 % uncertainty when oil is not defined.
US 2017 oil production is from EIA MER: 9.4 Mb/d for crude, 13.1 Mb/d for crude plus natural liquids and adding refinery gain (1.1) and biofuels (1.2), an all liquids of 15.4 Mb/d or a range of 65 % from crude to all liquids.
The oil production can be reported as volume (m3 or barrel) or as weight (tonne) or as energy (petajoules (Canada NEB report) or tonne oil equivalent (IEA) or quad (quadrillion Btu) USDOE)
There is a relationship between density (or °API) and heat content (Xavier Chavanne PCS in GJ/m3 = gross heat content). In France, diesel fuel contents 13% more energy by volume than gasoline, mainly because it is heavier.





The quality (heat content) of oil varies with country (EIA 2014 Sudan oil = 5084 kBtu/b, Cuba = 6393 kBtu/b, average = 5860, range + 26%) or and within country with time.
All barrels are not equivalent! An oil production in t (tonne) is not equal to the production in toe (tonne oil equivalent)

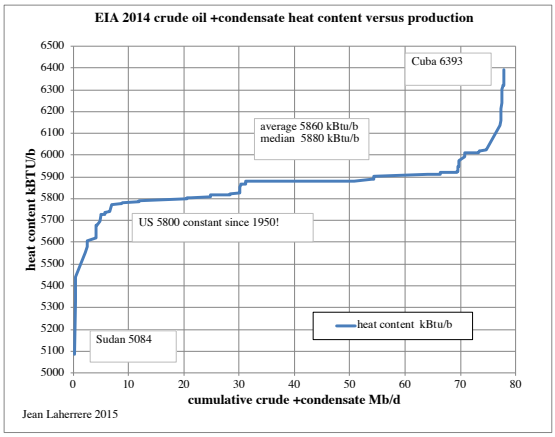
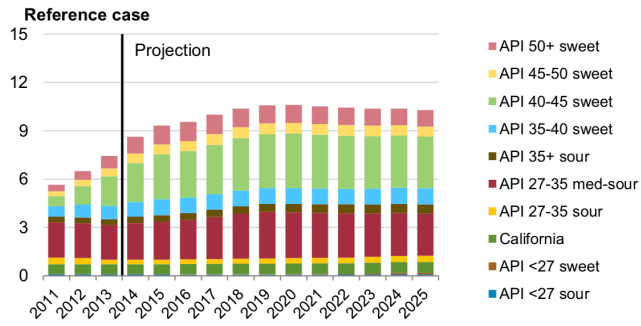
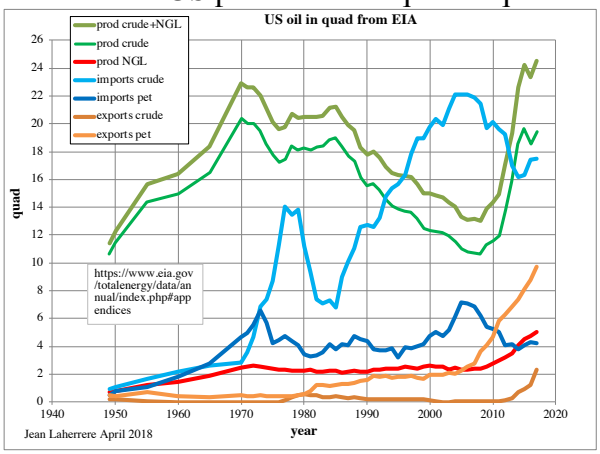


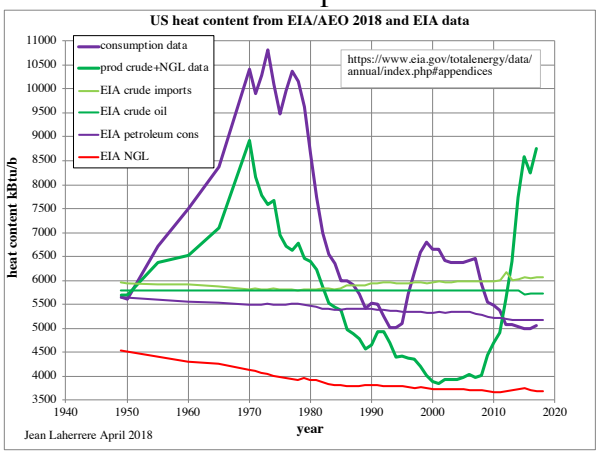
Figure 1. U.S. crude oil production by crude type, Reference case



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2015.*

The problem is that EIA is unable to report the real heat content of the US crude oil production before 2011, using from 1949 to 2014 an arbitrary constant heat content of 5.8 MBtu/b for crude oil when for crude oil + NGL the heat content varies from 4 to 9 MBtu/b from 1950 to 2017, when dividing quads and b/d from EIA reports.
EIA data on US production in quad is questionable and not in line with production in volume.





EIA was reporting international oil production data (crude +condensate, NGPL and all liquids) for every country, but since 2015 their report is less complete and they report US production in crude oil only, when in the past small producers sold crude and lease condensate together.
IEA wrongly defines condensate either as crude oil if sold with crude oil or as NGL if sold with NGL, crude oil then varies with sale contract and only crude +NGL is reliable.

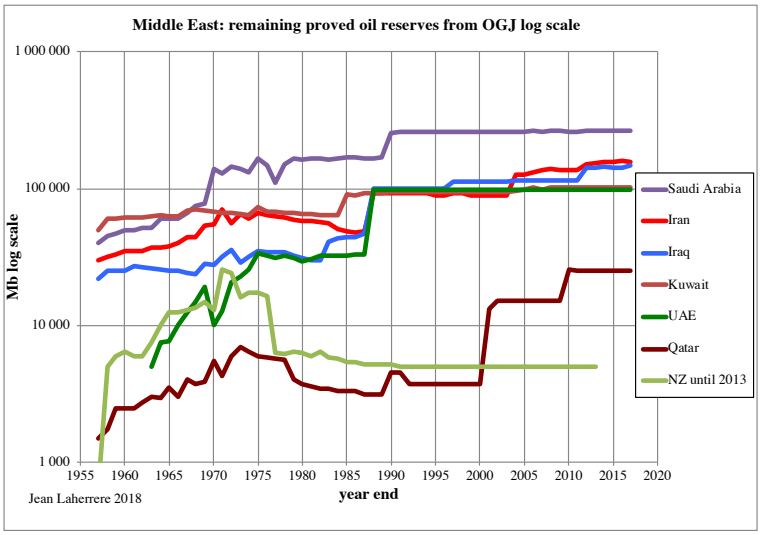
This study concerns crude oil with reference with EIA data in barrel = volume.
A study dealing with weight should be different, but world reserves data in weight is incomplete.

In order to forecast future production, it is necessary to guess the ultimate reserves (cumulative production from start to end), called estimated ultimate recovery EUR by some, but also "ultimate" by Hubbert (see 1956 below) or initial 2P reserves for field.
What is called reserves is in fact the recoverable resources, resources being what is in the ground.
Reserves are estimated at a certain date (usually end of the year) = cumulative production from the following year to end but most of reports forget to mention the date.

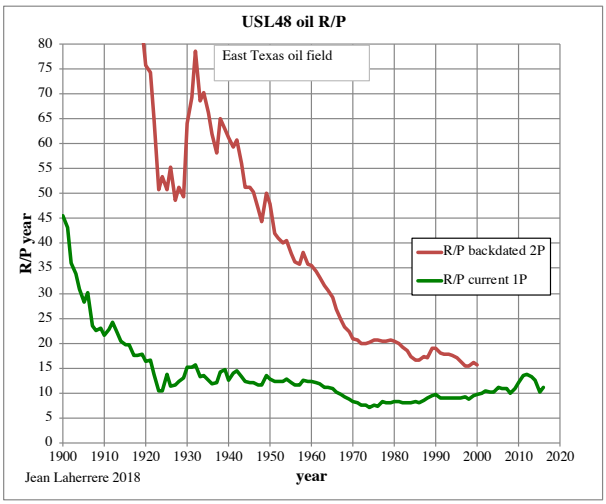
Reserves are an important subject in the oil industry but there is no world consensus on this subject and there are different classifications.
In the oil world (contrary to football) there is no world rules, no world umpires and no world red cards, only local practices. Anyone can lie, there is no sanction!

There are several reserves classifications:
-OPEC unaudited proved reserves = fight for quotas 1985-1989 giving 300 Gb speculative resources (S. al-Husseini London 2007) = it is a political value
-SEC audited proved reserves (defined with a reasonable certainty to exist, but no definition of reasonable), forbidding to report probable reserves = it is a financial value to please the bankers, every international oil company listed on the oil market is obliged to follow the SEC rules. Reserves at year end were in the past estimated with the oil price at the 31st December, now with the annual average.
-SPE/WPC/AAPG PRMS: 1P = proved = P90, 2P = proved +probable = P50, 3P = proved + probable + possible = P10, arithmetic addition is only correct for 2P. Every international oil company uses SPE rules internally to decide the development of a field but keeps the data confidential.
-Russian ABC1 grossly exaggerated (Khalimov 1959 & 1993) = 3P using the maximum theoretical recovery
-Norwegian classification = mean value
There is also a reserves classification by the United Nations, but no one uses it, because too complex (3D)!

It is incorrect to add arithmetically the proved field reserves to get the world proved reserves, giving an underestimation, leading to artificial reserves growth (= bad practice of reserves reporting), but everybody adds proved reserves, without knowing that it is wrong, believing that it should be right because everyone does it!
Audited proved reserves are US SEC practice (being the rule for companies listed on the US stock market) and the SEC goal was to protect the banker lending money to a producer to develop proved reserves estimated with a high probability to exist: in case of bankruptcy of the producer, the banker is sure to recover his loan (except if the oil price has decreased).
OPEC practice is to report also proved reserves but without any audit. After the 1985 oil countershock, oil quotas were based on population, but also reserves. Then in 1986 Kuwait increased its reserves by about 50%, followed by Iraq, Iran and later in 1989 by SA, but the Neutral Zone (owned 50/50 by SA and Kuwait) reserves did not increase!
Since 1996 to 2017, UAE proved reserves are constant at 97.8 Gb, as if every year (during 22 years) UAE was discovering the exact amount of oil produced (this is unreal), when in fact during this period less than 1 Gb was discovered and 19.7 Gb has been produced.
It is as OPEC members were confusing their remaining reserves with their ultimates.
OPEC oil proved reserves are a political game, as confirmed by S. al-Husseini (former Aramco VP) in 2007 in London “Oil and money conference”!



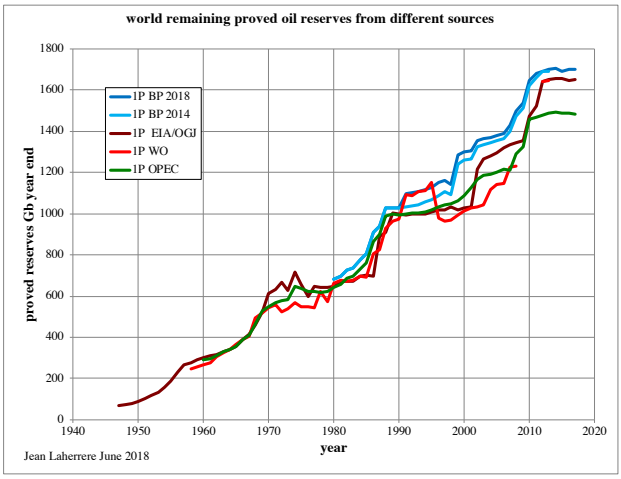
But proved reserves lead to a very poor forecast of the future production: the best proof is that the R/P, at a certain year, given in years (R/P = remaining reserves at a certain year divided by the annual production of this year) displays for the US oil a graph where R/P is around 10 years (meaning that there is only 10 years of oil to be produced, if produced at the same level) for the last 90 years. No one seems to worry that, for almost one century, US proved reserves told that there is only oil to cover only the next decade!
It is obvious that proved reserves are not the tool to forecast the future production: it is only a financial tool. In contrary R/P from backdated 2P reserves (proved +probable discoveries reported at discovery year using the present estimate) gives a R/P of 80 years on 1931 (discovery of East Texas) and 15 years in 2000 (before the discovery of LTO), showing that R/P is not a good indicator for forecasting production, but mainly that proved reserves are of no use.



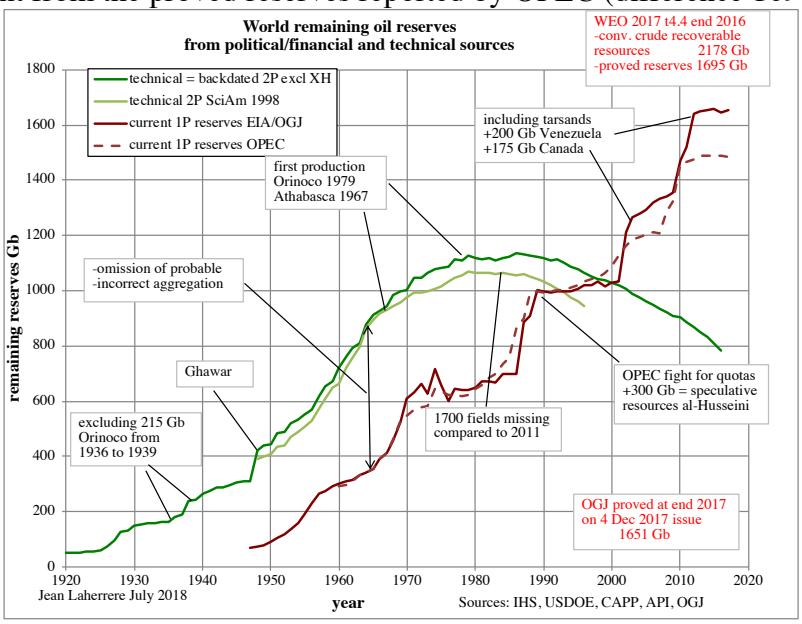
All reported oil reserves by EIA, IEA, OPEC, Enerdata, BP to please the SEC and OPEC are proved reserves, which are either political or financial data, useless to forecast production.
But the world oil industry is mainly ruled by the US practice: oil price is reported in dollar per barrel (the US oil barrel is not an official US unit and USDOE/EIA is obliged in their report to add after barrel (42 US gallons). The official US liquid barrel is 31.5 US gallons!
Oil price is mostly in $/b, because the US dollar makes up 63 % of all known central bank foreign exchange reserves, against 20% for euro and 5% for yen.

The heat content of oil varies largely between fields and countries, in particular if reported in volume, the variation is much less when reported in weight. Oil production and reserves are reported in UK in volume and in weight (tonne). EIA is unable to report before 2011 the °API value (density) of US crude oil production.

Before producing oil, it is necessary to find it. Wallace Pratt said that "oil is found first in the mind of a geologist". Geologists are searching for a good prospect, gathering the right source-rock, the right generation, the right migration and the right trap with the right seal. When a geologist has a good prospect, he has to sell it to his boss and his presentation shows the good reasons why he is right and concludes with the size (and the risks) of the prospect: the size is given in volume with a range of minimum; most likely and maximum. If the boss likes the prospect, he asks a producer to estimate production, costs and expenditures, then an economist assuming the oil price evolution during all the life of the possible field to estimate the Net Present Value (NPV) based of the mean reserves.
When a large field is on production, producers run a simulation of the production of the field during its all life, the model includes all the data from seismic studies, well logs, wells oil, gas and water production, pressure, temperatures and many other items reported on a grid of many cells (Ghawar field grid covers 100 million cells) The model is run through Monte Carlo simulation runs (usually over 50 000 runs: it is why oil companies have the largest computers in the world).
Every year remaining reserves are estimated = future production from this year until end estimated (mean value and others) but kept confidential. Scout companies try to obtain from operators these data in their 2P field inventories. Some have confused 2P with ABC1.
The discrepancy between sources for the world proven reserves is striking: it is obvious that they do not have the same definition of crude oil and the same source.
OPEC crude oil reserves excludes oilsands when OGJ does not.
OGJ reports reserves in their magazine of beginning of December for the first of next year, well before any serious study is done, and never corrects previous data. When WO waits August to report the reserves of last year and revises the reserves of the previous year.
BP (series starting in 1965) contrary to other sources changed the past data: BP 2018 edition is different with BP 2014 edition (the big change was in Russia and in 2014 BP was operator of TNK-BP, but BP was dropped as operator and later changed drastically proved reserves in Russia).
World Oil magazine (in red) has tried to distinguish between 1P and 2P reserves, but WO stops reporting world reserves in 2009 and again in 2014.
EIA (which was our best source until 2015) recopied OGJ reserves values (see below) without any warning on the poor quality of the data.
The most friendly and homogenous world 1P reserves (series starting in 1960) are now OPEC data (last 2018 edition). But the small producing countries are grouped together.
At end 2017 OPEC reports the world 1P lowest value. At end 1975 and end 2005 it was WO reporting the lowest value. BP reports the highest value!



So mean reserves (base of NPV, in fact 2P reserves) are confidential data and never published in company's annual reports (exception Gazprom). UK is the only country reporting 1P, 2P and 3P reserves.
But oil companies want to know what the reserves of their competitors are and buy very expensive inventories of world field reserves from scout (spy) companies, as IHS, Rystad. If the public reported proved reserves were reliable, scout companies would not be as prosperous as they are.
In the next graph the green curve is the technical (confidential) 2P backdated remaining reserves, when the brown curve is the political/financial current proved reserves reported by OGJ/EIA, different from the proved reserves reported by OPEC (difference 169 Gb in 2017)



The brown curve is always on the rise, changing definition by including in 2012 oilsands (Athabasca) reserves, which were in production since 1967. It is why official energy agencies, believing this rise in reserves, forecasts for 2040 a world oil production also rising.
It is now recognized that GDP, in the past connected only to labor and capital, depends primarily on energy. Our society of consumption is based on energy and nobody wants to change, it is why everybody wishes growth (without defining which one) and the idea of energy peak is politically incorrect.

OGJ magazine reports every year in December the result of an inquiry (a survey) in the fall upon every national energy agency on the amount of oil and gas reserves on the first of January of next year.
Any serious study on oil reserves at the end of the year needs to wait at least the end of the year to know any new discover, and the value of cumulative production at year end . Any serious oil company cannot issue a reliable study before end of February (I know because when in charge of Total technical exploration services and research, one of my duty was to supervise the estimate of Total oil & gas reserves: it takes time to collect recent data up to end of December, to analyze them and to estimate remaining reserves). Most of national agencies does not answer (they do not have in the fall the real data on next Jan 1) and for OGJ no answer is no change.
OGJ Dec 4, 2017 p2, there are 65 countries reported as no change in oil reserves from Jan1, 2018 to Jan 1, 2017, as if there were discovering exactly what they produced: it is a joke. But EIA considers that these OGJ proved reserves outside the US are the truth and EIA reports OGJ reserves values in their world proved crude oil reserves.
It is a pity to see how badly oil reserves data is treated. Oil reserves are the future and anyone should under the Free Information Act should in any country be able to obtain reliable field reserves data. In Europe only UK, Norway and Denmark reports field reserves and production. France was reporting field reserves but stopped in 2015: France will stop granting new exploration permits as seeking to end all oil and gas production by 2040, but stopping reporting field data is against

The US practice is the rule in the world, but the US have a very particular point compared to the rest of the world: the underground belongs to the land owner in the US when it belongs to the government in the rest of the world. The US cannot be compared to the rest of the world: they are different, having also a large number of operators (20 000 against 1 in Saudi Arabia), and a large number of services companies. The US and Canada have more rigs (except in 1992 & 2016) than the rest of the world. The US is the country which has produced the most oil 222 Gb at end 2017 against 177 Gb for Russia and 148 Gb for Saudi Arabia.

King Hubbert in his 1956 paper "Nuclear energy and fossil fuels " Am. Petrol. Inst. Drilling & Production Practice, Proc. Spring Meeting San Antonio Texas p7-25 issued his famous US (L48 as Alaska was not yet in the US) conventional oil forecast for a peak in 1965 for an ultimate of 150 Gb or in 1970 for an ultimate of 200 Gb. He was right US oil production peaked in 1970. The most astonishing was the small shift of 5 years (1965 to 1970) when increasing the ultimate by one third (150 to 200 Gb)

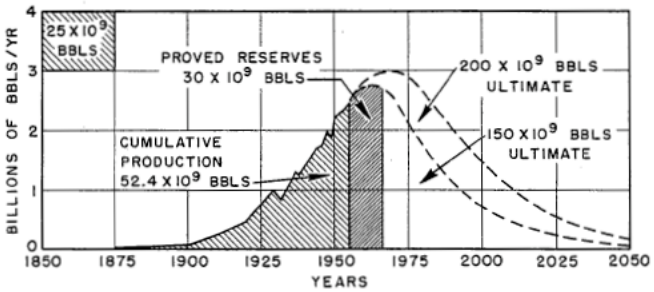


Figure 21 – Ultimate United States crude-oil production based on assumed initial reserves of 150 and 200 billion barrels.

Hubbert was using the term “ultimate” (see graph) for the ultimate recovery which is called “Estimated Ultimate Recovery” or EUR by many
Hubbert was using Wallace Pratt 1956 range of ultimate estimates (200 Gb being the highest estimate), in 1956 the oil cumulative oil production was 52.4 Gb. In 1962 Hubbert ultimate

was 175 Gb against Zapp (1961) 590 Gb ultimate, making wrong assumptions on the oil recovery per foot and the future drilling.

Pratt, Wallace E., 1956, The impact of peaceful uses of atomic energy on the petroleum industry, in Peaceful uses of atomic energy, background material for the report of the panel on the impact of the peaceful uses of atomic energy to the Joint Committee on Atomic Energy. 84th Congress, 2nd Session, v 2, p. 89-105.

-Method & equations

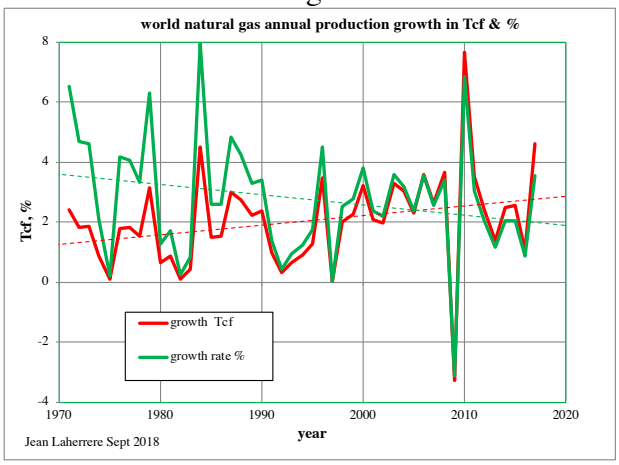
My model of bell curve for annual production is aP = 2Pm/(1+COSHb(t-tm))
where Pm is the peak value, tm the peak time and b the steepness of the curve (equal to 5 /half width =c)
The ultimate U = 4Pm/b
Other equation with c: aP = 2Pm/(1+COSH(-5/c(t-tm))

COSH = hyperbolic cosine COSHx = 1/2(EXPx+EXP-x).

For the S curve for cumulative production is CP = U/(1+EXP(b(t-tm))
Derivative = b*EXP(b(t-tm)/(1+EXP(b(t-tm))2

The goal is to extrapolate past production to estimate ultimate and then to model production with a Hubbert cycle fitting the ultimate and the past production (both the aP and the CP graphs with the same parameters U, Pm and b).

This extrapolation of past data could be done on different displays:
-aP versus CP (called oil decline): at the end of the field aP = zero
-aP log scale versus CP : extrapolation of decline to zero = ultimate (works only after peak)
-aP/CP% versus CP (called Hubbert linearization = HL when the extrapolation is taken as a straight line and not a curved line): the extrapolation of last data towards zero = ultimate
-aP/CP% log scale versus CP
-production growth versus time to forecast peak time (annual growth and 9-year smooth curve) when crossing zero line
-production growth versus cumulative production to forecast ultimate when crossing up zero line
-production growth rate versus time: growth rate in percentage evolution is different from growth in volume and the trend looks better than the growth
The best example is the world natural gas production growth trend 1971-2017: the growth in Tcf increases when the growth in % decreases and it is almost symmetrical

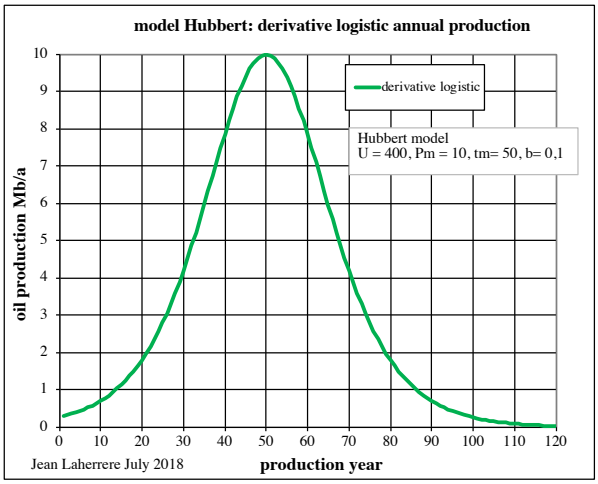


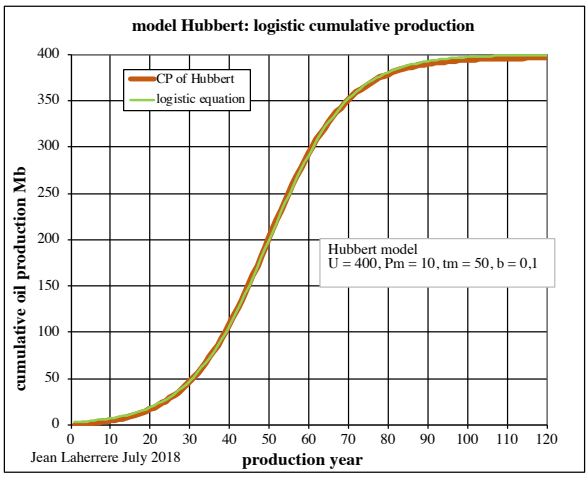
-production growth rate versus cumulative

Previous papers using extrapolation of the past to forecast the future:
-Laherrere J.H. 2015 « Some examples of oil and gas production linear extrapolation to estimate ultimate » http://aspofrance.viabloga.com/files/JL_Hubbertlineraization24May.pdf
https://aspofrance.org/2015/05/24/some-examples-of-oil-gas-production-linear-extrapolation-to-estimate-ultimate-may-2015-jean-laherrere
-Laherrere J.H. 2018 "Graphs on North America oil & gas net imports" ASPO France meeting 5 June 2018 https://aspofrance.files.wordpress.com/2018/06/namnetimportforecasts.pdf
-Laherrere J.H. 2018 "US, Canada & Mexico oil & gas production, consumption & net import" May https://aspofrance.files.wordpress.com/2018/05/uscame2018.pdf -Laherrere J.H. 2018 "Forecasts for Canada oil and gas production" May https://aspofrance.files.wordpress.com/2018/05/canada2018.pdf
-Laherrere J.H. 2018 "Forecasts for US oil and gas production" March https://aspofrance.files.wordpress.com/2018/03/lahall19march.pdf
https://fr.scribd.com/document/375780747/Forecast-for-US-Oil-and-Gas-Production- Laherrere-Hall-2018
-Laherrere J.H. 2018 « Some updated graphs of world oil production » Jan https://aspofrance.files.wordpress.com/2018/02/graphsjljan2018.pdf
-Laherrere J.H. 2017 "Updating fossil fuels production and CO2 emissions graphs » June https://aspofrance.files.wordpress.com/2017/07/updatingffgraphs.pdf
-Laherrere J.H. 2016 « San Joaquin, Permian basin oil production & reserves-Comments on Nehring's 2006 paper on Hubbert's unreliability » August http://aspofrance.org/files/SJ-PB2016.pdf
https://aspofrance.org/2016/08/11/bassins-san-joaquin-et-permien-us-aout-2016-jean-laherrere/
-Laherrere J.H. 2015 « Some examples of oil and gas production linear extrapolation to estimate ultimate » http://aspofrance.viabloga.com/files/JL_Hubbertlineraization24May.pdf
https://aspofrance.org/2015/05/24/some-examples-of-oil-gas-production-linear-extrapolation-to-estimate-ultimate-may-2015-jean-laherrere/
-Laherrere J.H. 2015 « Jean Laherrere uses Hubbert linearization to estimate Bakken shale oil peak in 2014 » Jan http://crudeoilpeak.info/jean-laherrere-uses-hubbert-linearization-to-estimate-bakken-shale-oil-peak-in-2014
-Laherrere J.H. 2014 «Steel production, Hubbert linearization and forecasts» July http://aspofrance.viabloga.com/files/JL_2014GraphsSteel.pdf
-Laherrere J.H. 2014 «The end of the peak oil myth » MIT club de France- Paris 28 April http://aspofrance.viabloga.com/files/JL_MITParis2014long.pdf
-Laherrère J.H. 2009 «Oil peak or oil plateau» St Andrews economy forum, St Andrews University Scotland 2 May http://aspofrance.viabloga.com/files/JL_StAndrews2may2009.pdf
-Laherrère J.H. 2005 «Fossil fuels future production» Romania Oil & Gas Congress, Bucharest, 23-24 March http://www.oilcrisis.com/laherrere/bucharest.pdf
-Laherrère J.H. 2003 " Modelling future oil production, population and the economy " ASPO Second International workshop on oil & gas, Paris, May 26-27 http://www.oilcrisis.com/laherrere/aspoParis.pdf
-Laherrère J.H. 2002 "Modelling future oil production" The International Workshop on Oil Depletion Uppsala, Sweden, May 23-25 www.isv.uu.se/iwood2002 and http://hubbertpeak.com/laherrere/uppsalaJHL.pdf
-Laherrère J.H. 1999 "Assessing the oil and gas future production and the end of cheap oil ?" CSEG Calgary April 6 http://dieoff.com/page179.htm

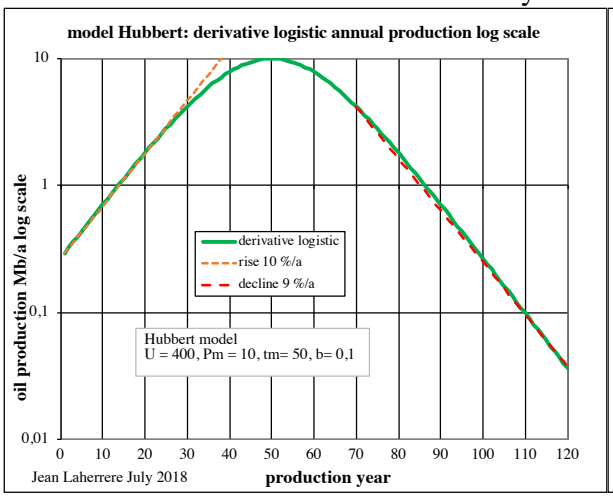
In order to see what it the best way to estimate Ultimate, we have chosen two models of oil production

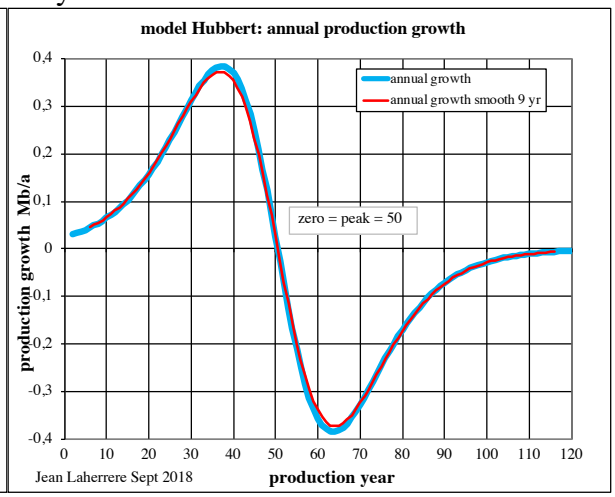
-first model: symmetrical Hubbert bell curve model (derivative of logistic function)



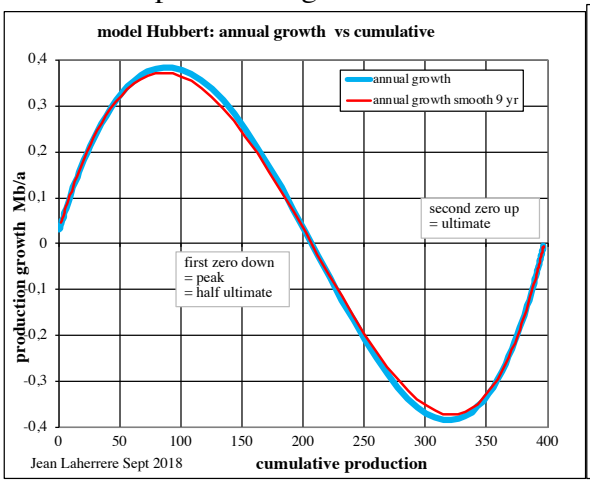


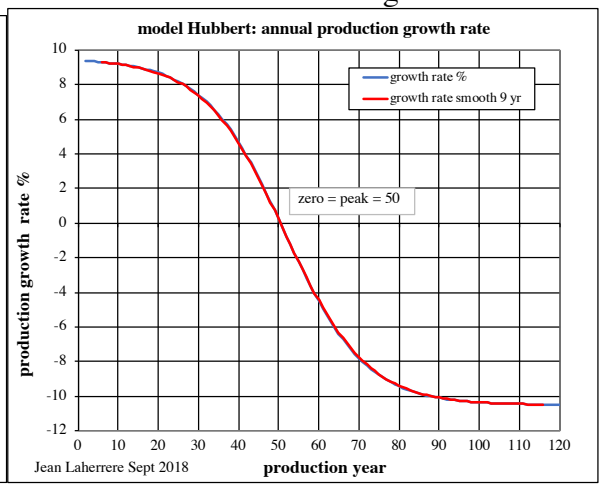
The parameters of the model are: U = 400 Mb, tm = 50, Pm = 10 Mb, and b = 0.1 (10%)
aP = annual production CP =cumulative production
The display of aP in log scale versus time shows that from year 1 to year 30 the model fits well with a rise rate of 10 %/a and from year 70 to year 120 with a decline rate of 9 %/a





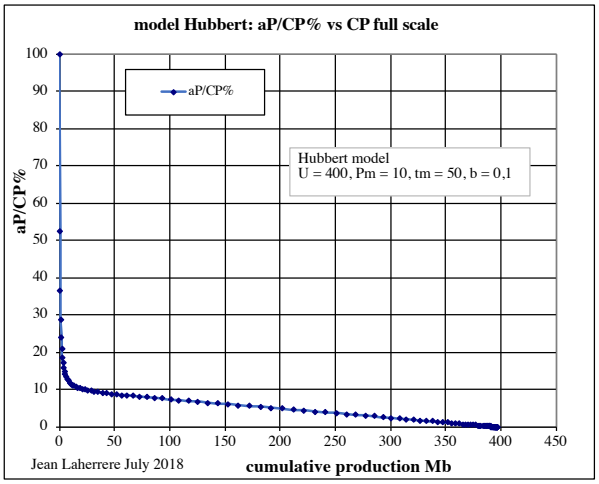
Plotting the annual production growth versus time gives the peak time when crossing the zero line. The production growth smoothed for 9 years is similar.
The zero line is crossed first showing the peak and at last returns to zero which is the end of production.
Plotting the annual production growth versus cumulative production gives the half ultimate when crossing the zero line down and the second zero up gives the ultimate.
The annual production growth rate in % versus time is a better model than growth in M



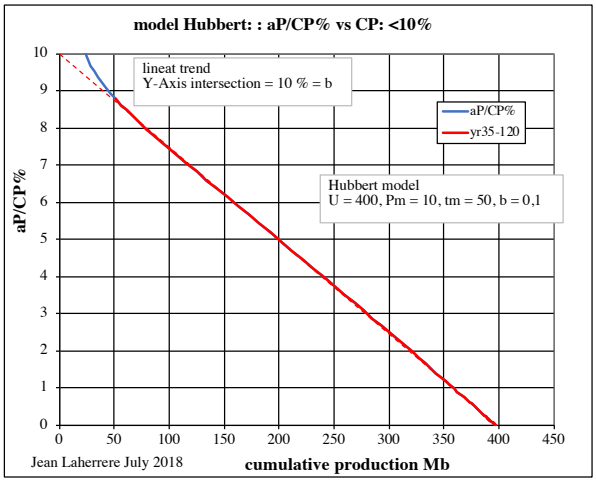


The Hubbert Linearization called HL (plotting aP/CP% versus CP) which is straight from start in equation (as described by Hubbert in 1982 assuming a continuous curve) is different when using annual productions, aP/CP% starts a 100% first year and falls sharped and turning straight linear starts only below 10 % at over year 30.

aP/CP% full scale

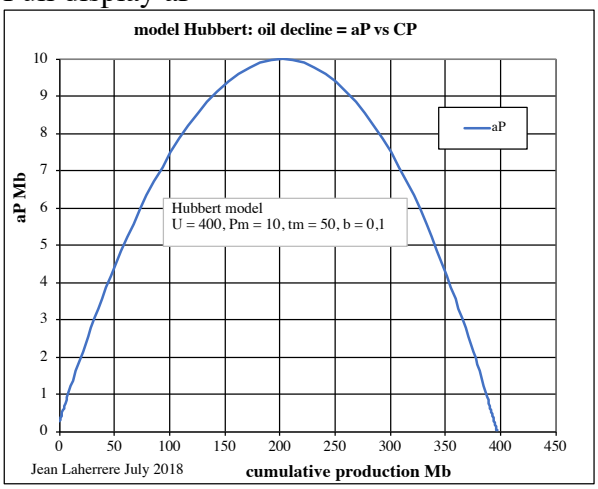


aP/CP% for below 10%

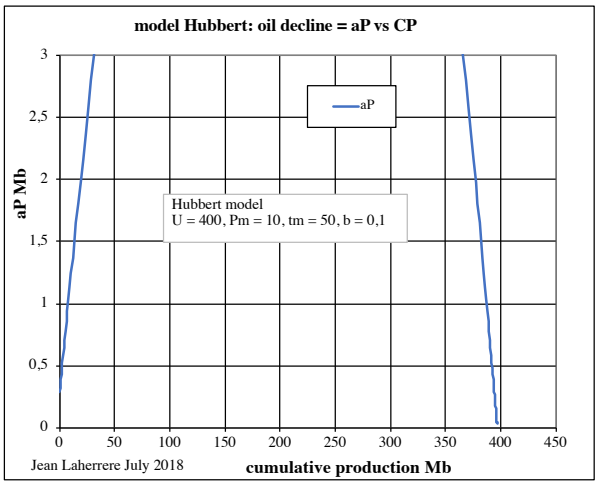


The plot aP versus CP (called oil decline or OD) is close to a parabola but plotting only the annual production below 3 Mb/a, the plot is close to linear.

Full display aP

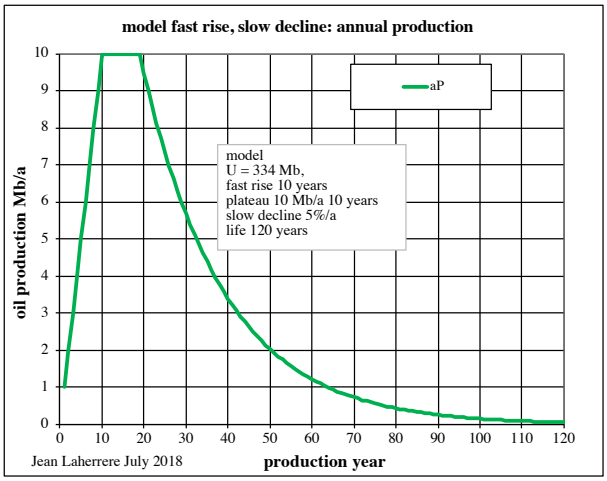


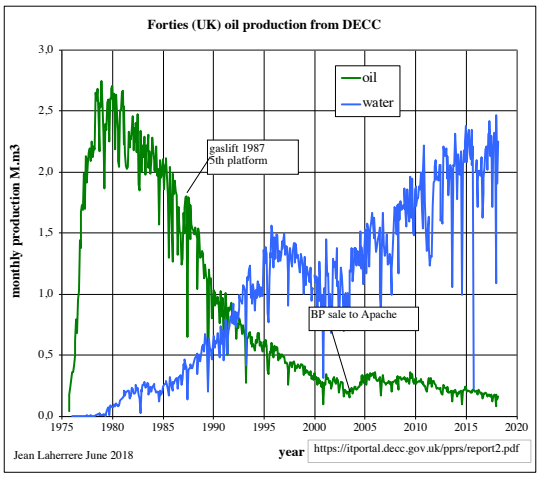
aP<3 Mb



-second model: production with fast rise and slow decline

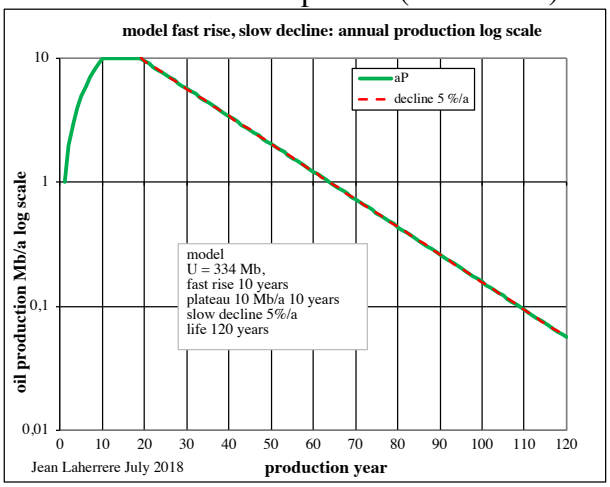
This model is similar with Forties (North Sea) production before sale from BP to Apache

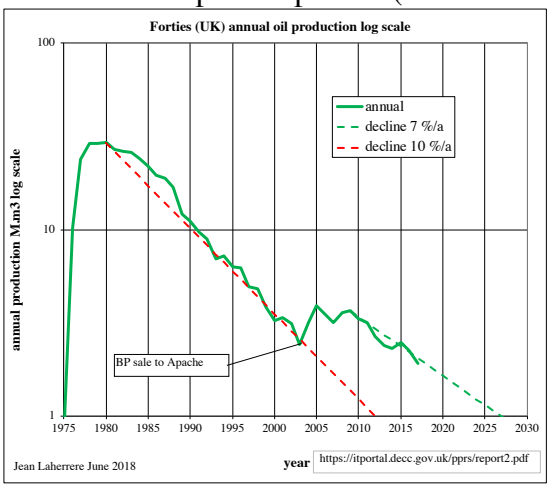




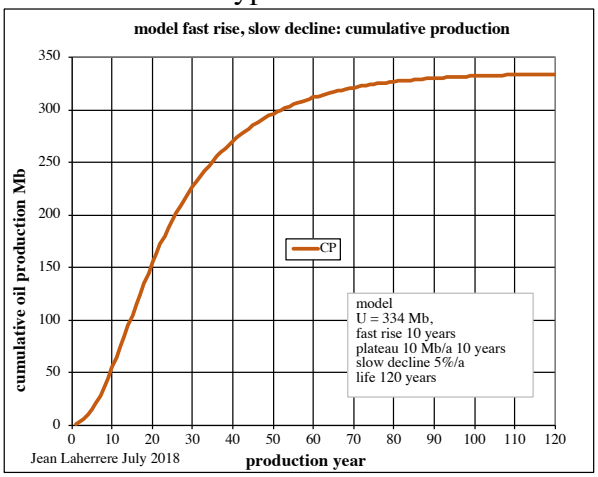
The parameters are U = 334 Mb; fast rise in 10-year, plateau on 10 years at 10 Mb/a and slow decline at 5%/a, which is assumed to be the world decline of mature oilfields.

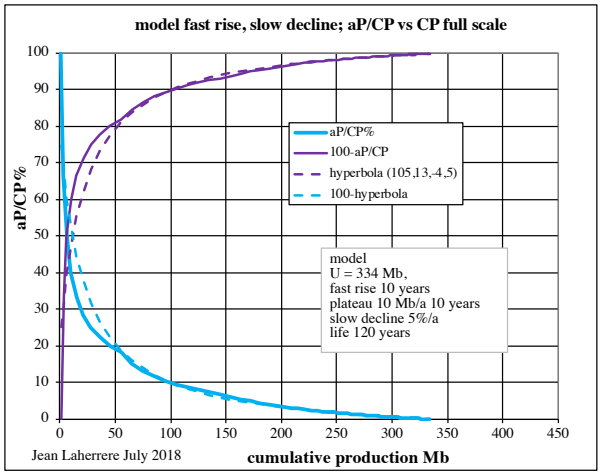
The display of aP in log scale versus time shows that from year 19 to year 120 the decline rate of 5 %/a is equal to the model. The Forties plot of aP log scale versus time displays a decline rate of 10 %/a for BP operator (1990-2003) and of 7 %/a for Apache operator (2010-2017



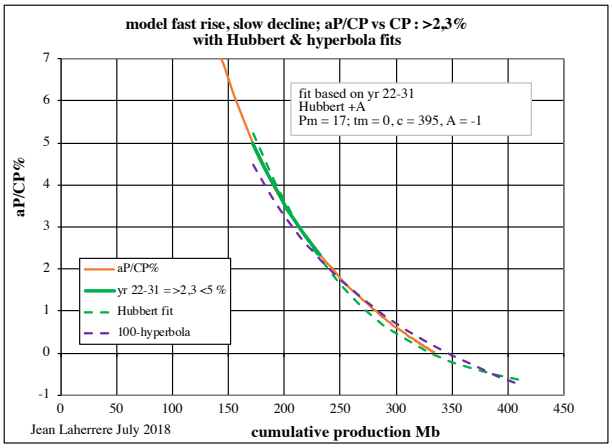


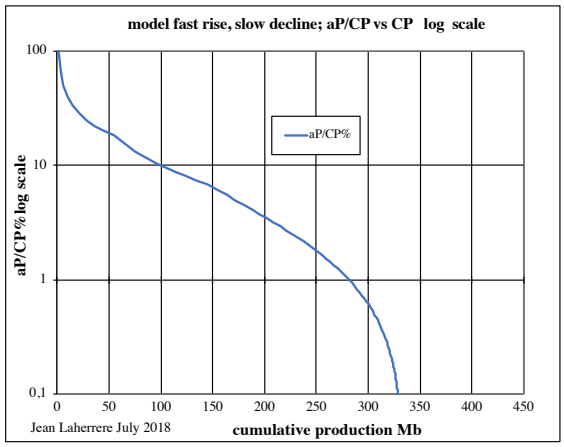
A decline rate of 5 %/a is considered to be the world average decline of mature oil fields
The CP is closer to a hyperbola than a S curve. The HL full scale is curve and 100-HL modelled with a hyperbola.



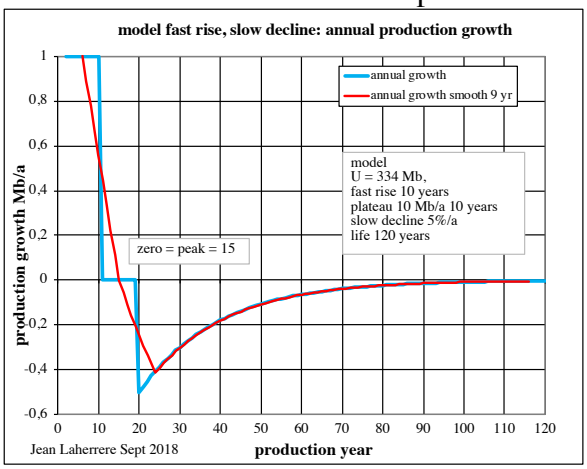


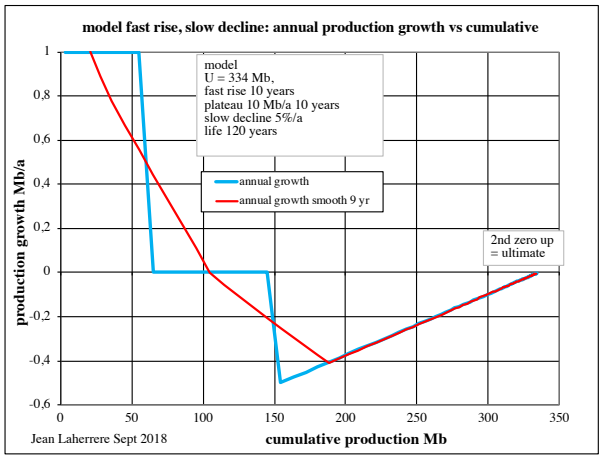
The HL less than 7% is modeled with a hyperbola (asymptote at 105) and a Hubbert curve
The HL in log scale is hard to model.



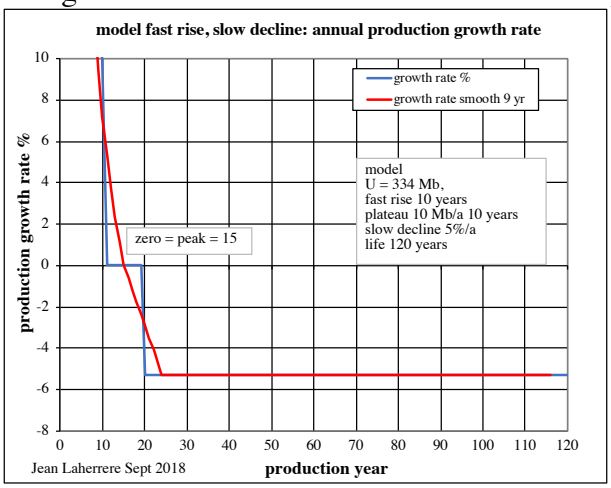


The annual production growth versus time gives the peak time, which is in fact a plateau. The annual production growth versus cumulative production: the first zero down is not related to ultimate when the second zero up is the ultimate.





The growth rate in % crosses the zero in a sharp decline

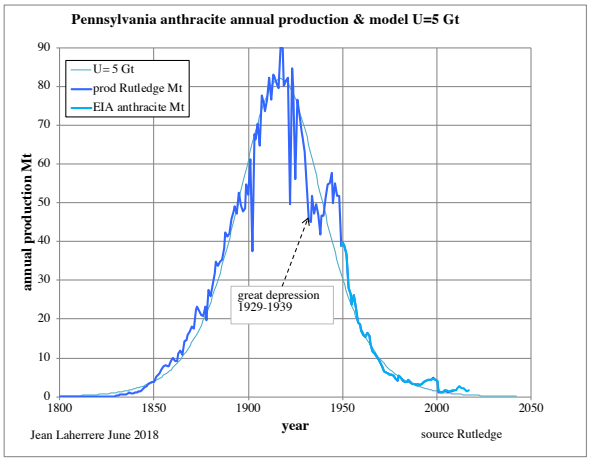


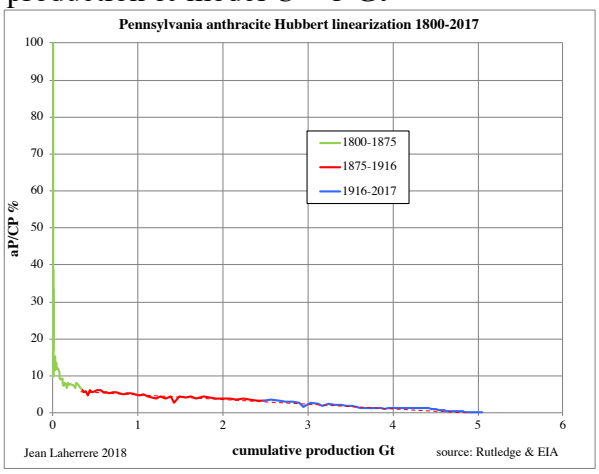
-Applications to world, countries and fields

-Pennsylvania anthracite production

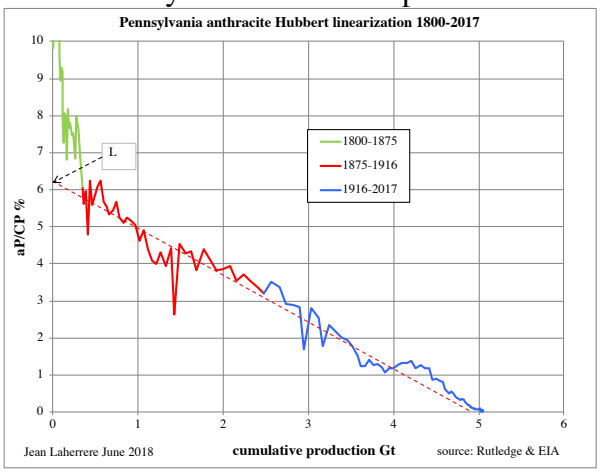
Pennsylvania anthracite annual production displays a remarkable symmetrical bell curve from 1800 to 2017, except during the Great depression (1929-1939)

Pennsylvania anthracite annual production & model U = 5 Gt

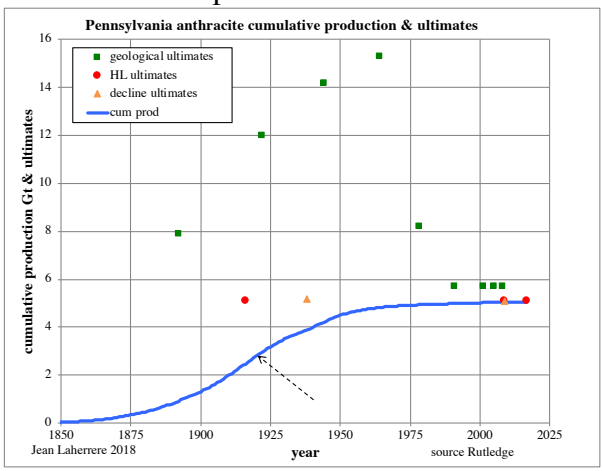




HL of Pennsylvania anthracite production



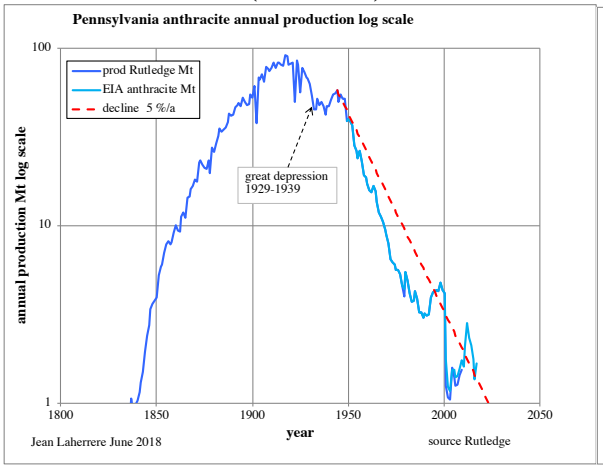
cumulative production and reserves

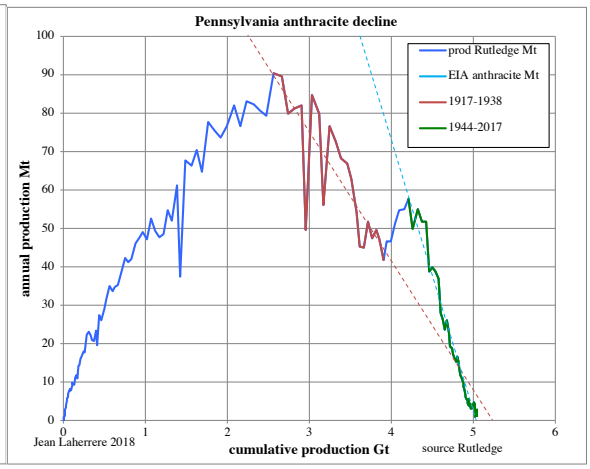


HL can estimate ultimate reserves in 1916 at 5 Gb = real value, before the peak in 1917.
Geological reserves in 1954 at 15.4 Gt were three times the real value!

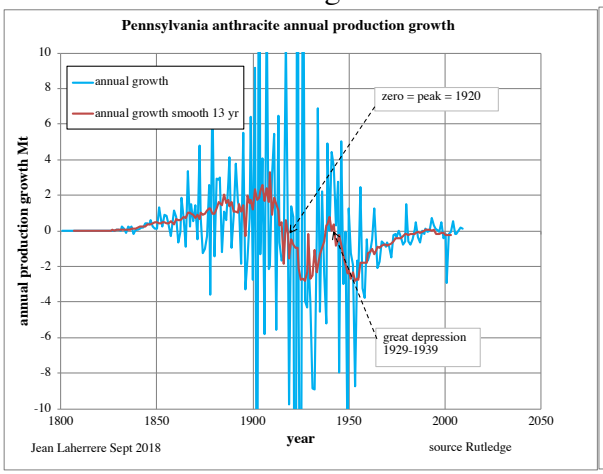
It appears that HL is much better to estimate ultimate than geological volumetric estimates, but a constant decline rate of 5 %/a is also a simple model which works well for the period 1944-2017.

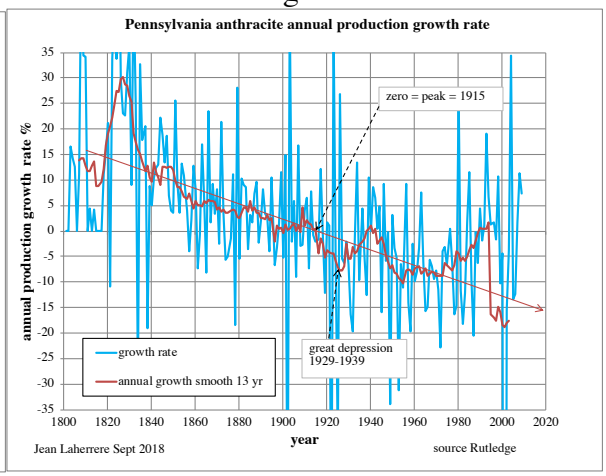
Anthracite decline (aP vs CP) trends towards the ultimate after 1944.





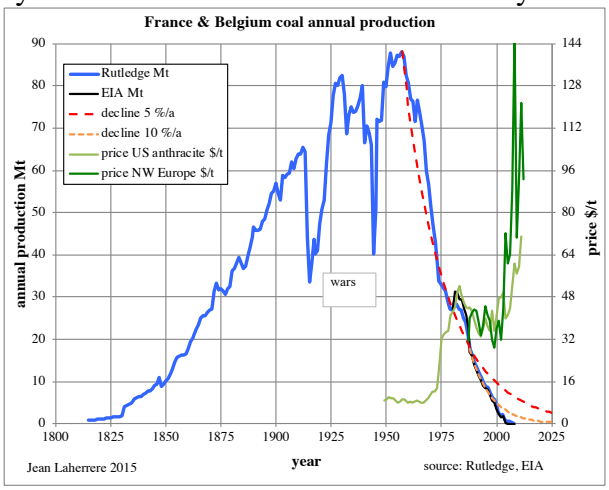
The plot annual production growth allows to find the peak when crossing the zero. It is obvious that the trend of growth rate in % is better than the trend of growth in Mt.

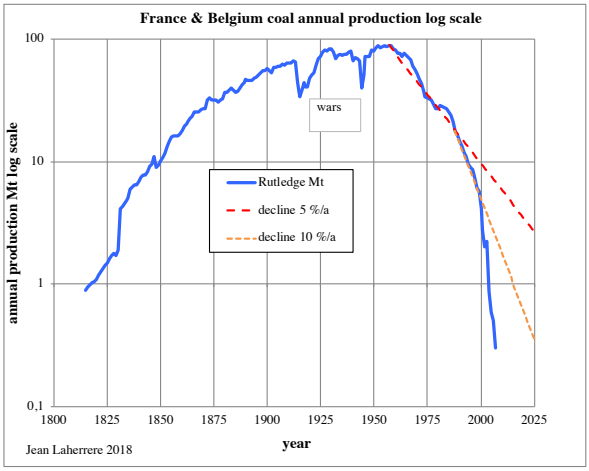




-France & Belgium coal production

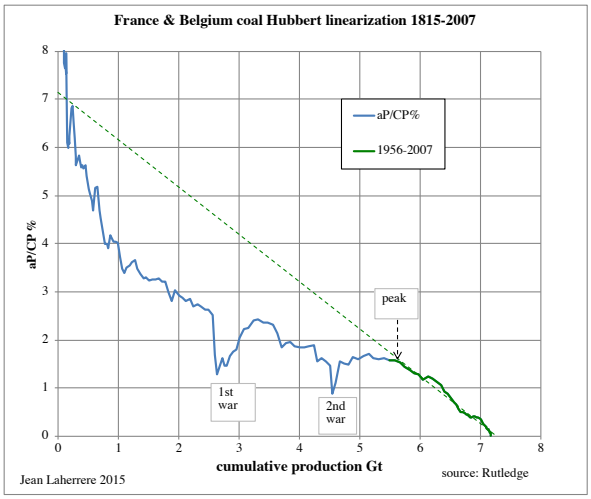
France & Belgium coal production started in 1815, peaked in 1957 and stopped in 2008 with a total production of 7.2 Gt. The bell curve, contrary to Pennsylvania anthracite is not symmetrical at all: slow rise disturbed by the two world wars and sharp decline after peak.

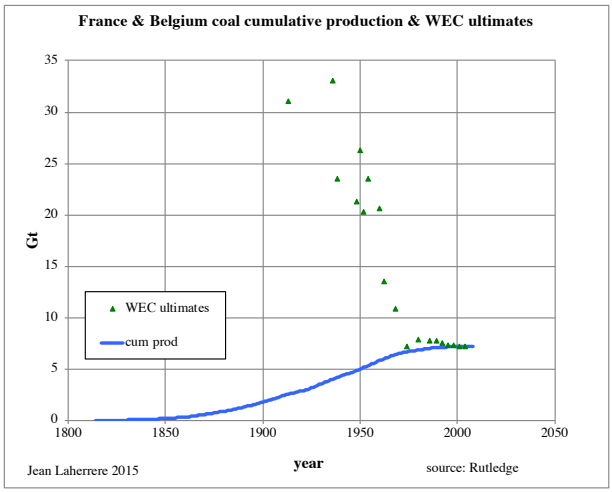




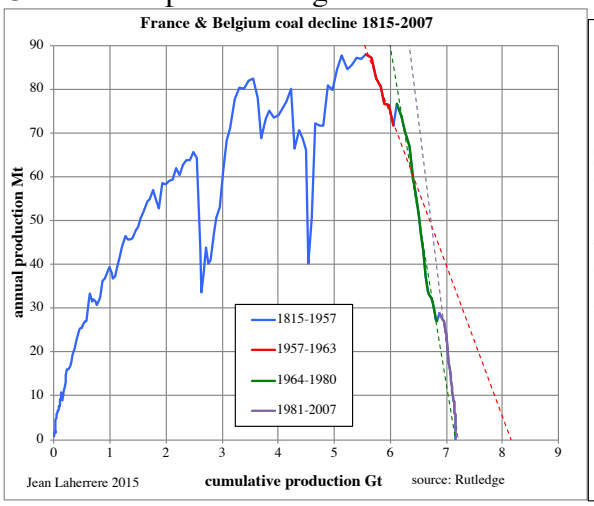
A decline rate of 5 %/a fits well for the period 1957-1988 and of 10 %/a for the period 1988-2007

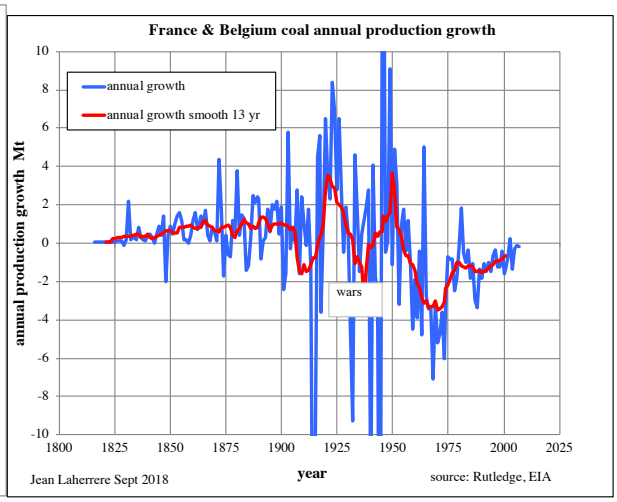
HL of coal production is curved for the period 1927-1947 trends towards 6.3 Gt , but for the period 1956-2007 (below 2%) it trends towards 7.2 Gt.
WEC ultimates (geological estimates) were in 1920 around 20 Gt (33 Gt in 1936!)



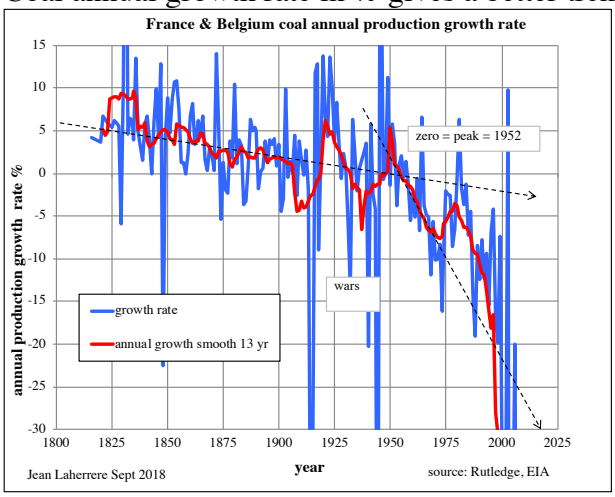


Coal decline trends towards the ultimate after 1964.
Coal annual production growth is chaotic because wars.





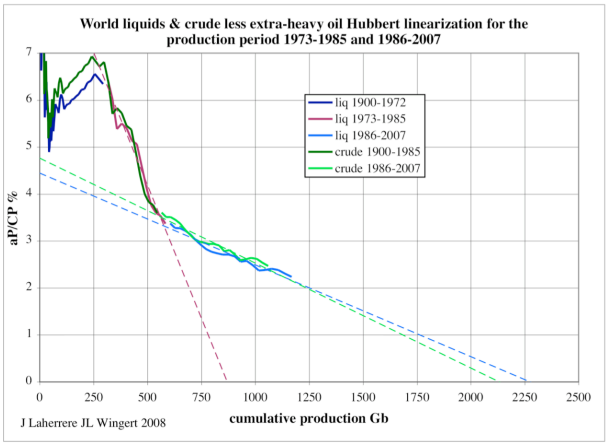
Coal annual growth rate in % gives a better trend when smoothed on 13 years, the trend



-world crude oil less extra-heavy (XH) oil production forecast

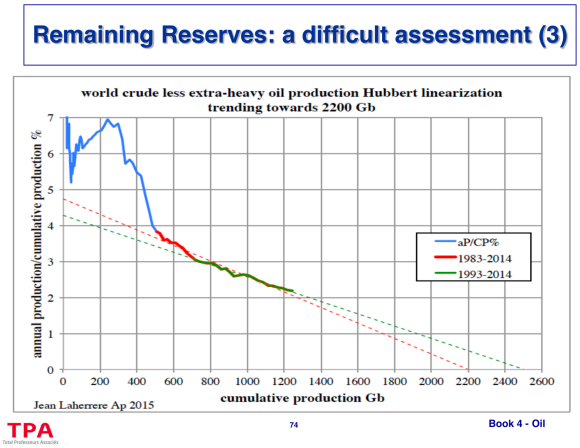
Graph in 2008 -Laherrère J.H. & JL Wingert 2008 « Forecast of liquids production assuming strong economic constraints» ASPOVII Barcelona 20 October
http://aspofrance.org/news/aspo-vii-barcelona

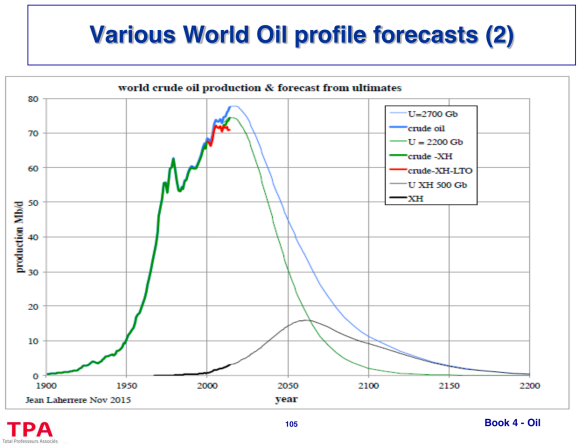
In 2008, HL of crude less XH rends towards 2100 Gb



Graph April 2015 HL (1993-2014) trends towards 2200 Gb
Christian Gueritte's Book 4 TPA (Total Prof) Jan 2018

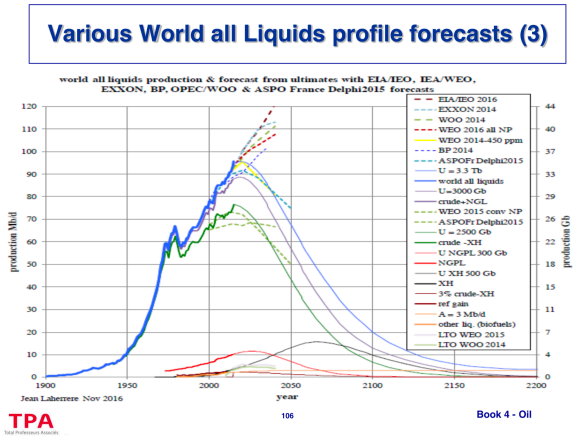
Graph Nov 2015 production forecast for U= 2200 Gb

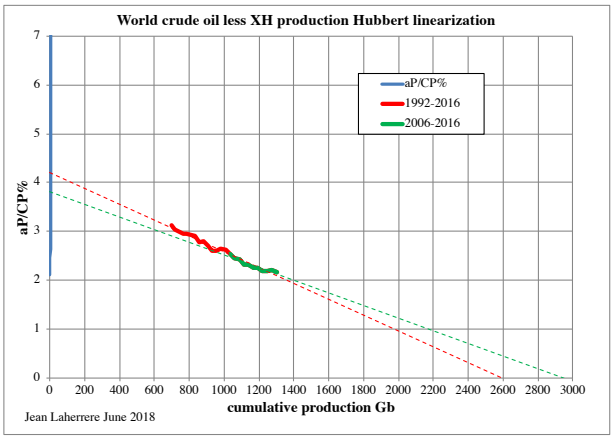




It is obvious that HL is not very accurate because the small angle between HL and X-axis, and furthermore that HL is often crooked or curved.

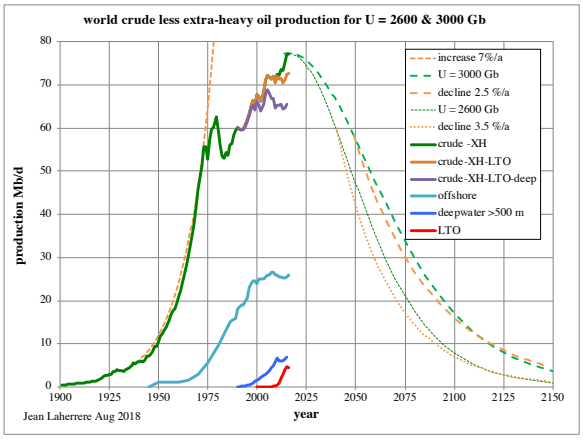
Graph Nov 2016 production forecast for U = 2500 Gb Graph June 2018

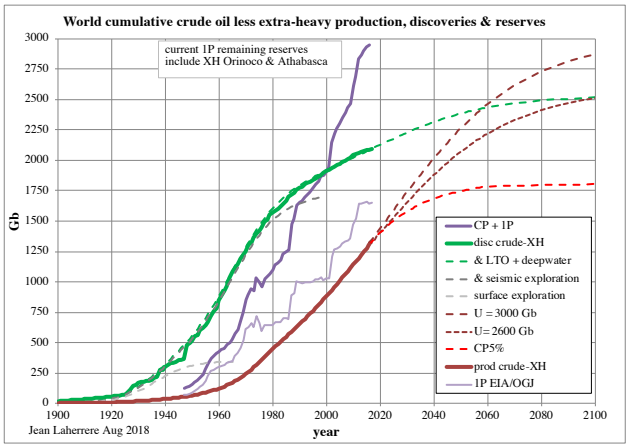




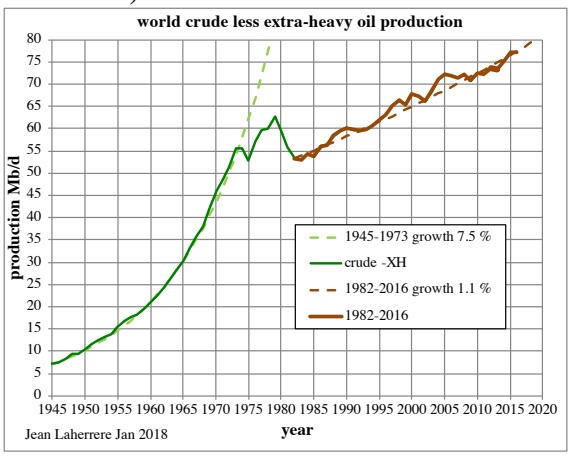
HL (1992-2016) trends towards U = 2600 Gb & (2006-2016) trends towards 3000 Gb

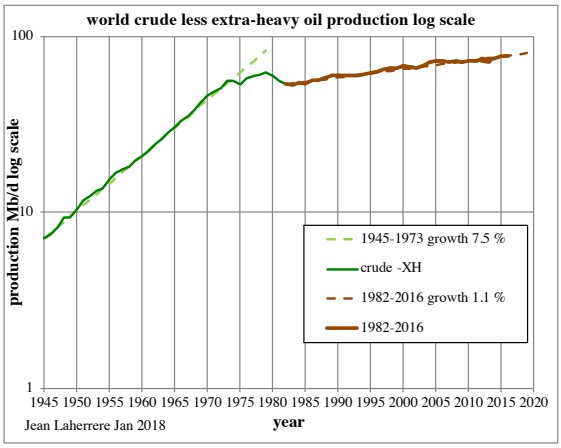
Graph 2018 production forecast for U = 2600 (creaming curve) & 3000 Gb (HL)
CP5% is far too low, because the peak is now and the 5% decline is taken now, too soon, it will come later



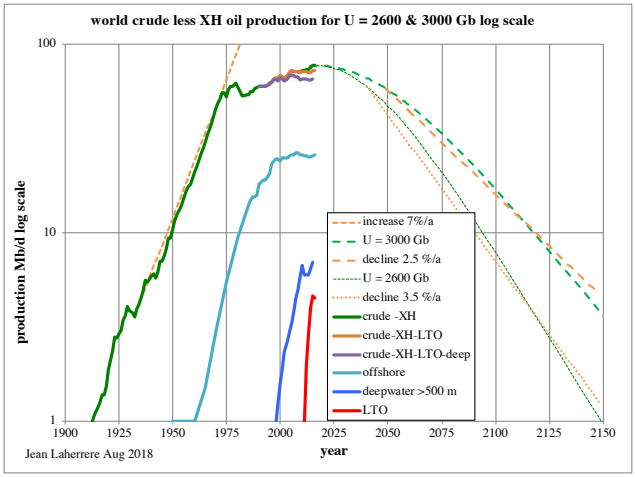


Graph 2018 past production with growth rate 7.5%/a 1945-1973 (called the "Thirty Glorious") and 1.1%/a 1982-2016





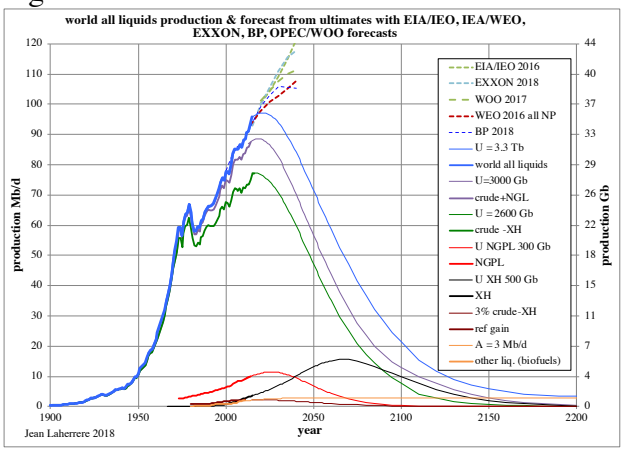
From 1932 to 1973, the increase rate is 7 %/a.
The future decline rate will be for U = 2600 Gb 3.5 %/a after 2040 and 2.5 %/a for U = 3000 Gb after 2050.

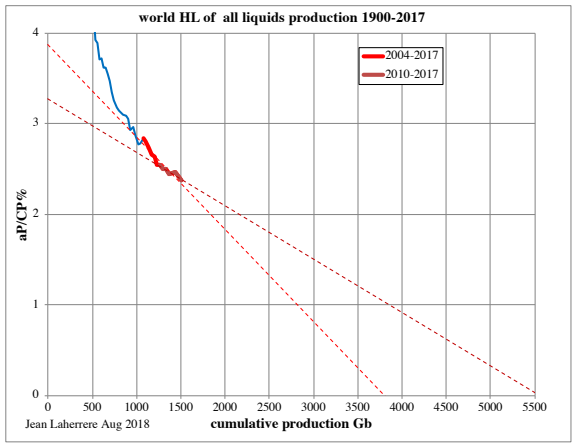


Oil decline (aP vs CP) cannot work, aP still rising.

If the ultimate for crude oil less XH is 2600 Gb, adding the NGL brings the ultimate for crude +NGL at 3000 Gb and adding refinery gain and XTL (X= gas, shale, biomass (biofuels) brings the all liquids ultimate to 3300 Gb

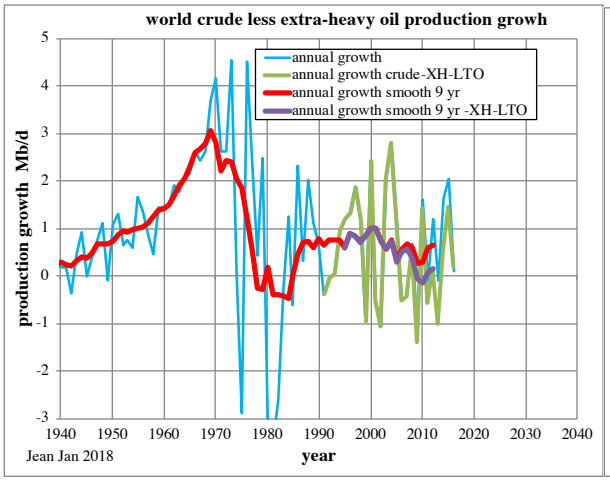
HL of all liquids for the period 2004-2017 trends towards 3750 Gb and the period 2010-2017 towards 5500 Gb: much too high, meaning the HL does not help much for such short period corresponding to the burst of shale plays: oil and gas (NGL): the gap of uncertainty is too high.

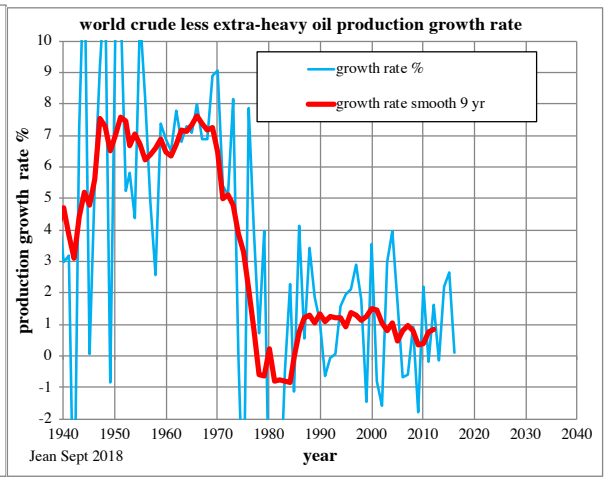




It will be interesting to see the evolution of such graph in 5 years.

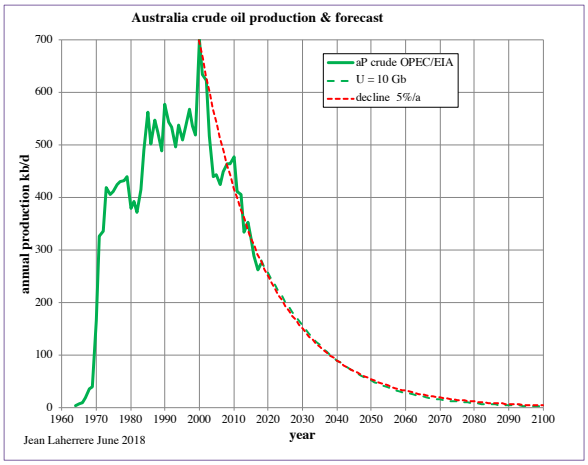
World crude oil -XH annual production growth crossed the zero line in 1978 (first peak) but the extrapolation of the decline since 2001 to zero is difficult (curve red = smooth on 9 years) but the 9 yr smooth for crude -XH-LTO (purple curve) looks as going below zero before 2020 The population growth rate in % is a better indicator for shiwing the peak when crossing the zero

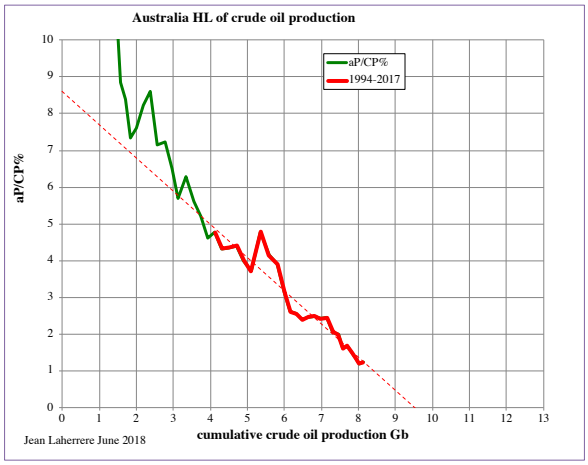




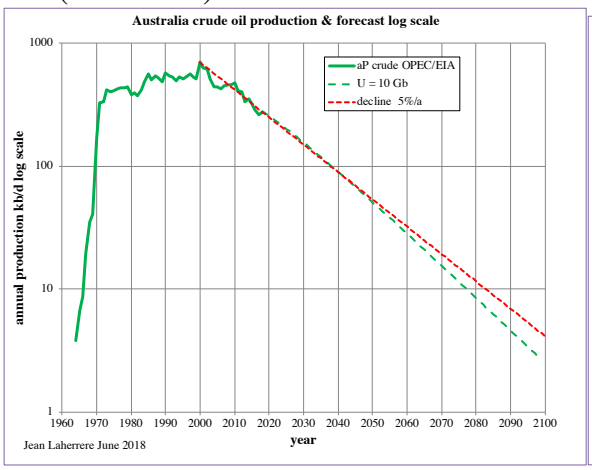
-Australia

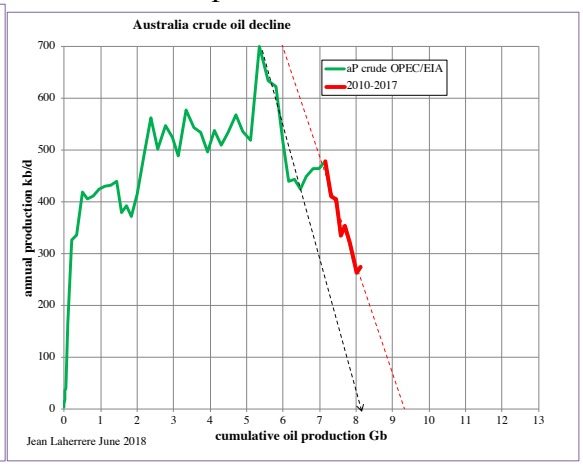
Australia crude oil production peaked in 2000 at 0.7 Mb/d and despite a trough in 2006 the decline in 2017 from 2000 is 5 %/a. The HL trends towards 10 Gb and then forecast for 10 Gb fits well with a continuous decline of 5 %/a





OD (oil decline) trends towards the same value as HL for the period 2010-2017





But the creaming curve of 2P trends towards an ultimate higher than 10 Gb (>14 Gb). However, T.G. Powell Geoscience Australia APPEA Journal 2004 p730 Figure 2, "Australia's Hydrocarbon province- where will future production come from?" states the difference between 2P backdated reserves and initial reserves as reserves growth , he should have called that bad practice instead! 2P reserves look overestimated, as confirmed by Kingfish 2P 1988 will too high?

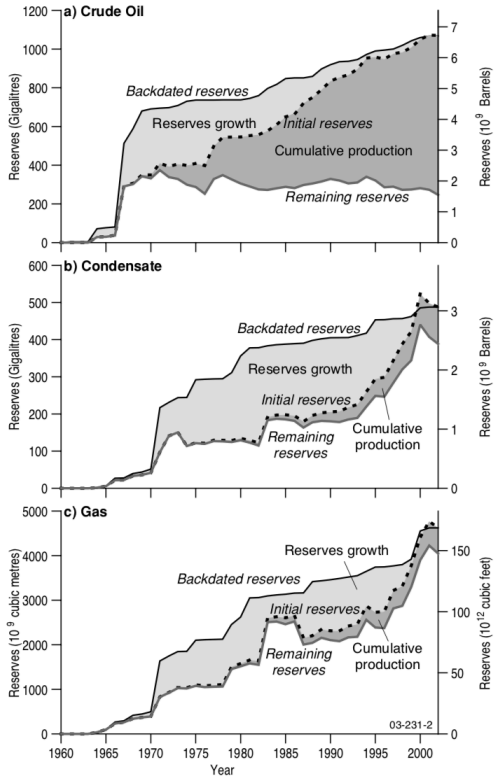
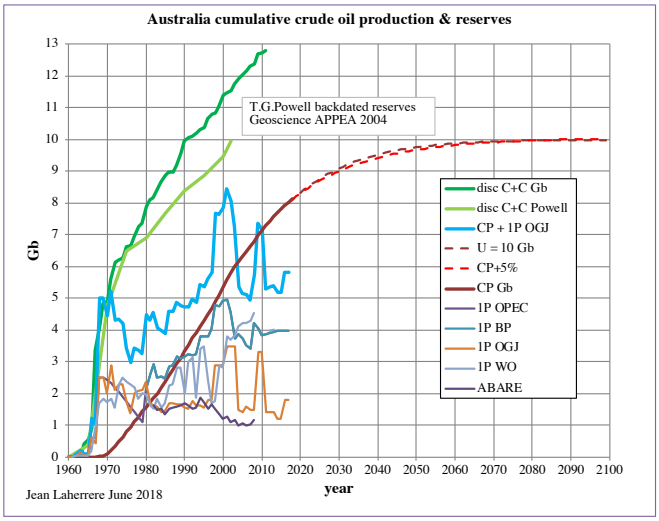
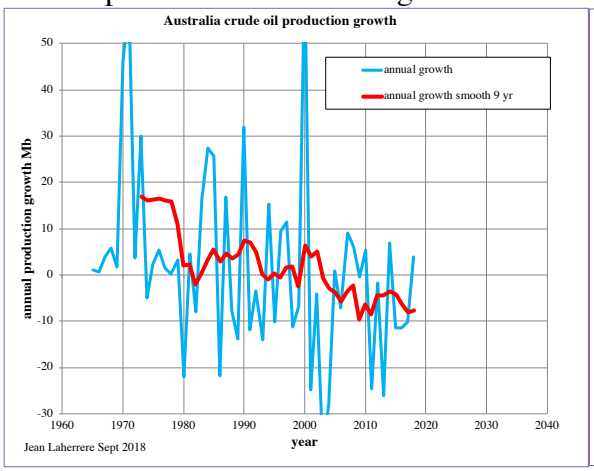
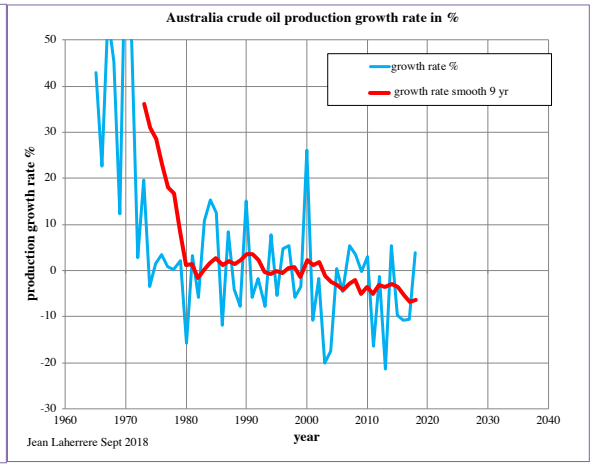


Figure 2. Australian petroleum reserves through time: **a.** Crude oil, **b.** Condensate, **c.** Gas. Backdated Reserves are the cumulative reserves recorded up to 2003 backdated to the year of discovery of the host field; Initial Reserves represent the cumulative reserves known to have been discovered at a particular time. Remaining Reserves represents the identified reserves that remain to be produced.



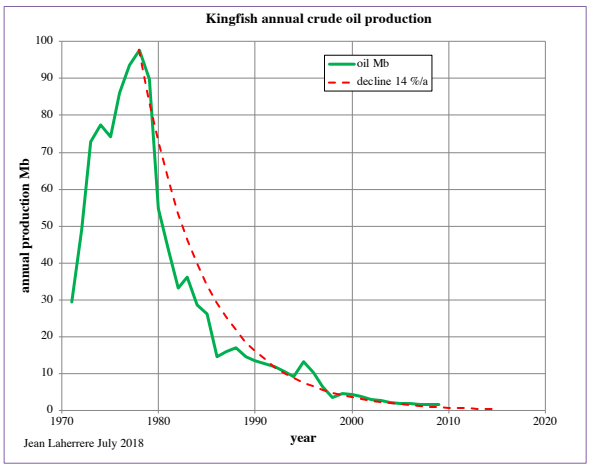
Australia crude oil production growth is mainly declining, but often close to zero because a bumpy plateau from 1985 to 2000. The sharp peak of 2000 does not show well on the 9 yr smooth plot. It is better on the growth rate in %

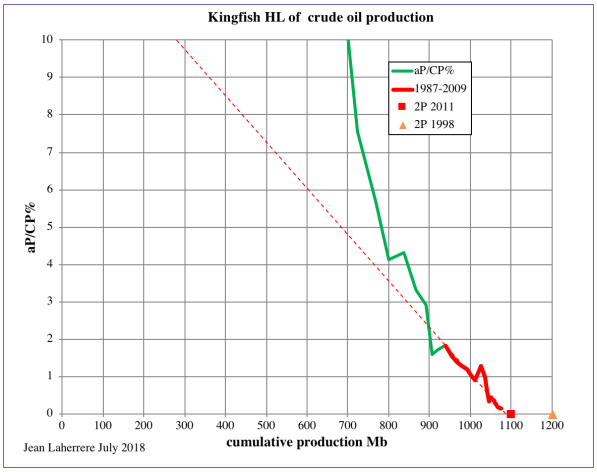




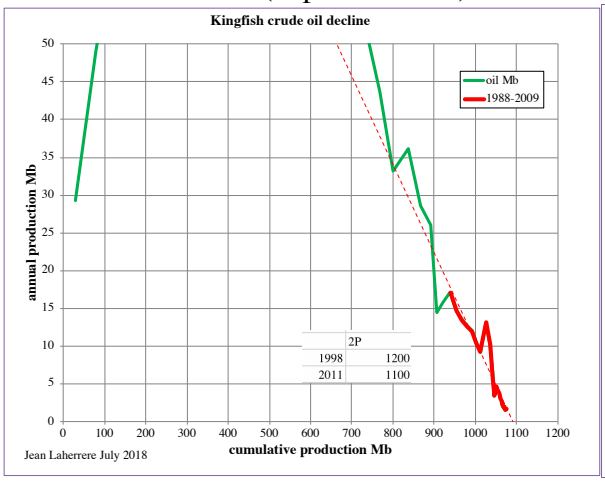
-Kingfish oil field

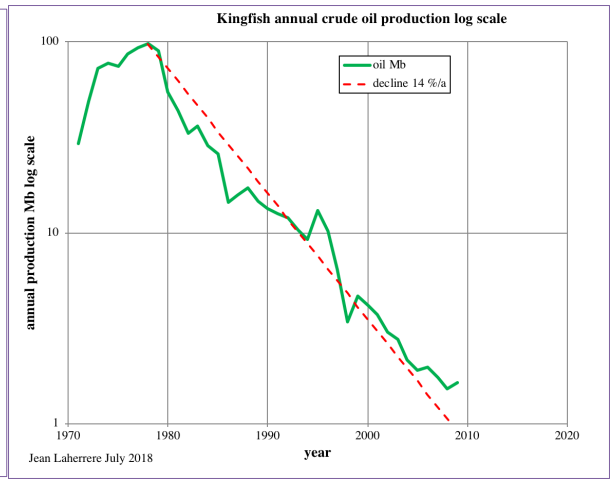
Kingfish crude oil production displays a fast rise and a fast decline (most offshore production displays fast decline because the high production rates and the high maintenance costs).
HL is reliable only below 2%. 2P 1988 at 1200 Mb were too high compared to 2P 2011 (1100 Mb) and HL extrapolation kingfish has a high rate of decline with about 14 %/a





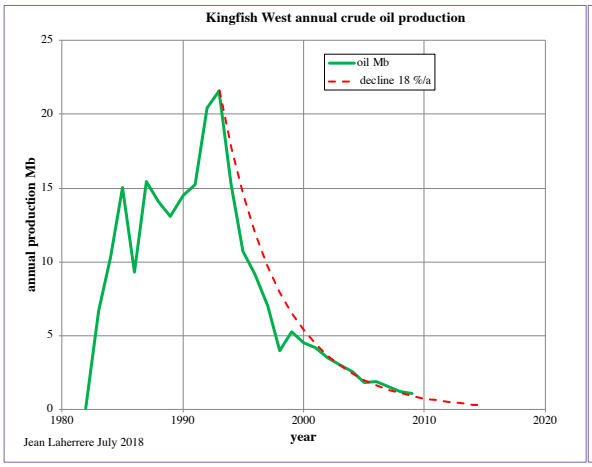
The extrapolation of aP vs CP (oil decline) gives an ultimate identical to HL because the field is almost exhausted (depletion 98%)

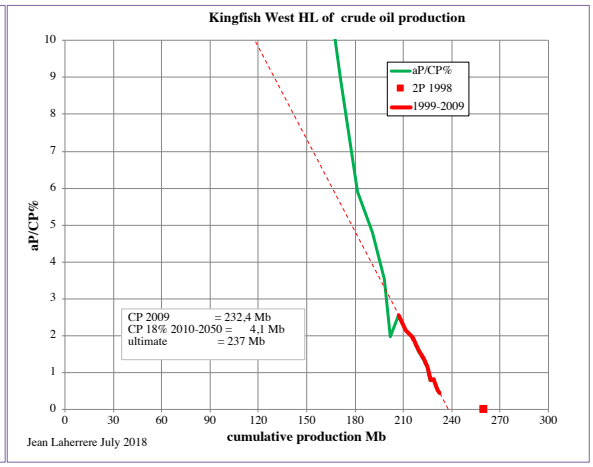




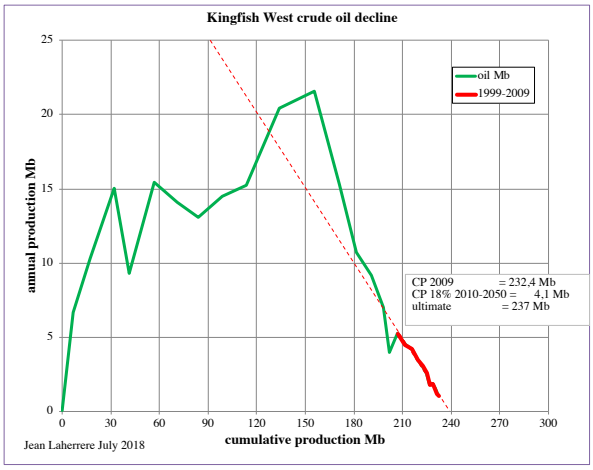
-Kingfisk West

HL is reliable only below 3% and its extrapolation at 240 Mb below 2P 1998 (260 Mb)
The aP displays a high decline rate = 18 %/a (offshore), giving with CP 2010-2050 (4.1 Mb) an ultimate of 237 Mb



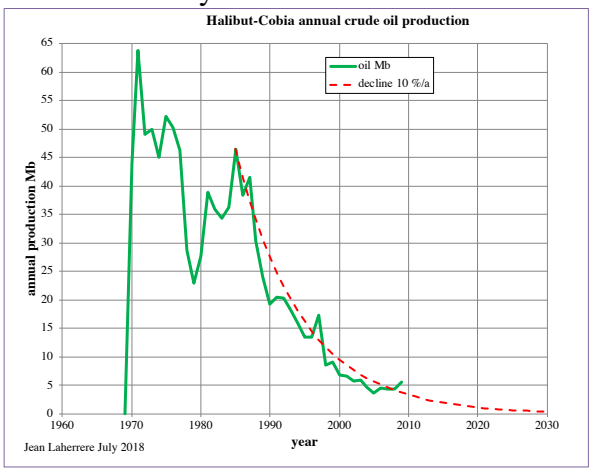


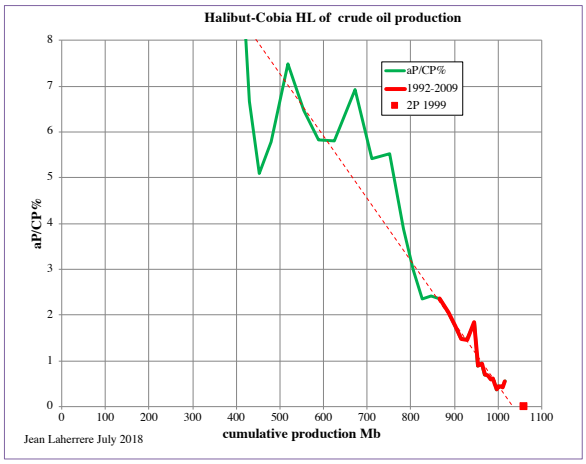
OD for 1999-2009 trends towards 240 as HL, likely the field being almost depleted.



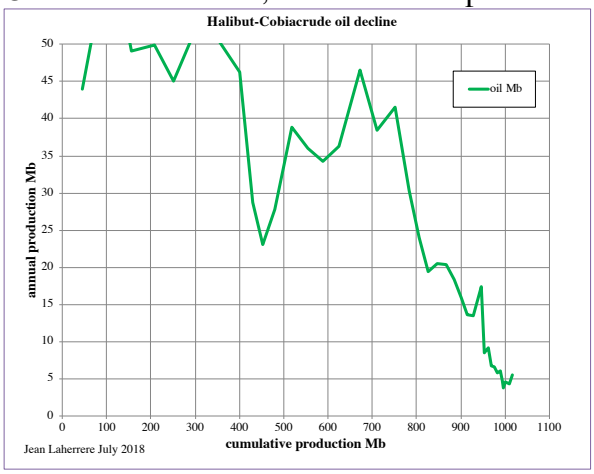
-Halibut-Cobia

HL reliable only below 3 % and in line with 2P and 10 %/a decline rate (offshore)





OD is similar to HL, field almost depleted.

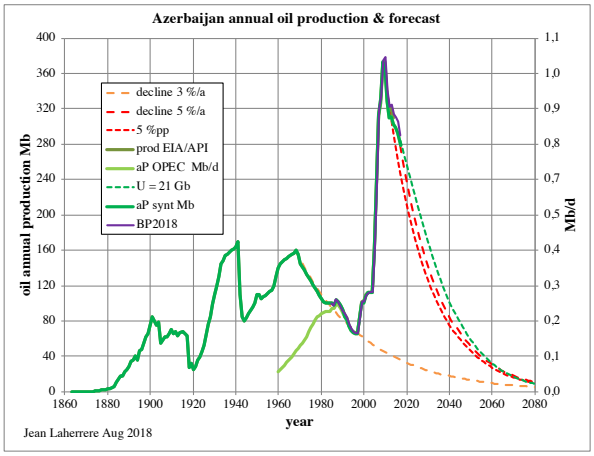


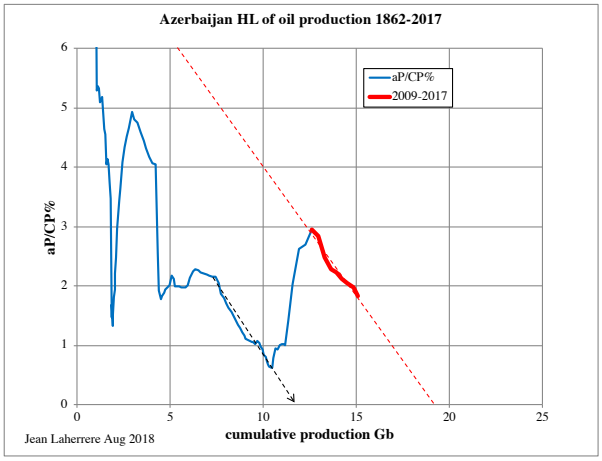
-Azerbaijan

Azerbaijan crude oil production peaked in 2009 over 1 Mb/d and to day its decline is about 5 %/a, equal to the future decline rate for an ultimate of 20 Gb, which combines HL, ABC1 creaming curve and CP+1P.

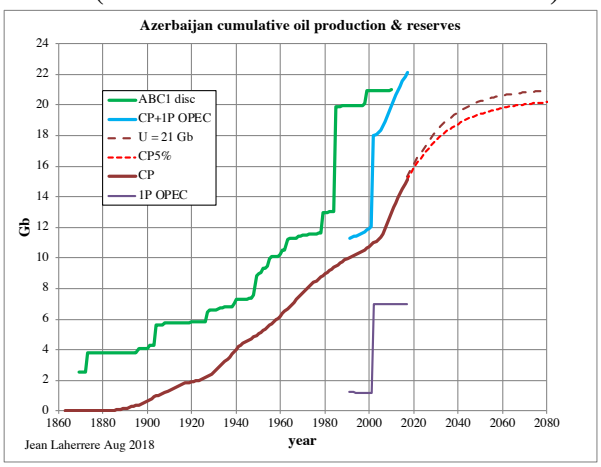
Bakou (Asheron Peninsula) is the oldest oil production area in the world, with wells drilled in the 10th century at 10-12 meters, production reported by Marco Polo in 1275. But production data is recorded only from 1863.

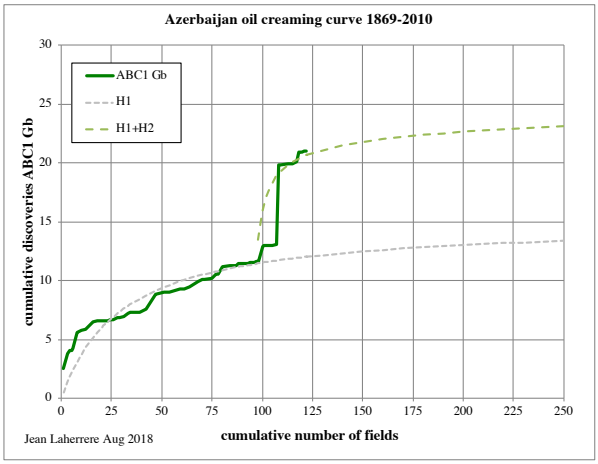
Scout companies as IHS, Rystad, report the estimates of the operator. For western oil companies reserves estimates are 2P following SPE classification , but for former Soviet Union countries, reserves are ABC1 (Khalimov classification 1979, which was stated by the same Khalimov in 1993 as grossly exaggerated: 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)
Crude oil production as reported by OPEC since 1960 is quite different before 1989 with EIA /API data, which starts from 1863
HL of crude oil production trends towards >20 Gb. But OD (oil decline aP vs CP) trends towards 22.5 Gb
As creaming curve being in the middle, the ultimate is chosen as 21 Gb, giving a futre production with a decline rate of 5 %/a



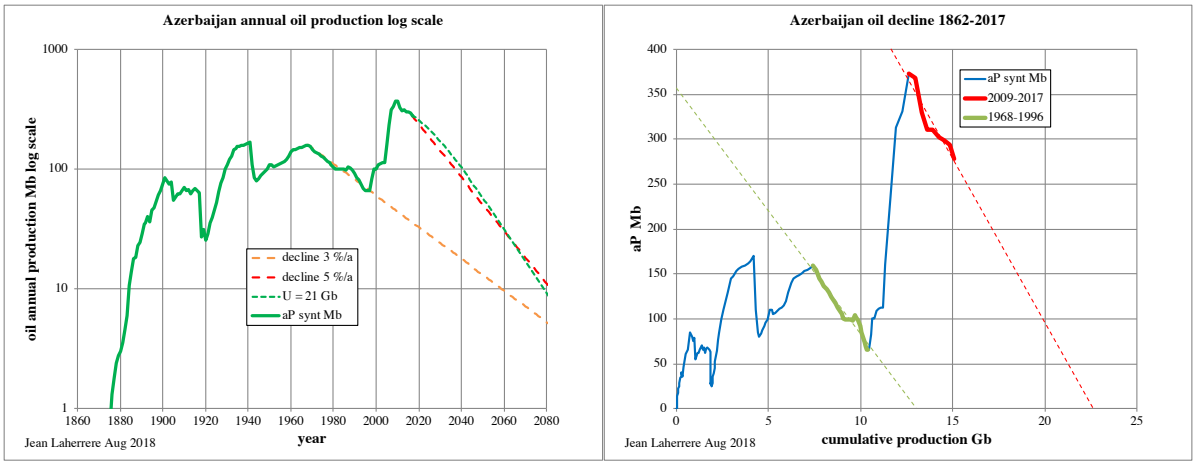


ABC1 discoveries at 2010 is over 21 Gb, but in Russia (see below) 2P are only about 70 % of ABC1. CP+1P OPEC is higher than ABC1, showing that 1P is political and useless to forecast production.
CP5% (5% decline rate from 2017 to 2100) is 20.3 Gb



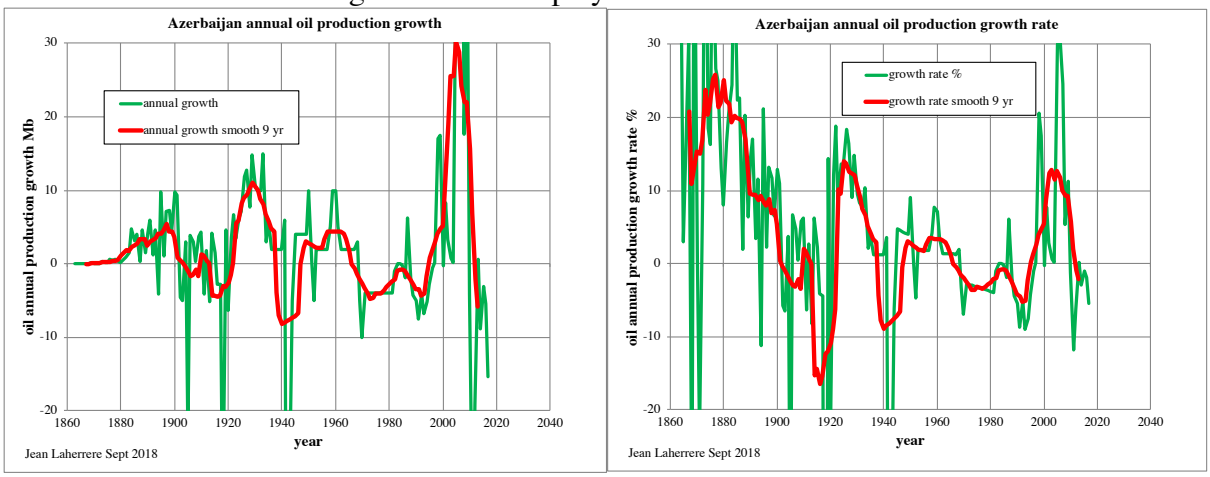


In log scale, the decline of 5 %/a fits with the decline for 21 Gb



What is interesting is to notice in the OD and the HL is the parallelism between the decline of 1968-1996 and 2009-2017

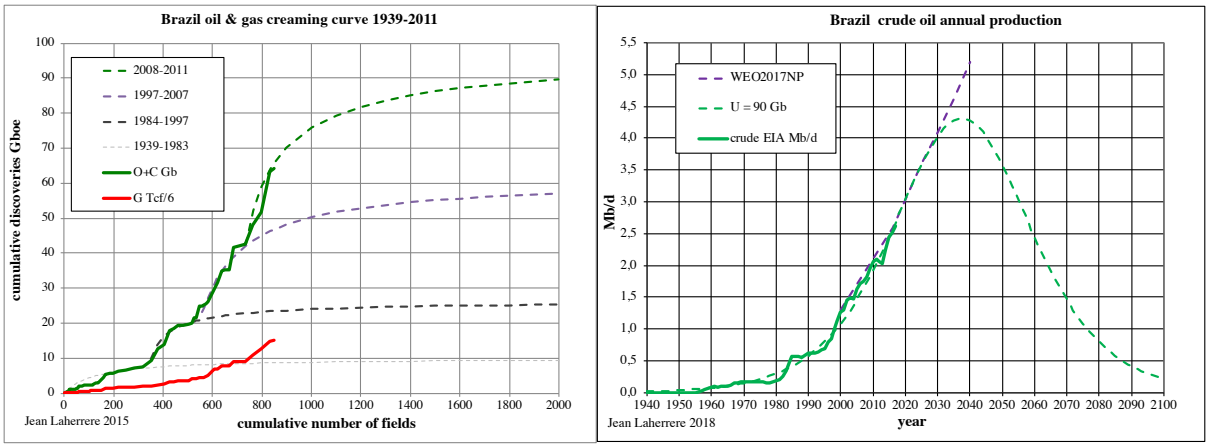
Azerbaijan crude oil production growth crossed the zero line often as there are several peaks. Growth rate in % does not give a better display



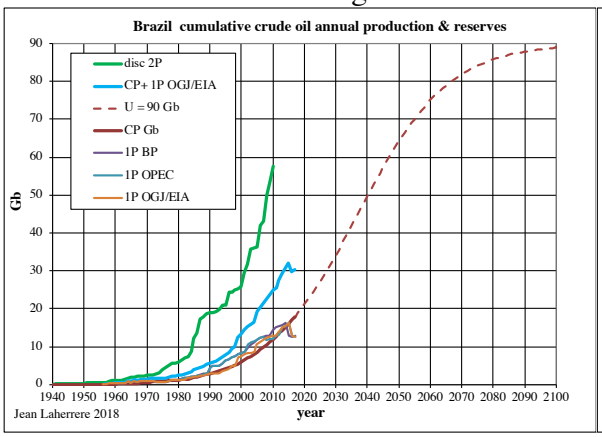
-Brazil

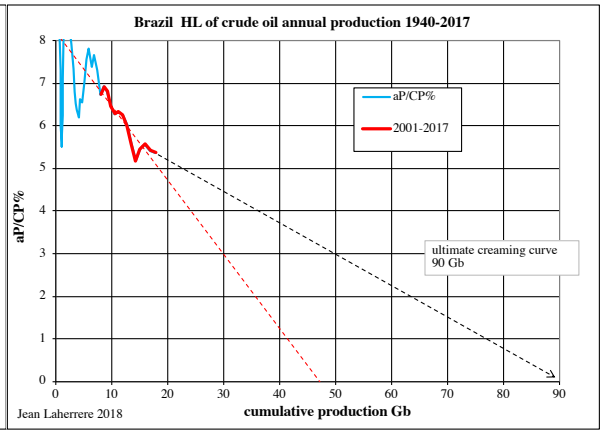
Brazil crude oil + condensate creaming curve (1940- 2010) is extrapolated towards an ultimate of 90 Gb

An Hubbert cycle fitting 90 Gb displays a almost perfect fit from 1940 to 2017: it is too good to be true!

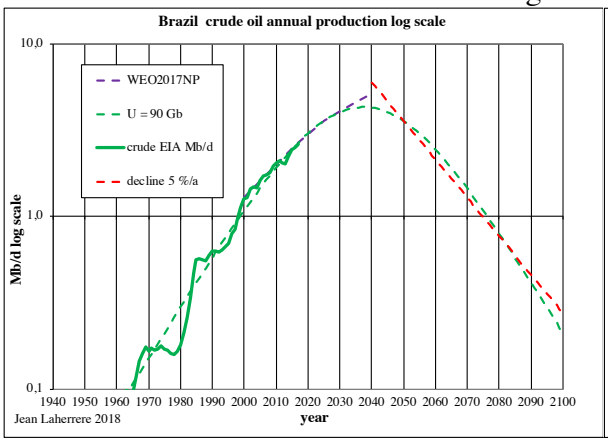


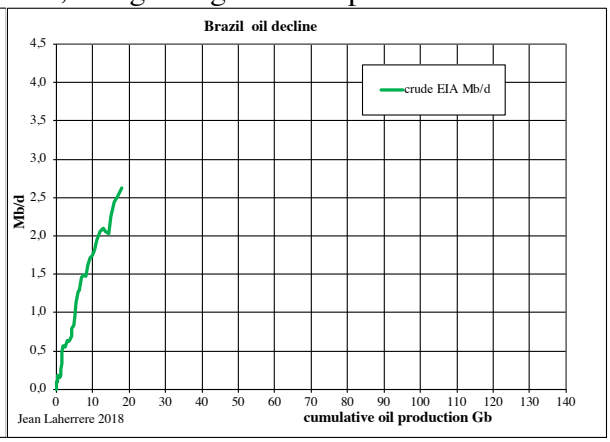
90 Gb ultimate from creaming curve looks high compared to a CP +1P of 30 Gb at end 2017 and a HL 2001-2017 extrapolation towards 50 Gb, but subsalt deeperwater discoveries are large and growing.
Brazil crude oil production will peak around 2040 at 4.3 Mb/d, when IEA/WEO2017NP forecast 5.2 Mb/d still rising!



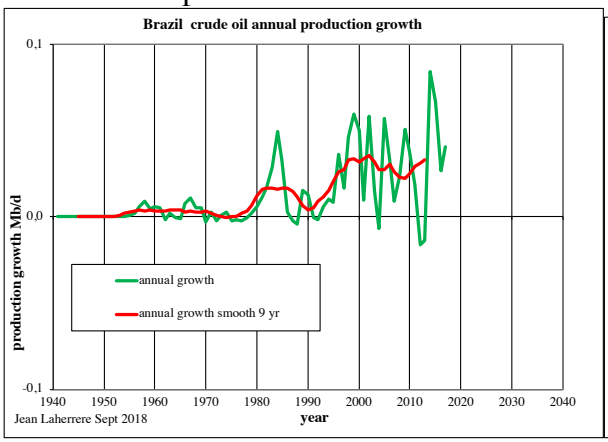


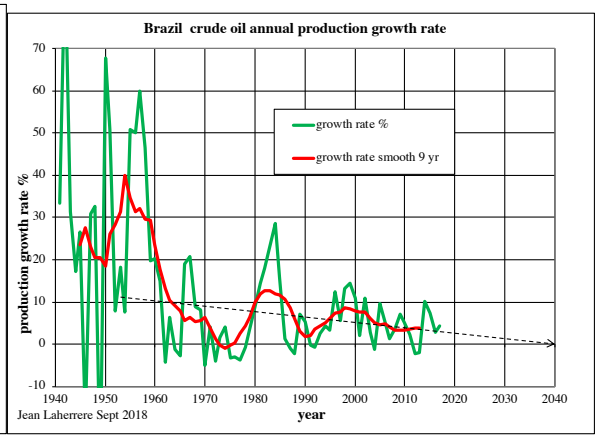
The future decline for U = 90 Gb is after 2050 close to 5 %/a
Present oil decline is useless to estimating ultimate, being rising far from peak.





Brazil annual crude oil production growth is unable to forecast the peak time. For growth rate in % the extrapolation towards 2040 looks fair.

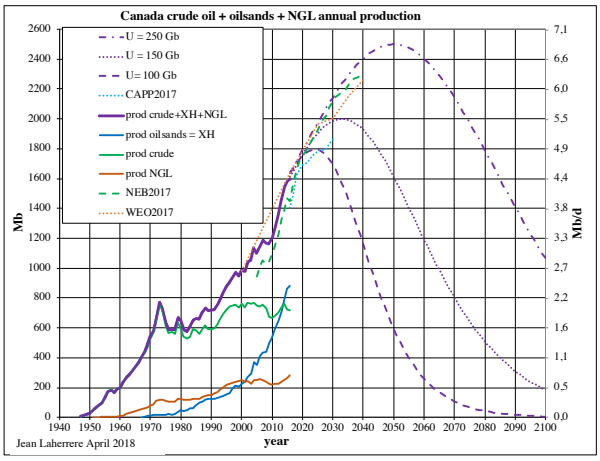


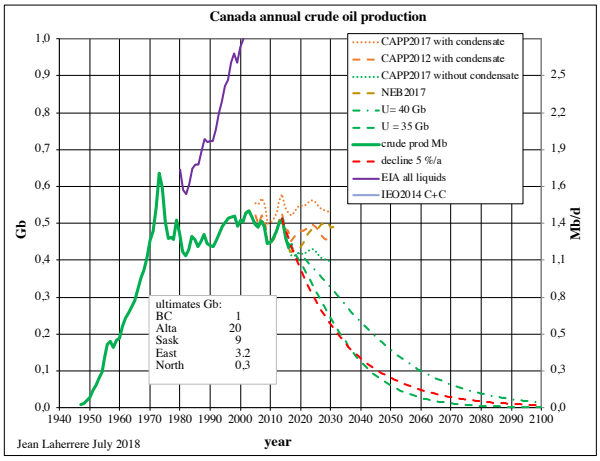


-Canada

The problem of Canada oil production is that the range of ultimate estimates varies widely (100 to 250 Gb) because the oilsands (mining and in situ) reserves are huge but constrained

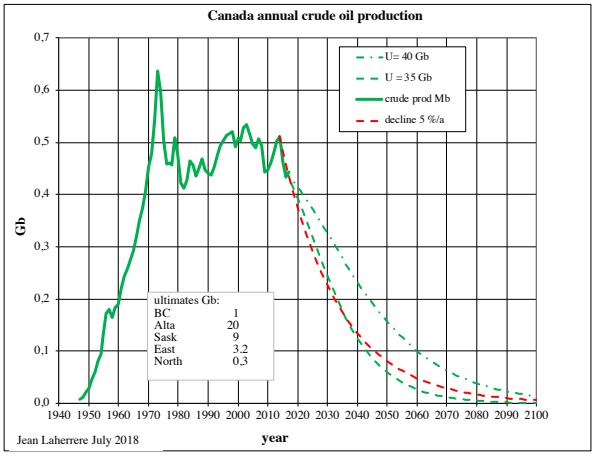
by economy, politics, pollution and pipelines. Crude oil ultimate is about 40 Gb (HL), when oilsands ultimate about 100-250 Gb.

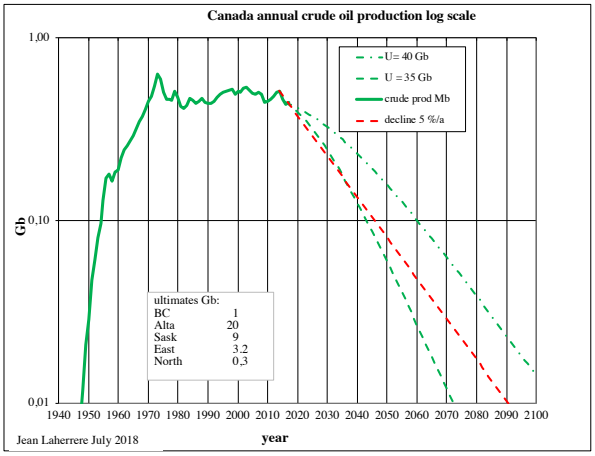




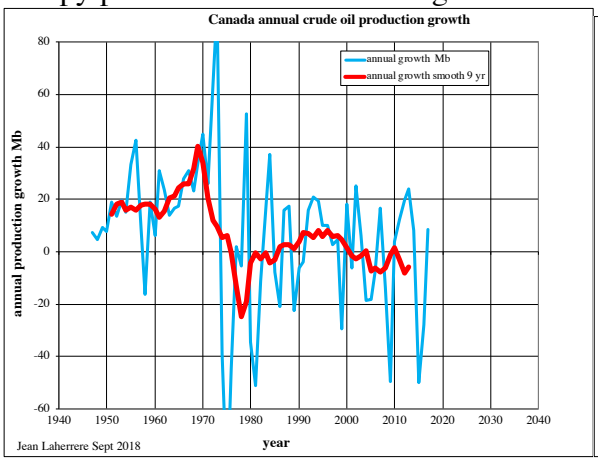
The current crude oil established discoveries display a linear trend since 1980, when backdated discoveries trends towards 35 Gb.

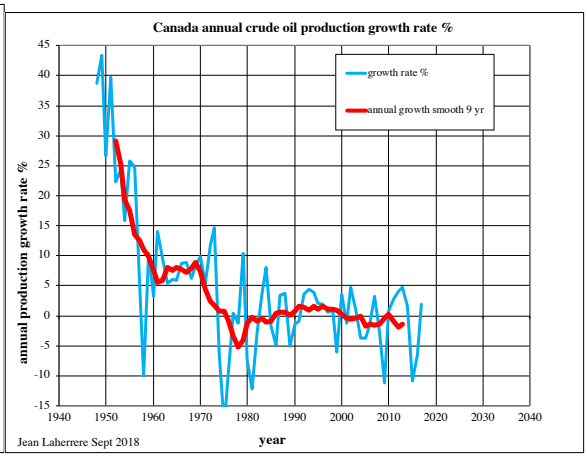
Canada crude oil is declining since the minor peak of 2014 at a decline rate of 5 %/a for the ultimate of 35 Gb.



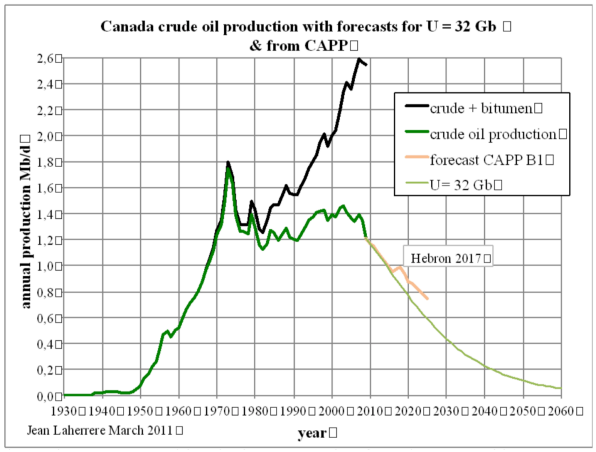


Canada crude oil production growth stays around zero since 1975, as the production is on bumpy plateau. It is the same for growth rate in %.

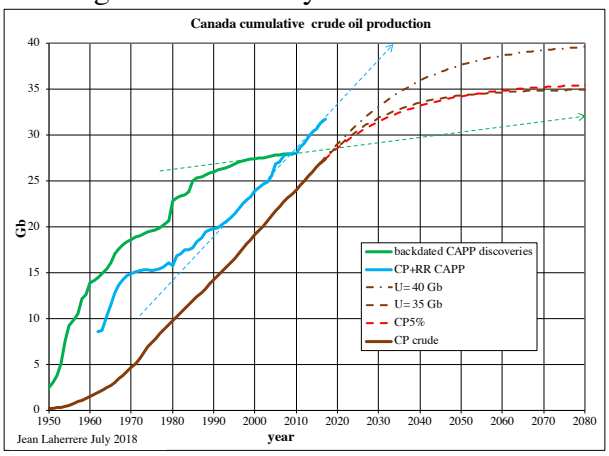


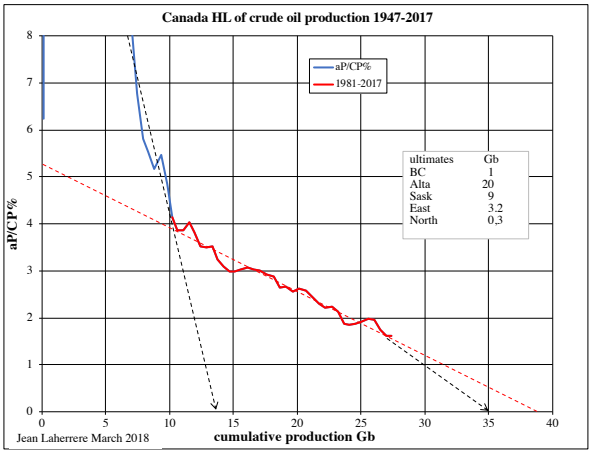


My forecast in 2011: -Laherrère J.H. 2011 «Backdating is the key » ASPO 9 Brussels 27 April http://www.aspo9.be/assets/ASPO9_Wed_27_April_Laherrere.pdf
http://aspofrance.viabloga.com/files/JL_ASPO2011.pdf

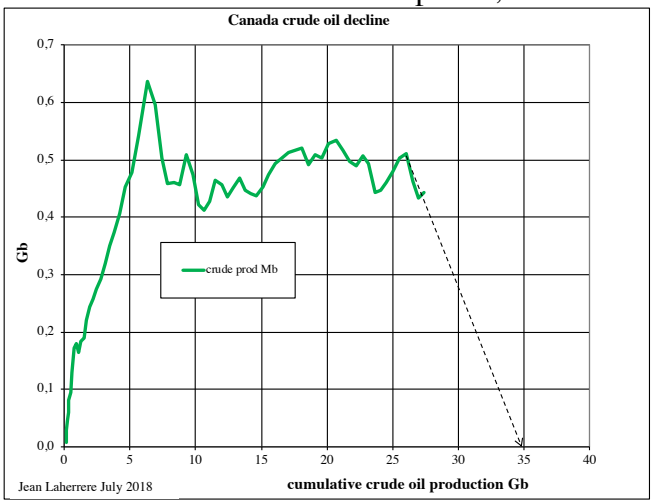


CAPP stopped reporting backdated discoveries in 2010 (were they displaying a too pessimitic view: see my paper -Laherrère J.H. 2011 «Backdating is the key » ASPO 9 Brussels 27 April http://www.aspo9.be/assets/ASPO9_Wed_27_April_Laherrere.pdf http://aspofrance.viabloga.com/files/JL_ASPO2011.pdf?)!
The backdated disocveries (green) is trending towards 35 Gb when the current CP+RR is trending towards the sky!

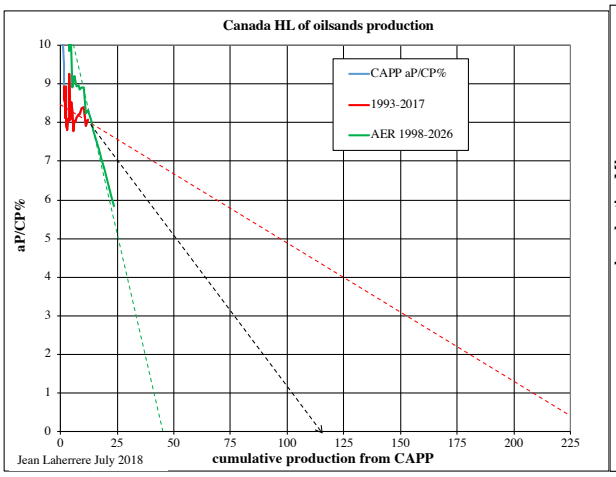


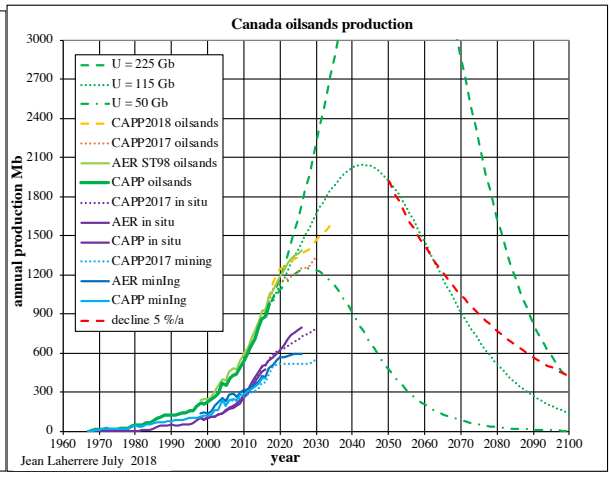


OD for crude oil is hard to extrapolate, 35 Gb could be possible, HL is more reliable



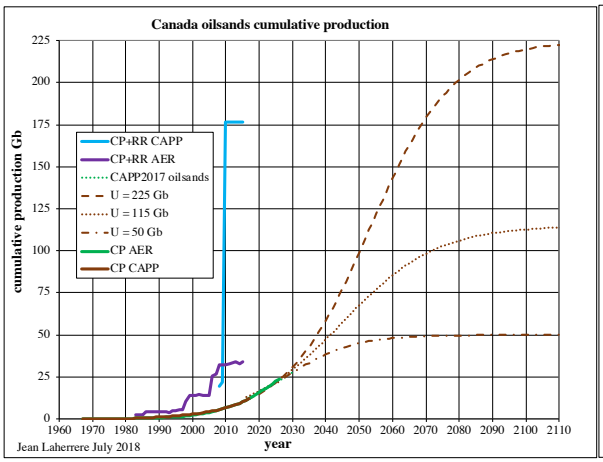
HL of oilsands production trends towards over 200 Gb but the series is too short when the forecast of Alberta AER tends towards 50 Gb
Canada oilsands is modelled with 50, 175 & 225 Gb

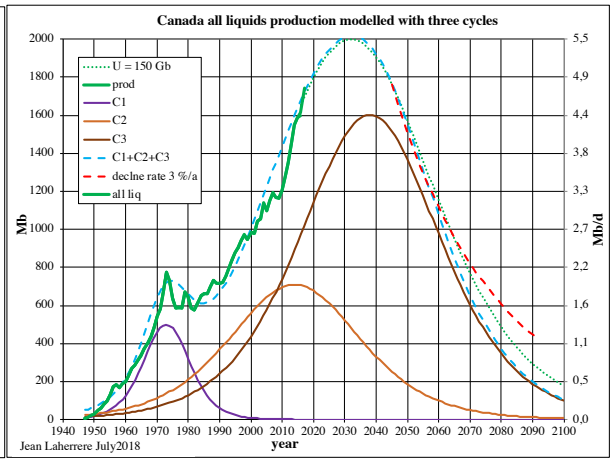




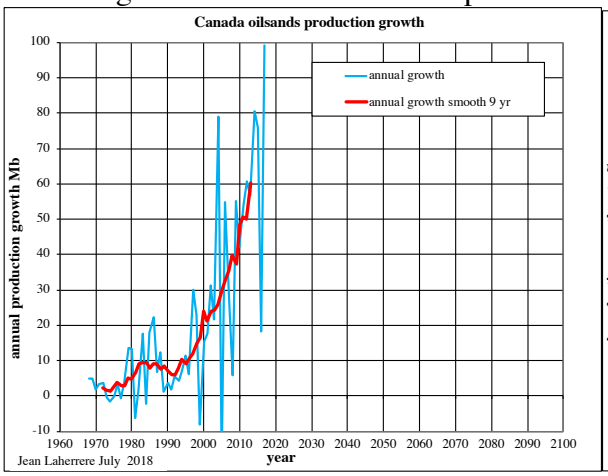
CAPP 2018 is more optimistic for oil sands future production than CAPP 2017, but Alberta AER reports smaller oilsands reserves

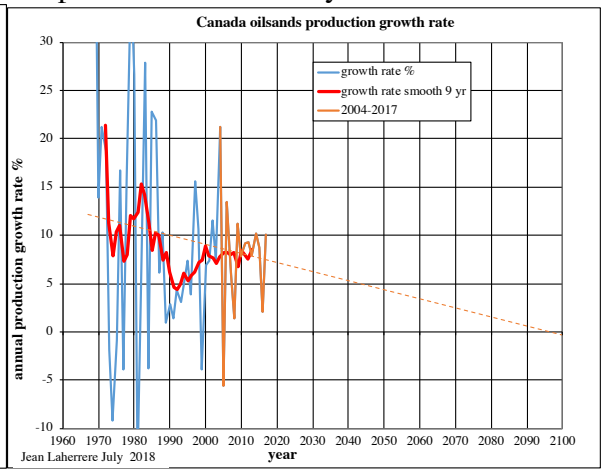
It is possible to model Canada all liquids (including NGL and refinery gain) with three cycle for an ultimate of 150 Gb





Canada oilsands production growth is on the rise and useless to forecast the peak. The oilsands growth in % could be extrapolated on the period 2001-2017 beyond 2100?



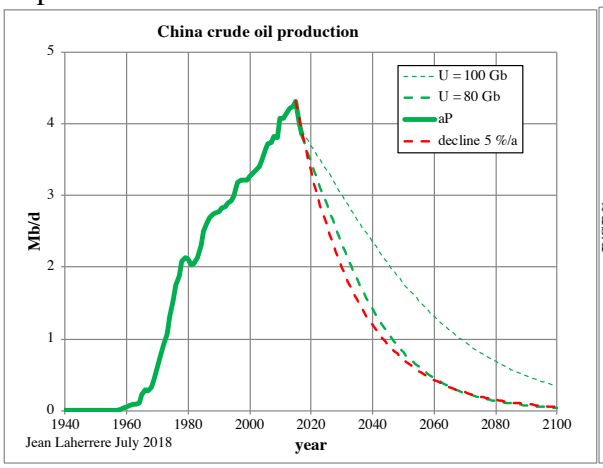


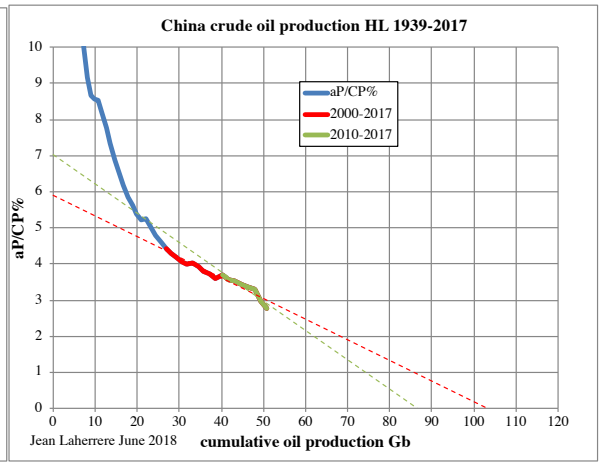
-China

China crude oil production has peaked in 2015 at 4.3 Mb/d, its present decline will continue for an ultimate between 80 Gb (rate of 5%/a) and 100 Gb.

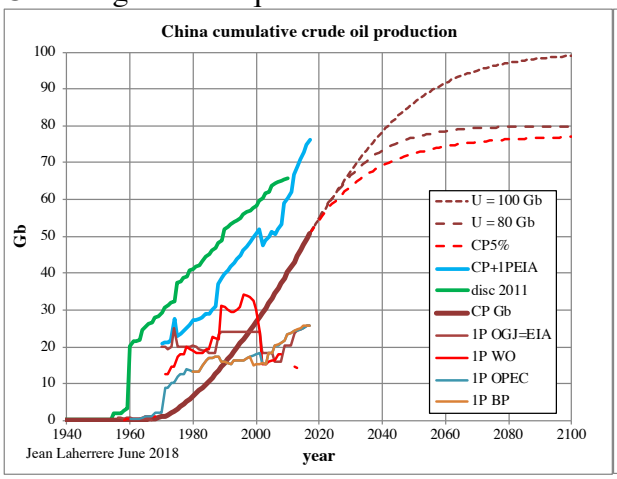
In 2040, production for U = 80 Gb will be about 1.5 Mb/d, equal to 1975 oil production!

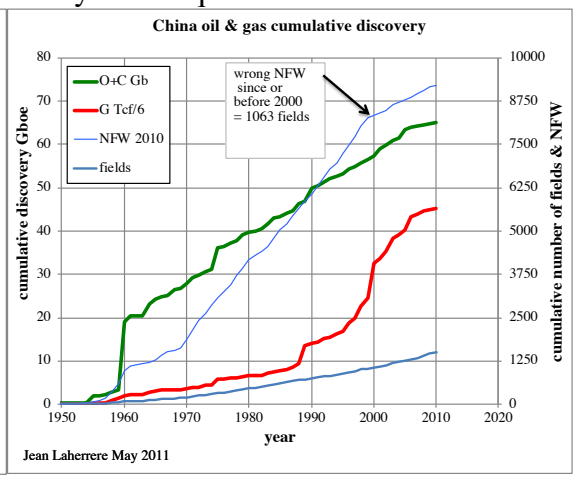
With oil production declining at 5% and GDP rising at more than 5% China will need to import a lot of oil!



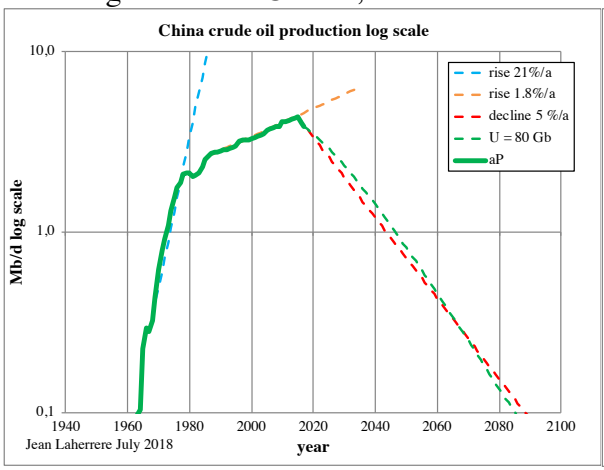


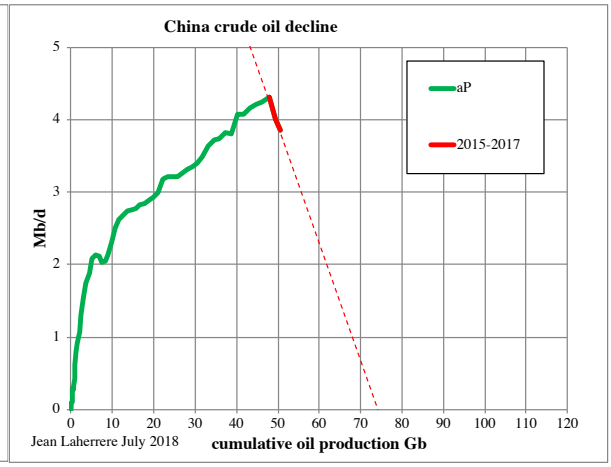
HL of past production is curved below 10 % and the last two years are fuzzy!
The range 80-100 Gb is possible for ultimate. 90 Gb is reported in our last gathering table.
Creaming curve is questionable because the discovery data is questionable.





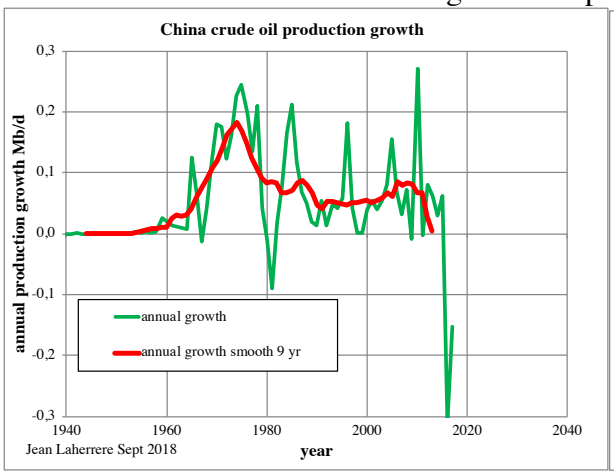
The aP log scale shows that China has only three rates of growth and decline: 1967-1979 rise 21 %:a, 1986-2015 rise 1.8 %/a, 2015-2080 decline 5%/a
OD (2015-2017) trends towards 75 Gb, not too reliable for this short period, but in line with creaming curve and CP+1P, and in fact closer than HL of our chosen ultimate of 80 Gb

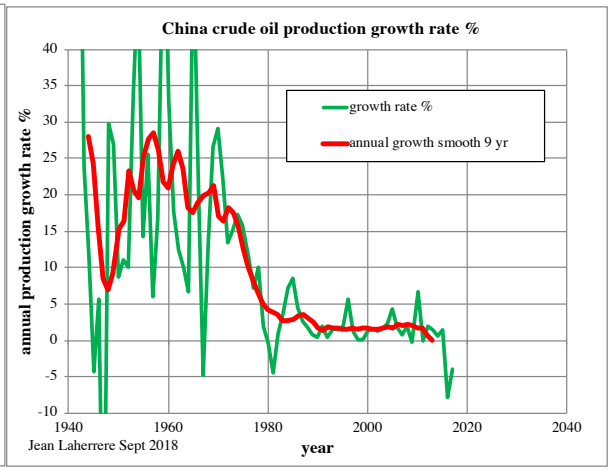




China crude oil production growth shows a sharp decline crossing the zero line in 2015. The 9 yr smooth curve is disturbed being at the end .

Growth rate in % looks better being close to peak.



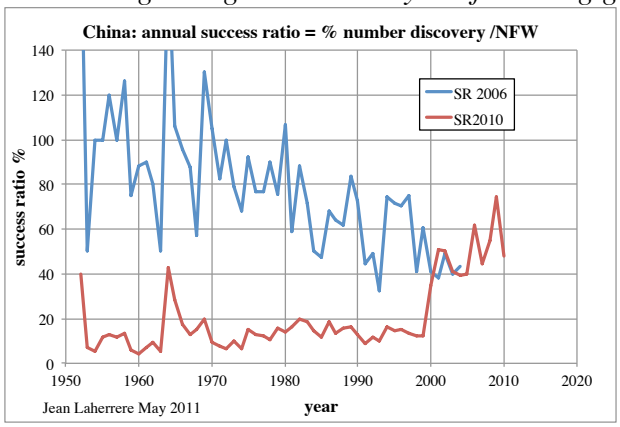


China data looks very unreliable from this discussion with the University of Beijing
-Laherrère J.H. 2008 «More questions to Feng Lianyoung on China's forecasts- 11 May 2008"
http://aspofrance.viabloga.com/texts/documents
-Laherrère J.H. 2008 « Questions to Feng Lianyoung on China's forecasts- 22 Jan 2008
http://aspofrance.viabloga.com/texts/documents

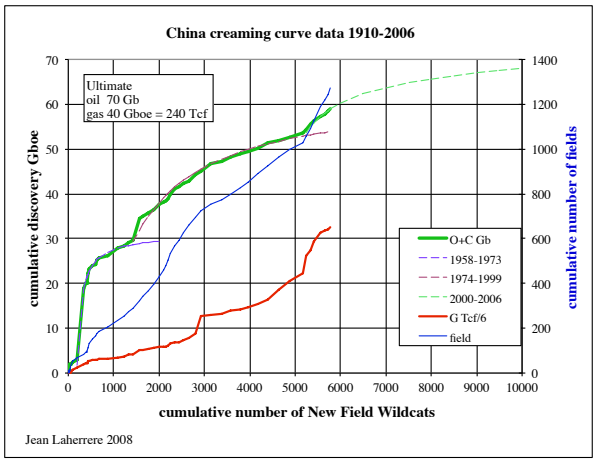
Jean Laherrere *26 November 2012*

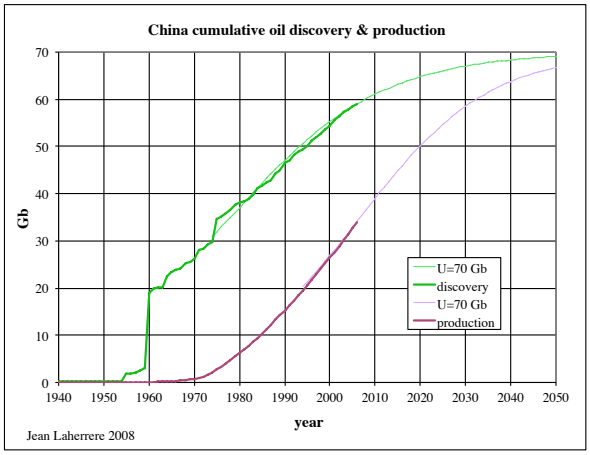
China creaming curve

The creaming curve cumulative discovery versus cumulative number of NFW is the best way but China NFW are a mess, been drastically changed in 2010
It was a big change as shown by the following graph on success ratio

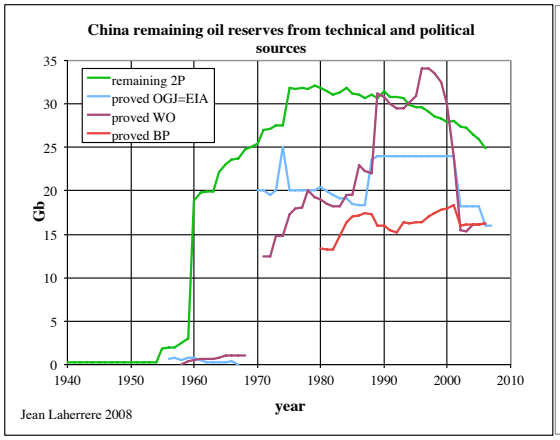


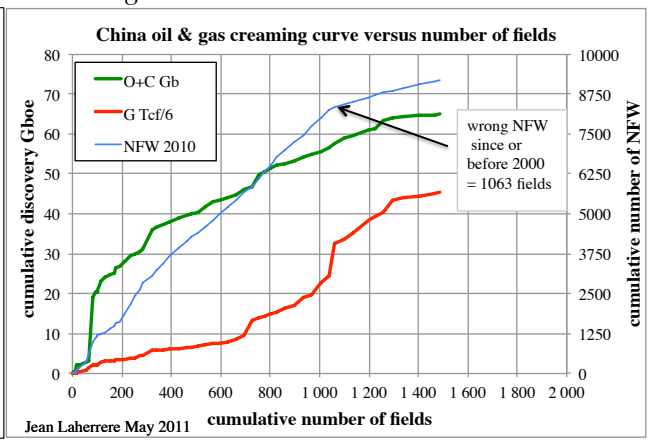
Corrected NFW before 2000 are completely changed, but still wrong after 2000
It was obvious that IHS was correcting older values which were unrealistic (SR over 100%) and I was waiting to have it corrected from 2000 up to 2010
But I learned that the IHS employee a Chinese born American was in jailed for 8 years for spying
It means that NFW in China are wrong since 2000 and it is unlikely that they will be corrected
It is why I use creaming curve against the cumulative number of fields
creaming in 2008

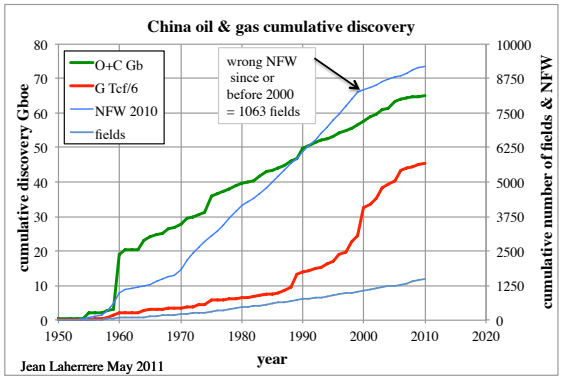




creaming in 2011







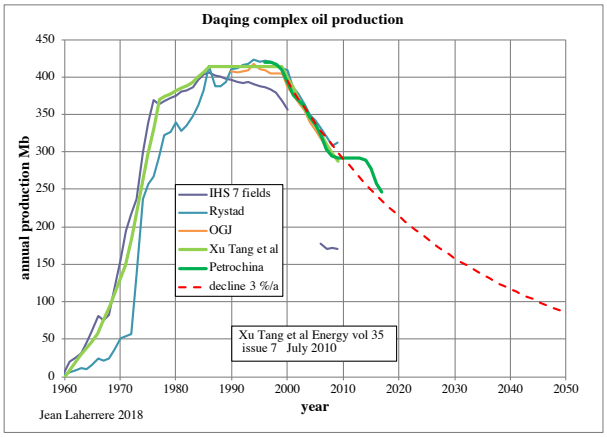
Ultimates can be estimated as 80 Gb for oil and 350 Tcf for gas
Big unknown on shale gas, but I have doubts on Tarim.

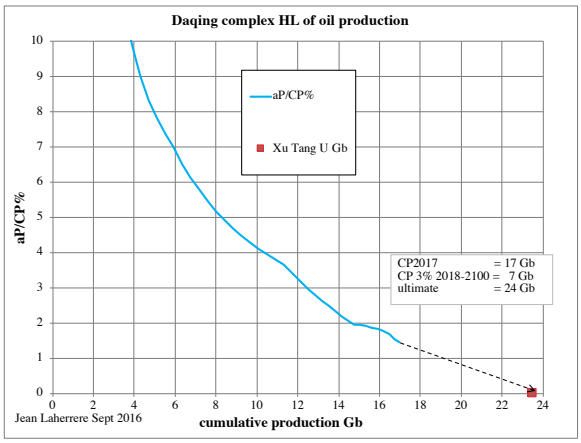
https://en.wikipedia.org/wiki/Xue_Feng
Xue Feng a naturalized American citizen, is a geologist who worked for IHS Inc. and was sentenced to 8 years of prison by Chinese authorities for espionage.
Xue, a Chinese-born US citizen, was first detained in November 2007 over the sale of a database on China's oil industry while working for US energy and engineering consulting firm IHS. Both Xue and IHS had said in the past that they believed the database to be a commercially available product. It was only classified as a state secret after Xue had bought it, according to Dui Hua. He was released in 2015.

-Daqing complex

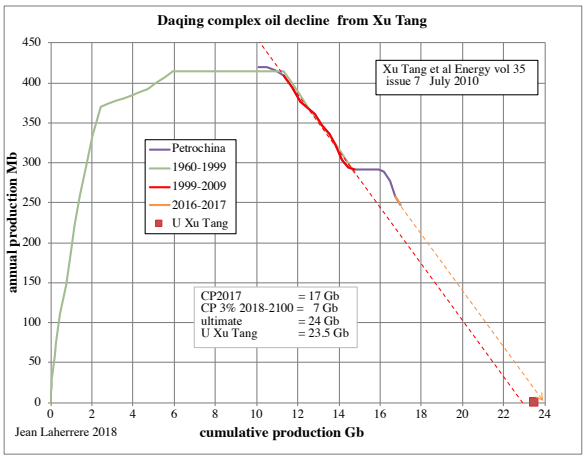
Daqing complex is the largest Chinese oilfield, gathering several fields. Daqing has peaked in 1995 and its present decline since 2000 is about 3 %/a.

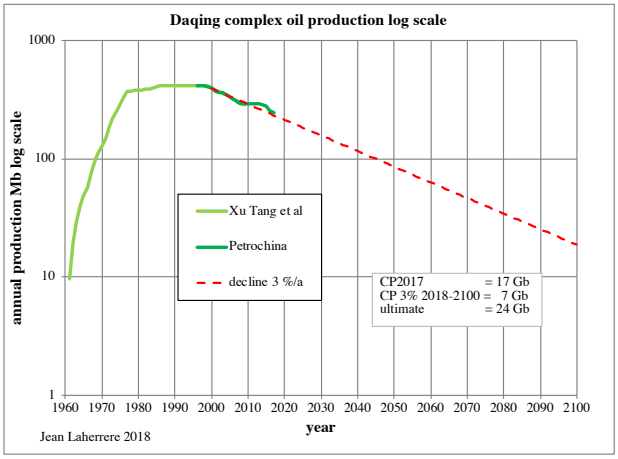
HL below 10% is obviously curved and its extrapolation towards 24 Gb looks reliable. Xu Tang 's ultimate is 23.5 Gb and the extrapolation with a decline rate of 3 %/a. is 24 Gb.





OD for 1999-2009 trends towards 23 Gb but last decline 2013-2017 trends towards 24 Gb

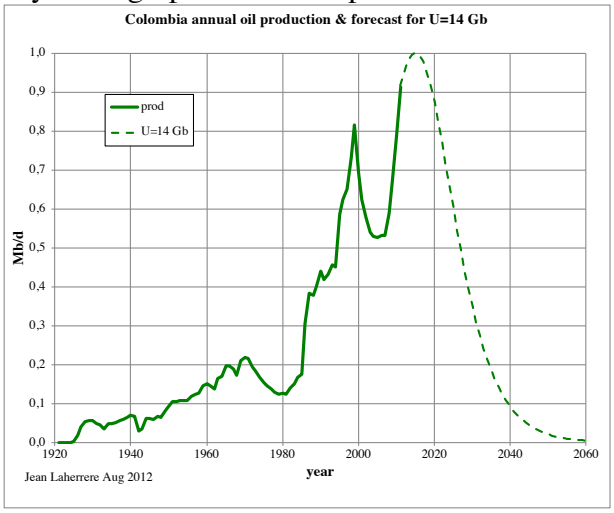




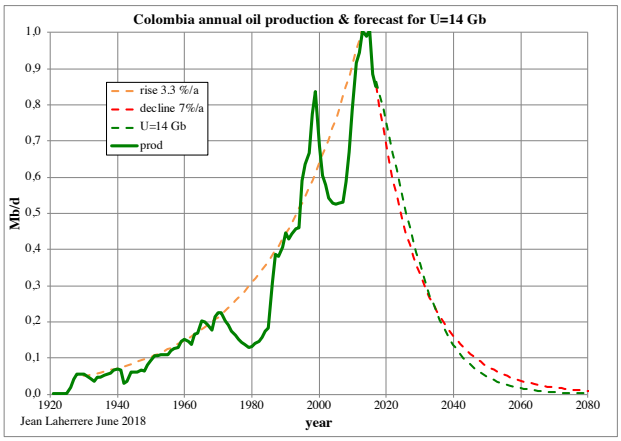
-Colombia

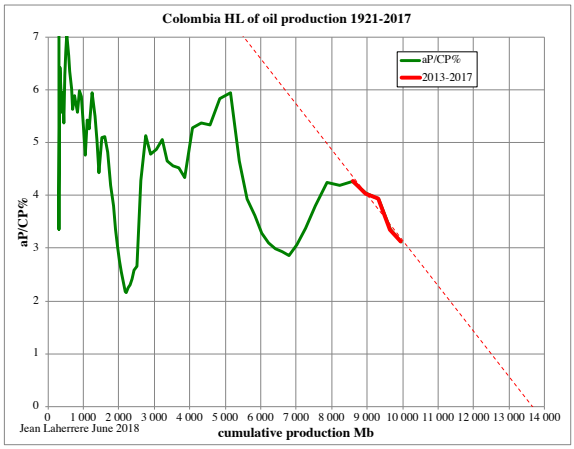
Colombia oil production was disturbed by the domestic war with the FARC.

My 2012 graph forecasted peak around 2015 for an ultimate of 14 Gb

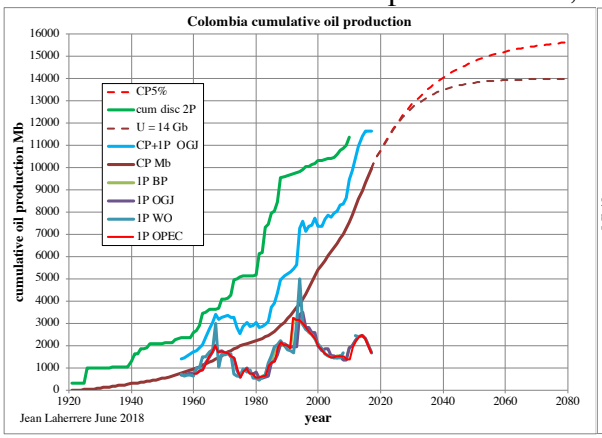


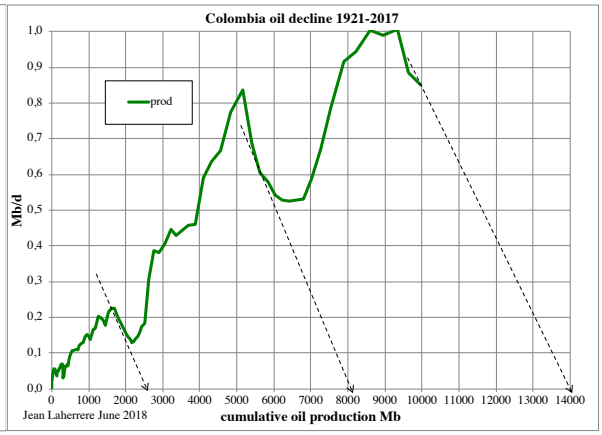
Colombia peak occurs in time and value as forecasted in 2012, the 14 Gb ultimate is confirmed by HL & creaming curve & oil decline. The production increased with a rise of 3.3 %/a from 1930 to 2013 and the decline from 2015 to 2080 at 7 %/a.

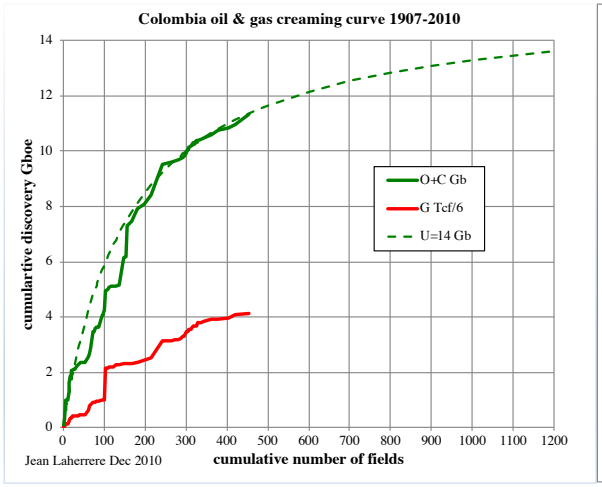


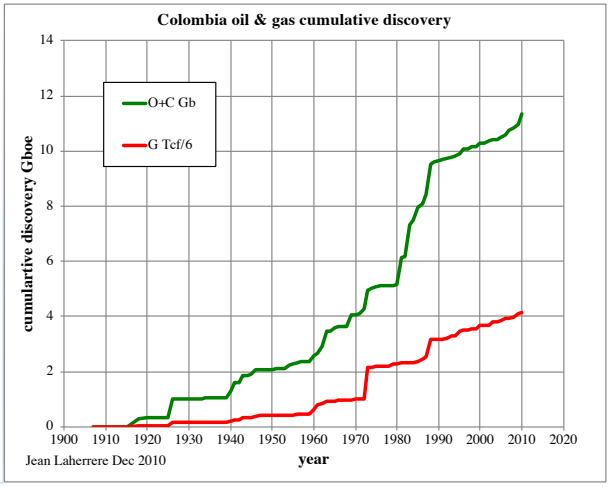


OD (2014-2017) trends towards 14 Gb, like HL, but it is interesting to notice the parallelism of the declines from the three peaks of 1971,1999 and 2015



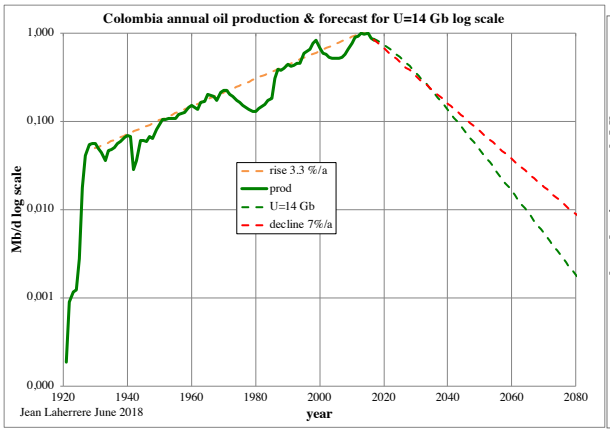


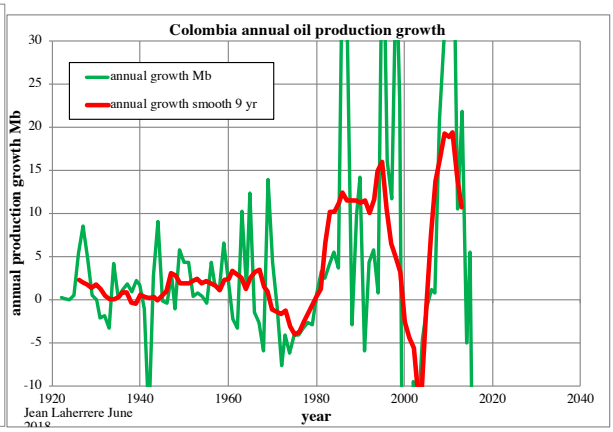


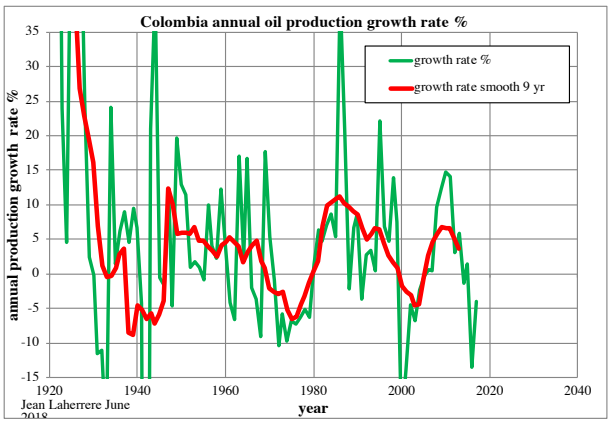


The decline for the ultimate of 14 Gb is about 7 %/a for 2018 to 2040, when the rise was 3.5 %/a from 1930 to 2016.

Colombia production growth crossed the zero line in 1999 and 2015, rather chaotic as the growth rate in %.

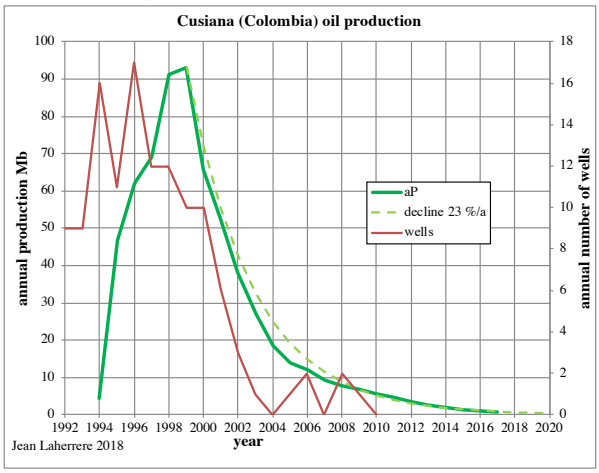


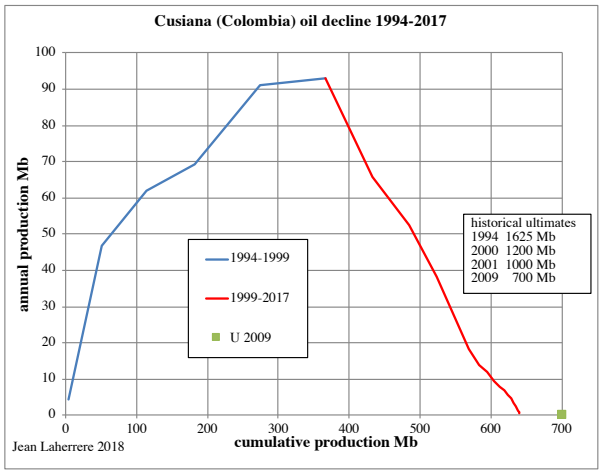




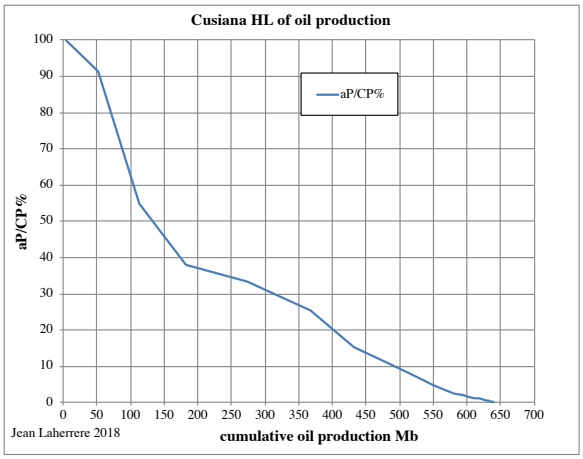
-Cusiana

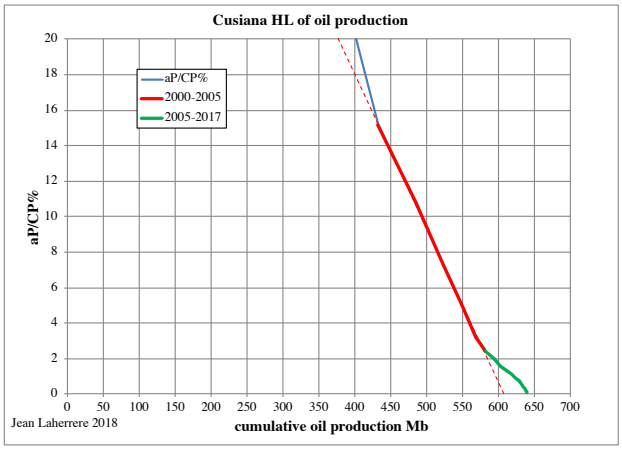
Cusiana oil field is a good example because the evolution of 2P reserves was wild, from 1625 Mb in 1994 to 700 Mb in 2009 as the field is almost depleted with 640 Mb.
Oil production peaked in 1999 at 255 000 b/d.
The annual oil production versus cumulative (oil decline = OD) is almost linear for the period 1999-2017, when HL is crooked at the end



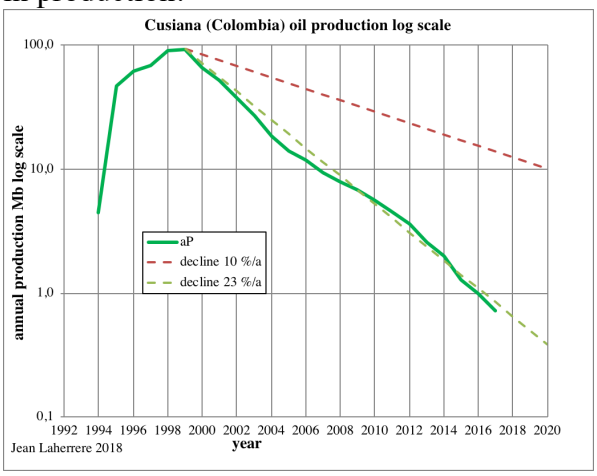


The annual oil production, which peaked in 1999 is well modeled up to 2017 with a sharp decline of 23 %/a
The whole HL is chaotic, but the period 2000-2005 trends towards 610 Mb too short.





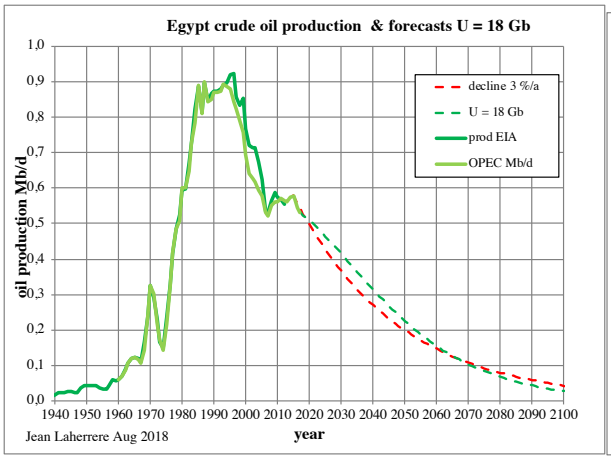
The plot aP log scale versus time can be fitted from 1999 to 2017 with an annual decline of 23 %. This large oil decline rate is unusual, compared to the world average 5 %/a of giants: it can be explained by overestimated initial reserves (122 wells from 1992 to 2010) and by the civil war with the FARC (the discovery well had its generator dynamited by the FARC when drilling). Cusiana is an example of reserve collapse (first estimate was 2.5 times the real value) and production capacity was taken too wide (too many wells), causing a sharp decline in production.

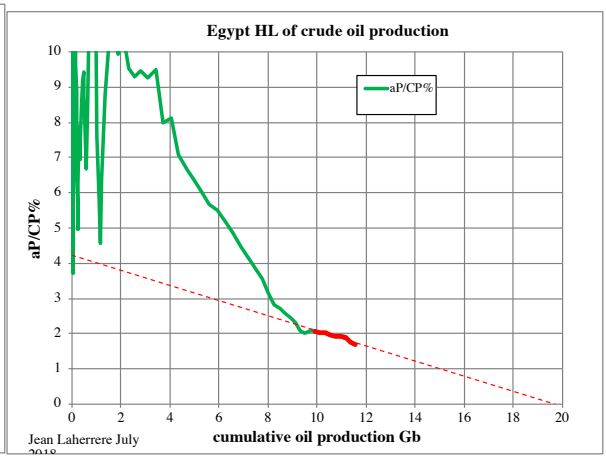


I was involved in the reserve estimate and the discovery of Cusiana :see my 2007 paper http://aspofrance.viabloga.com/files/JL_Sophia17oct07.pdf

-Egypt

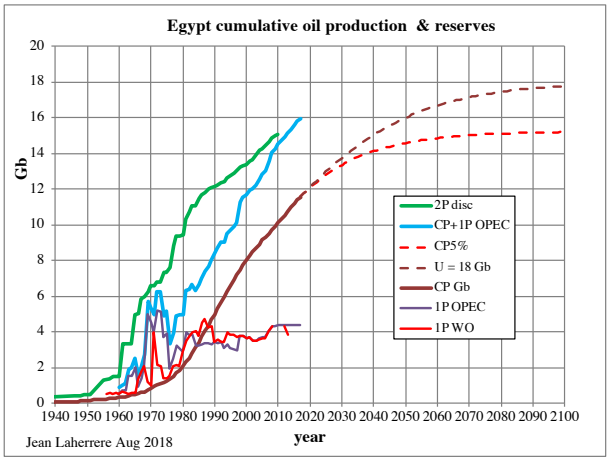
Egypt crude oil production has peaked in 1996 above 0.9 Mb/d and presently declining and will continue to do so for an ultimate of 19 Gb, as estimated by HL.

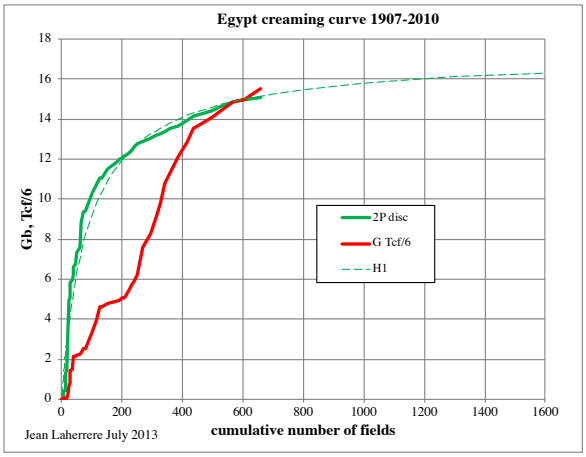




The creaming curve (1907-2010) is a perfect hyperbola for crude oil, but trending for less than HL

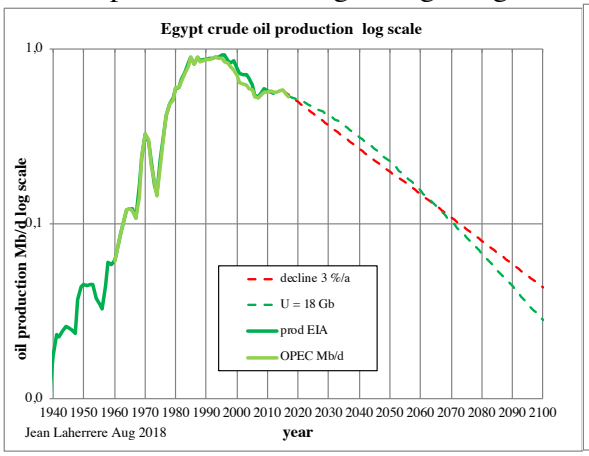
But Egypt has discovered large gasfields in the Mediterranean Sea and it will be a large volume of NGL. CP +1P OPEC are 16 Gb at end 2017

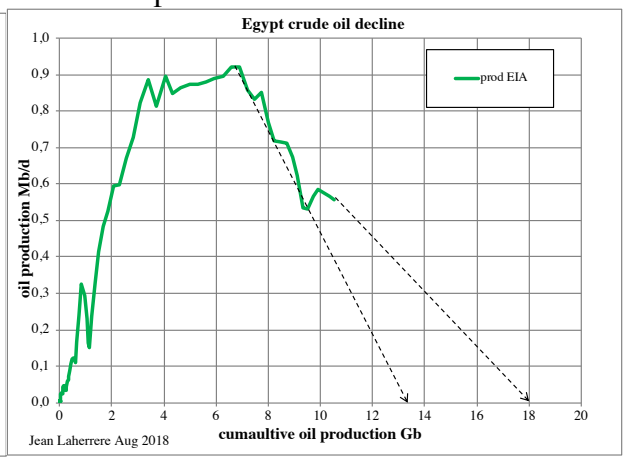




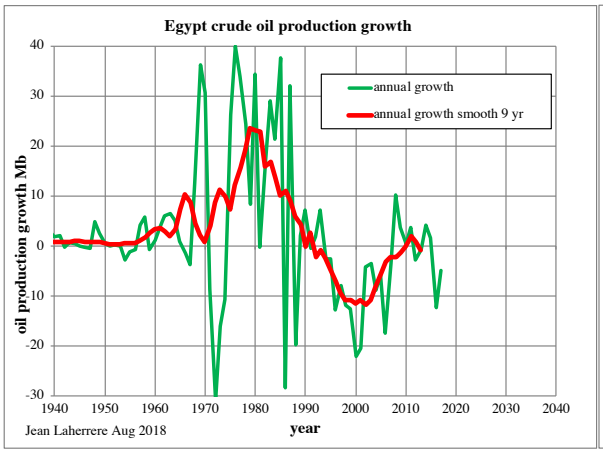
The plot of aP scale log versus time shows that the decline for U = 18 Gb has a decline rate of 3 %/a for the period 2015-2050

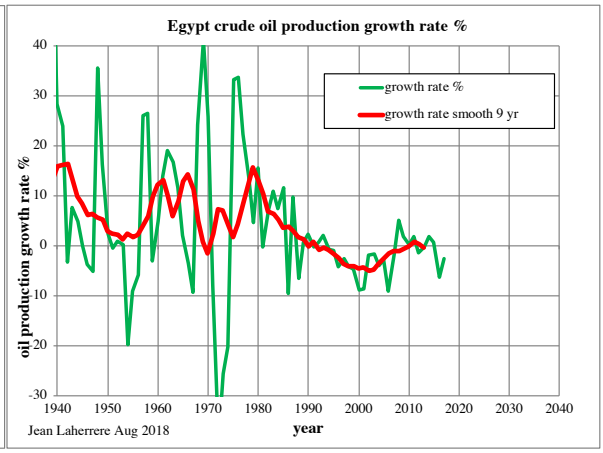
OD last points are not long enough to get a reliable extrapolation





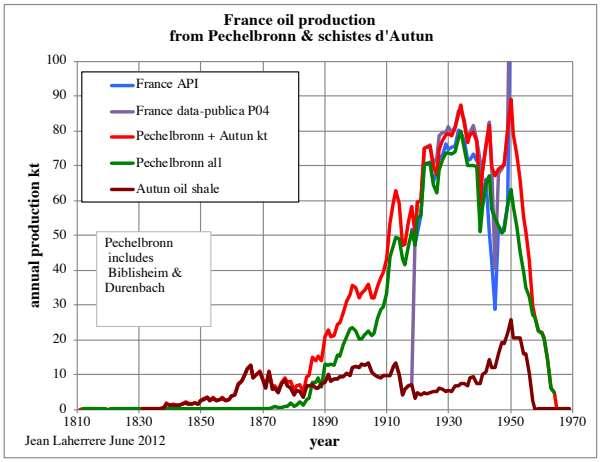
Egypt annual crude oil production growth displays a straight decline for the period 1980-2000 on the 9yr smooth curve. Growth rate in % is not better.

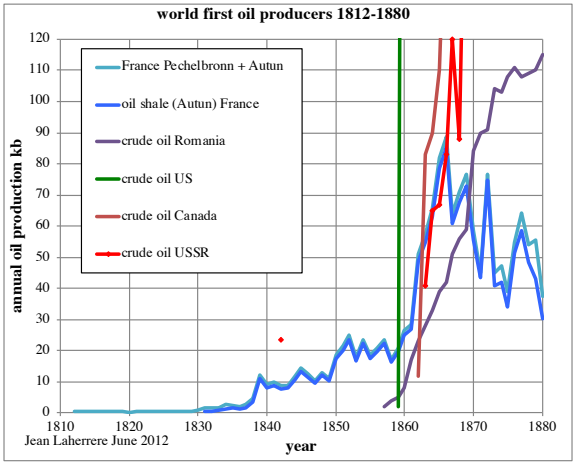




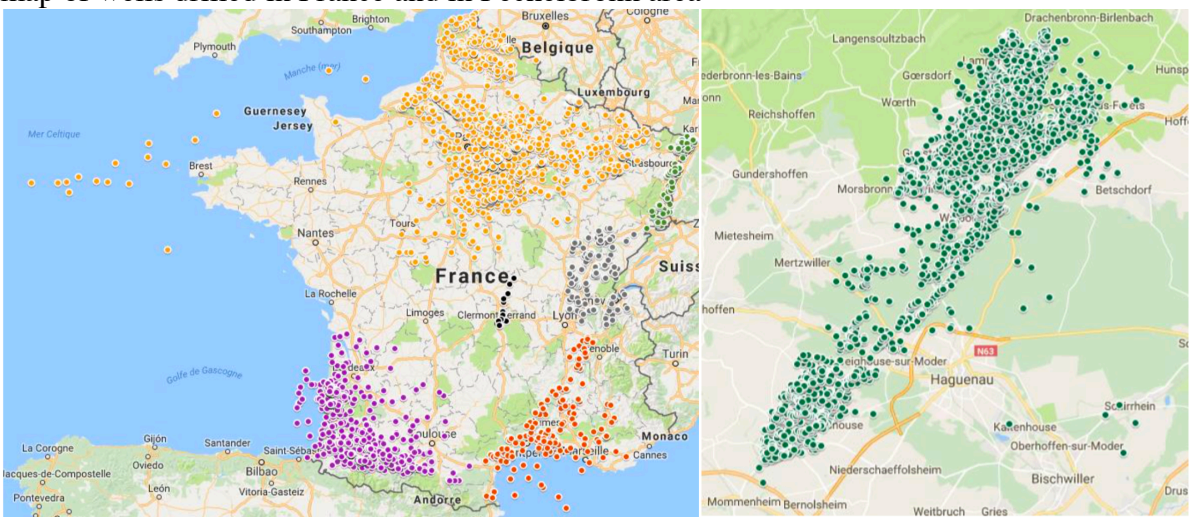
-France

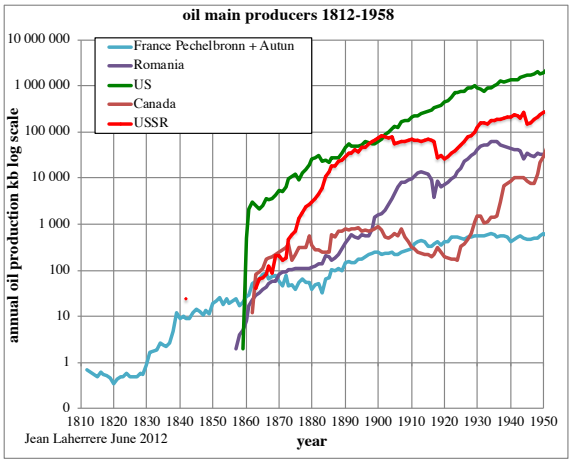
France produced shale oil with “Schiste d’Autun” since 1811 to 1969 and oilsands with Pechelbronn since 1831. Up to 1859, France was the world largest reported oil producer. Baku was producing more but there is no continuous historical data .

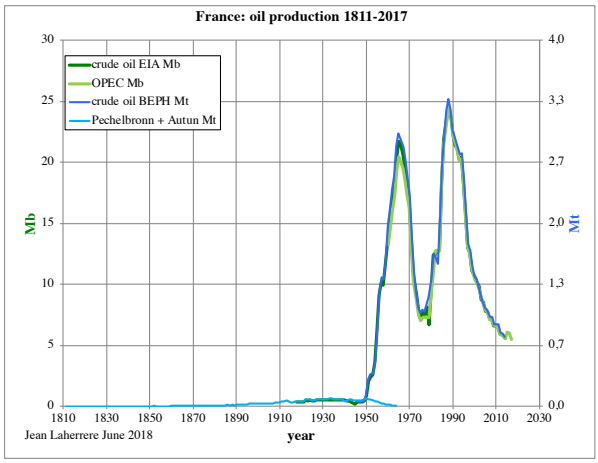




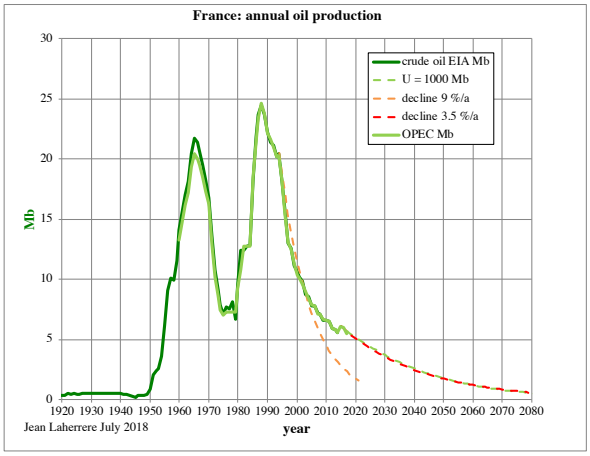
France has been thoroughly explored (>12 000 wells), onshore as offshore, as shown by the map of wells drilled in France and in Pechelbronn area

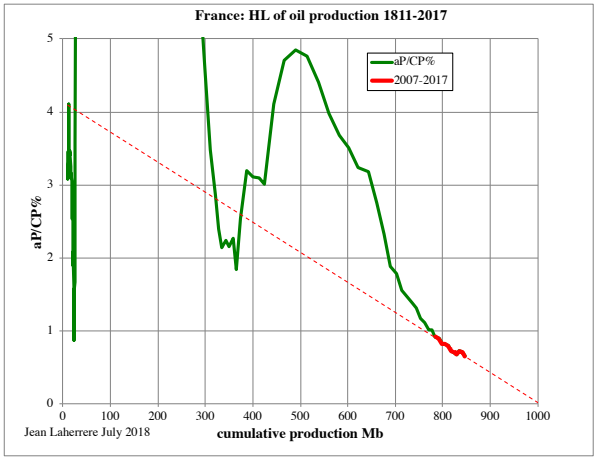




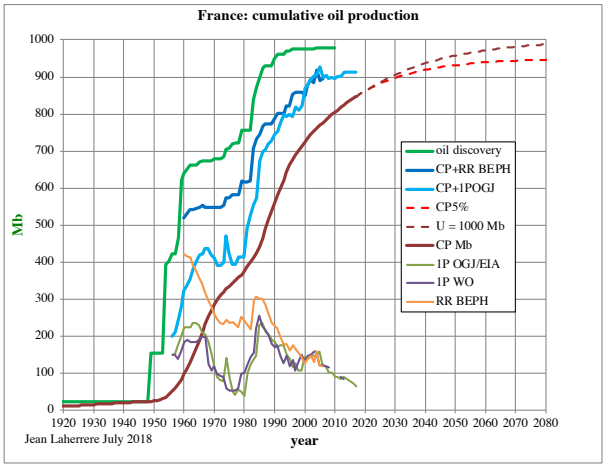


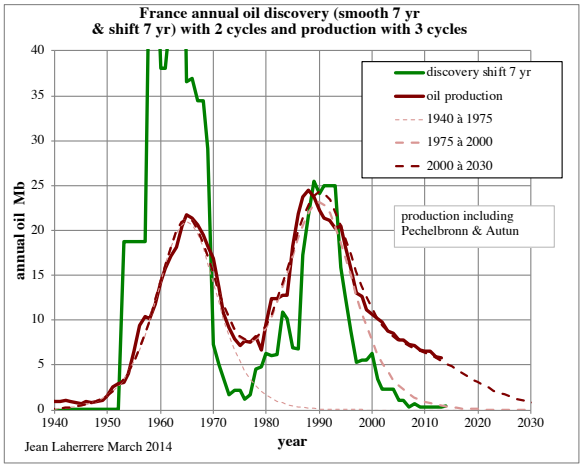
France crude oil production has peaked in 1966 and 1989 (two peaks in production because two peaks in discovery.
Hl of past production trends towards 1 Gb, as the creaming curve from 20 as also CP +1P OGJ
The decline rate of future production for an ultimate of 1 Gb fits perfectly with a decline rate of 3.5 %/a for the period 2015-2060



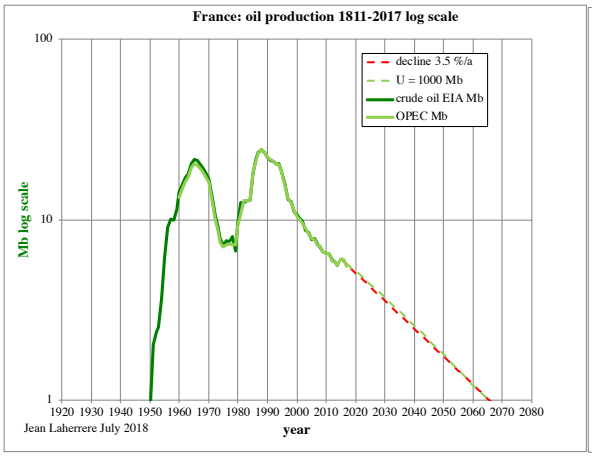


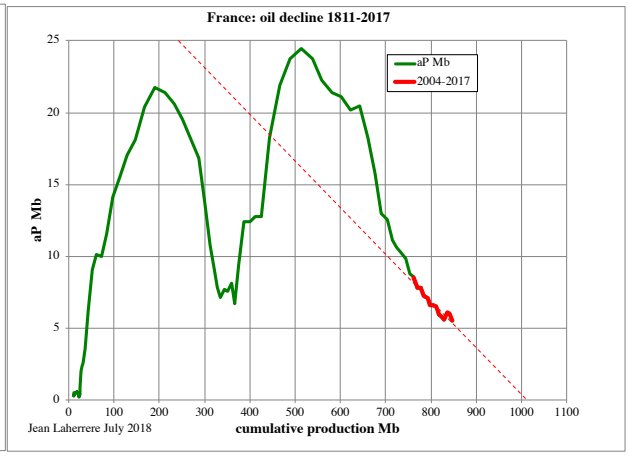
Forecast in 2014



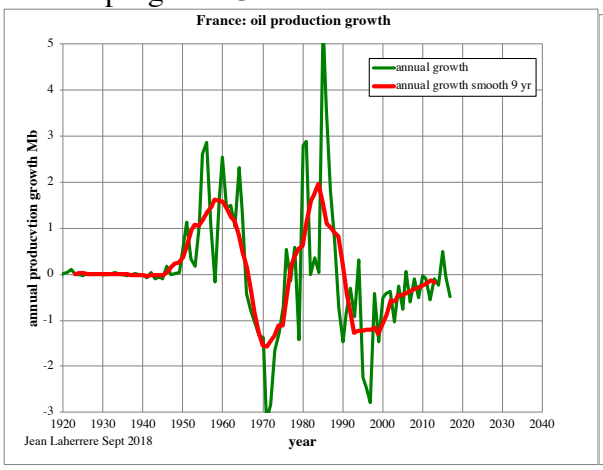


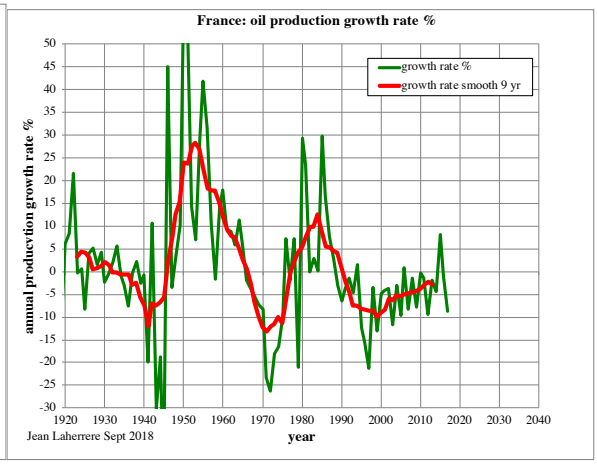
OD for the period 2004-2017 is extrapolated towards 1010 Mb, a little higher than HL





France crude oil production growth displays a two cycles plot for 9yr smooth curve with one third in progress. Growth rate in % looks similar.

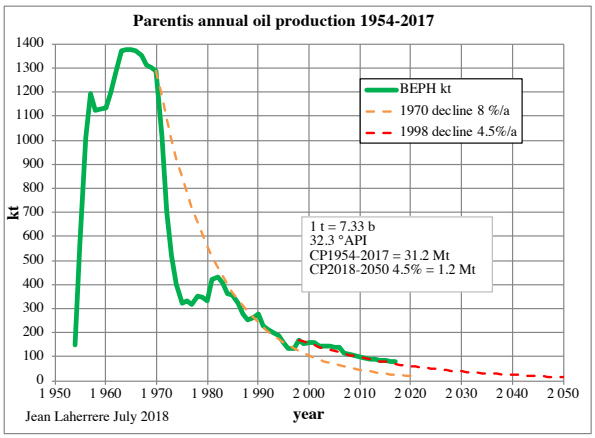


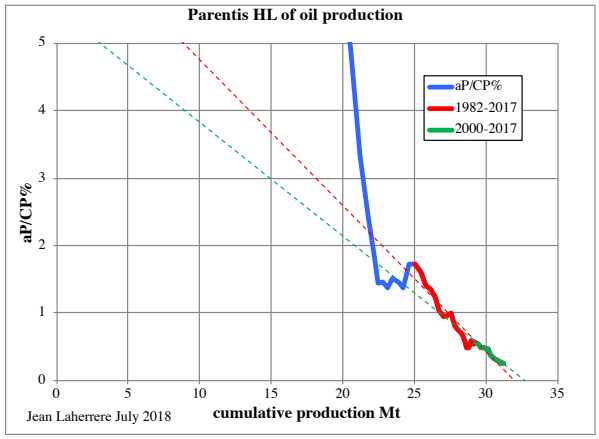


In the past oil and gas production data were reported in full by BEPH (Bureau Exploration Production des Hydrocarbures) , but BEPH was replaced by BRESS with energy covered by climate (minister being Nicolas Hulot (well known with Ushuaia using big engines with high fuel consumption) and they have decided to stop reporting field production in 2015, despite that 1789 chapter 15 of "Déclaration des Droits de l'homme et du citoyen" allows the citizen to be informed about public data.
France joined in 2014 with other 75 countries the Open Government Partnership, leading in particular to the opening of public data. French resources in the ground belongs to the people and the government just leases concession to private companies, which are obliged to report the crude oil production, data which was public in the past and should be now. The Greens are so strongly against fossil fuels and nuclear that they feel free to do anything to avoid reporting on the matter.

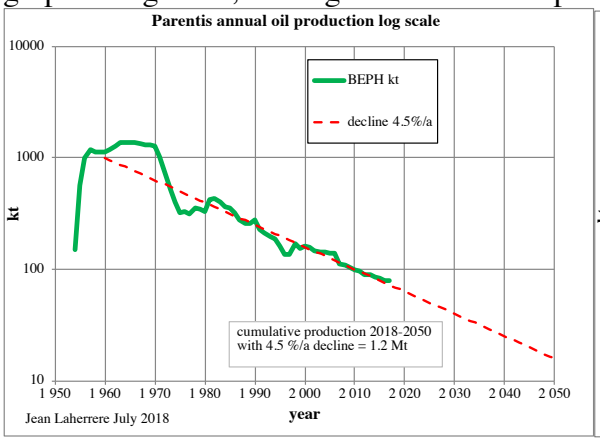
-Parentis

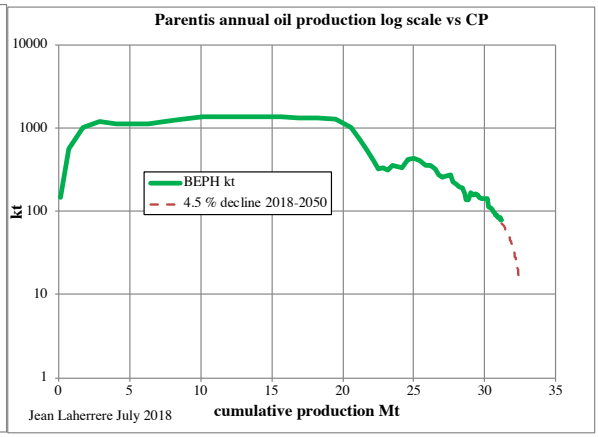
Parentis (Aquitaine Basin) was discovered & produced by Esso, which sold it to Vermillion in 1997 (87% depleted for U = 33 Mt) (like BP sold Forties to Apache when 87% depleted).
HL (period 2000-2017) trends towards 32 Mt



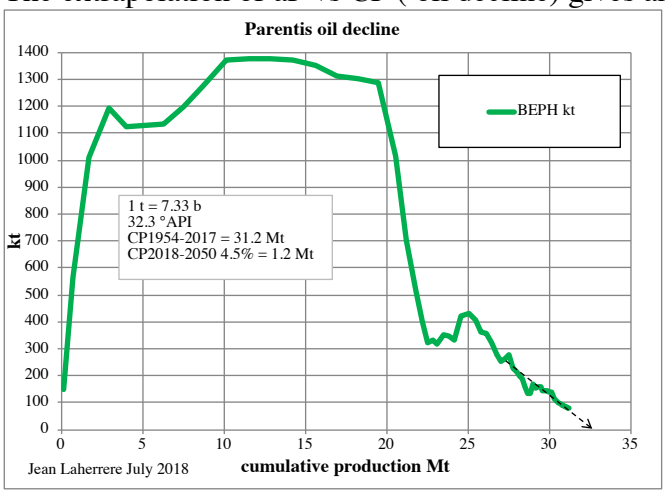


Parentis oil decline is 8 %/a from 1970 to 1997 and 4.5 %/a since 1980, as shown by the graph in log scale, leading to a cumulative production of 32.4 Mt in 2050.





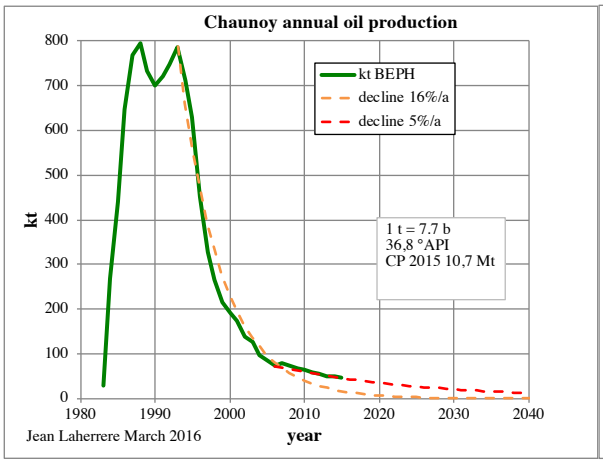
The extrapolation of aP vs CP (oil decline) gives an ultimate identical with HL

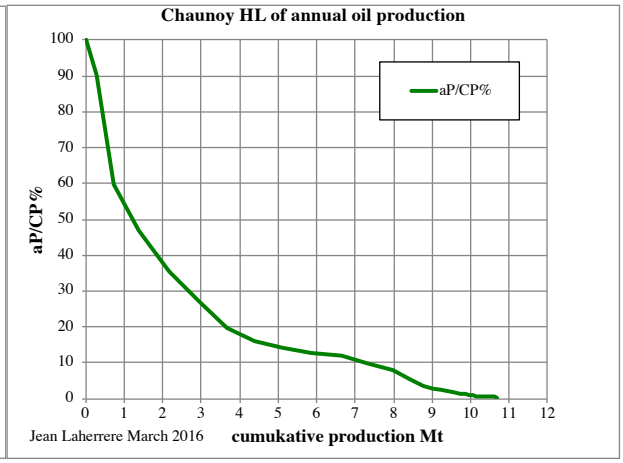


Parentis is a little different to the model “fast rise, slow decline”, being “fast rise, fast decline turning to slow decline” (close to 5%/a)

-Chaunoy

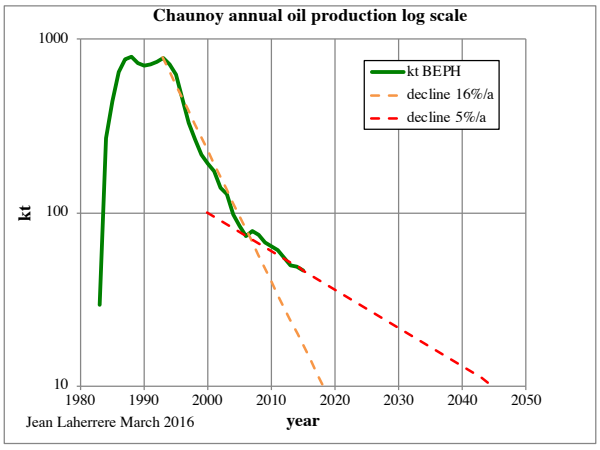
Chaunoy (Paris Basin) is similar to Parentis: fast decline (16%) turning into slow decline (5%).

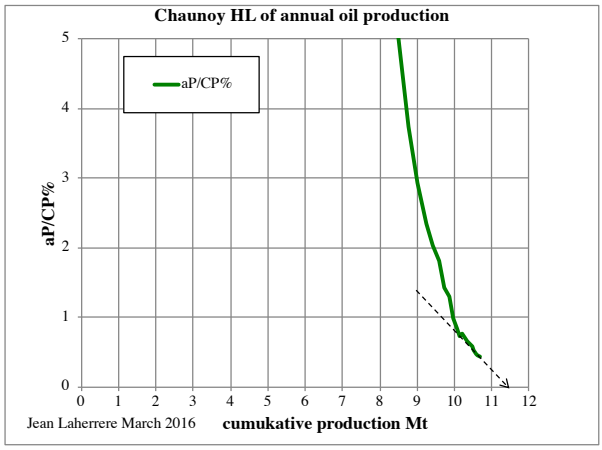




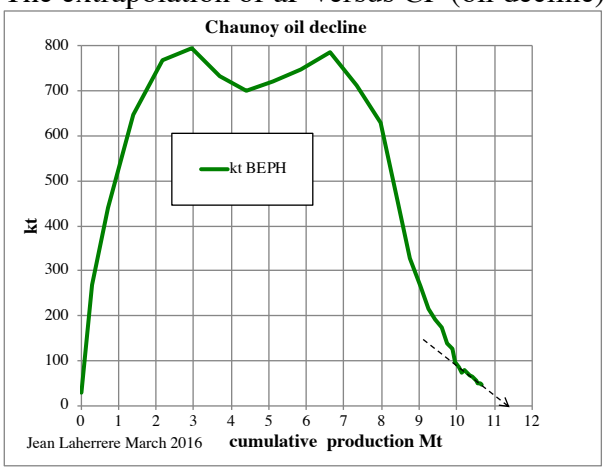
The annual decline is 16 %/a for the period 1993-2000 and 5 %/a after 2000, which is the average decline of most fields.

As most oilfields, Chaunoy will be abandoned when its flow will be uneconomical, but still producing. Furthermore, the French government (Nicolas Hulot being minister) wants to cease all French oil and gas production by 2040! Fossil fuels and nuclear are politically incorrect!





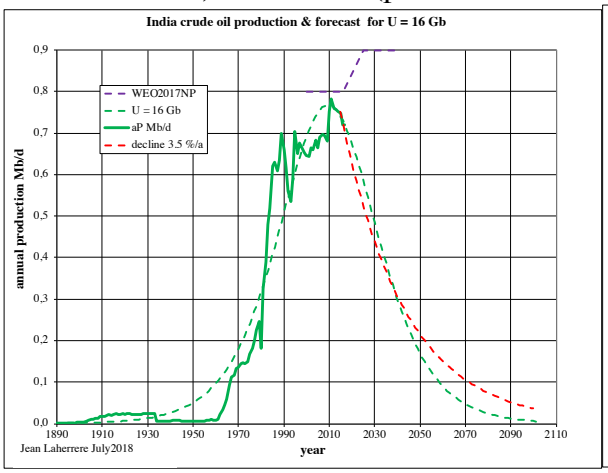
The extrapolation of aP versus CP (oil decline) gives an ultimate identical with HL (t = 8 b)

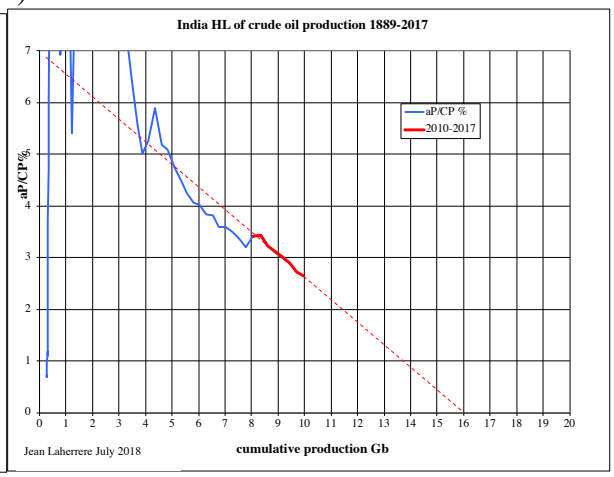


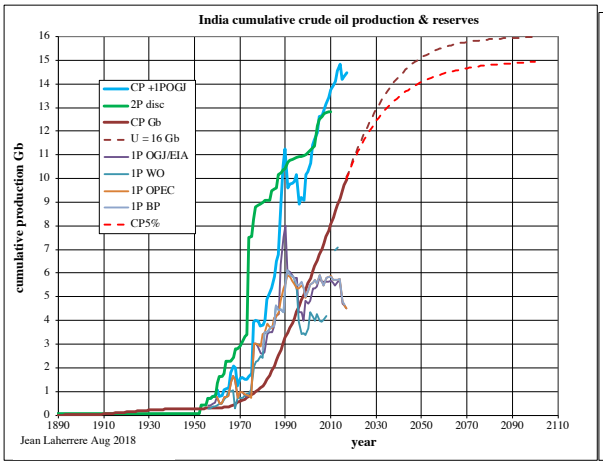
-India

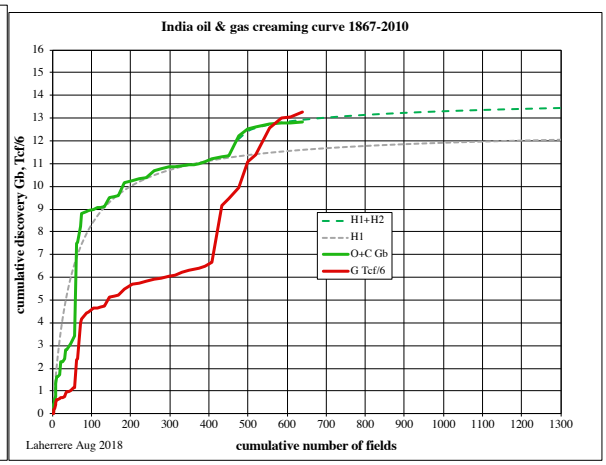
India crude oil production has peaked in 2011 and is declining now and in future for an ultimate of 16 Gb, but IEA/WEO 2017 NP forecasts 0.9 Mb/d in 2040 against 0.3 Mb/d in my

forecast = drastic difference! This ultimate of 16 Gb is justified by the creaming curve (close to CP +1P OGJ) and the HL (period 2010-2017)

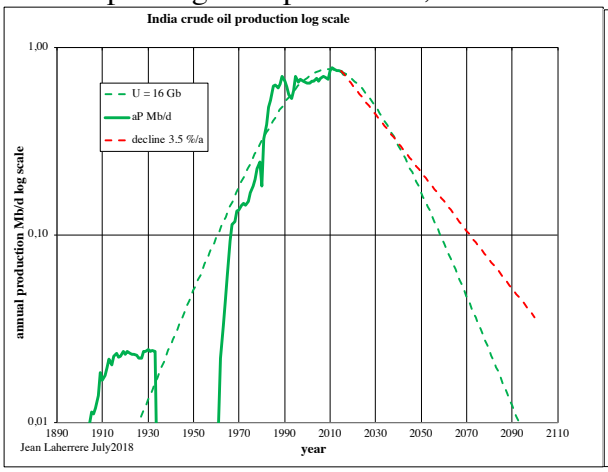


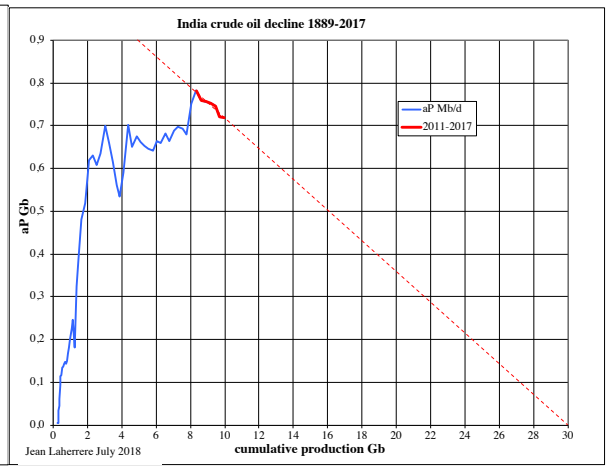




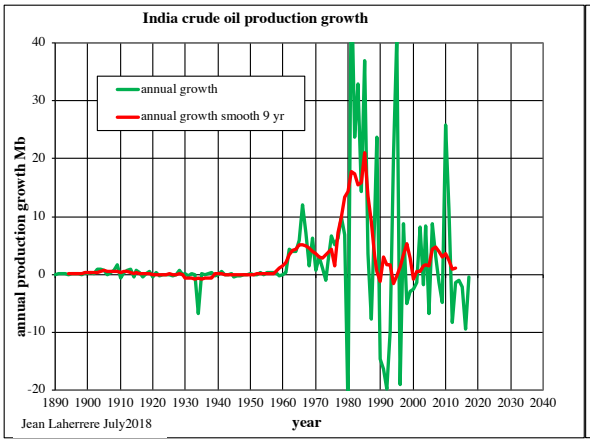


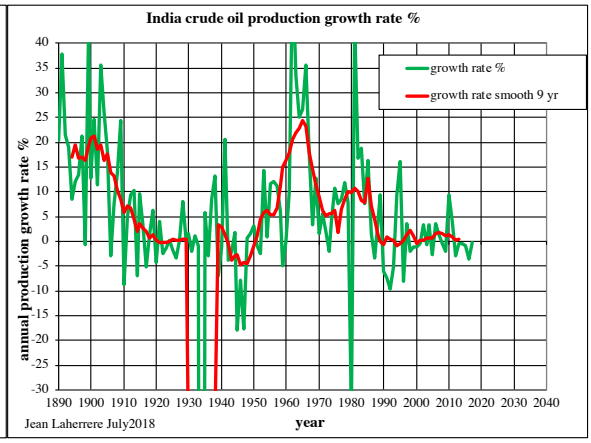
IEA forecast is against the EIA reported reserves.
OD for the period 2011-2017 is extrapolated towards 30 Gb which is obviously too high (almost twice the ultimate of 16 Gb) and showing a wild difference with HL. It seems that India is pushing their production, but the future decline rate is below normal!





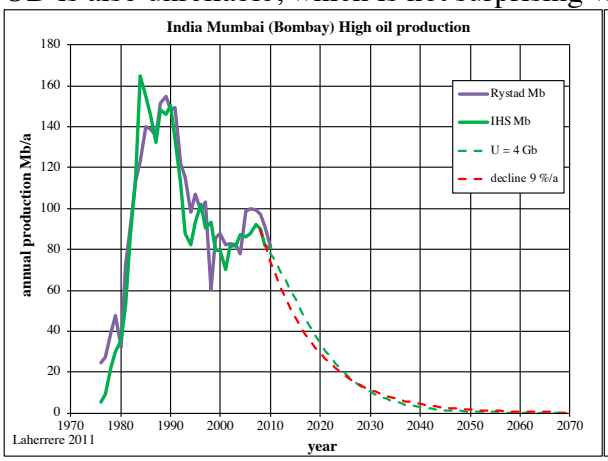
India crude oil production growth displays a bright cycle during the 1980s and a poor future. With growth rate in % the 1960s looks brighter.

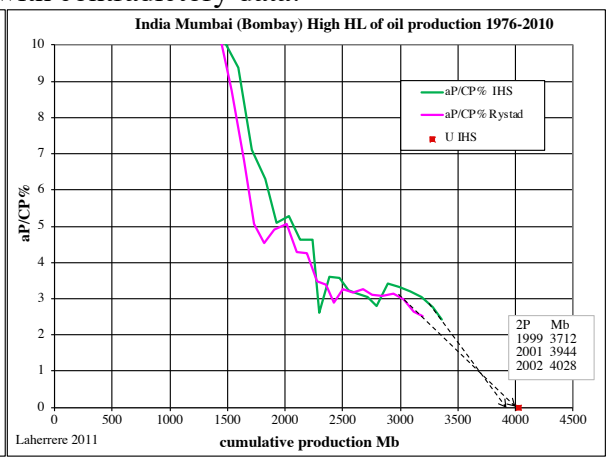


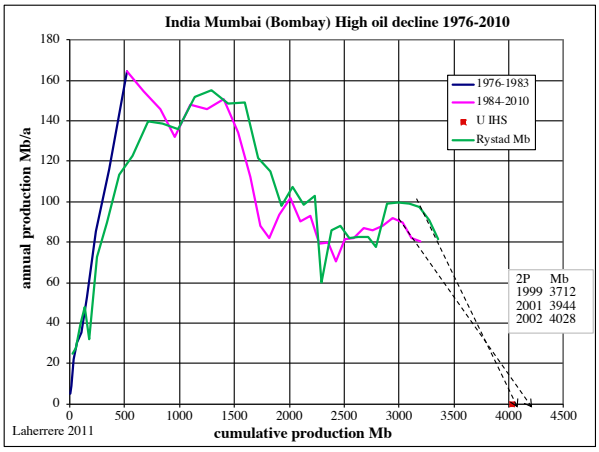


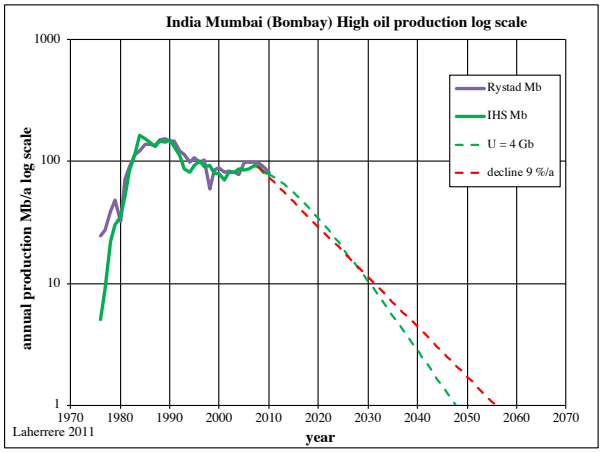
-Mumbai High

Mumbai High has a cumulative oil production oil decline for 1976-2010 about 3.3 Gb for a 2P discoveries of 4 Gb. HL is hard to extrapolate with different data from sources, as the production was almost flat for the last 20 years, but last two points trends towards 4 Gb. OD is also unreliable, which is not surprising with contradictory data.

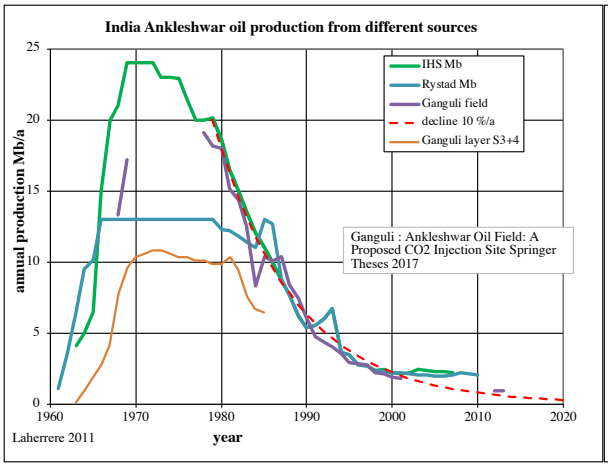


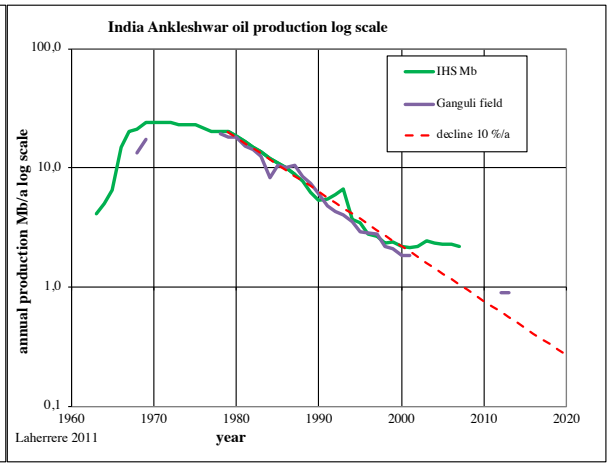




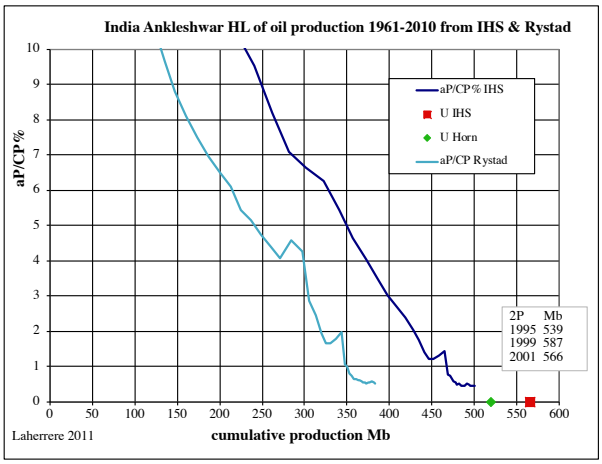


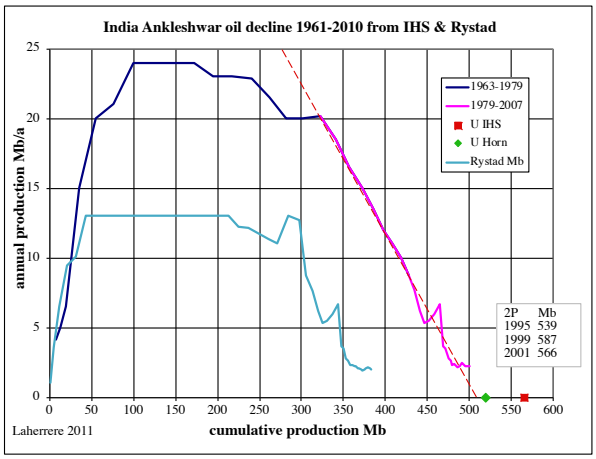
OD extrapolation is better than HL, but Rystad data differs from IHS data: comparing to the thesis Springer 2017 S.S. Ganguli Ankleshwar Oil Field: A Proposed CO2 Injection reporting the oil production from the field but also from the layer S3+4 it appears that IHS look better. Ankleshwar oil production declines for 1979-2011 at a rate of 10 %/a





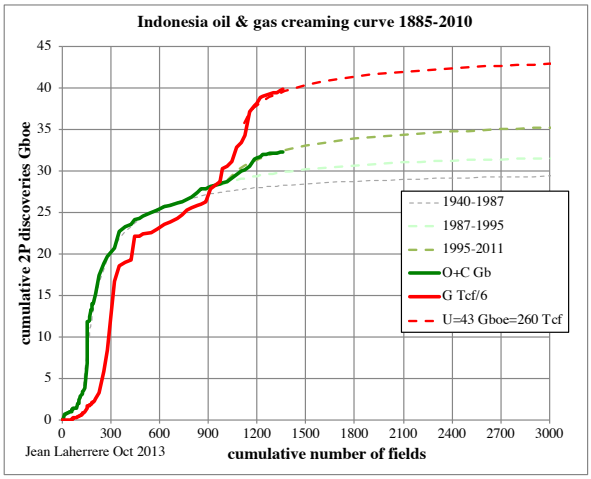
HL of oil production (IHS) trends towards 520 Mb (Horn estimates) against 2P (2001) of 566 Mb

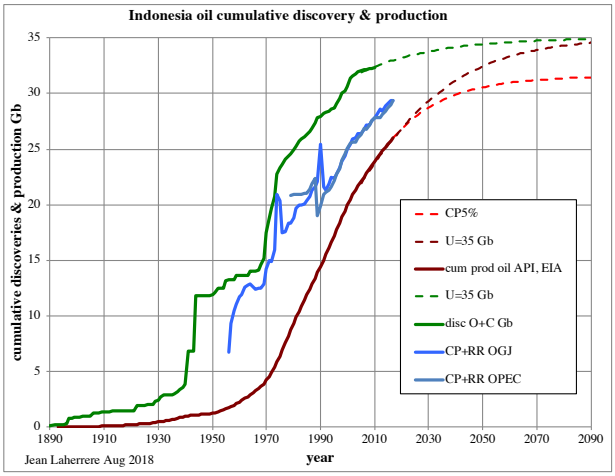


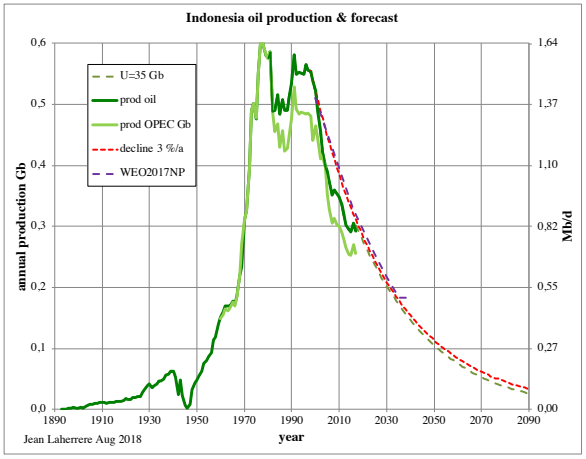


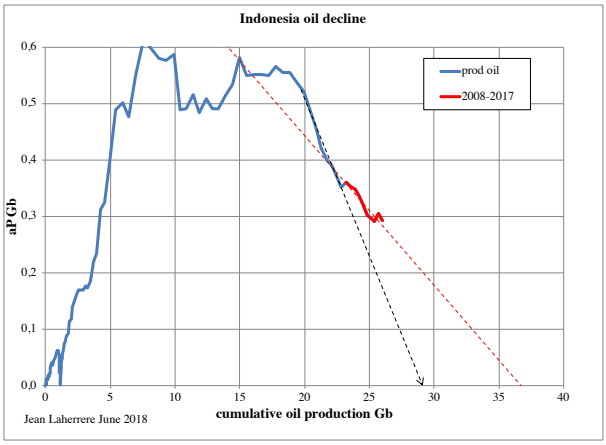
-Indonesia

Indonesia crude oil production has peaked in 1978 at 1.6 Mb/d and a slightly lower peak in 1991. OPEC data is less than EIA data because the condensate.
Creaming curve of 2P discoveries trends towards 35 Gb
HL of past production 2008-2017 trends towards 36 Gb
Despite a small increase in 2016, crude oil production will decline at a rate of 3 %/a since 1998 for an ultimate of 35 Gb

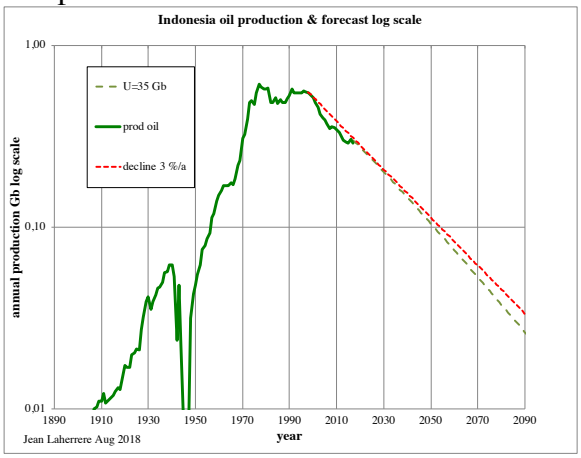


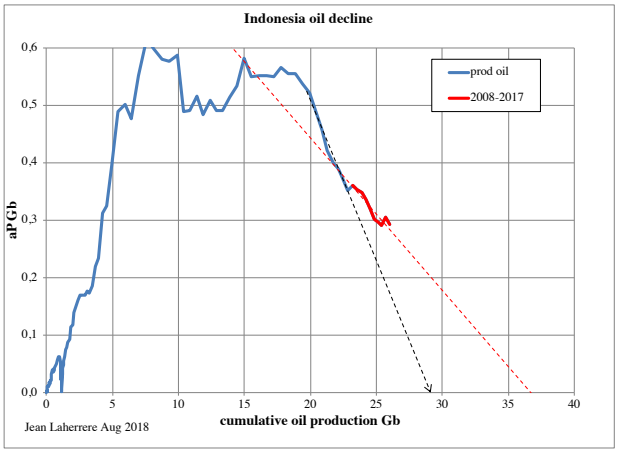




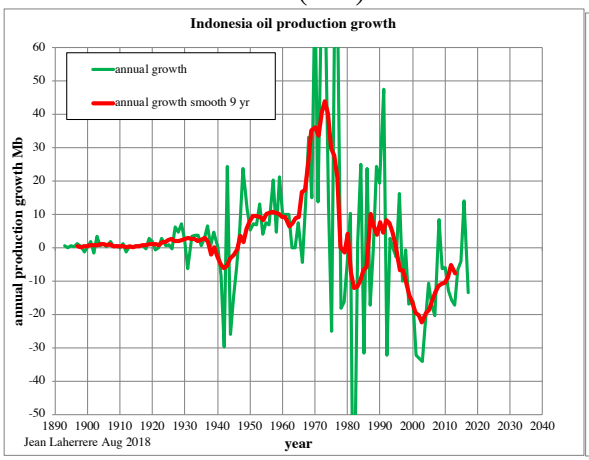


My forecast for 2035 for an ultimate of 35 Gb agrees with IEA/WEO2017 NP with 0.5 Mb/d but IEA stops the decline for 2040 when for me it continues
OD period 2008-2017 trends towards 36 Gb



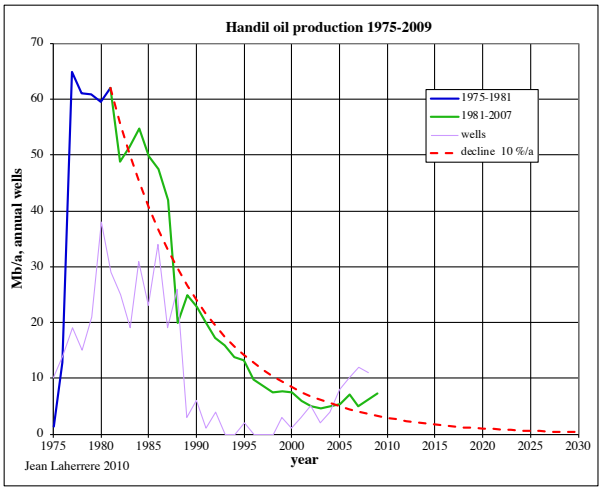


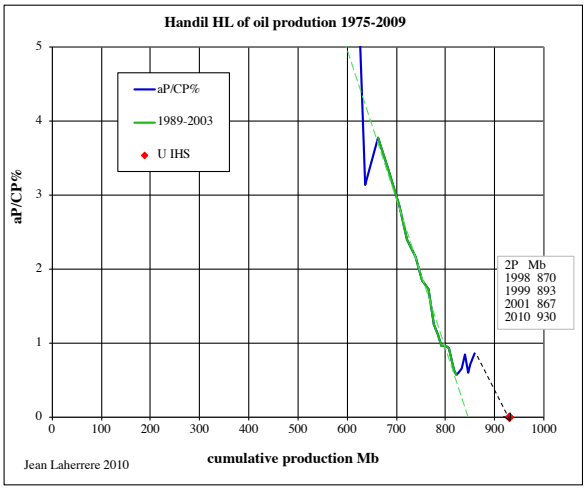
Indonesia crude oil production growth displays up and down. Growth rate in % displays a better trend after 1950 (war)



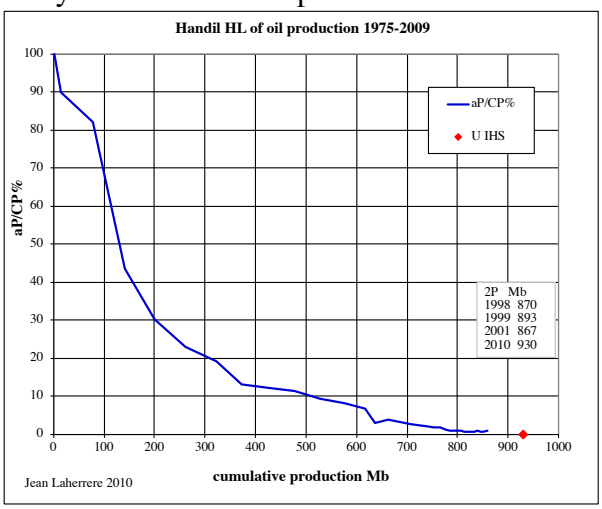
-**Handil**

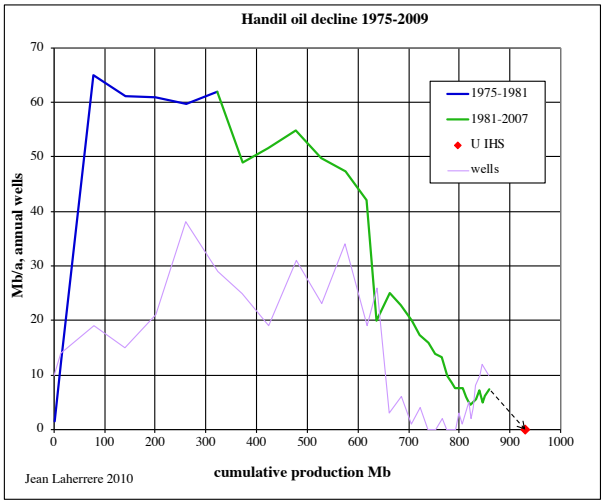
Handil oil field was discovered in 1974 & is operated by Total . It has many thin reservoirs (over 300) with an oil column of 245 m (Grosjean)
Handil has a decline rate for 1982-2009 of 10 %/a



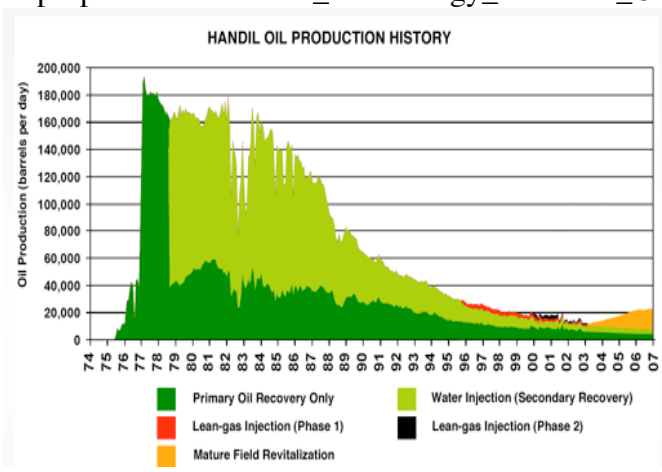


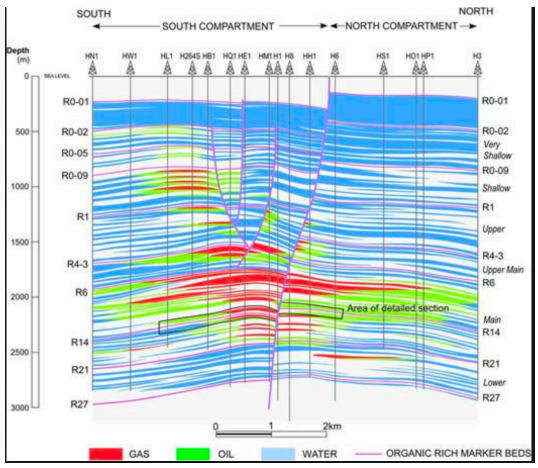
The HL full scale is obviously curved. But the tail below 5% is rather linear, except for the last years and the extrapolation is unreliable as for OD





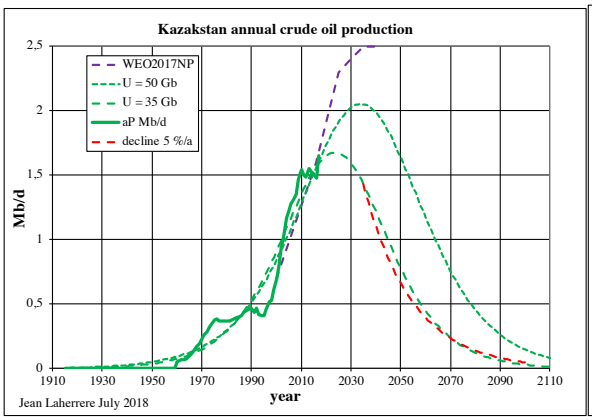
http://philhart.com/How_Technology_Increases_Oil_Production

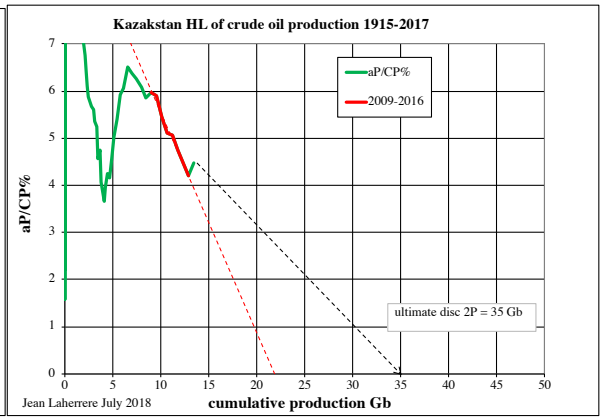




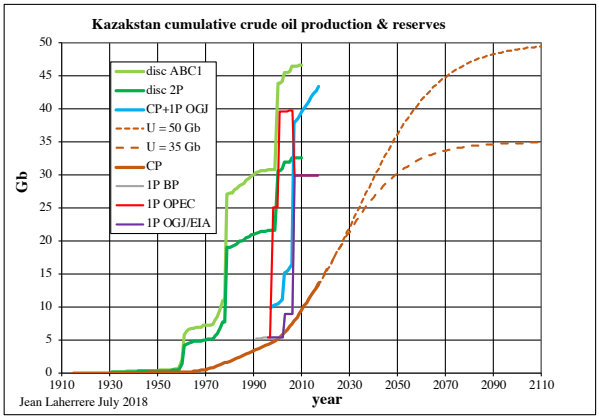
-Kazakhstan

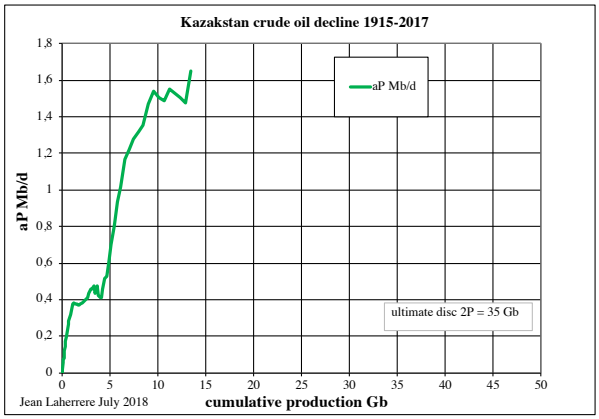
Kazakhstan crude oil production will peak either in 2024 or 2034 for an ultimate of 35 or 50 Gb. IEA WEO2017 NP forecasts peak in 2035 for a higher value.



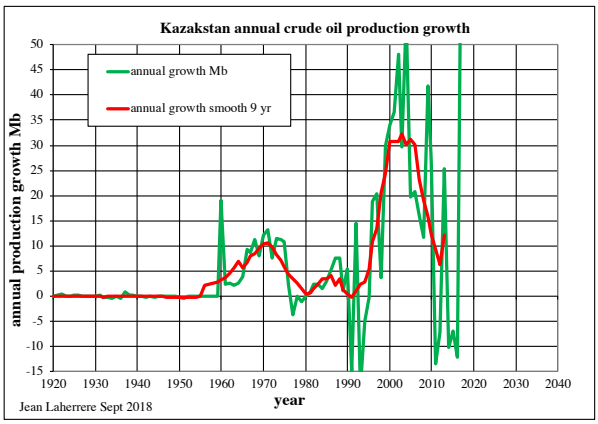


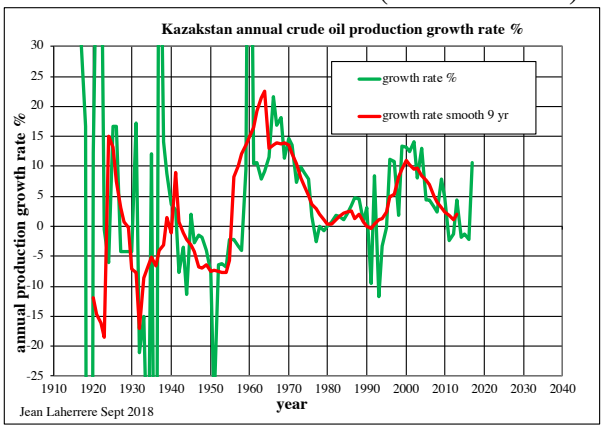
The problem for Kazakhstan oil reserves is that they are reported as ABC1 in the Russian classification, and audits from Gazprom has shown that 2P = 0.7 ABC1. The creaming curves leading towards 50 Gb with ABC1 has be corrected into 35 Gb. The HL displays a linear part for 2009-2016, but it is likely that next period will trends towards 35 Gb.
OD is useless before the peak forecasted in 2025.
For an ultimate of 35 Gb the decline rate for 2035-2100 will be about 5 %/a





Kazakhstan crude oil production growth displays 2 distinct cycles in 1970 and 2005, but the extrapolation of the last decline is disturbed by the 2017 increase, preventing to forecast the next peak. Growth rate in % displays a better trend since 2000 close to zero (but as in 1980).

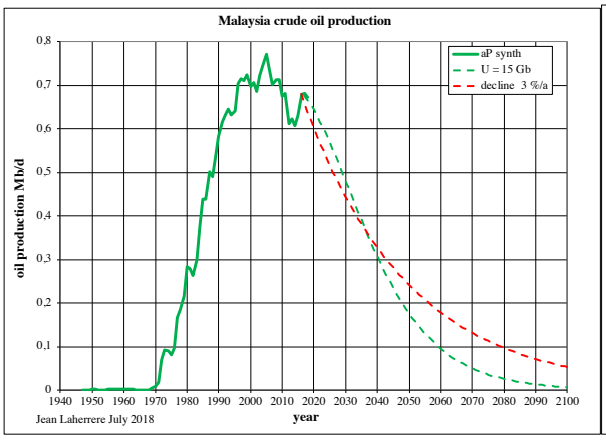


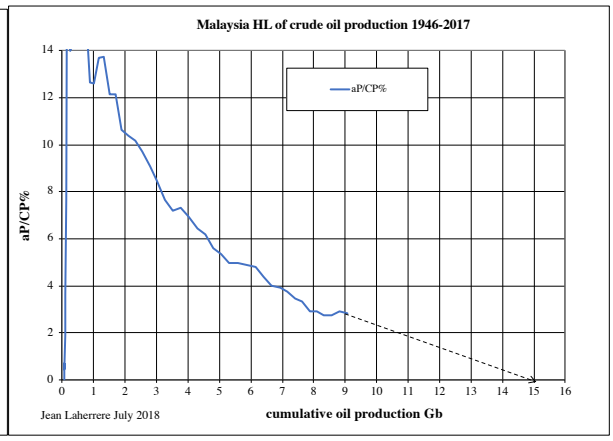


The big problem of Kazakhstan oil fields like Tengiz and Kashagan is the high level of H2S in the crude (17%), obliging to expensive investments.

-Malaysia

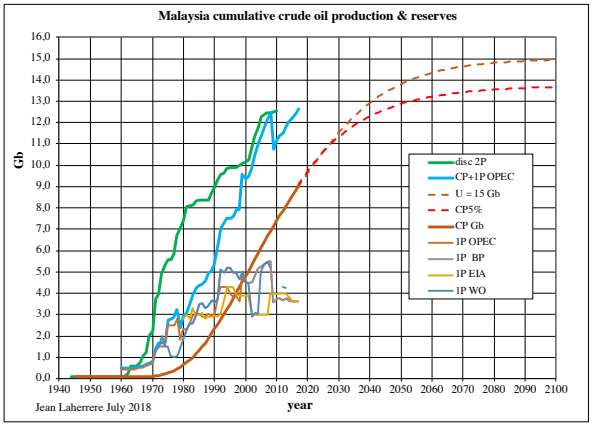
Malaysia crude oil production has peaked in 2004 at 0.77 Mb/d and a secondary peak in 2016 at 0.68 Mb/d. It will continue to decline for an ultimate of 15 Gb

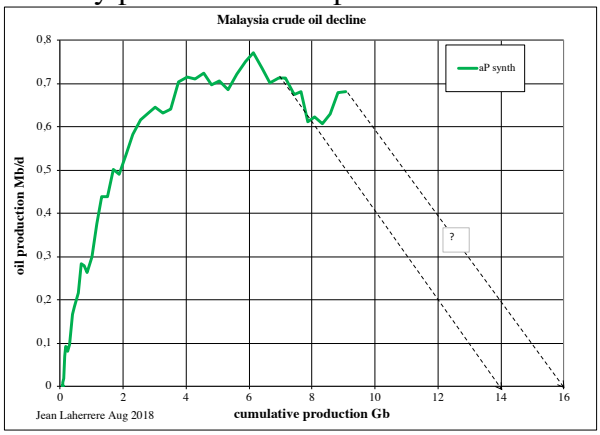




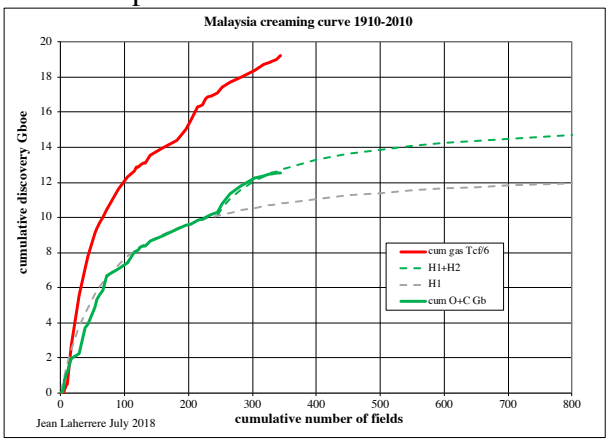
HL tail to 2017 is curved and the 15 Gb ultimate is chosen from the creaming curve, in line with CP+1P OPEC.

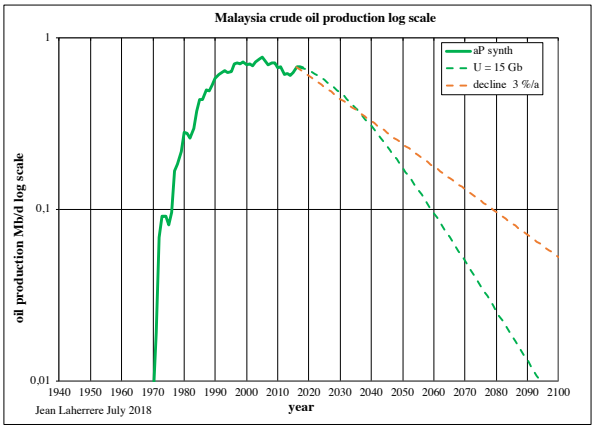
OD is hard to extrapolate, maybe trending to 16 Gb by parallelism with previous decline



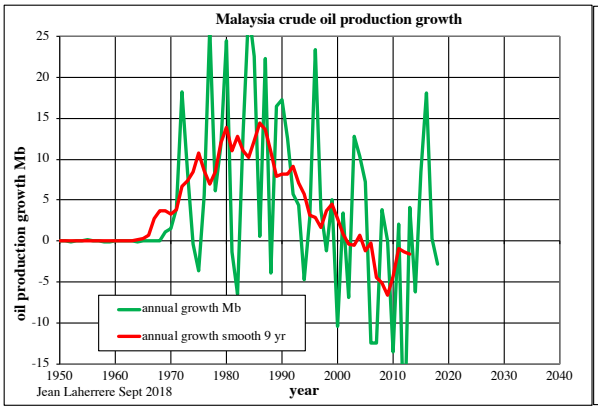


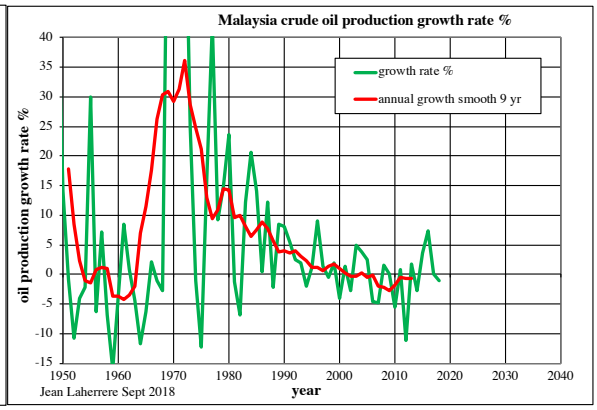
Crude oil production decline after 2016 to 2040 will have a decline rate of 3 %/a





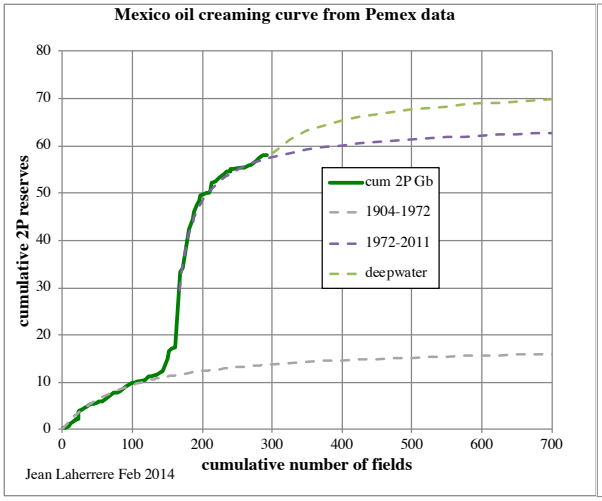
Malaysia crude oil production growth displays a first simple cycle up to 2000, but the last decade is difficult to extrapolate. Growth rate in % is better, the decline will continue.

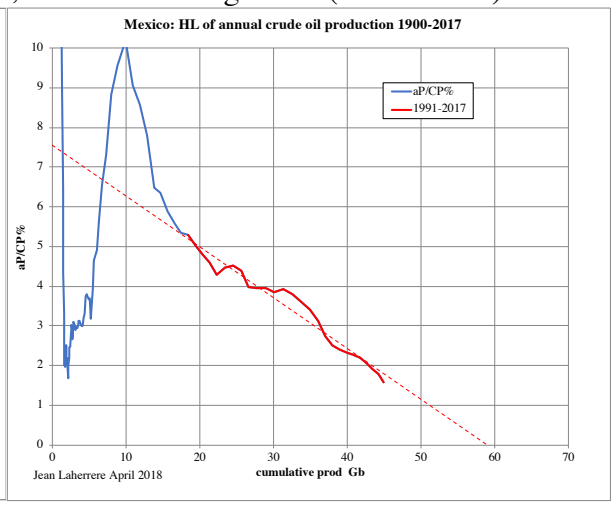




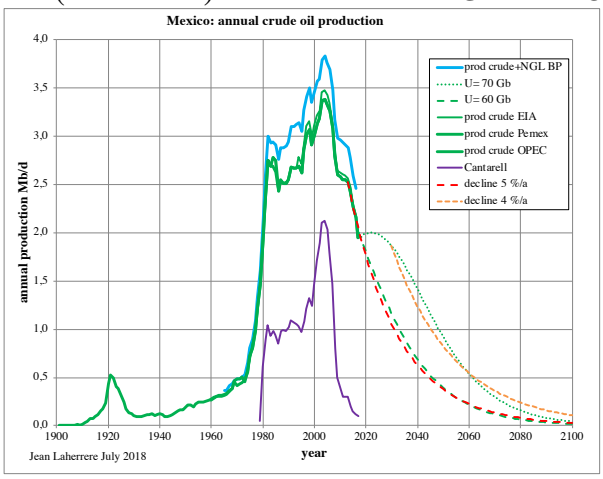
-Mexico

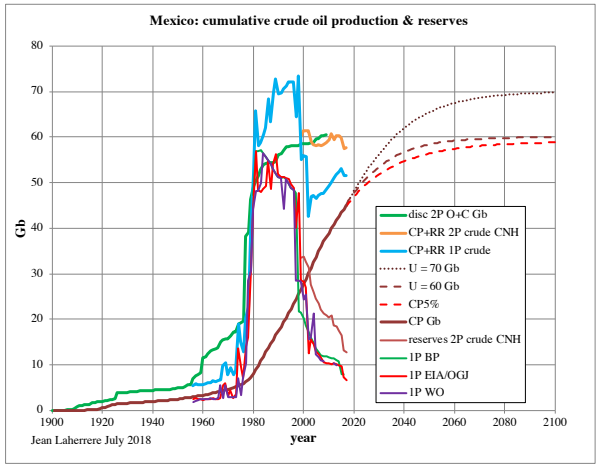
Mexico crude oil production has peaked in 2004 and has sharply declined, due to the sharp decline of Cantarell. The decline could continue for an ultimate of 60 Gb (giving a decline rate of 5 %/a from 2013 to 2100) but stopped for a while for the 70 Gb ultimate (giving a decline rate of 4 %/a from 2030 to 2100). The new discoveries in deepwater (Perdido) will make the difference. HL trends towards 60 Gb, but the creaming curve (before 2011) to 70 Gb

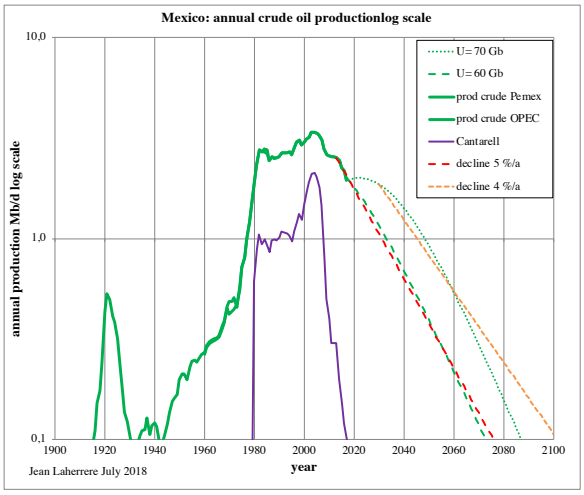


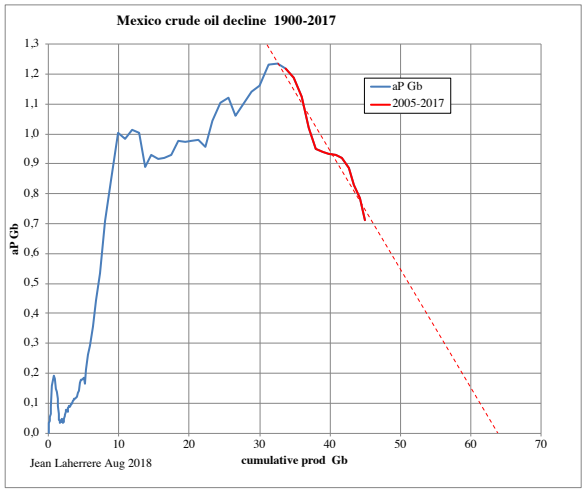


HL (1991-2017) trends towards 59 Gb when OD (2005-2017) trends towards 63 Gb

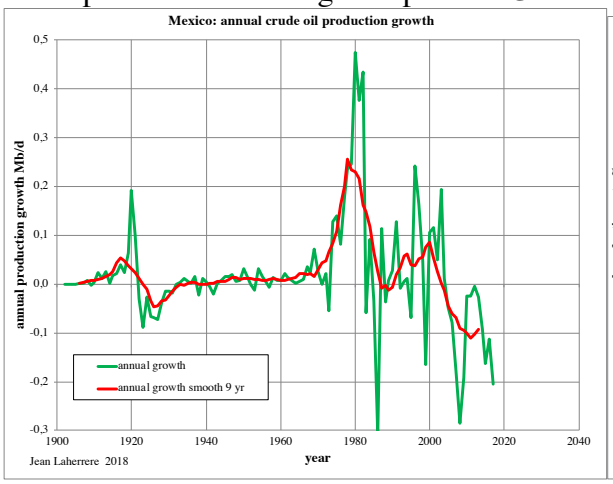


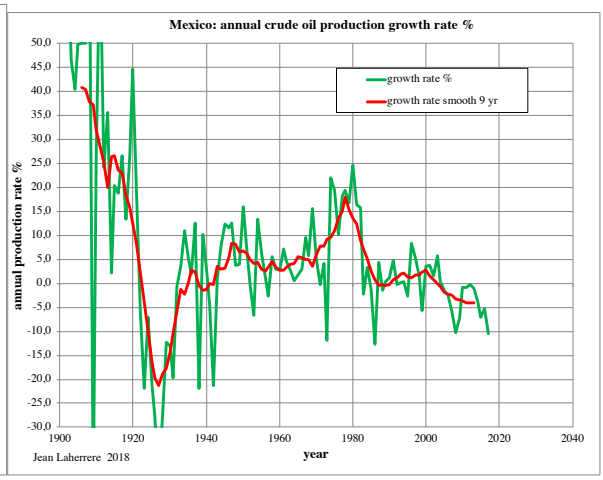






Mexico crude oil production growth displays a decline with a poor future, but the exploration of deepwater could change the picture. Growth rate in % looks the same.

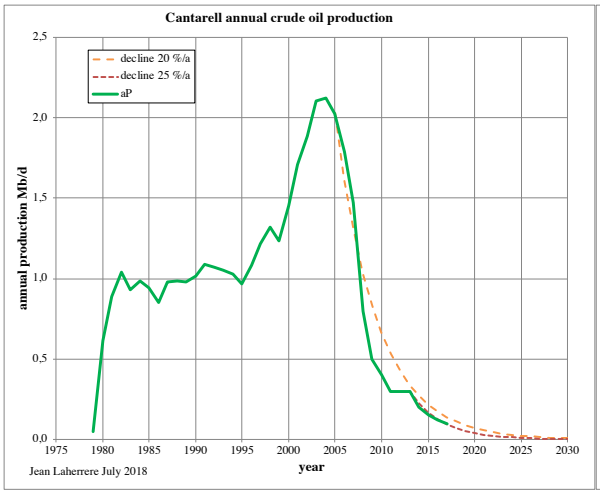


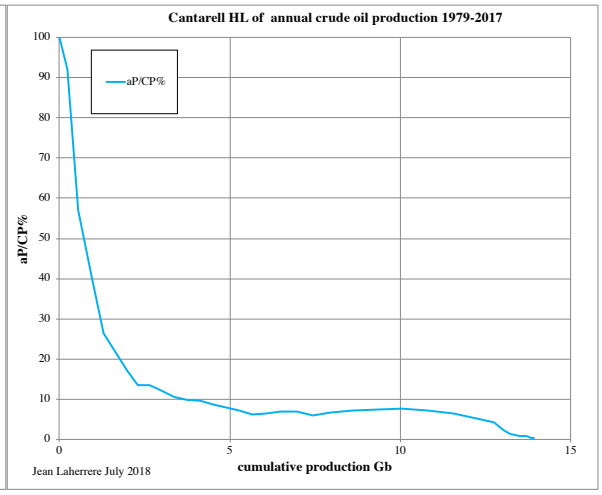


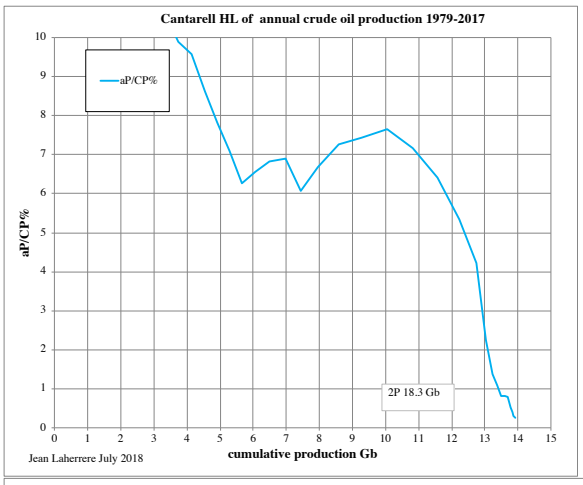
-Cantarell complex

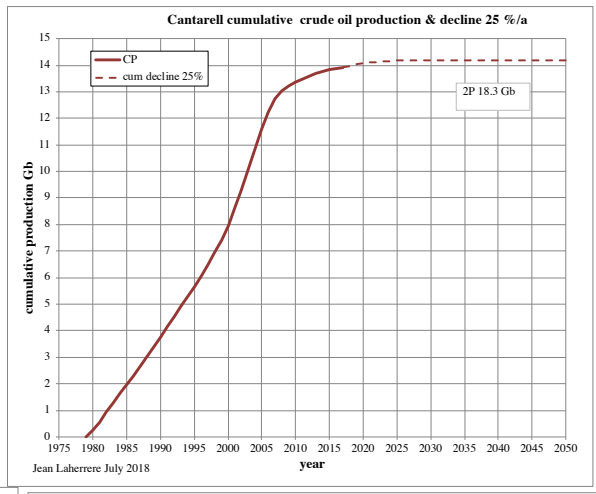
Cantarell is the name of the fisherman who indicated to Pemex the oil seep in the sea polluting his nets.

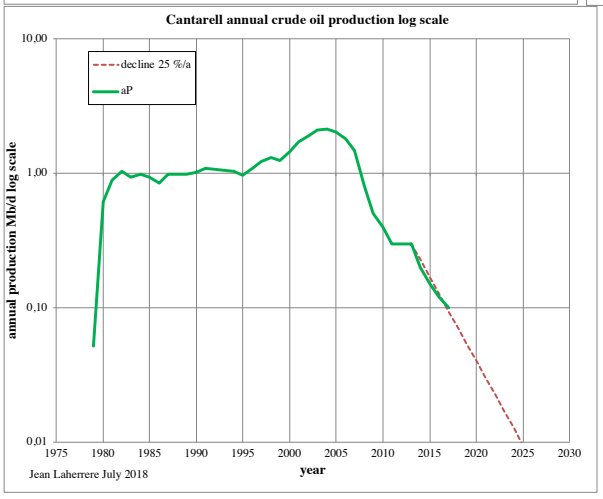
Cantarell complex includes several fields : Akal, Chac, Kutz, Nohoc, Sihil. It was produced using nitrogen injection (better than water for heavy oil) and his decline was sharp, so HL does not work. Each field should be studied separately. Cantarell oil rise was sharp to the peak in 2004 at 2.1 Mb/d, but its decline rate was steeper, above 20 %/a (25 %/a since 2013). HL is curved except for the tail below 6 %. Cantarell ultimate is 14.2 Gb, when cumulative production at end 2017 is 13.9 Gb. Remaining reserves at end 2017 are about 0.3 Gb

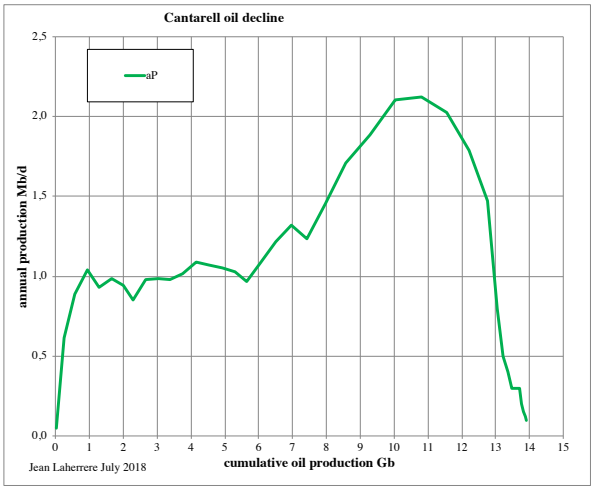






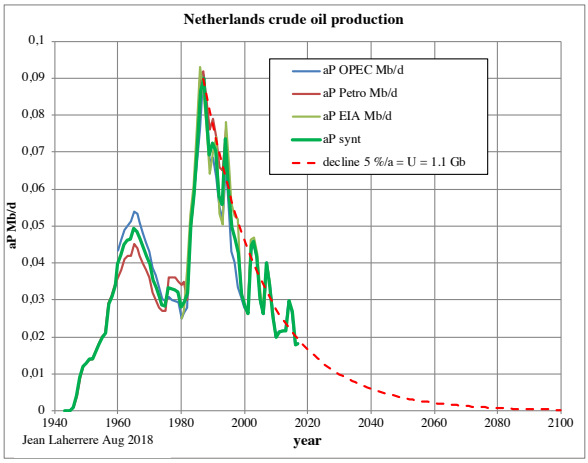


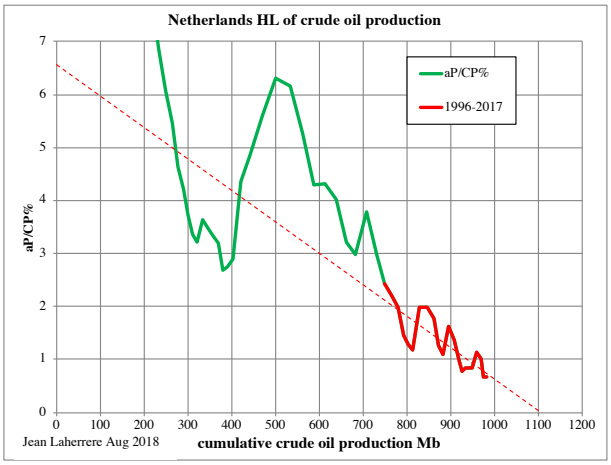




-Netherlands

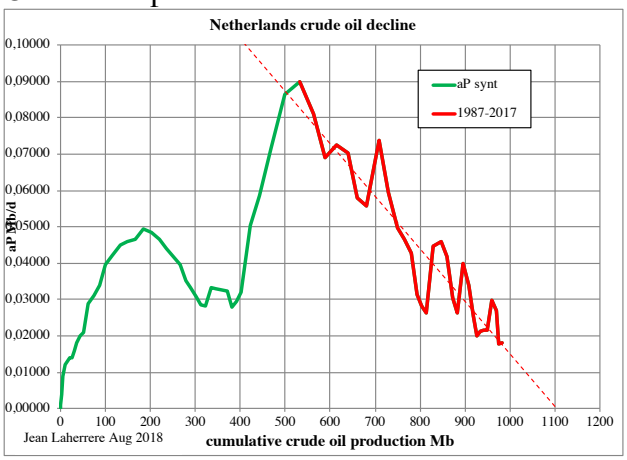
Netherlands crude oil has peaked first in 1966 (minor) and in 1988 (major) and since 1988 has a decline rate of 5% which will continue for an ultimate of 1.1 Gb

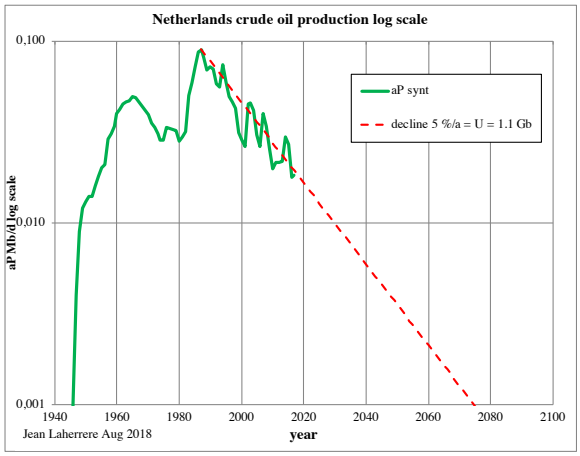




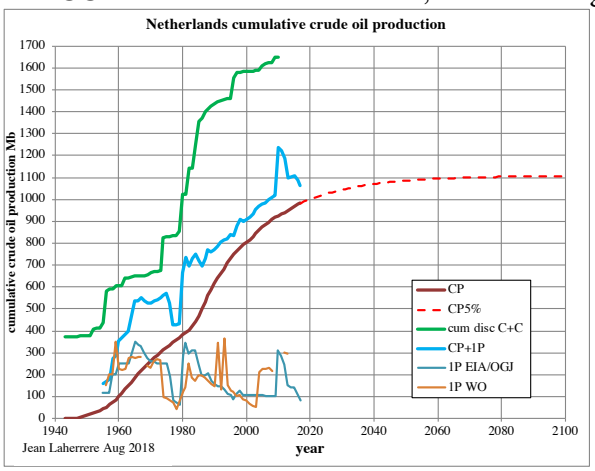
HL for the period 1996-2017 trends towards 1100 Mb

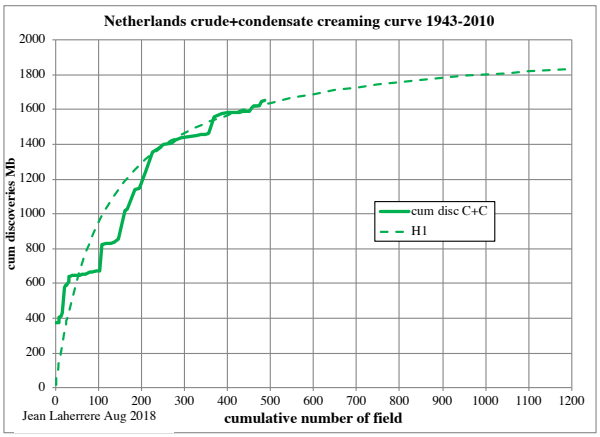
OD for the period 1987-2017 trends towards 1100 Mb





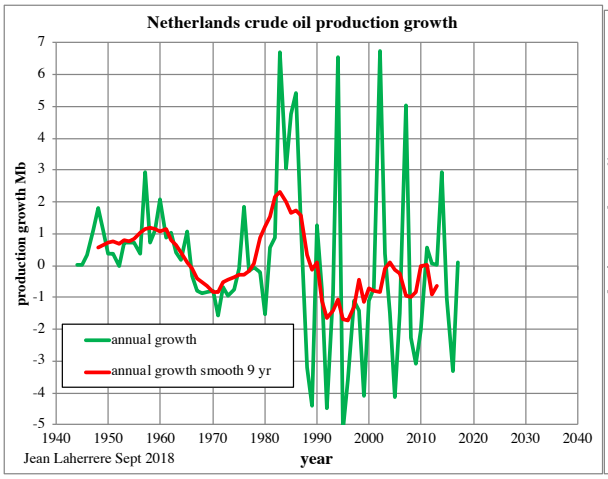
But CC trends towards 1800 Mb, much too high compared to past production

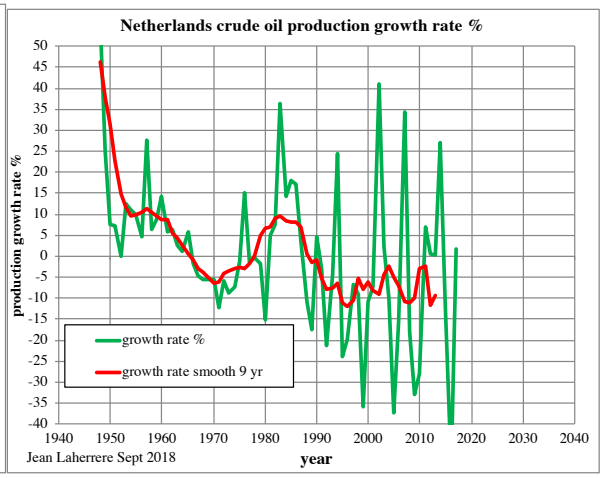




NL creaming curve has obviously too optimistic 2P values: a check to fields is necessary

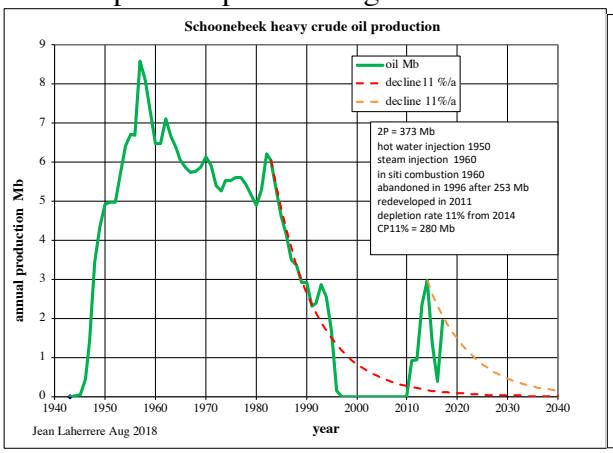
NL crude oil production growth is full of up and down and hard to extrapolate. Same with growth rate in %.

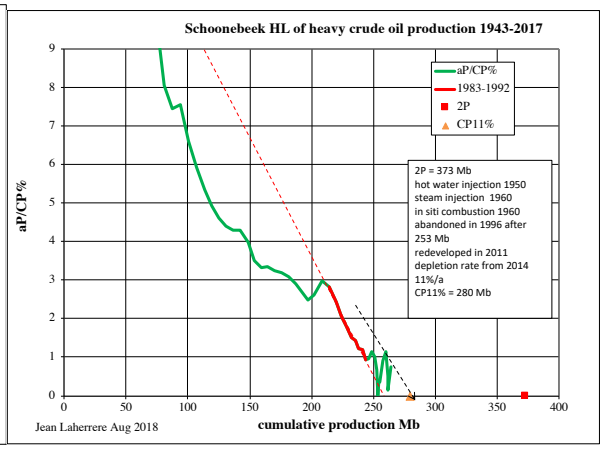




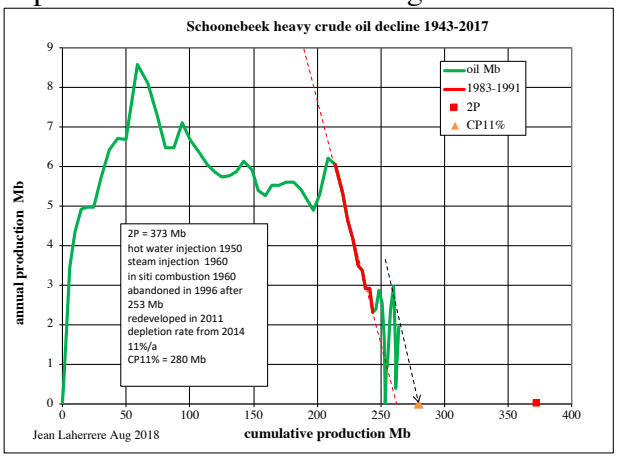
-**Schoonebeek oil field**

Schoonebeek has produced from 1943 to 1995 heavy oil, enhanced by hot water injection, steam injection and in situ combustion: it was stopped in 1996 after a production of 253 Mb (short of the 2P estimated at 373 Mb), because production was uneconomical. The field was redeveloped and produced again in 2011.





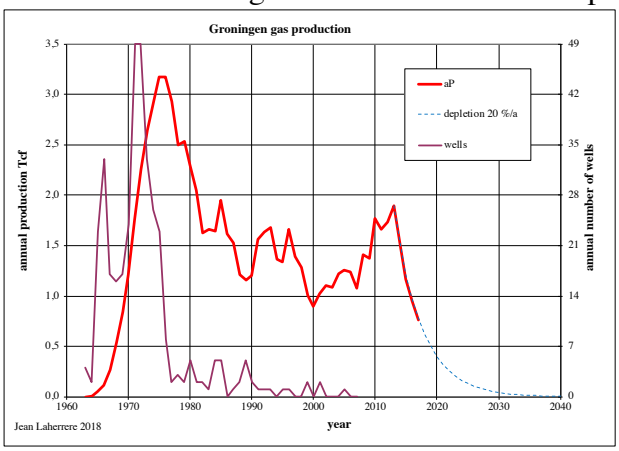
HL & OD for the period 1983-1992 (depletion rate = 11%/a) trends towards 255 Mb and for the period 2014-2017 towards 280 Mb which is the cumulative production up to 2050 for a depletion rated of 11%/a starting in 2014

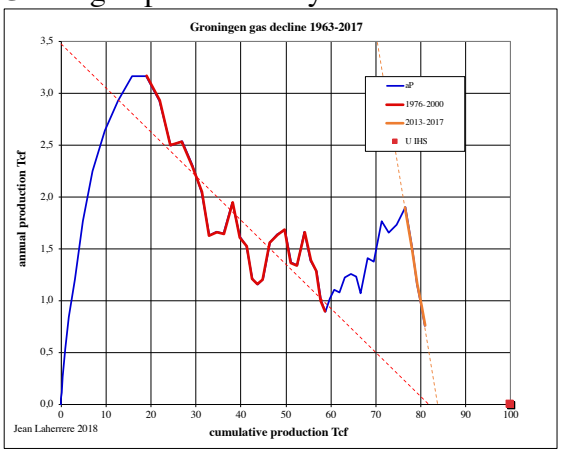


NL 2P reserves are too optimistic, for Schoonebook and for Groningen

-**Groningen gas field**

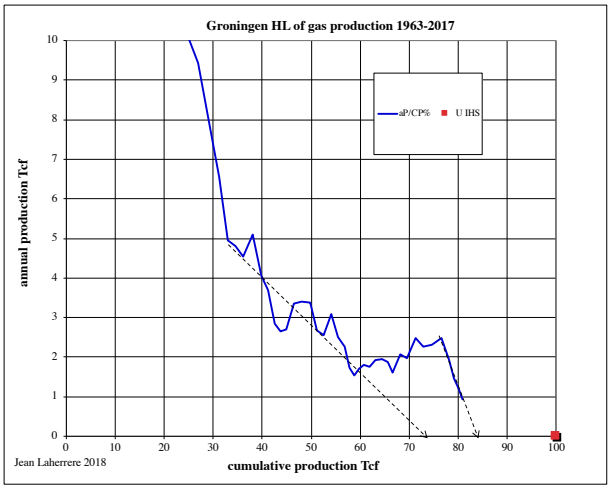
Groningen 2P reserves was estimated in 2001 at 100 Tcf. Groningen gas production was restricted in order to produce first the small fields, but lately Groningen area was disturbed by earthquakes related to the gas production and its production was reduced.
In March 2018 the government decided to stop Groningen production by 2030

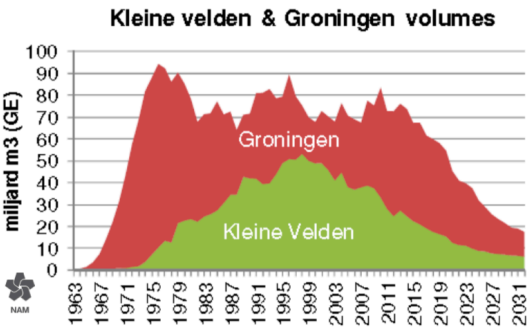


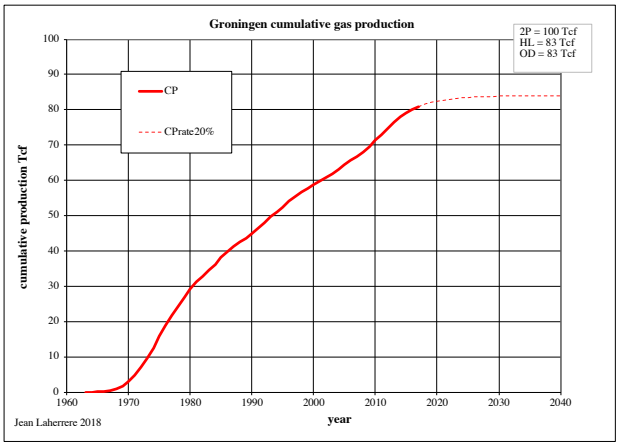


In fact, HL and OD both for the periods 1976-2000 and 2013-2017 trends towards 84 Tcf, 16 Tcf lower that the 2P (2001), but leaving only 3 Tcf to produce
The rate of depletion (disturbed by politics) since the secondary peak of 2013 to 2017 is 20 %/a leaving in 2030 a negligible production.
The forecast reporting a production of more than 10 M.m3 in 2031 for Groningen looks much too high.

Groningen and small fields 2015 Hazard & risk

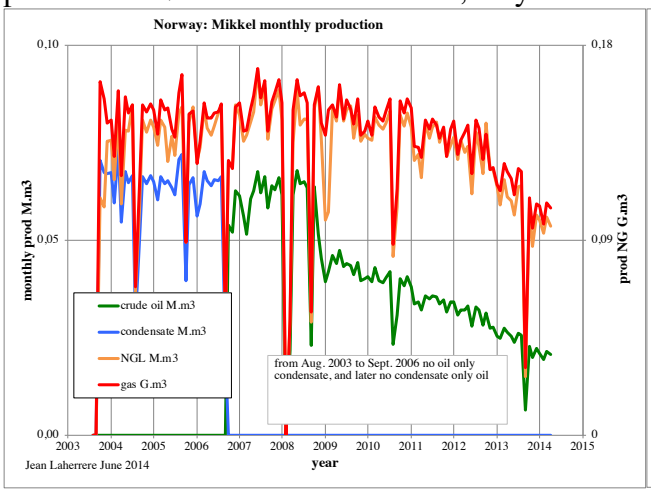


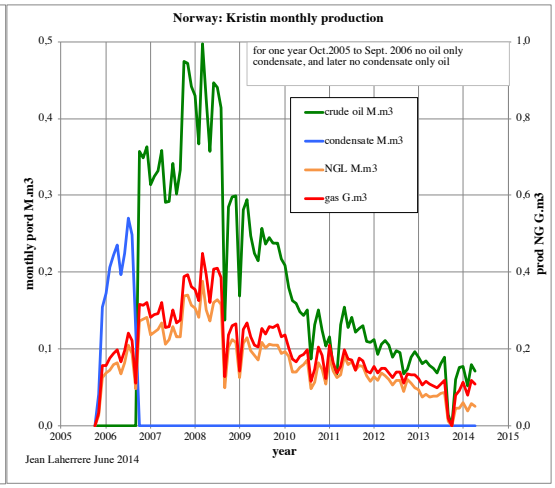




-Norway

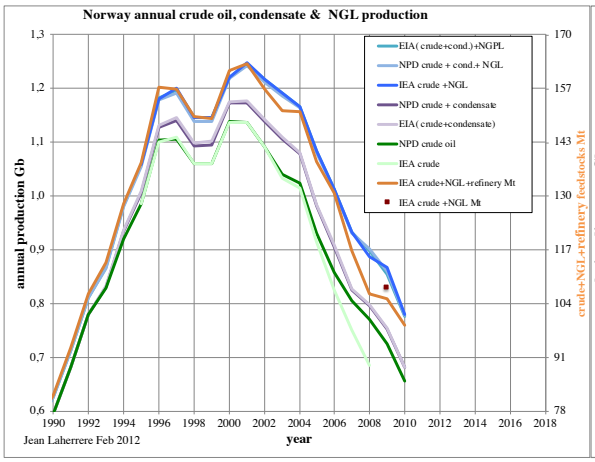
The problem of Norway (NPD data) is that the condensate is reported as crude oil if sold with crude or as NGL if sold with NGL: examples Mikkel & Kristin. It means that crude oil production NPD data is not reliable, only crude +NGL

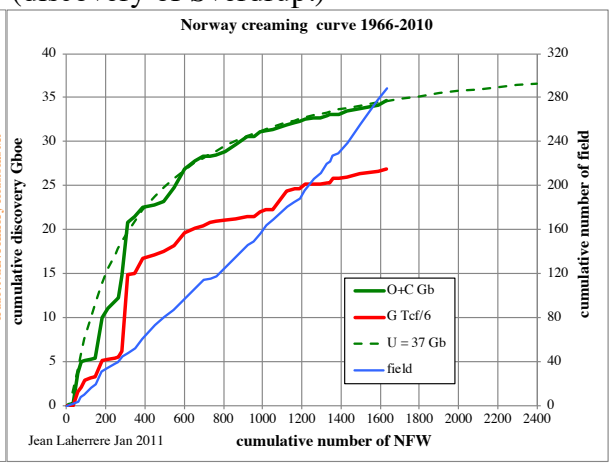




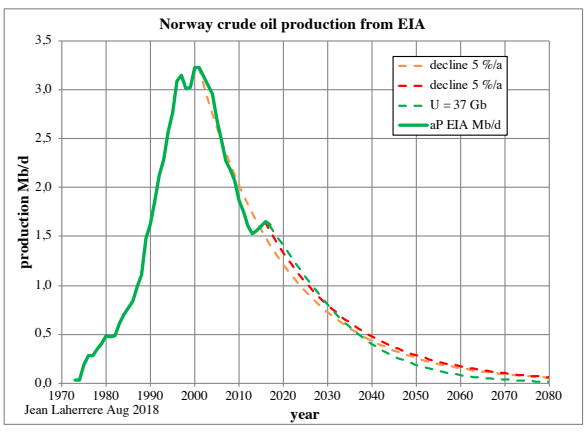
It is why EIA T11.1 crude oil data is taken, instead of NPD.

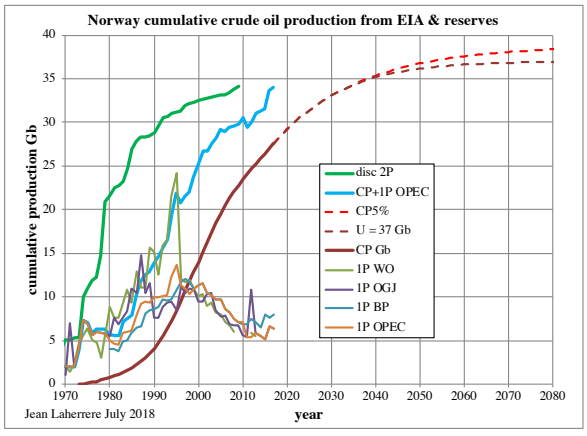
The creaming curve gives an ultimate of 37 Gb for crude +condensate, when HL of EIA data is linear for 1990-2013 but not for 2014-2017 (discovery of Sverdrup.)





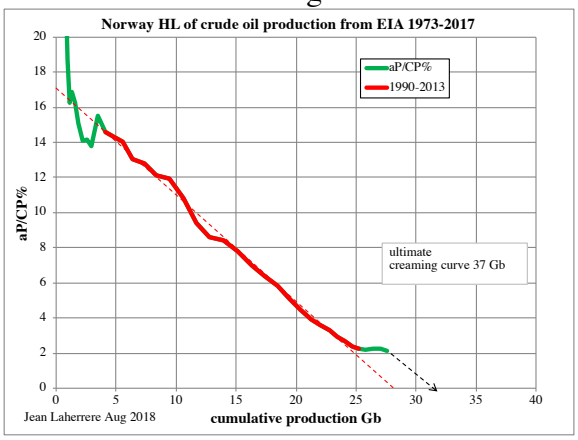
Norway crude oil (EIA) production has peaked in 2001 and for an ultimate of 37 Gb, its decline rate will be 5 %/a from 2016 to 2050

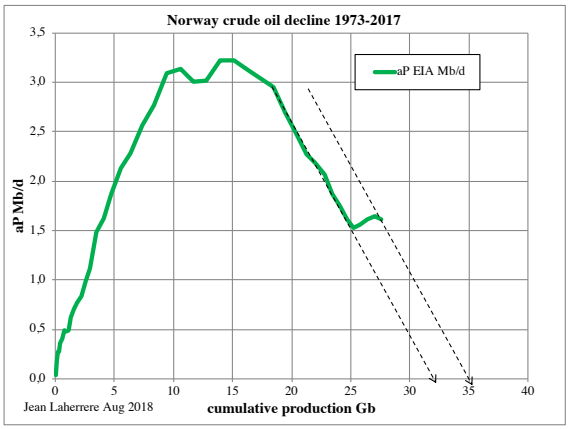


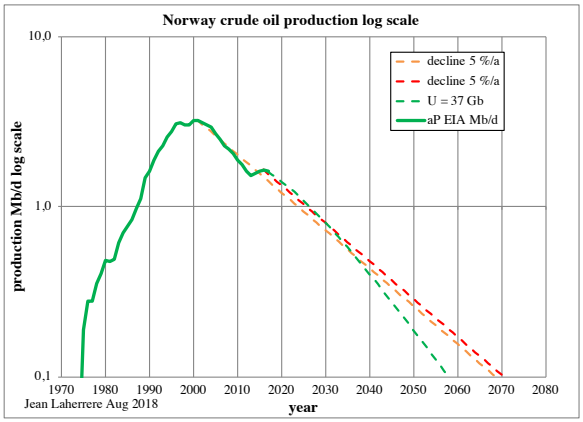


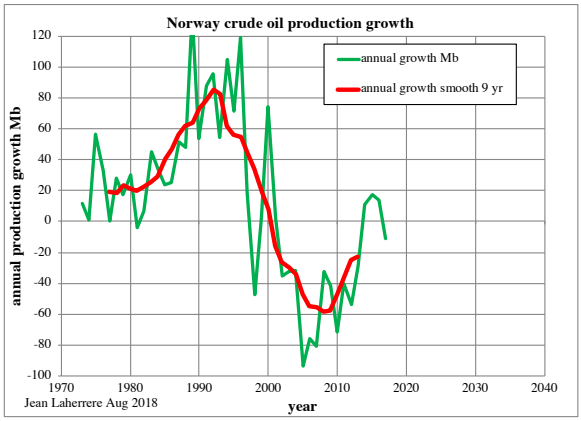
HL hard to extrapolate with recent shift, parallel to last trend, trending towards 32 Gb

Same with OD, trending towards 35 Gb.
Best estimate is creaming curve.

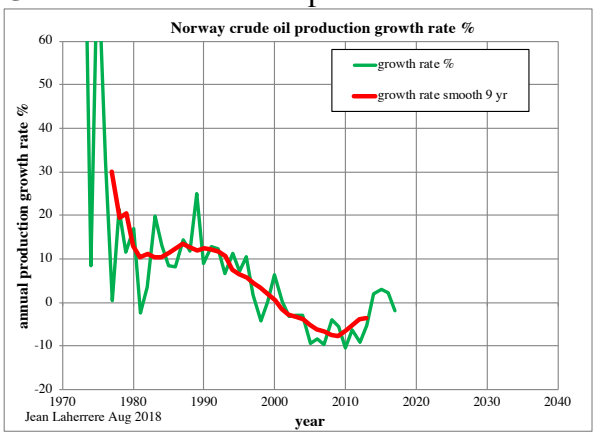






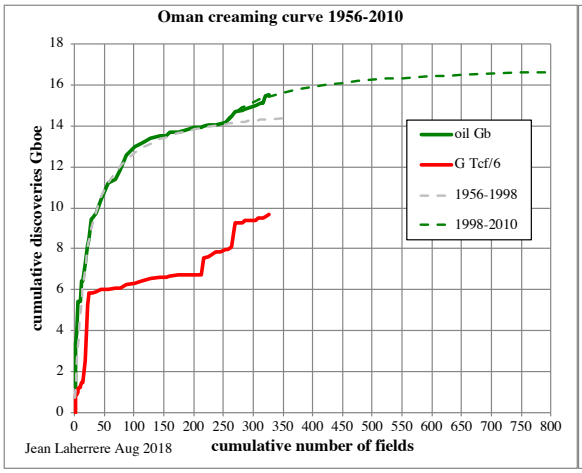


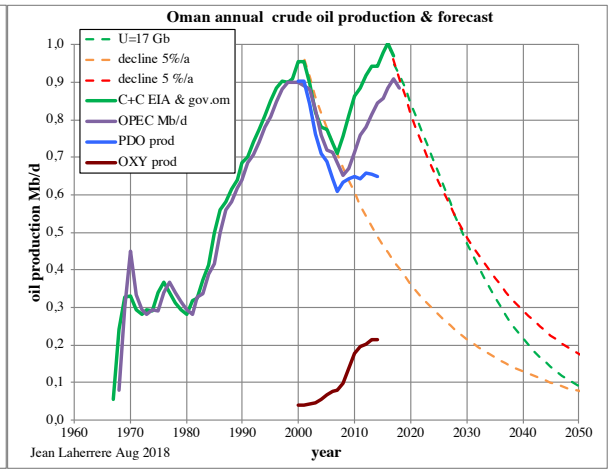
Norway crude oil production growth shows clearly the peak by crossing the zero line in 2001.
Growth rate in % is simpler.



-Oman

Oman oil production from EIA differs from OPEC data since 2008, it peaked in 2001 and 2016 and it declined at 5%/a from 2001 to 2007 and its declines from 2016 is also 5 %/a for an ultimate of





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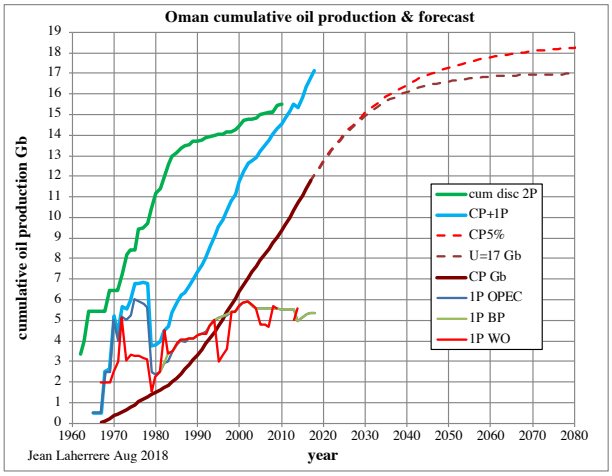
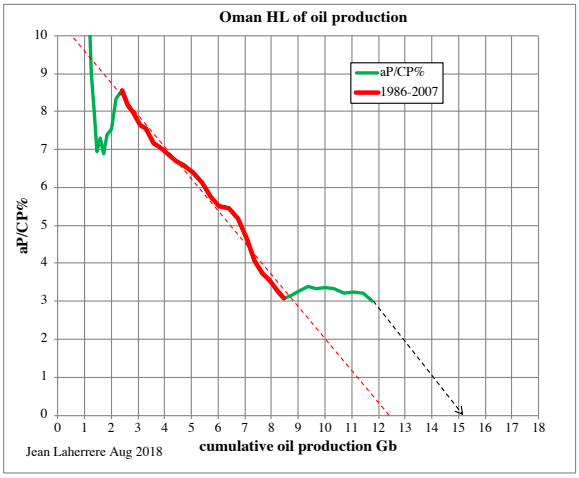
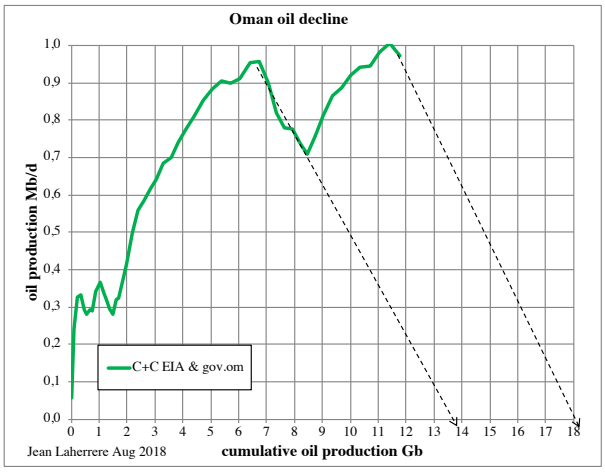
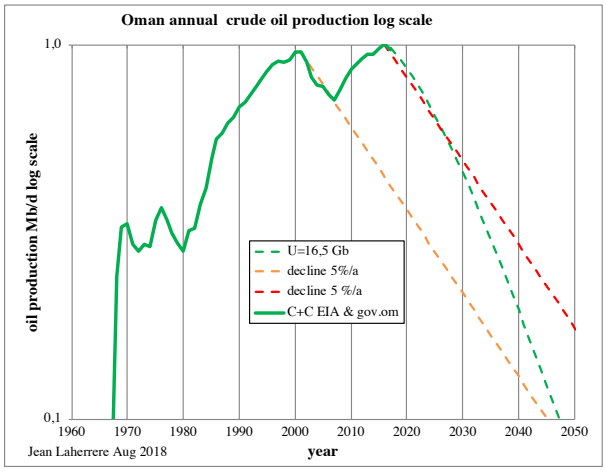
CC is extrapolated towards 16.5 Gb. HL is linear from 1986 to 2007, but the last point in 2017 is hardly declining ; a parallel of the previous decline trends towards 15 Gb, but it is unreliable.



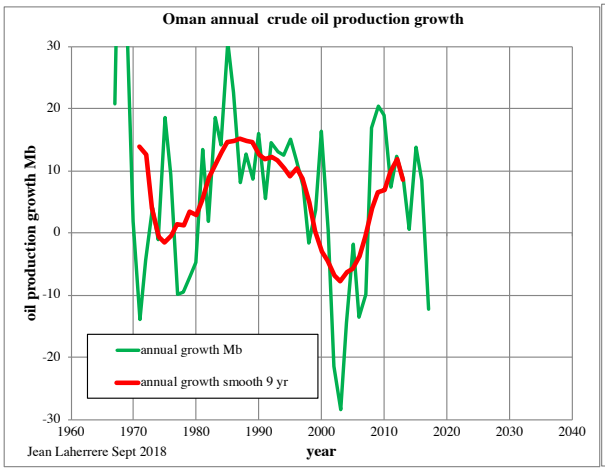


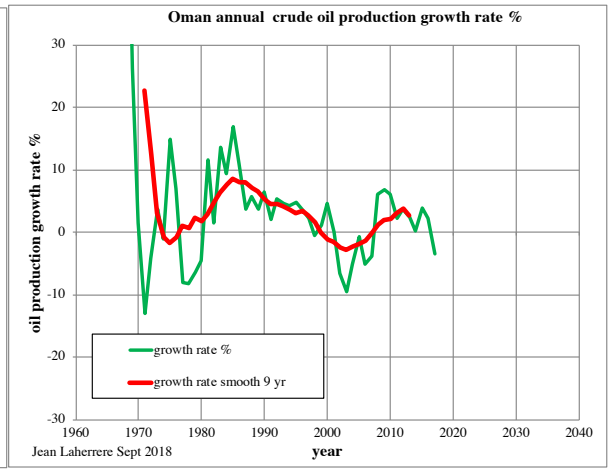
OD as HL is extrapolated with a parallel of the previous trend from 1986 to 2007 towards 18 Gb. The ultimate is taken as 17 Gb as CC





Oman crude oil production growth displays well the first peak, but badly the second peak, too recent. Growth rate in % is similar.

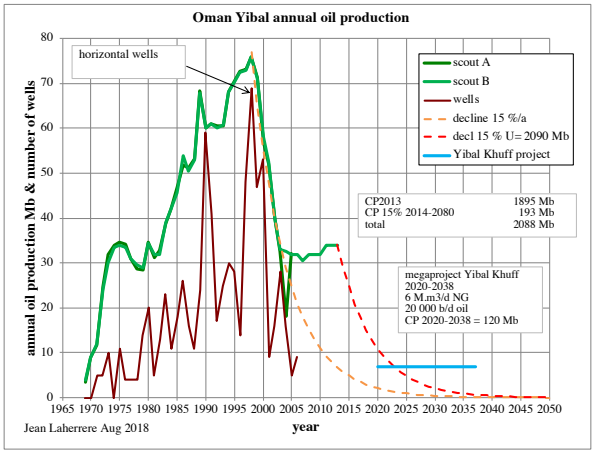


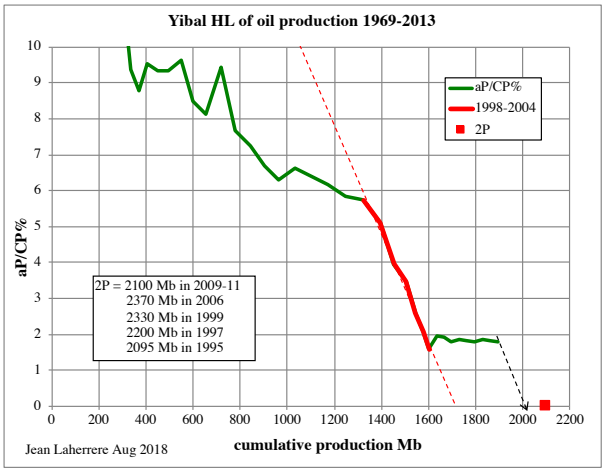


-Yibal

Yibal (like Rabi-Kounga in Gabon) is a good example of the power of technology (horizontal wells) to produce faster conventional fields, but not higher reserves. Yibal peaked in 1998 with a sharp rise thanks to horizontal wells, but the decline was sharp too with 15 %/a down to 2004 and nil up to 2013. HL is extrapolated with a parallel from the last point with the trend for 1998-2004 towards 20 Gb.

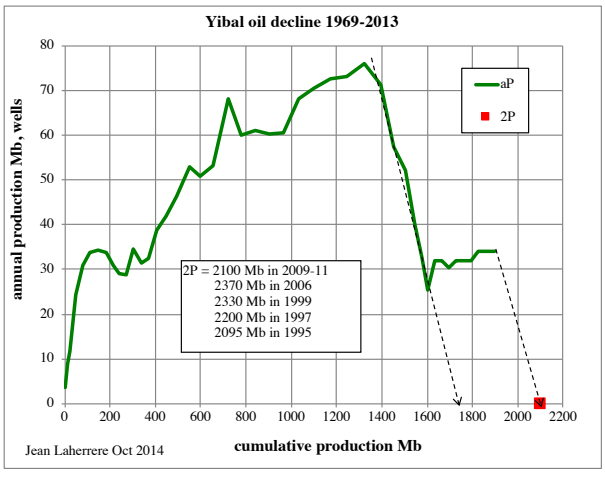
2P was 2095 Mb in 1995, rises to 2370 Mb in 2006 and down to 2100 Mb in 2010.





OD using the same parallel as 1998-2004 trends also towards 2100 Mb.

If from 2018 Yibal declines at the same rate of 15 %/a as 1998-2004 the CP2050 will be 2090 Mb.

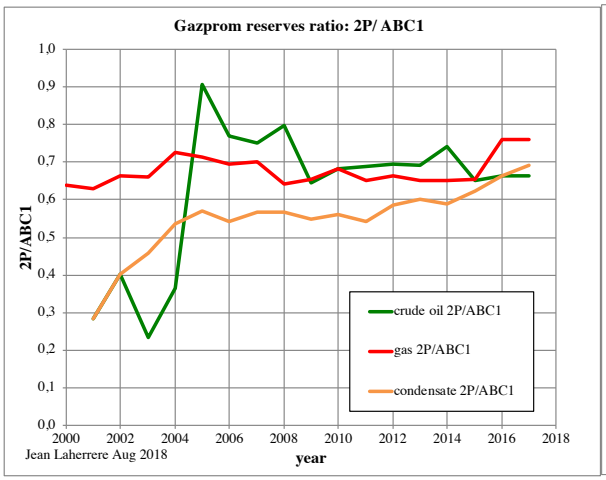


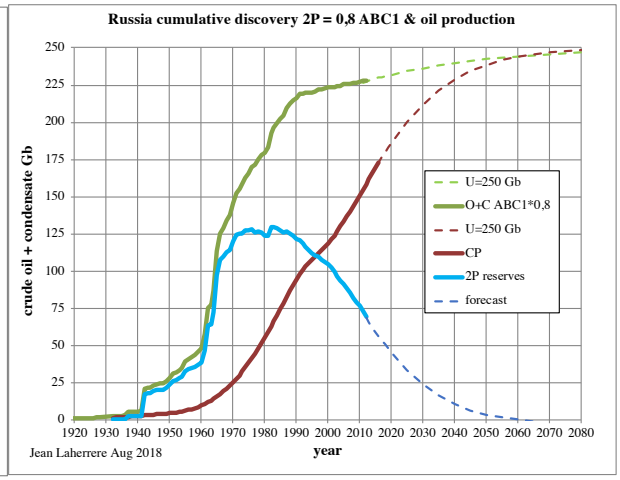
Yibal has now a megaproject = natural gas from the Khuff formation (deeper than oil) and oil production is not anymore reported after 2013. The Khuff production is forecasted for 2020-2038 6 M.m3/d of gas and 20 000b/d of oil: CP 2020-2038 =120 Mb, but it is a different field.

-Russia

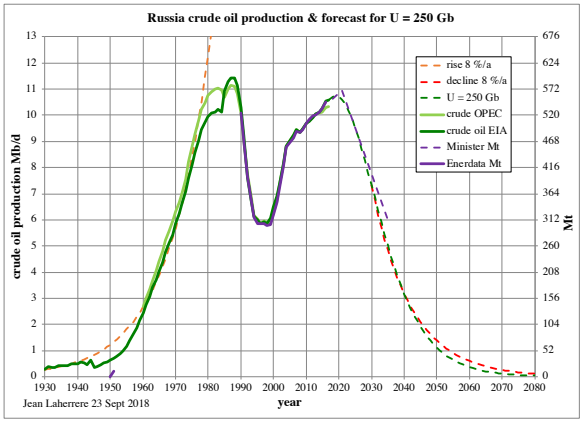
HL of past production does not work, as the crude oil production is still rising, the 250 Gb ultimate is based on the creaming curve of the corrected Russian classification ABC1 (2P = 0.8 ABC1). Gazprom reserves audits reports the ratio for the last 18 years It varies for the last 10 years between .0.5 and 0.8. Russian ultimate being uncertain, the rounded 250 Gb was chosen, corresponding to the ratio 0.8.

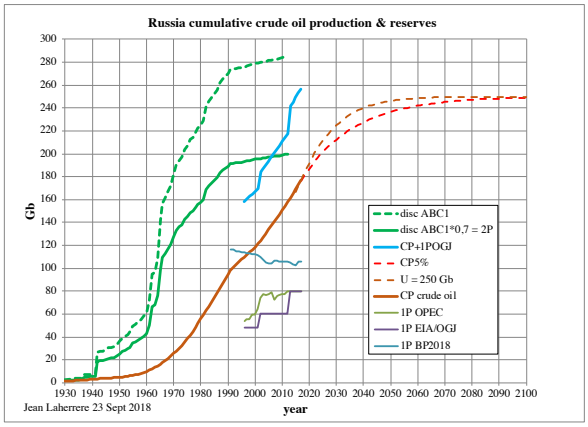
Gazprom is the only Russian company reporting in detail their reserves in 2P and also in ABC1.



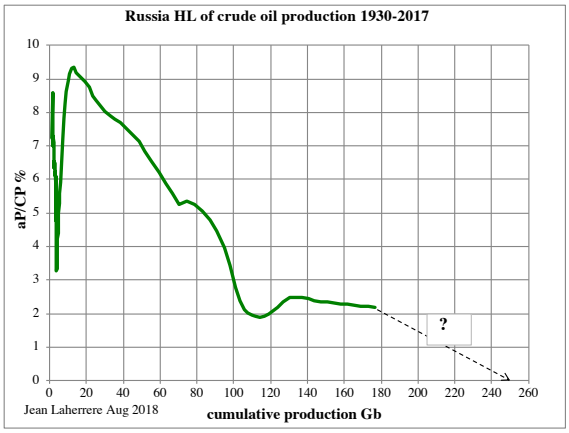


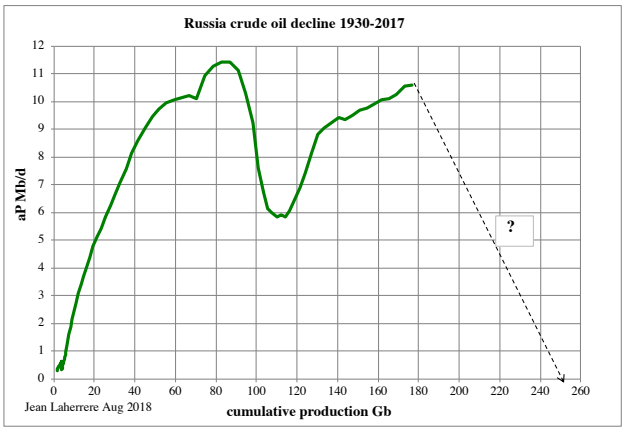
Russia crude oil production has peaked in 1988 and will peak again in 2019 for an ultimate of 250 Gb , giving a decline rate of 8 %/a from 2030 to 2050 (identical to the rise of 8 %/a from 1930 to 1977). A recent statement by the Oil Minister forecasts the peak in 2021 followed by a strong decline similar to my forecast? I corrected my peak to be in 2019 instead than 2017/ the fit between Mb/d and Mt is good for the period 1990-2017.



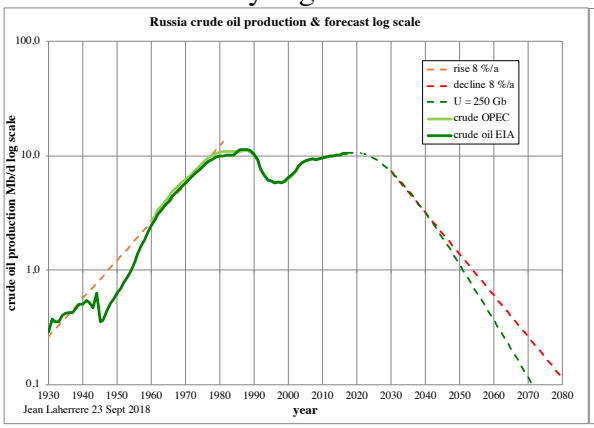


HL and OD are hopeless for estimating ultimate, only CC could be used but Russia oil reserves are questionable with ABC1, in fact the 250 Gb estimate looks good because the symmetry of future production with the past

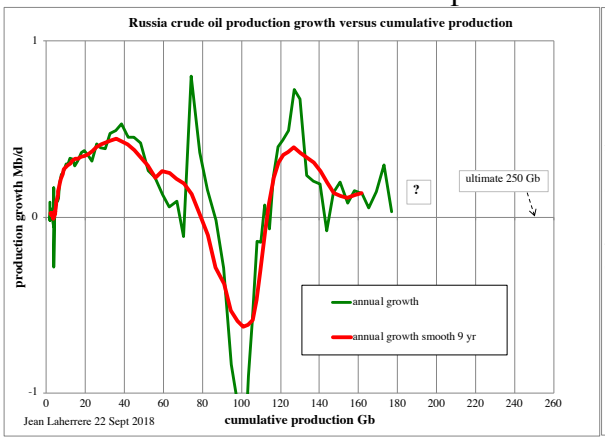




Russia crude oil annual production growth shows a decline since 2003 which can be extrapolated towards 2019, which is close to the peak year of 2021, announced by the Russian oil Minister few days ago.

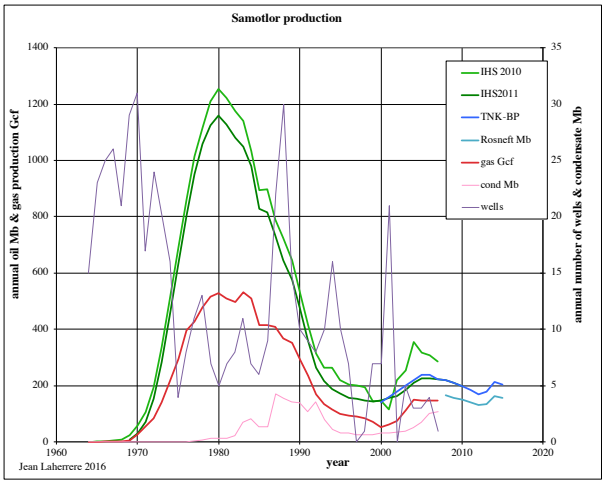


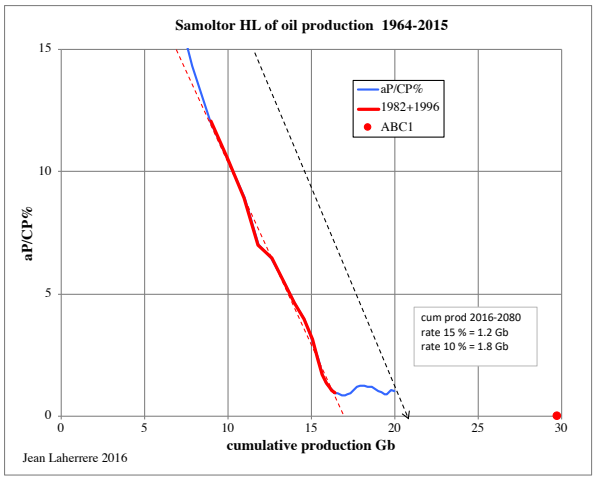
Russia annual production growth versus CP is hard to interpret; because the trough due to the USSR breakdown, the ultimate is the last zero up and presently the data is above zero, as present production is close second peak.
Growth rate in % trends towards a peak in 2020.



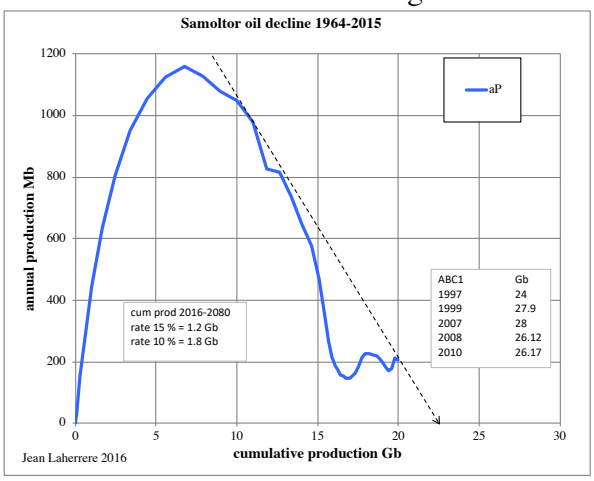
-Samotlor

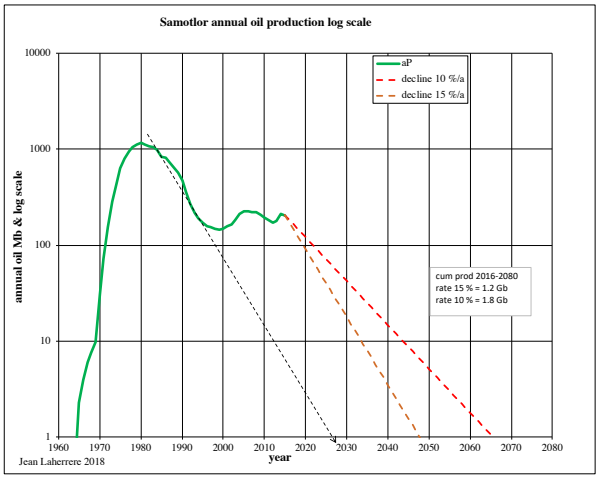
Samotlor in Western Siberia is the largest oilfield in Russia (followed by Romashkino). It peaked in 1960 and its decline was almost symmetrical to its rise. It reached a low in 2000 and increased to a peak in 2006 and 2014. Over 19 000 wells were drilled and Rosneft plans to drill 2400 horizontal wells from 2018 to 2027 to recover about 370 Mb, thanks to some subsidy. In 2017 the watercut was 96 %.





The cumulative oil production up to 2015 is 20 Gb.
Samotlor ultimate is 21-22 Gb against 26 Gb for ABC1

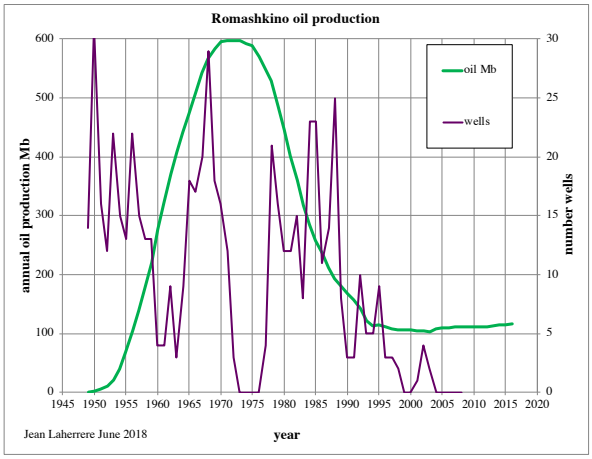


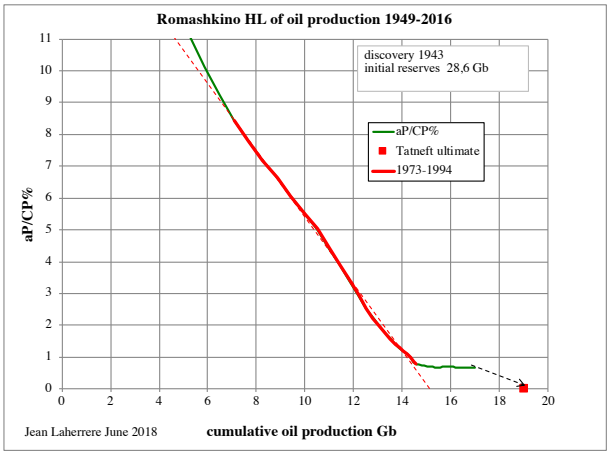


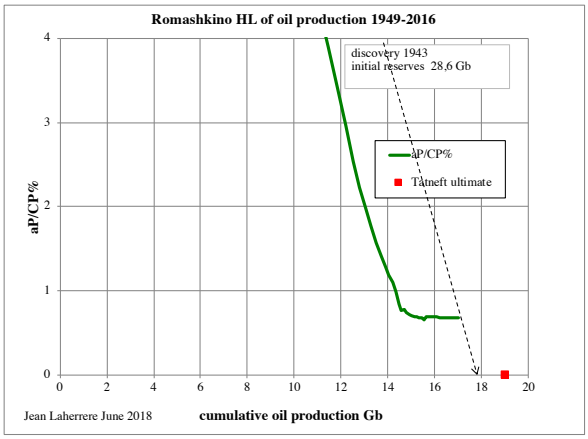
The future decline rate after 2015 could be 10 or 15 %/a and the cumulative production 2016-2080 is 1.2 Gb for 10% and 1.8 Gb for 15 %

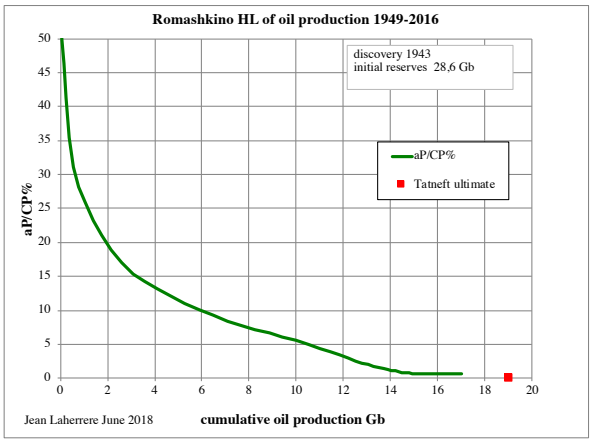
-Romashkino

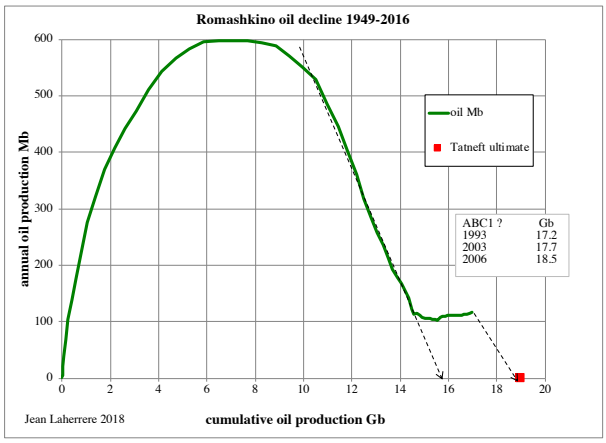
Romashkino (Urals-Volga basin) oil production displays a sharp rise, a sharp decline within the Soviet Union and a long flat tail after the break-up.
HL 1973-1994 trends towards 15 Gb but the ultimate is now estimated by Tatneft at 19 Gb



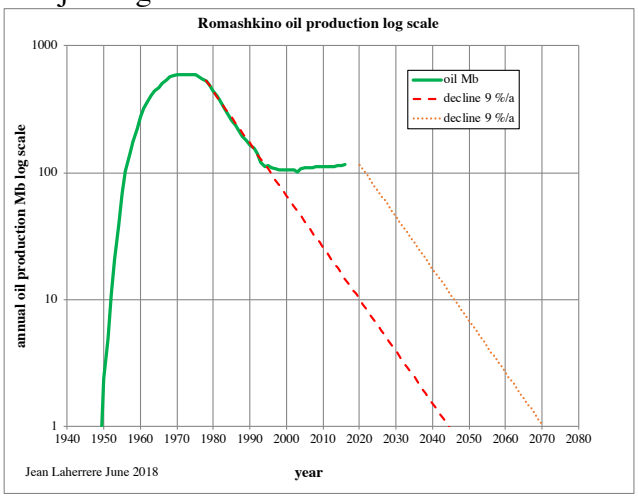








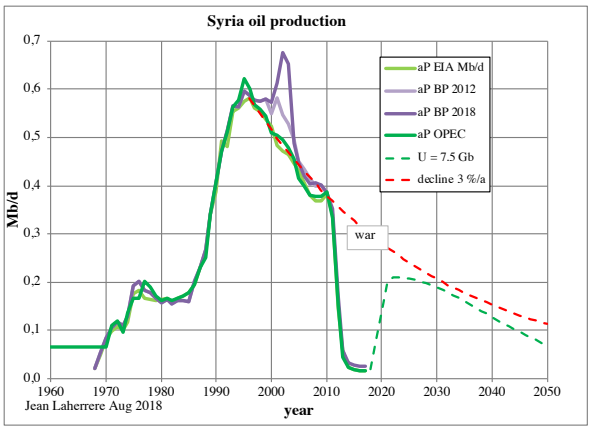
Romashkino oil production is almost flat since 1993 to 2016, around 110 Mb/a, in fact slightly rising since 2003 with 2016 being the highest value (15.9 Mt from Tatneft the operator)
After 2020 the decline rate of Romashkino would be 9 %/a, like for the period 1978-1994, but it is just a guess!

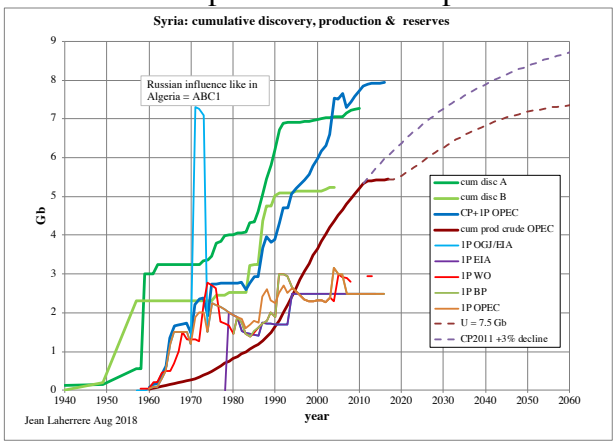


-Syria

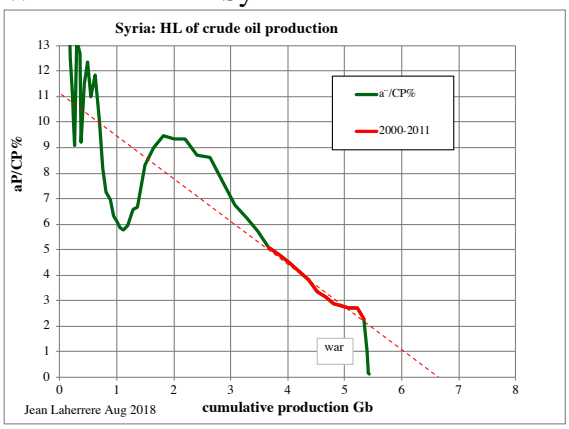
Syria crude oil production peaked in 1995 at 0.62 Mb/d (except for BP recent years with a peak in 2002, but not there for BP 2012) and since 2010 the civil war has destroyed oil production. OPEC reports a suspicious constant production (65 kb/d from 1960 to 1970, in disagreement with other sources, which start production only in1968.

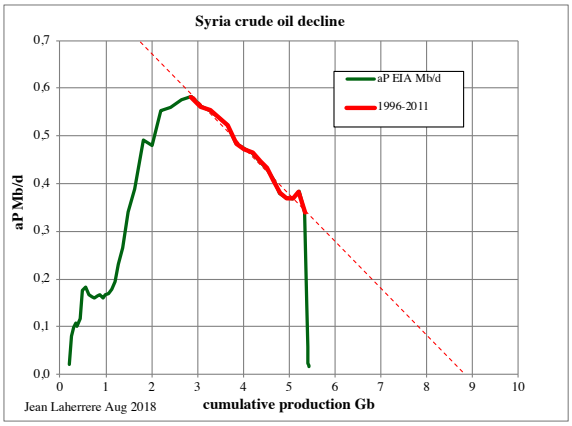
Syria oil production has declined from 1995 peak at a rate of 3 %/a until 2010 with collapse in 2009 due to the war.
We assume that Syria will be in peace in 2020 and resume oil production with a peak in 2022



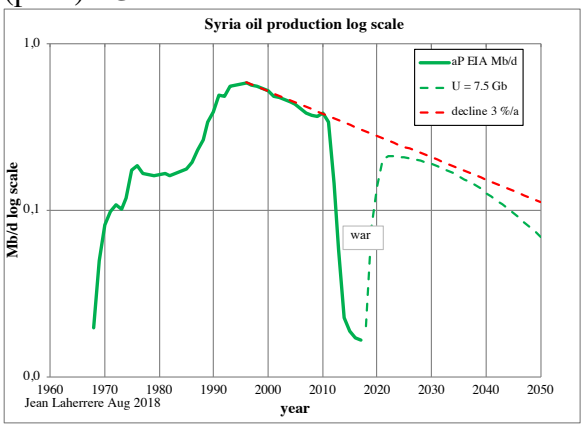


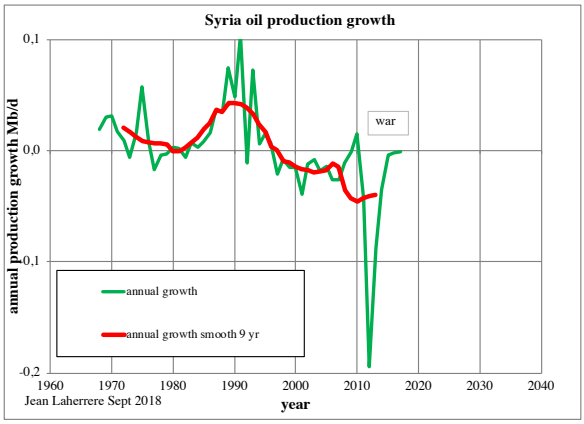
OGJ reports Syria reserves very high in 1971 & 1972 (being influenced by Russians to report ABC1)
HL of 2000-2011 trends towards 6.5 Gb. CP +1P OPEC is higher as discoveries A '(but not discoveries B). OD of 1995-2011 trends towards 8.8 Gb?
Creaming curve is unreliable being ABC1.
CP end 2011 is 5.2 Gb and extrapolated with a decline rate of 3 %/a CP 2011-2100 will reach 9.4 Gb in 2100.
We have chosen Syria crude oil ultimate at 7.5 Gb

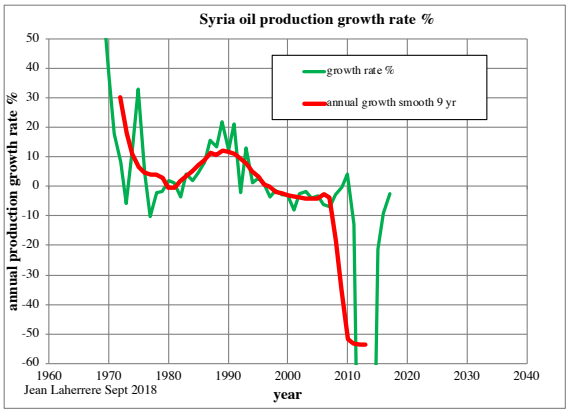




Syria crude oil production growth displays a decline since 1990 crossing the zero line in 1995 (peak). Growth rate in % is similar.



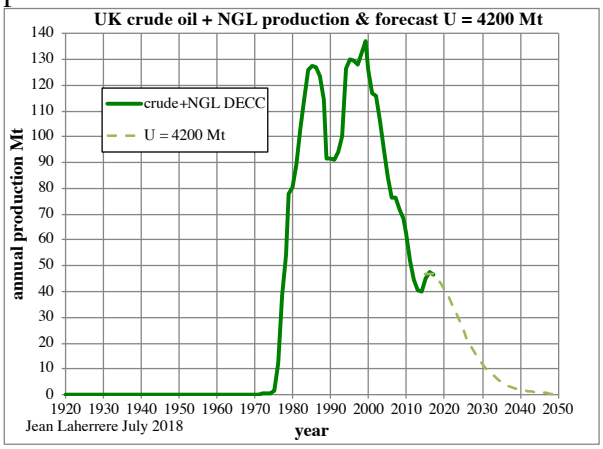


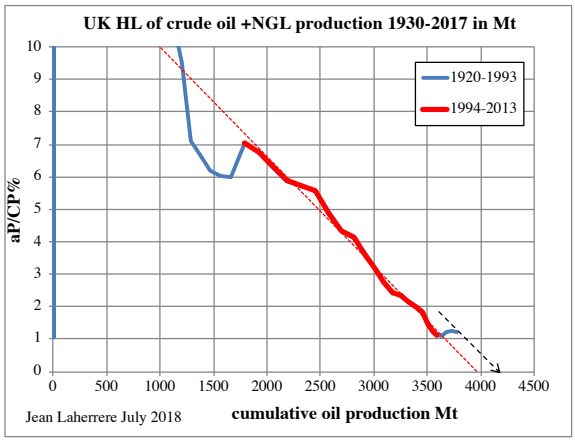


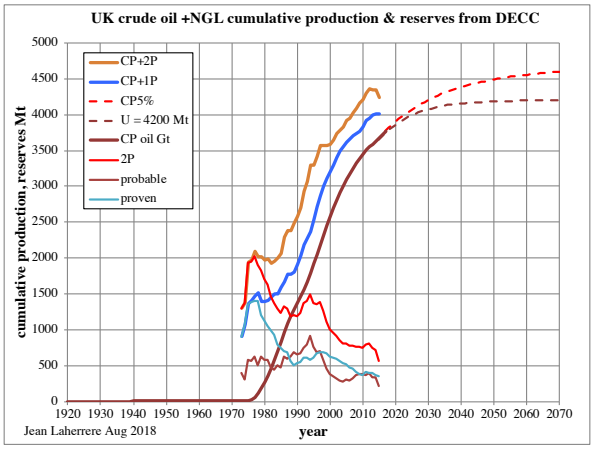
-UK

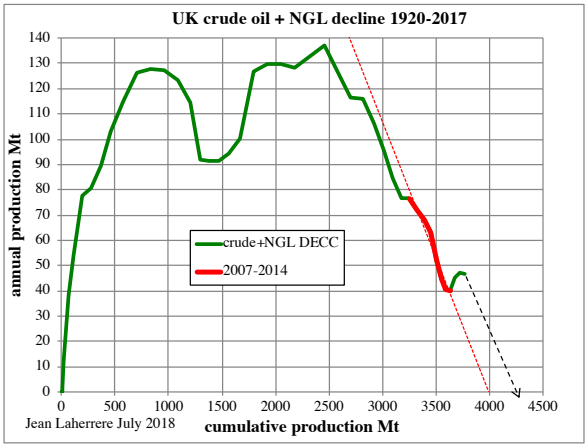
UK.gov reports data in Mt, but they stopped reporting reserves in Mt after 2015, only in m3 and barrels (US practice is winning despite that for UK (like the world except US, Myanmar & Liberia) the law is the metric system (SI))

My guess is for an ultimate of 4200 Mt, leading to a minor peak in 2016 and a negligible production in 2050

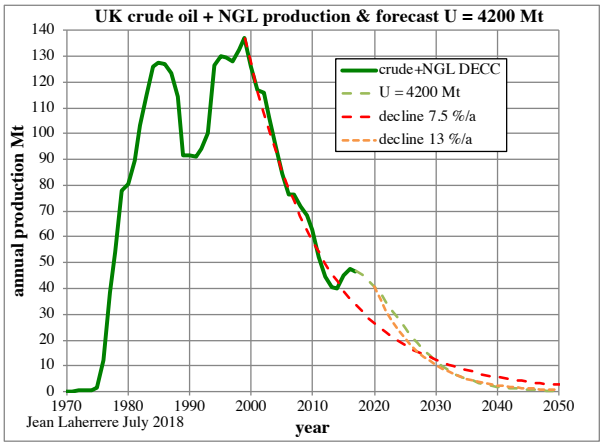


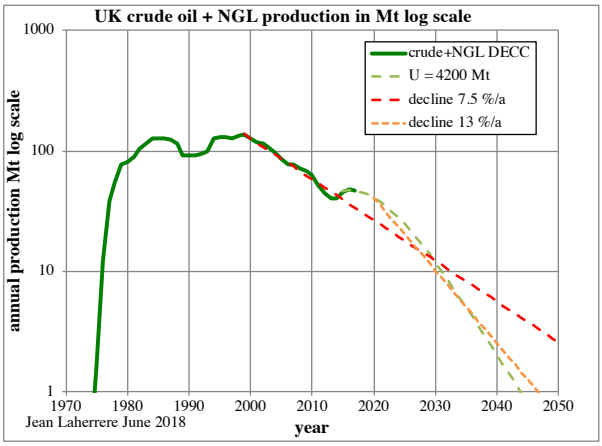




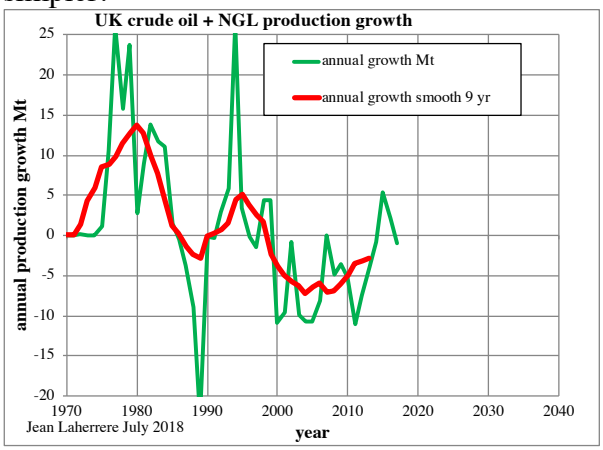


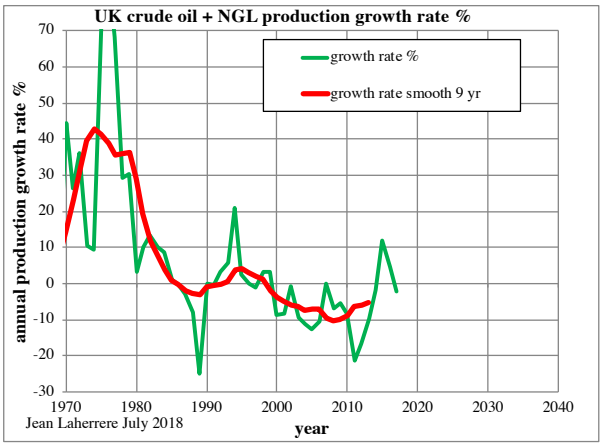
The plot in log scale shows that UK oil production in Mt has declined from the peak of 1999 to 2014 at 7.5 %/a and will decline from the minor peak of 2016 at 13 %/a





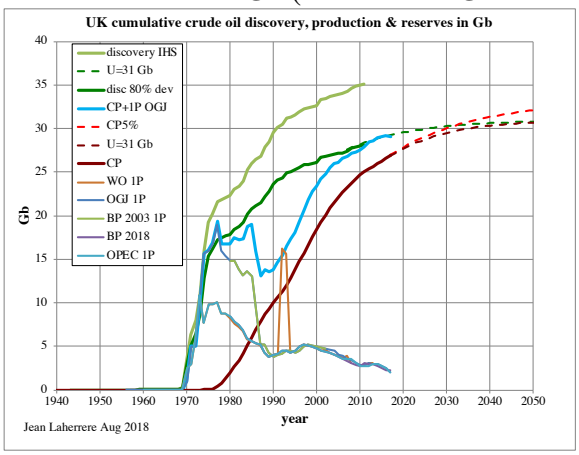
UK crude oil production growth in Mt is rather chaotic after 2000. Growth rate in % is simpler.



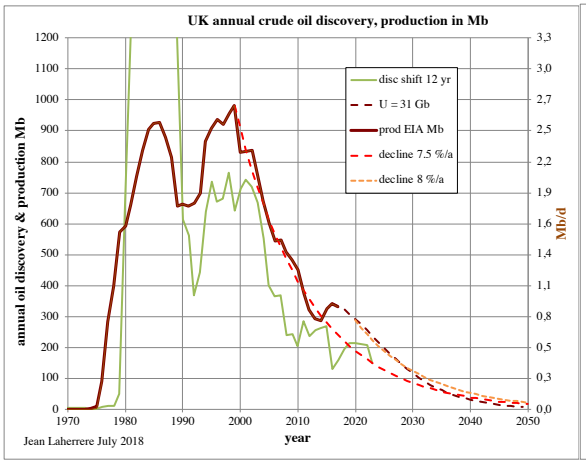


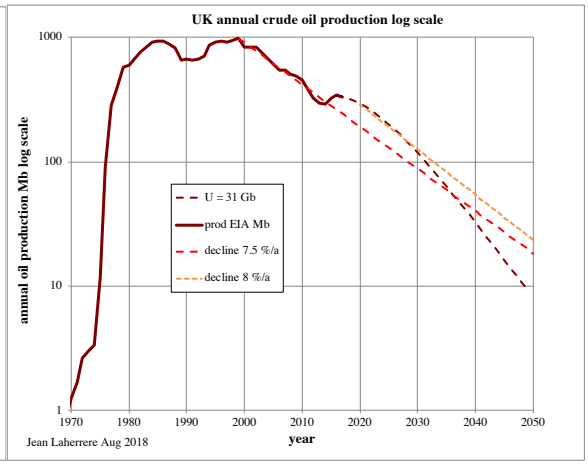
Production data in Mb

The ultimate is 31 Gb (same as 4.2 Gt for 1 t = 7.38 b

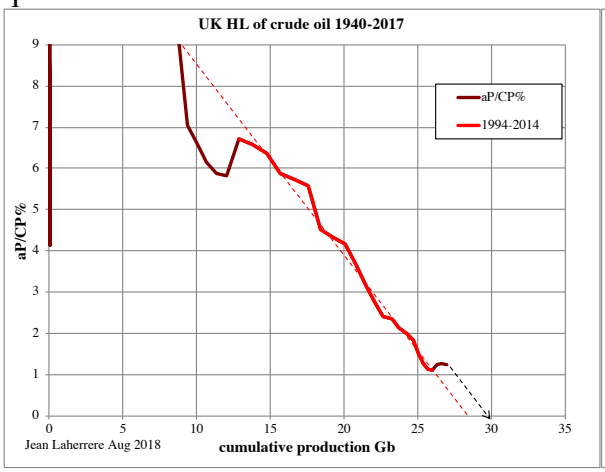


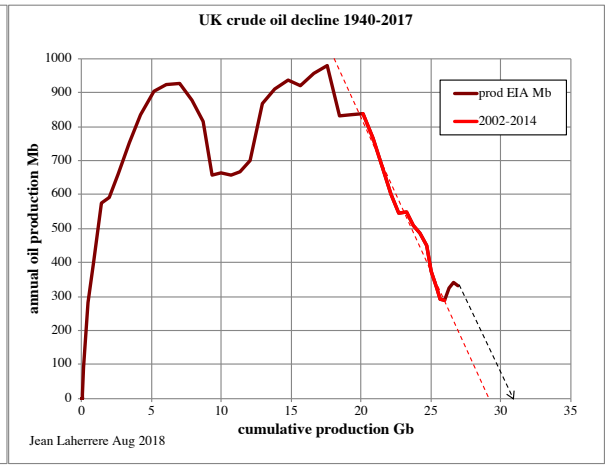
The decline rate from the peak of 1999 to 2014 is also 7.5 %/a and for the ultimate 31 Gb of 8 %/a





HL is linear for 1994-2014 and from 2017 extrapolated towards 30 Gb being parallel, when OD is linear for 2002-2014 and towards 31 Gb, being parallel. These estimates are questionable

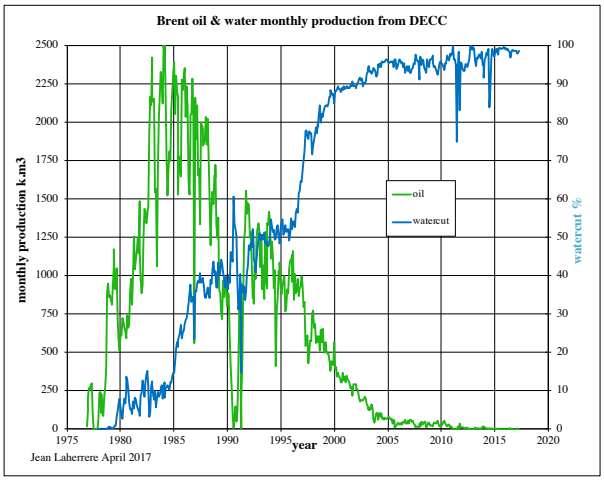


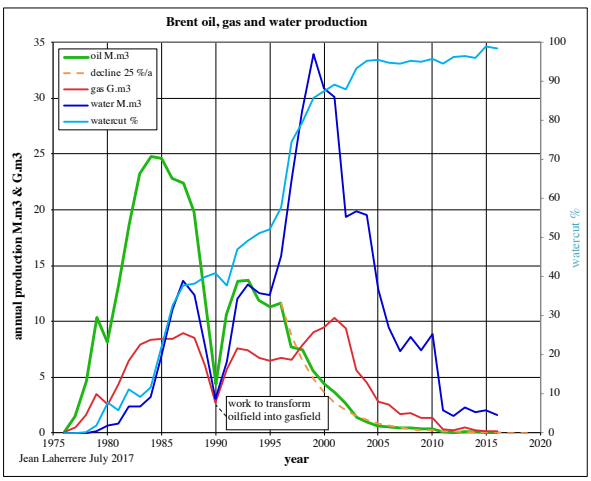


The problem is that many offshore discoveries are small and will never developed. Our estimate of 31 Gb for ultimate could be short!

-Brent oil field production

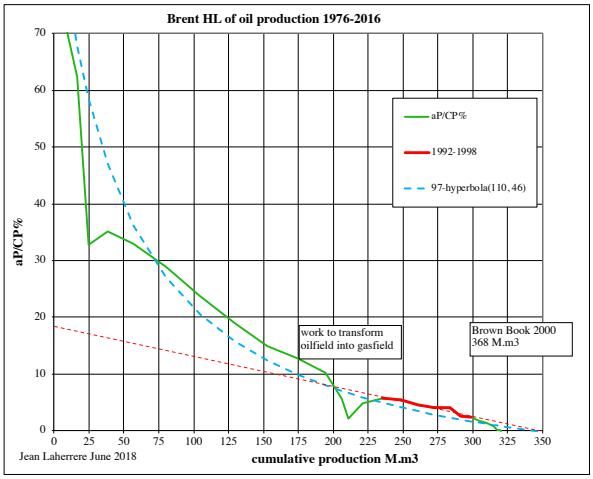
Brent crude oil production peaked in 1984, but in 1990 was stopped to transform the oil field in also gas field (gas production peaked in 2002). Since 1996 to the end in 2017 Brent crude oil has declined at a rate of 25%/a

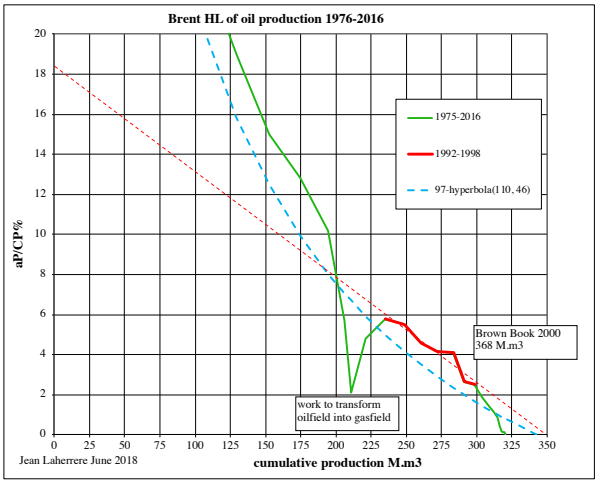




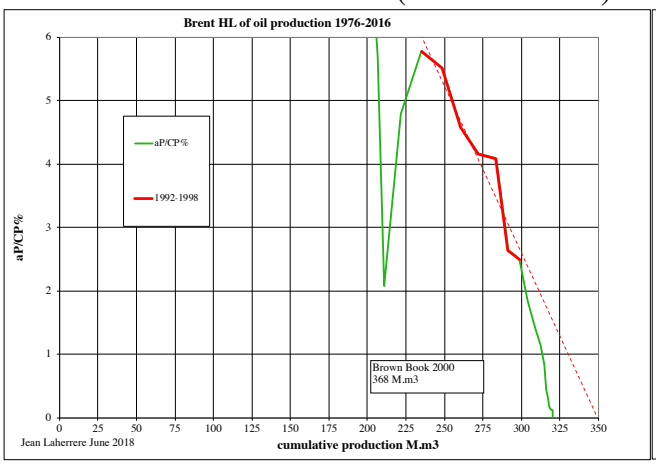
Brent oilfield produced from 1976 to 2016, the cumulative production at end in 2016 was 320 M.m3 (2015 Mb)
Brent oil field is a poor example because in the middle of the production Brent platform was transformed from an oilfield into a gas field

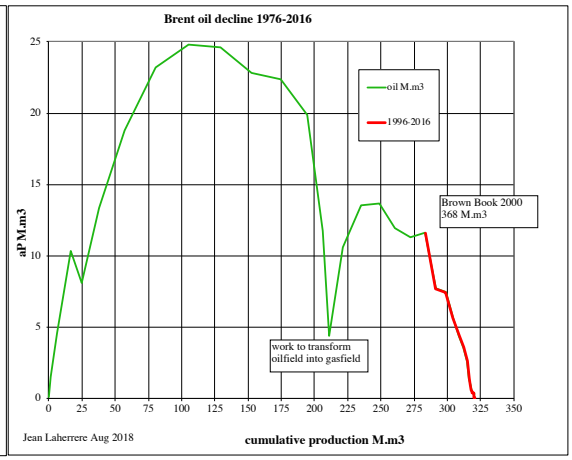
The HL of oil production displayed two linear periods:
1981-1988 trending towards 250 M.m3
1992-1998 trending towards 350 M.m3 when the real value is 320



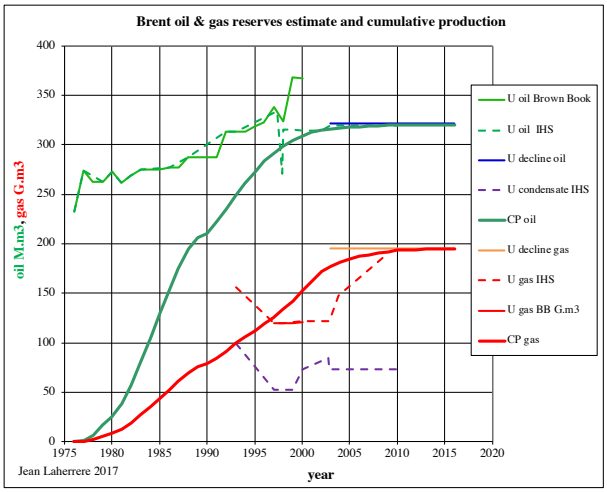


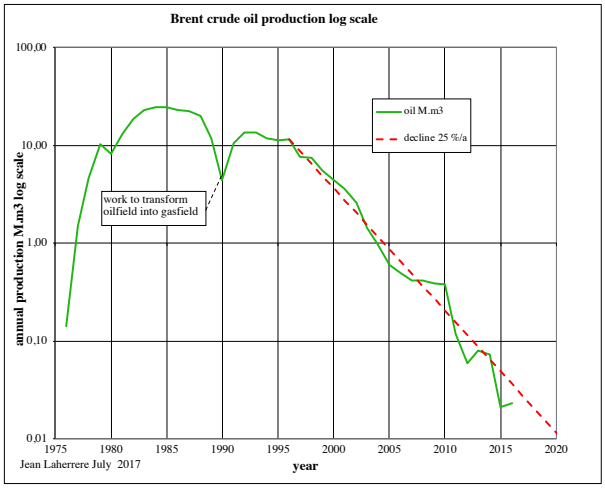
HL is linear from 1996 to 216 (end of the field) when OD is linear from also 1996 to 2016





The official estimate of initial oil reserves (Brown Book) displays a poor performance from 232 in 1976 to 350 M.m3 in 2000

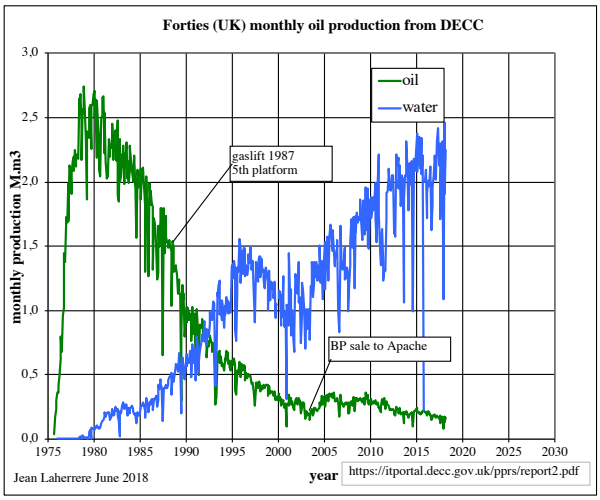


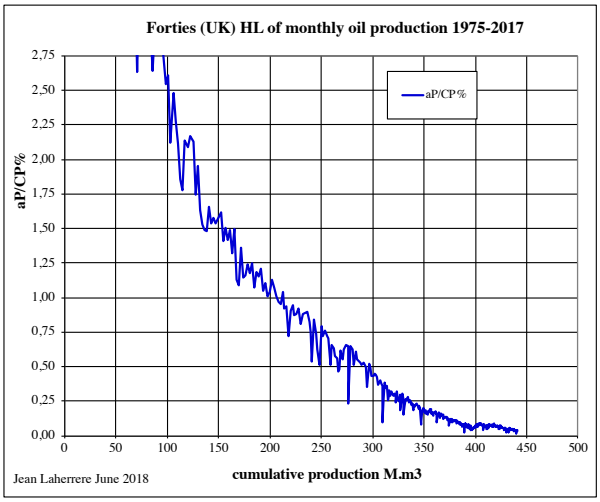


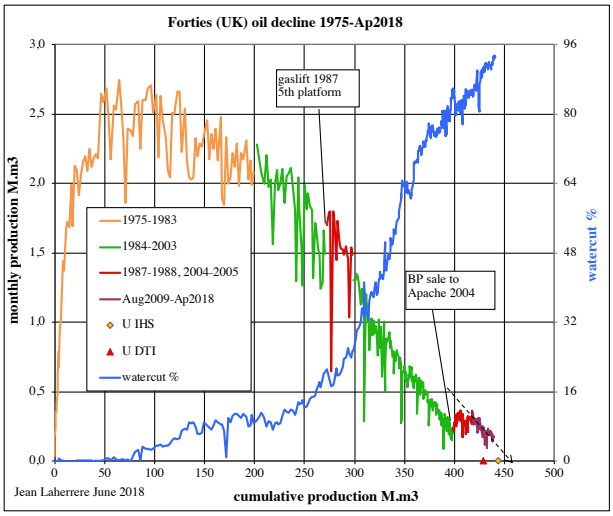
As for Forties and Thistle the HL plot is curved (with valleys due to works) and a hyperbola model is a better fit for the whole display.
It appears that the oil production for offshore fields displays an early peak and a long decline, because most of the producing wells (& most of water injectors) are drilled before the start of production (the platform is designed for a certain number of wells and it is much cheaper to drill them first) and the HL is mostly curved with almost few linear parts in contrary with onshore fields where production starts with few wells.
The best production forecast for mature field is to fit the past with a constant decline rate.

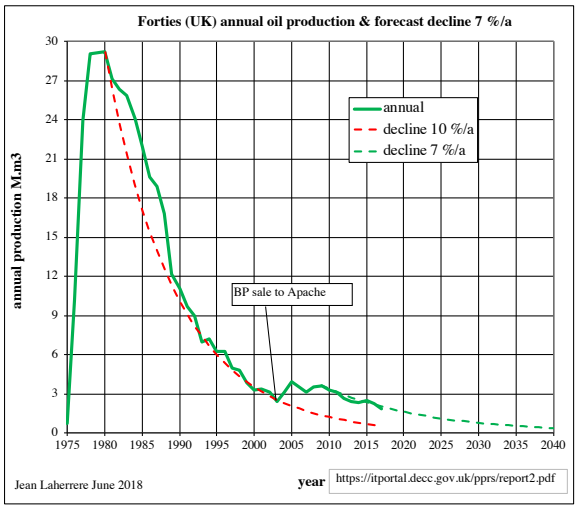
-Forties

Forties oil production is a good example of no linear but curved HL: both for monthly or annual production: it means that the linear trend = tangent and its slope is always moving towards a larger ultimate

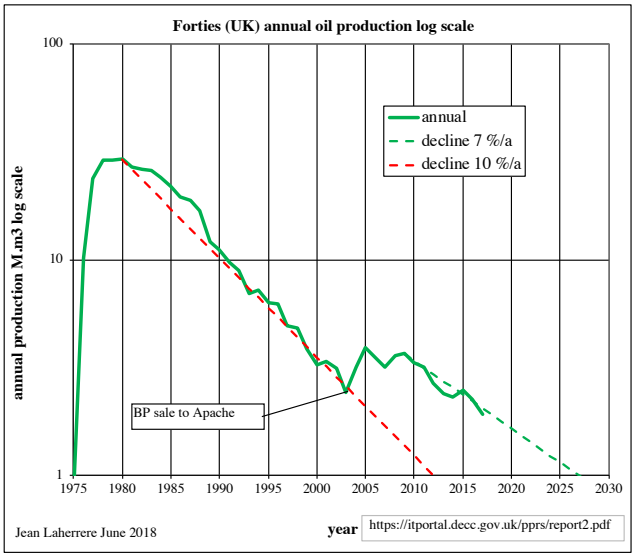


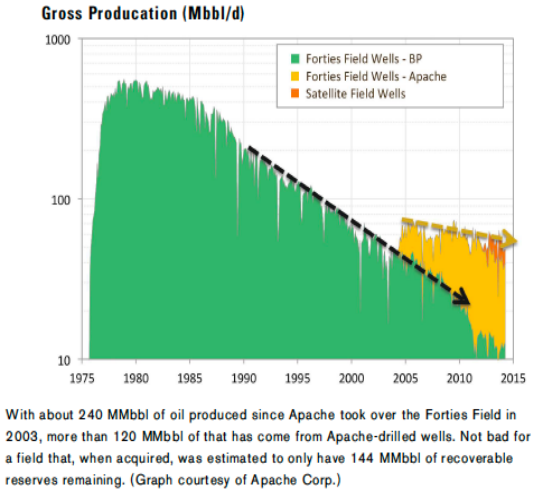






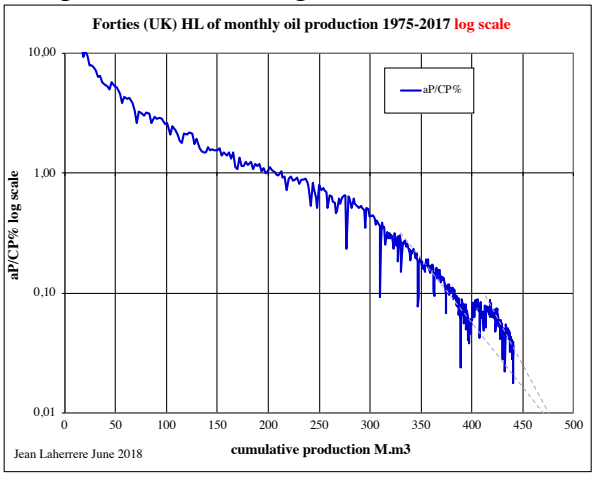
If it is difficult to see any linear portion in oil decline, the picture is different when plotted in log scale. Since 2010 the tail is linear fitted by a decline of 7 %/a
Apache uses also the display in log scale of the production versus time, but forgets to extrapolate it

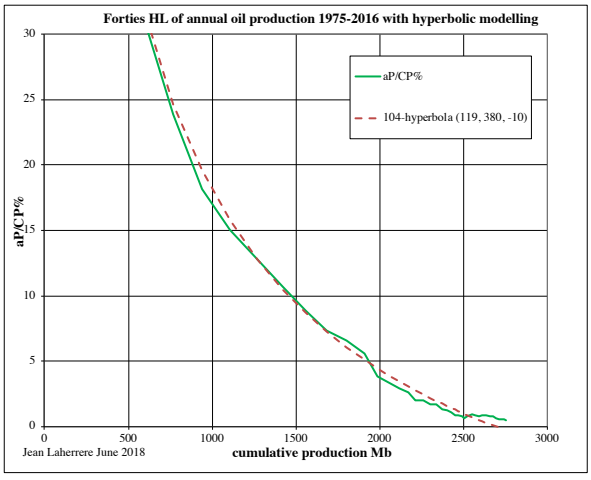


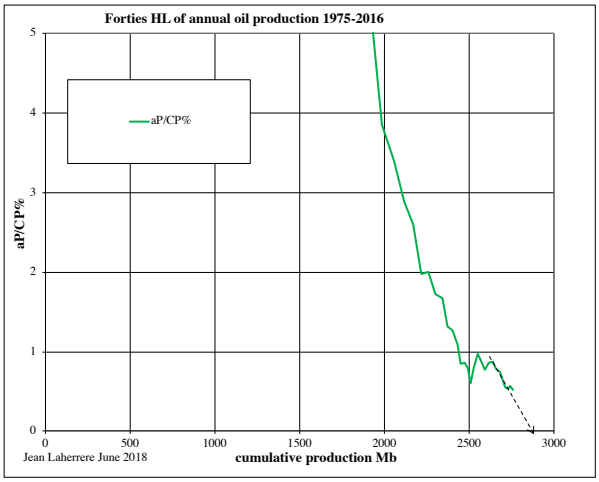


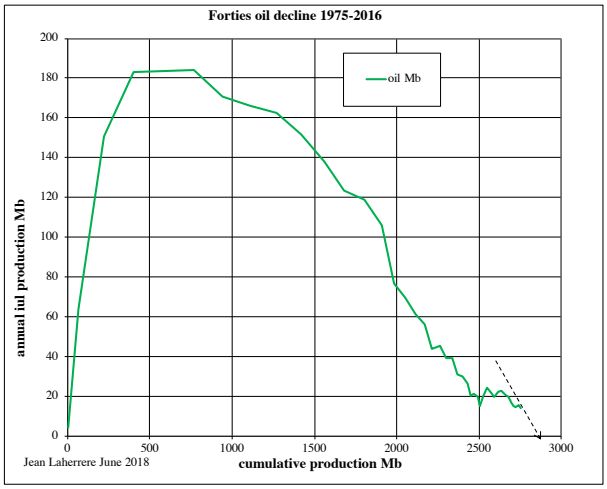
With about 240 MMbbl of oil produced since Apache took over the Forties Field in 2003, more than 120 MMbbl of that has come from Apache-drilled wells. Not bad for a field that, when acquired, was estimated to only have 144 MMbbl of recoverable reserves remaining. (Graph courtesy of Apache Corp.)

The plot of aP/CP% log scale vs CP is curved!

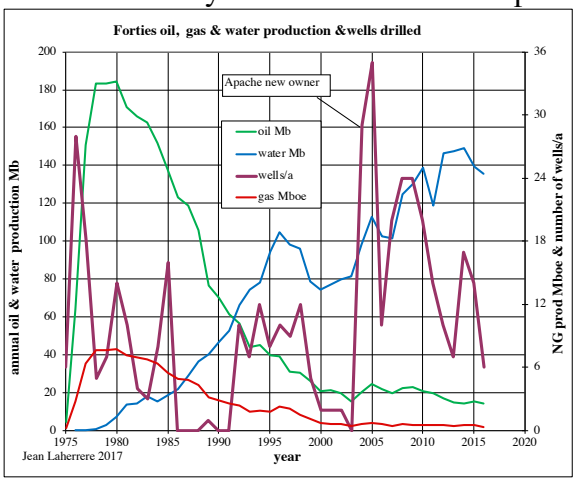


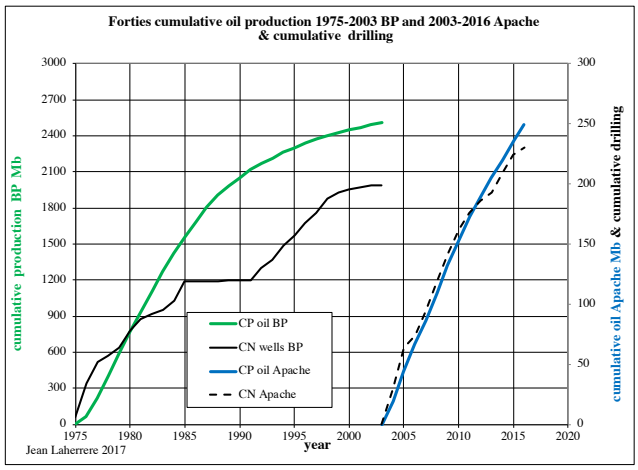






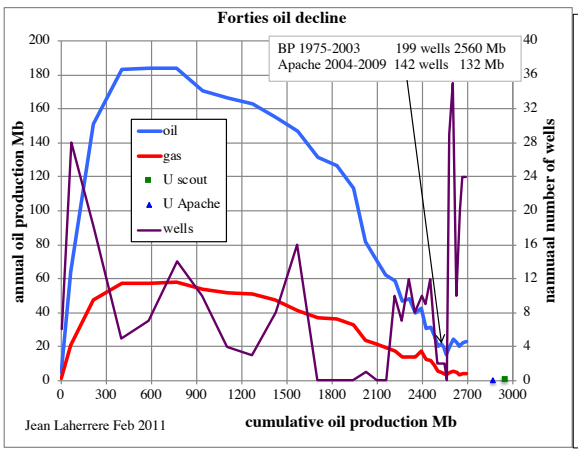
The annual production displays some correlation with the number of wells drilled, which varies drastically with the new owner Apache in 2004.

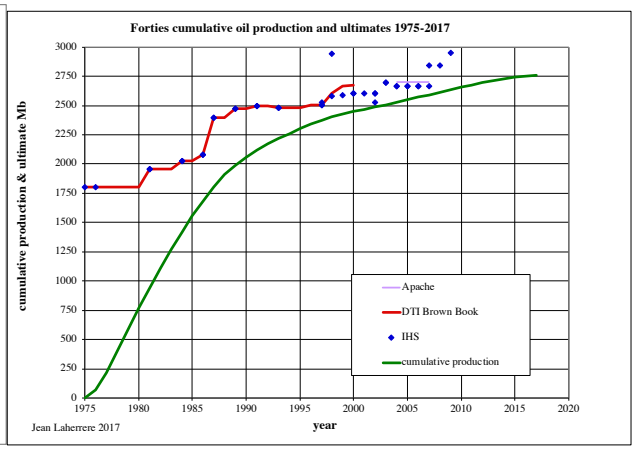




Forties was declining sharply, becoming uneconomical for a major company and it was sold by BP to Apache, which has lighter overheads and drilled some infilling wells. Up to Now BP has produced 2500 Mb with 200 wells up to 2003 when Apache has produced 250 Mb with 230 wells

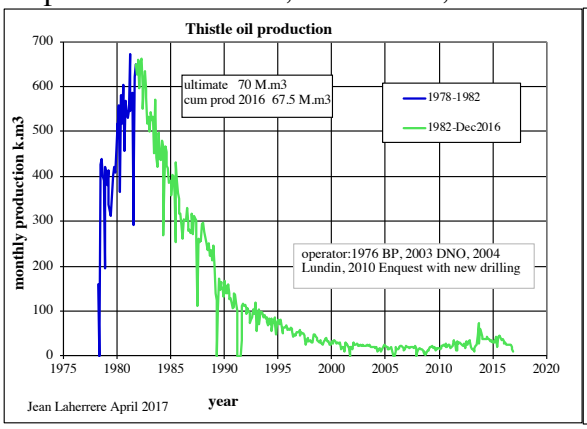
Forties oil reserves as reported by the government (DTI) in the Brown Book have increased from 1975 to 2000 close to the right value, when 2P IHS have continued to increase above this value.

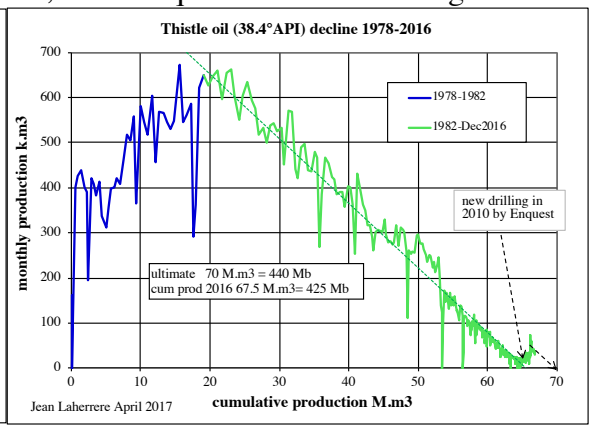


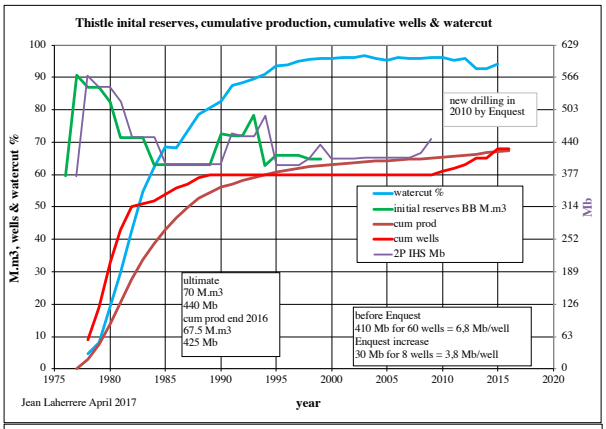


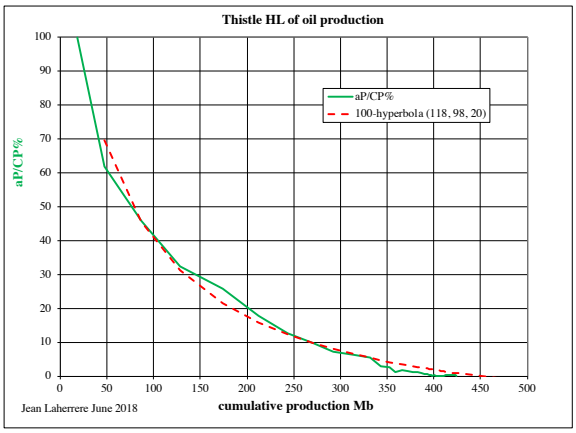
-Thistle

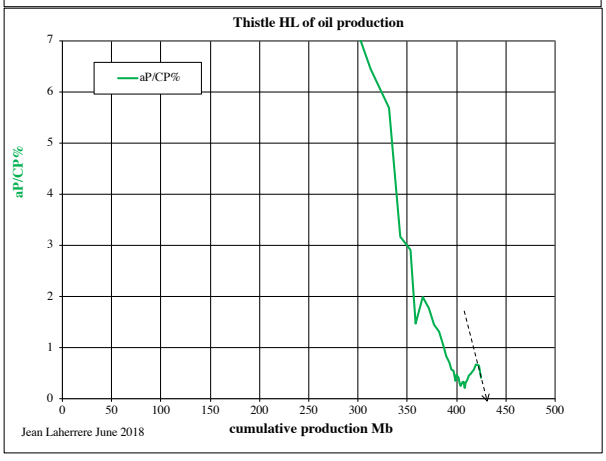
4 operators : 1976 BP, 2003 DNO, 2004 Lundin, 2010 Enquest with new drilling



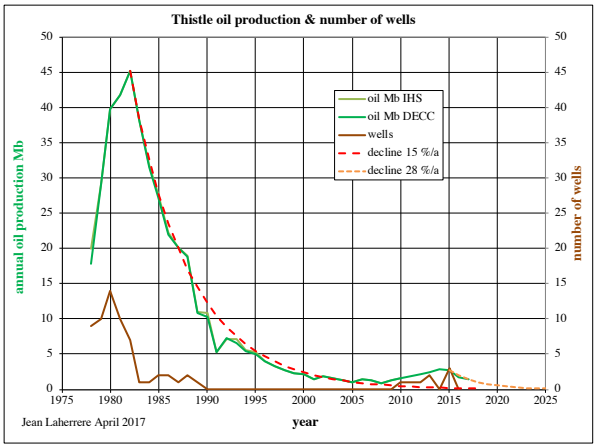


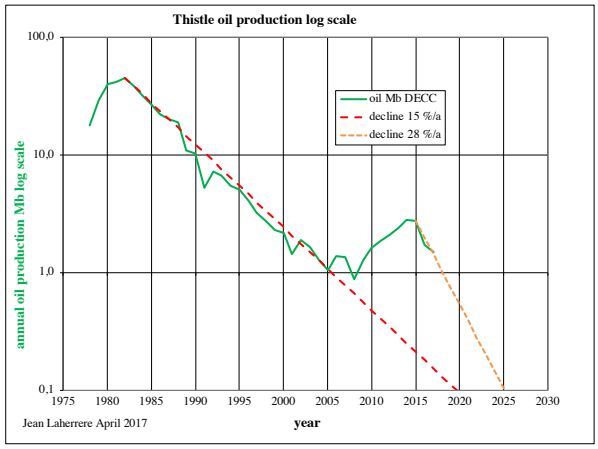






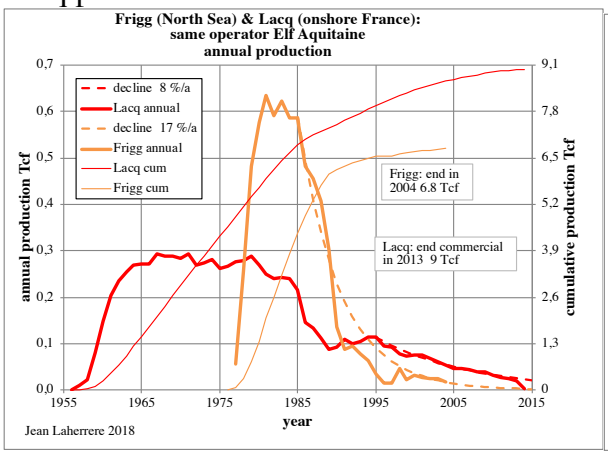
New drilling (EOR infilling) in 2009did add production after a decline rate of 15 %/a since 1982 to 2008 and at 28 %/a since 2015 to the end

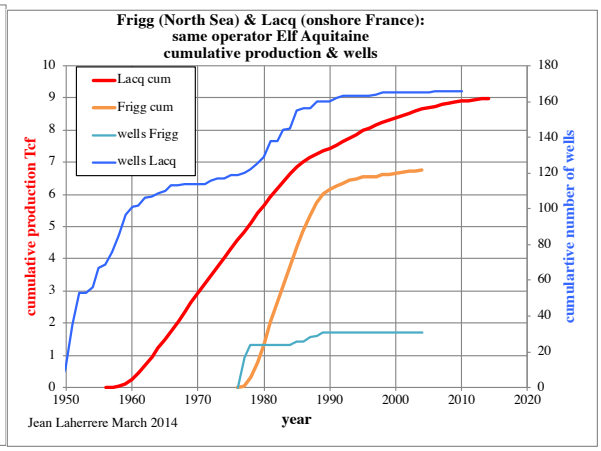


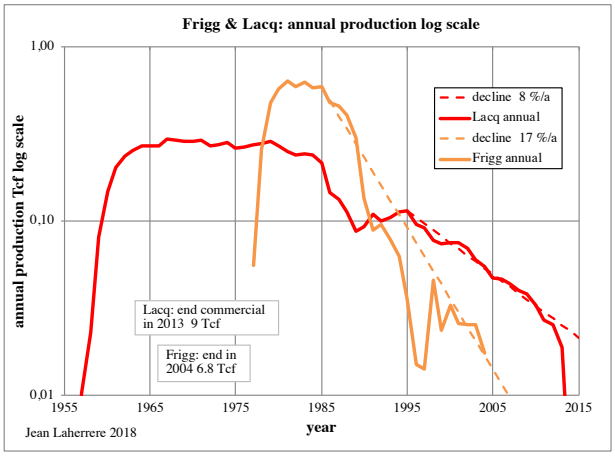


-Frigg and Lacq gasfields

In the North Sea Frigg (7 Tcf) is a gasfield shared between UK (51%) and Norway (49%) and the production was operated by Elf Aquitaine, as the gasfield of Lacq (9 Tcf) onshore France.
The comparison between offshore and onshore with the same operator is interesting
Frigg was produced much faster than Lacq. Offshore operating costs are much higher and the faster the better.
Frigg peak around 1980 is twice higher than Lacq peak (1967-1980)
Frigg production declined from 1985 to 2004 with a rate of 17 %/a (thanks to a high daily allowable)
Lacq production declined from 1995 to 2016 with a rate of 8 %/a

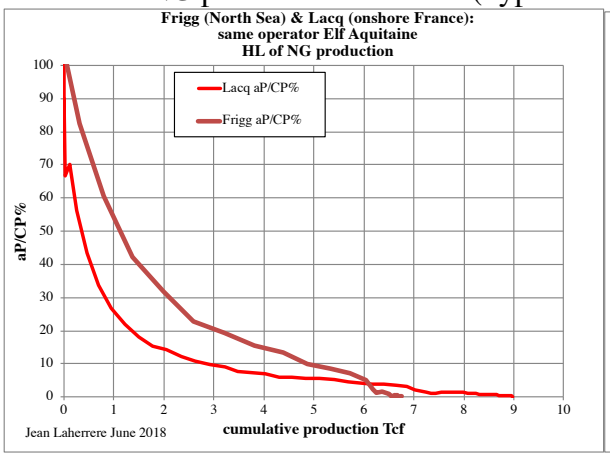


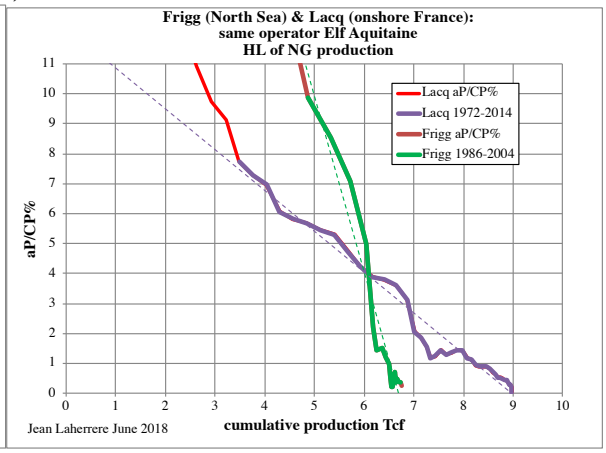




Lacq 9 Tcf was produced with 166 wells in 58 years when Frigg (6.7 Tcf) was produced with 31 wells in 29 years

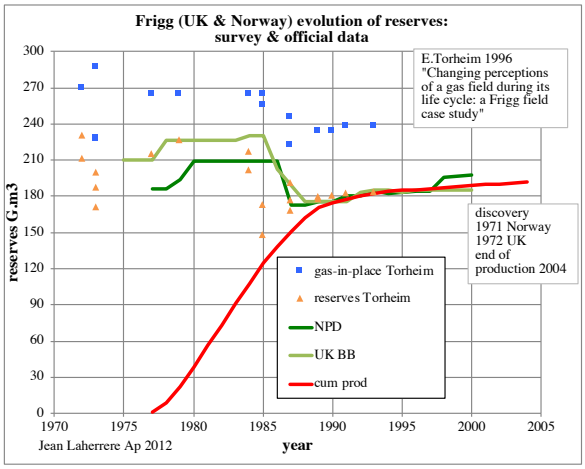
The HL of NG production is curved (hyperbola) for both fields

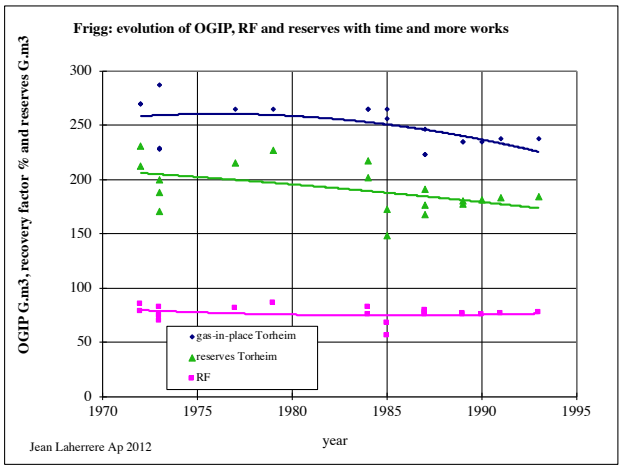




But the end of production: Lacq (1972-2014) and Frigg (1986-2004) is almost linear

Frigg NG reserves estimates were numerous and were in decline. It was advantageous for the operator to have high reserves estimate in order to obtain from the government a higher daily rate and to produce the field sooner: offshore field annual costs are higher than onshore annual costs.



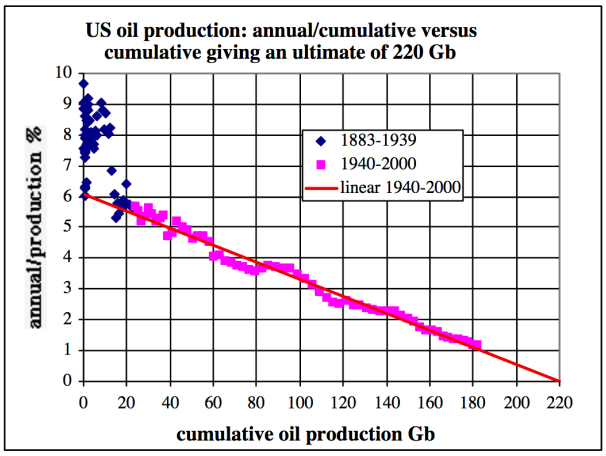


The evolution of in place reserves was similar to the evolution of 2P reserves , leaving the recovery factor steady around 77%.

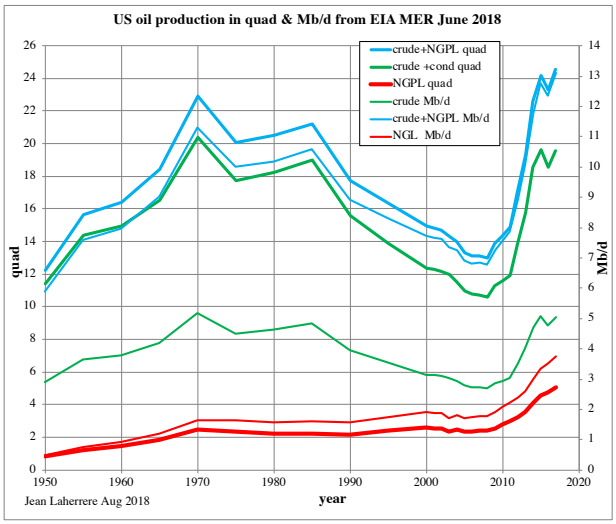
-**US**

In 2002 at first ASPO conference The International Workshop on Oil Depletion Uppsala, Sweden, I presented "Modelling future oil production" www.isv.uu.se/iwood2002 and http://hubbertpeak.com/laherrere/uppsalaJHL.pdf where I forecasted US crude oil ultimate at 220 Gb from HL (as OPEC and NOPEC crude oil ultimates)

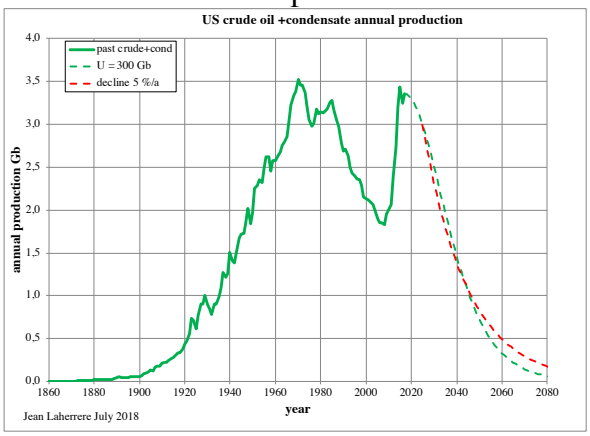
Figure 18: US annual/cumulative versus cumulative production

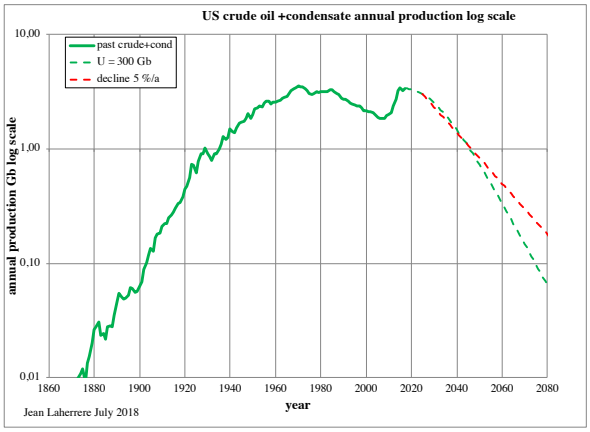


The problem of US production is that crude oil is reported in USDOE/EIA MER differently condensate in gas liquids (NGL & NGPL) in volume Mb/d (t3.1) and in energy (t1.2 quad = quadrillion BTU) with the LTO, crude oil becomes lighter. It is difficult to know when condensate is included or not in crude oil.

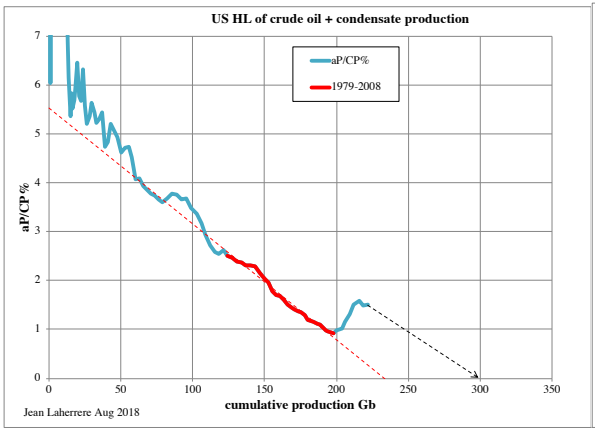


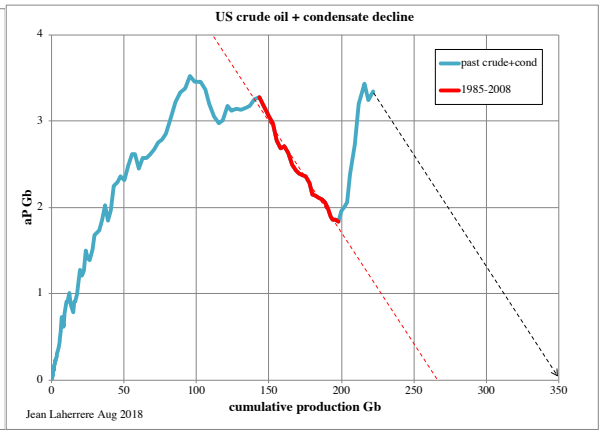
US crude +condensate peaked in 1970 and 2015 and for an ultimate 300 Gb it will decline at a rate of 5 %/a for the period 2025-2050

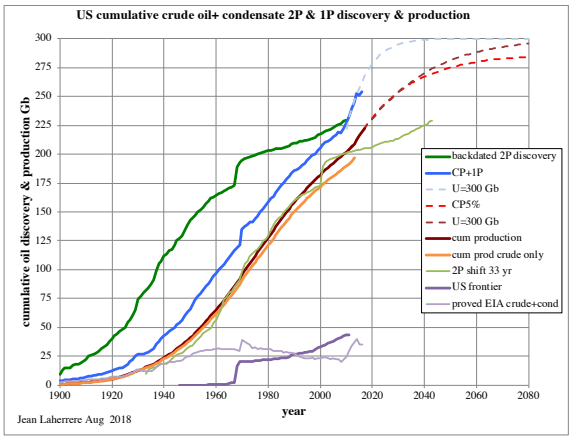


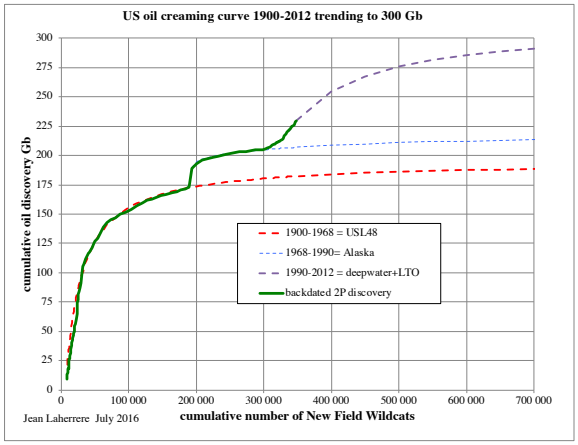


HL of crude +condensate is linear for 1979-2008, but with the LTO is extrapolated parallel to 300 Gb when OD, linear for 1985-2008 is extrapolated parallel towards 350 Gb: big difference!

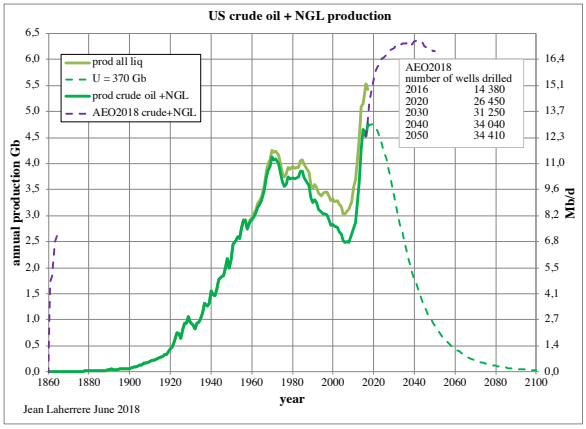


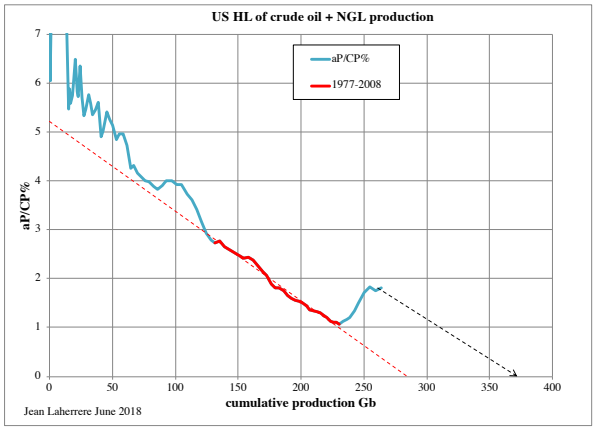






Crude +NGL





-US Lower 48

My 2010 paper «The peak of peaks or the peak peak» University of Evora Rui Rosa's jubilation 15 June http://aspofrance.viabloga.com/files/JL_Evora_2010.pdf displays my 2010 USL48 estimates USL48 ultimate as 230 Gb using HL of production as also discoveries.

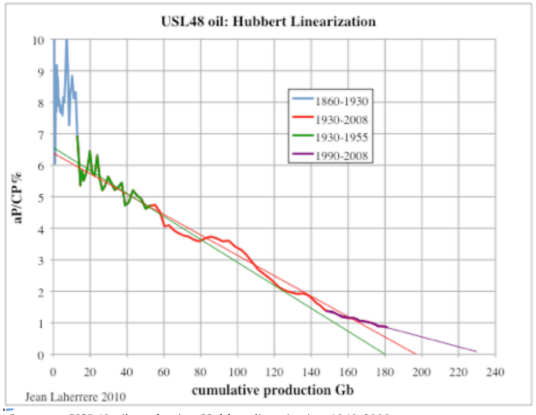


Figure 5: present USL48 oil production Hubbert linearization 1860-2008

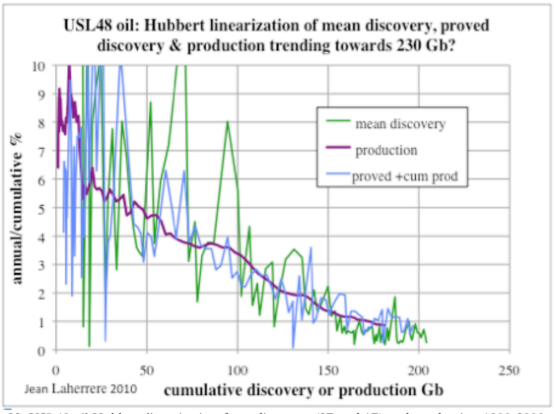
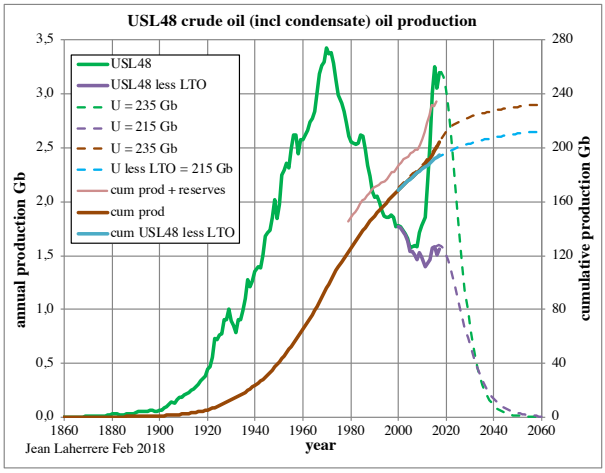
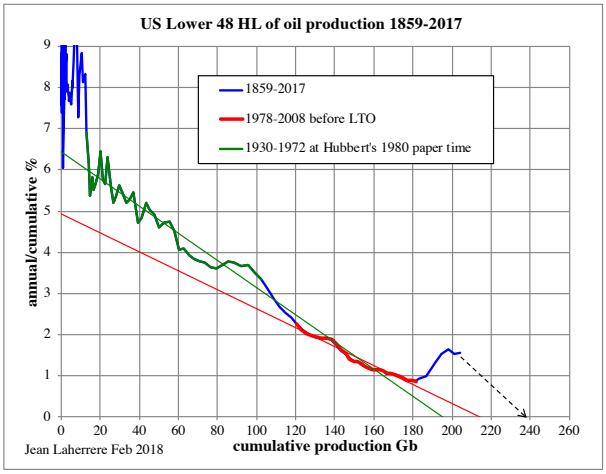


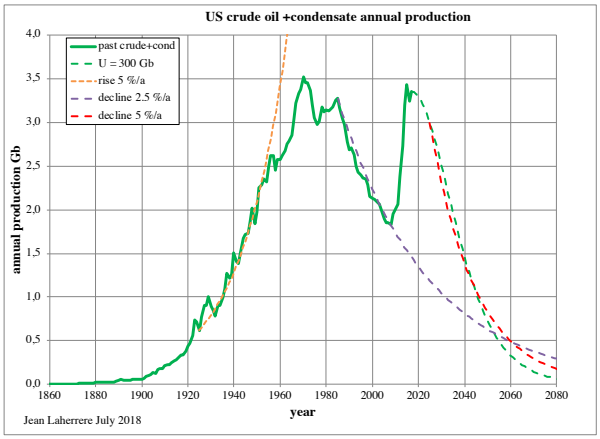
Figure 23: USL48 oil Hubbert linearization from discovery (2P and 1P) and production 1900-2008

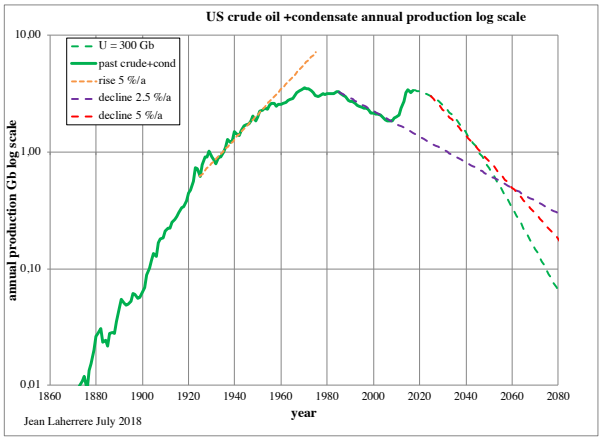
My present estimate including LTO is 240 Gb



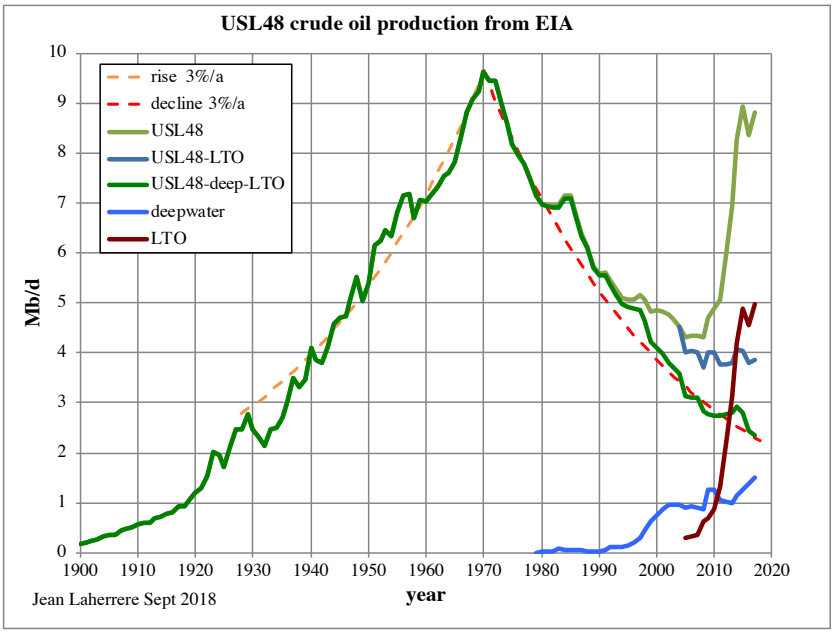


USL48 crude oil production declined since 1972 at a rate of 2.5 %/a until 2002 and will decline at a rate of 10 %/a after 2019





USL48 crude oil less LTO production is flat since 2005 but USL48 less LTO & deepwater displays since the peak of 1970 a decline rate of 3%/a, symmetrical of the rise 1930-1970 of 3%/a . I am amazed by the symmetry of such curve and by the symmetrical shoulders of 1955 (quota) and 1980 (high price). It is likely that the USL48 crude oil production less LTO and deepwater will continue to decline at 3%/a for the next ten years.



USL48 crude oil production growth displays drastically the importance of the peak of 1970 and of the 2010 LTO boom. But USL48 crude less LTO & deepwater production growth is about flat after 1970, showing the perfect symmetry already seen in the previous graph

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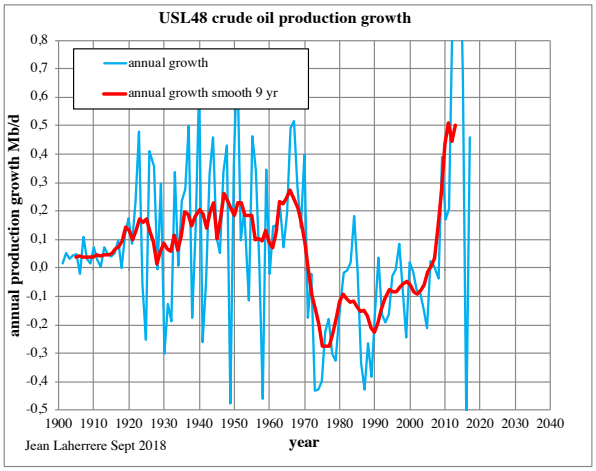
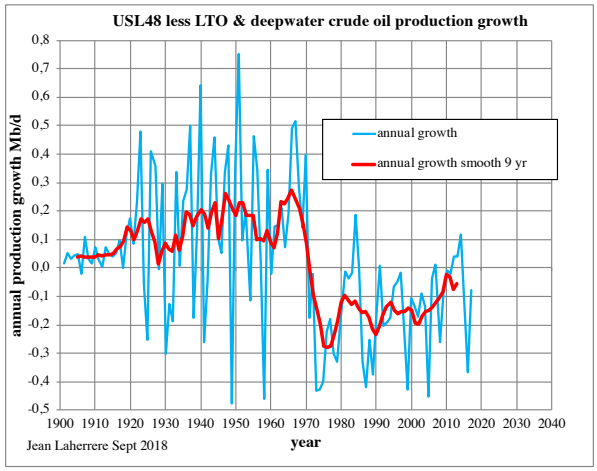
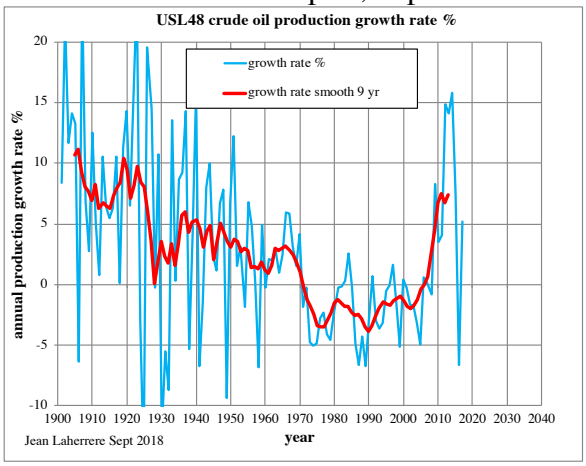
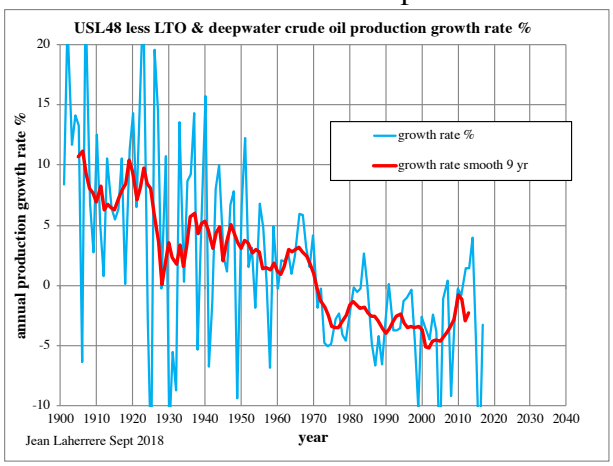




Growth rate in % is simpler, in particular for USL48 crude less LTO and deepwater

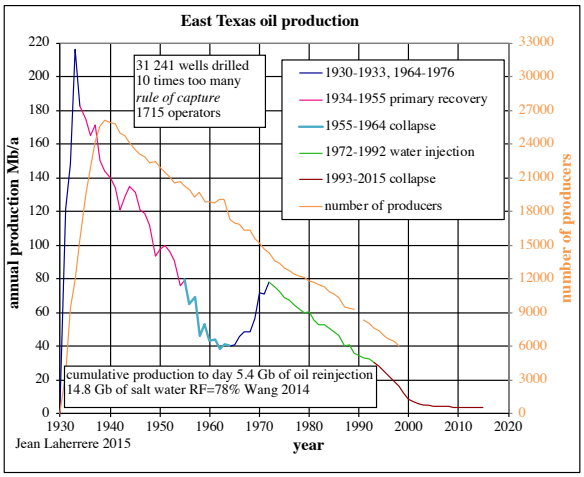


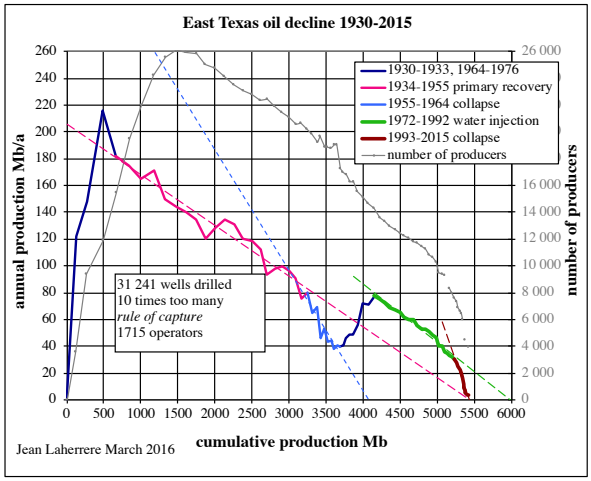


The main assumption of my forecasting model is symmetry, because of the USL48 example that I found more than 10 years ago (explained by the law of large numbers because the 20 000 US oil producers behaving at random, except when quota and high price, but the recent data (GOM deepwater for 2017 is very new) confirm completely my belief

-East Texas

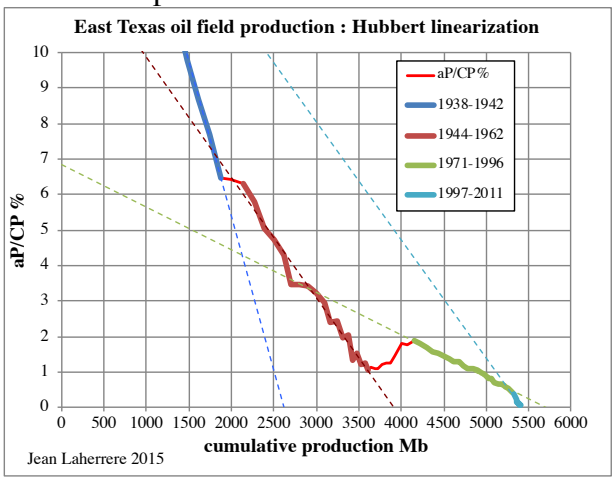
East Texas is an interesting example of reserves evolution, with a very early peak 3 years after discovery, with primary recovery followed by a secondary recovery (water injection) 42 years after production start

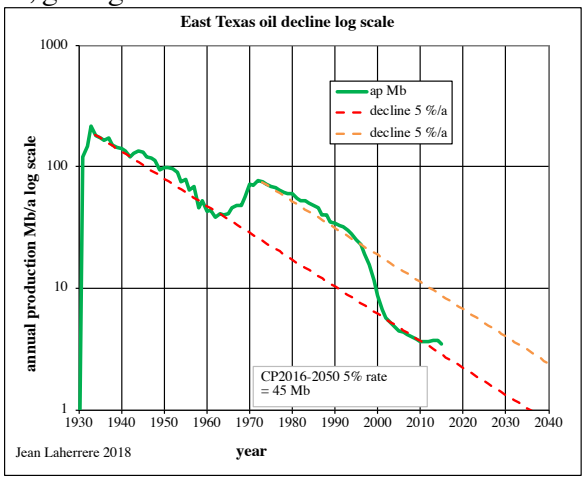




The oil decline (annual production versus cumulative production) gives better linear extrapolations than HL

East Texas has a decline rate of 5 %/a from 1934 to 1964 and from 2002 to now. The cumulative production 2016-2050 is about 45 Gb , giving an ultimate of 5470 Mb

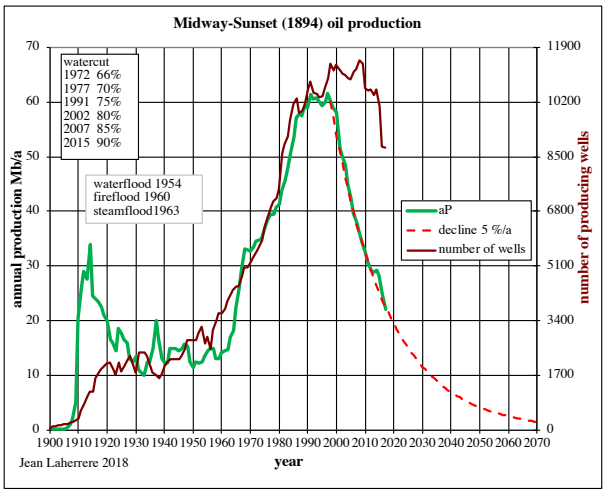


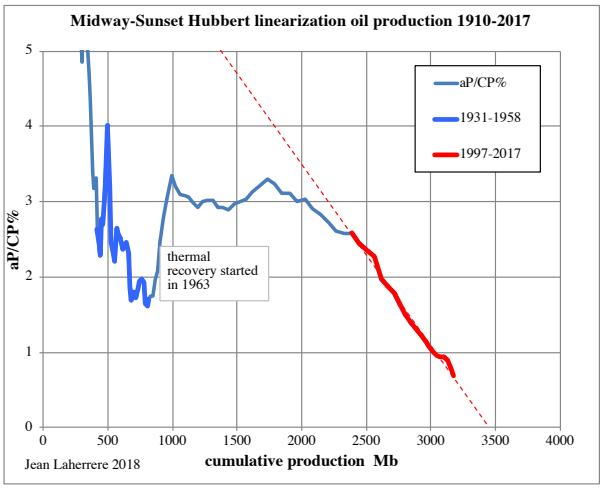


-Midway-Sunset

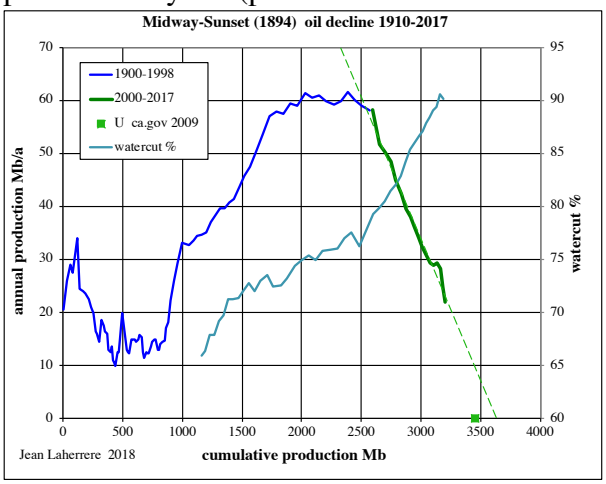
Midway-Sunset had peaked 100 years after discovery (heavy oil).: waterflood in 1954, fireflood in 1960 and steamflood in 1963. The best model for forecast is the fit of a decline rate of 5 %/a since 2000. In 2070 Midway-Sunset will be reduced to produce only 1.5 Mb (4000 b/d) A rate of 5 %/a represents a cumulative production from 2018 to 2100 of 400 Mb, the cumulative production up to 2017 is 3200 Mb.

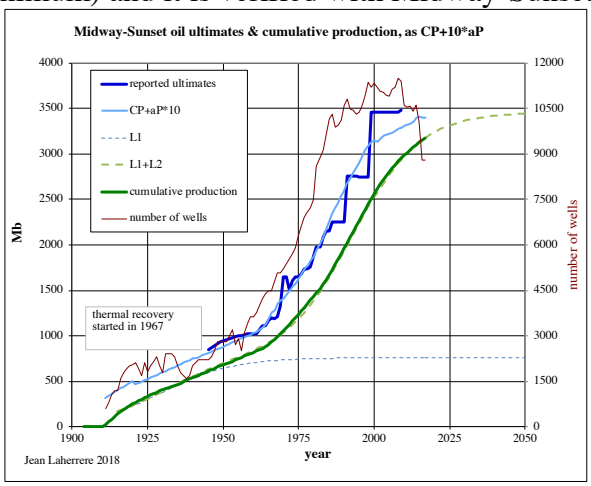
HL trends towards an ultimate of 3500 Mb, as oil decline close to the estimate by Ca.gov 2009 of 3457 Mb.

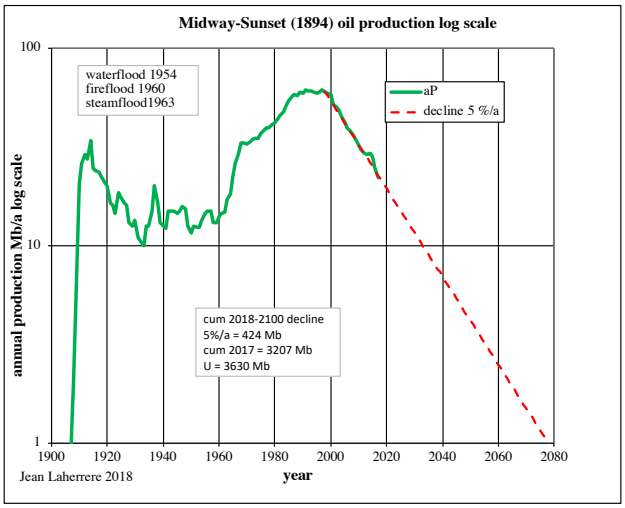




US Proved reserves were rumored to be estimated by many by multiplying the annual production by ten (practice in real estate for minimum) and it is verified with Midway-Sunset



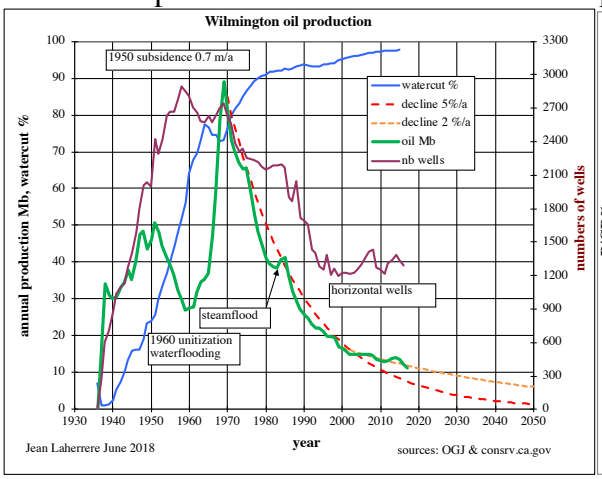


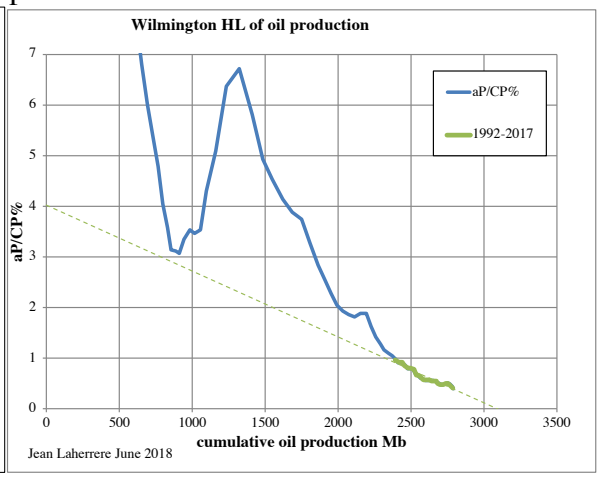


-Wilmington

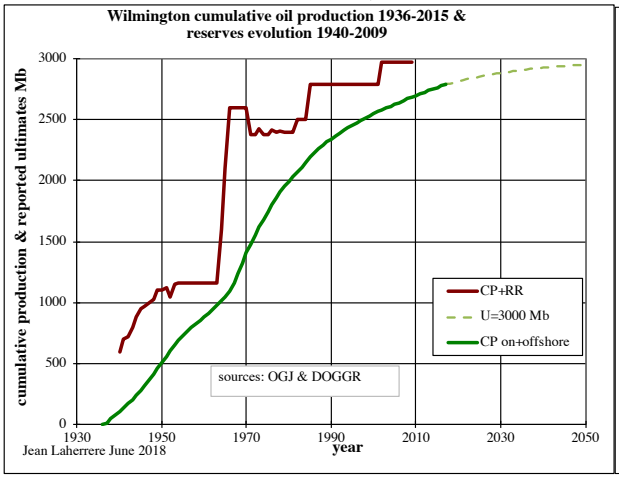
Wilmington crude oil production peaked in 1949 at 220 000 b/d (80 Mb) in primary production but the subsidence was high (0.7 m/a) and unitization was done with

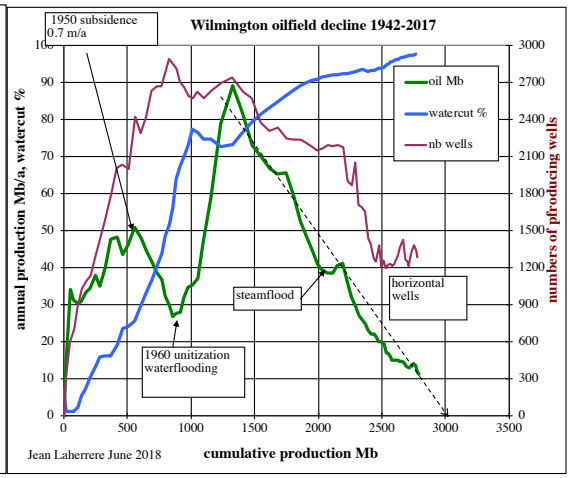
waterflooding, bringing a new peak in 1969 at 245 000 b/d, followed by a decline rate of 5 %/a for the period 1969-2000 or 2 %/a for the period 2000-2016

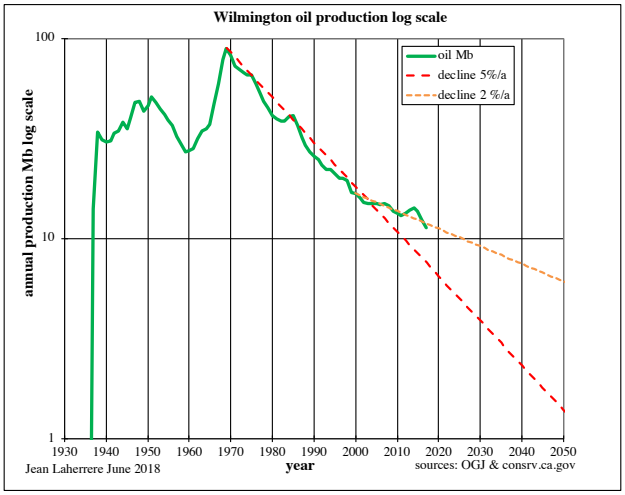




HL trends towards 3000 Mb, but the best forecast is a 5 % decline rate.

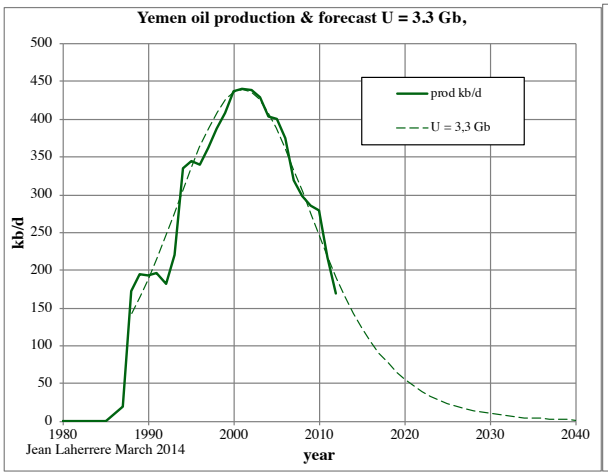


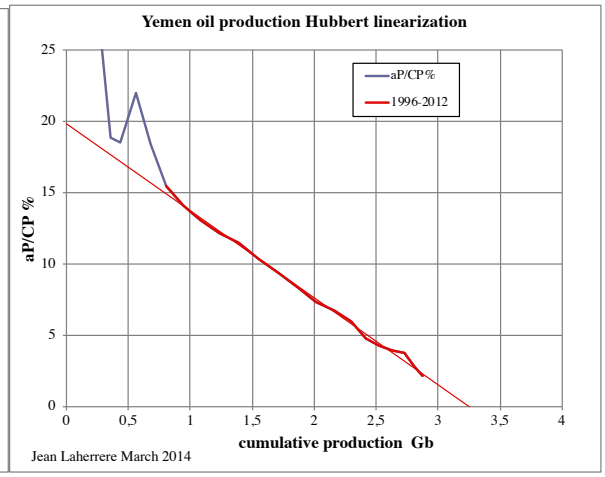




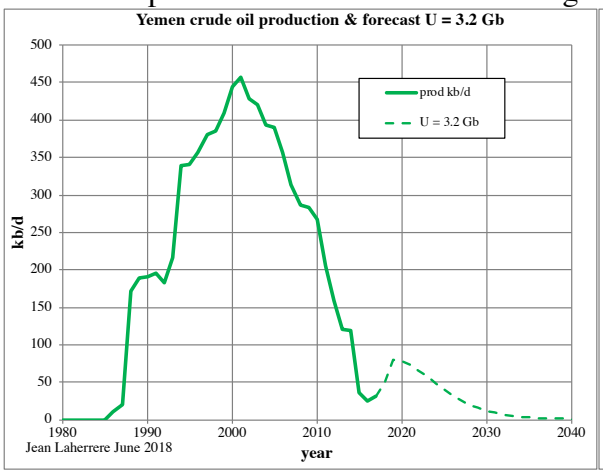
-Yemen

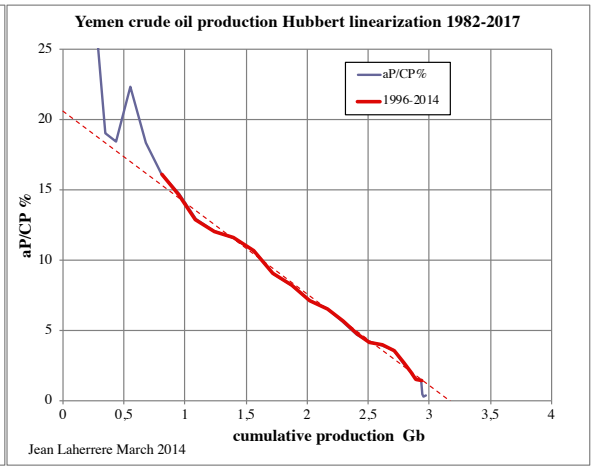
Yemen was united in 1990 gathering North and South (advised by Russians).
Good example of symmetrical production curve modelled in 2014 with up to 2012 data with an ultimate of 3.3 Gb estimated form HL (1996-2012)



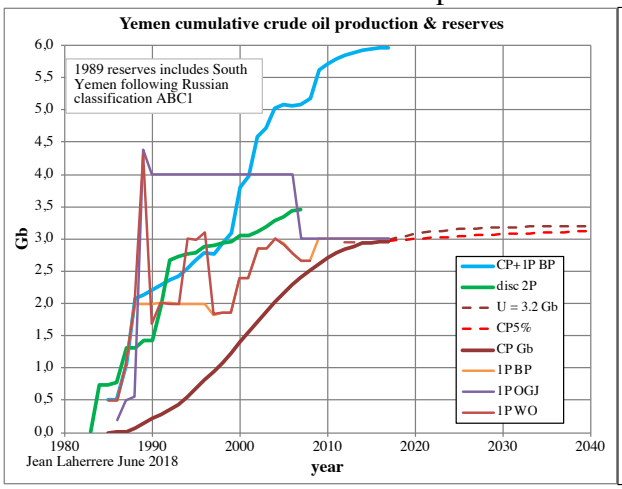


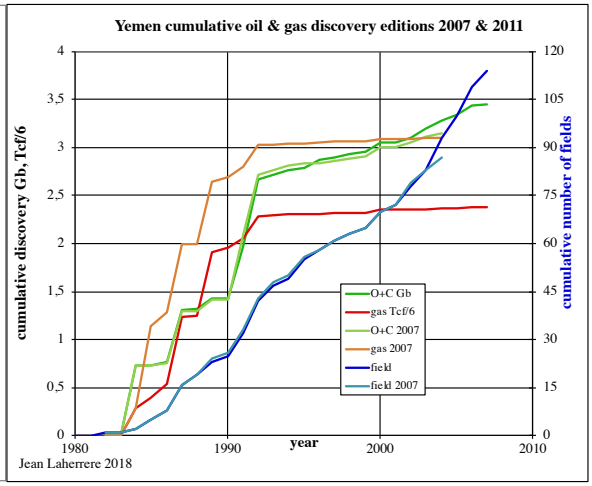
With up to 2017 data HL for the period 1996-2014 (2015 to 2017 data is disturbed by the present civil war) trends towards 3.2 Gb.
Annual oil production is modelled assuming an end of the civil war in 2019.



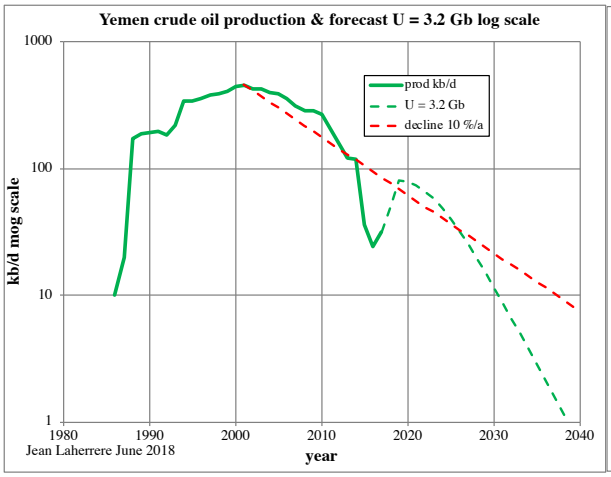


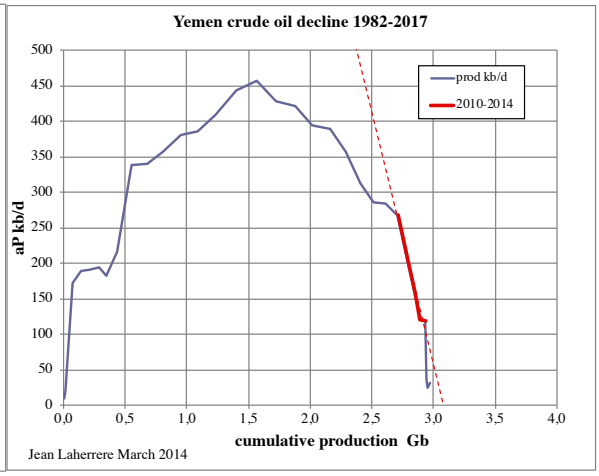
Yemen oil reserves were high in 1989, because including South Yemen reserves following the Russian ABC1 classification. Present 1P reserves are obviously overestimated by ten times!
OPEC ABS 2018 T31 does not report Yemen reserves.



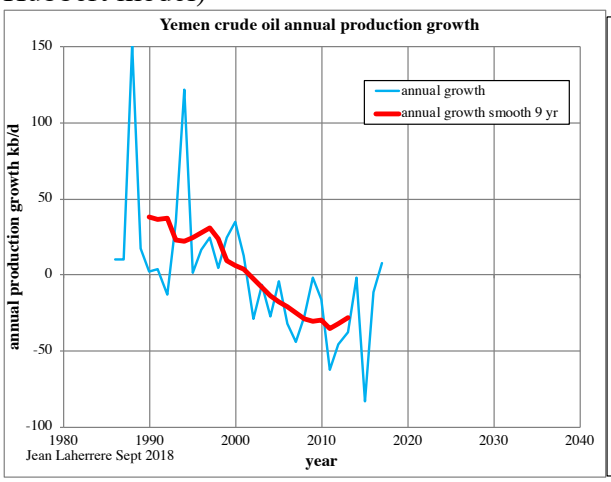


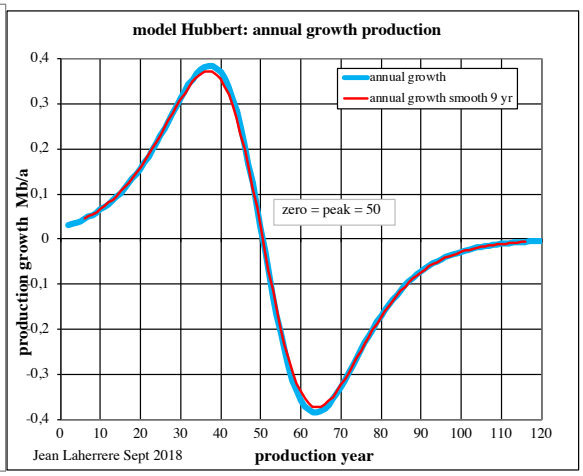
OD for the period 2010-2014 is extrapolated towards 3.1 Gb



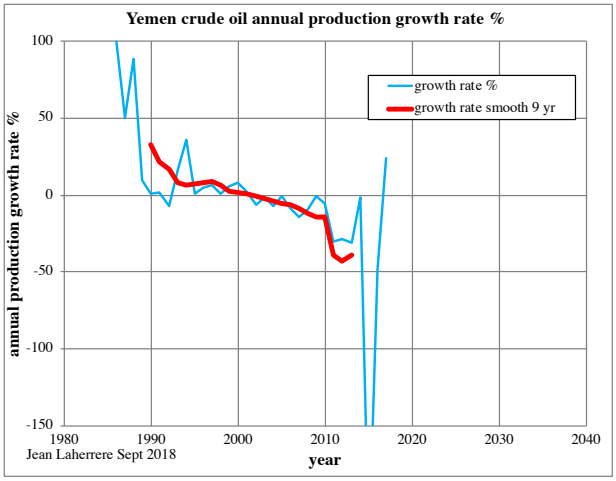


Yemen crude oil production growth displays for 9 yr smooth curve a straight decline, which is stopping, going to return to zero which is also the end of production (as shown with the Hubbert model)





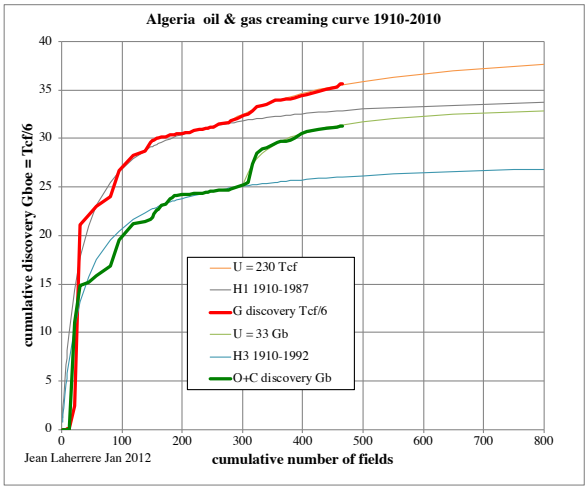
Growth rate in % is not better

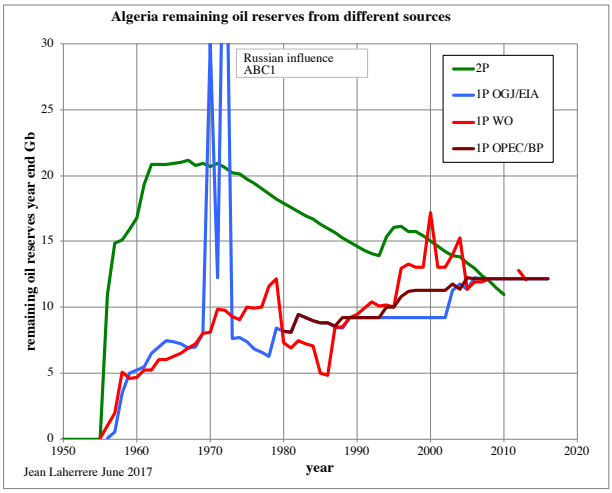


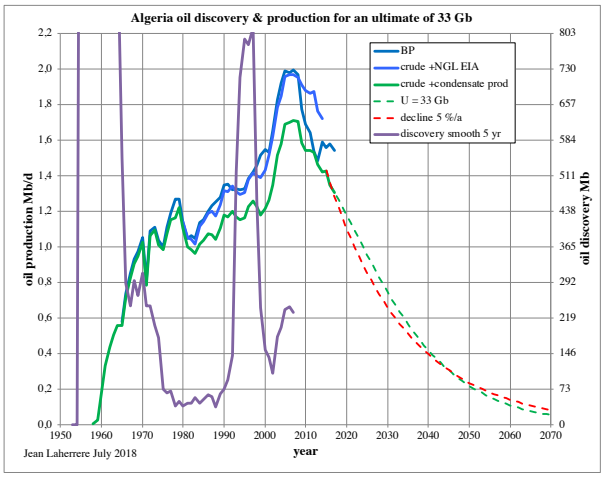
-OPEC

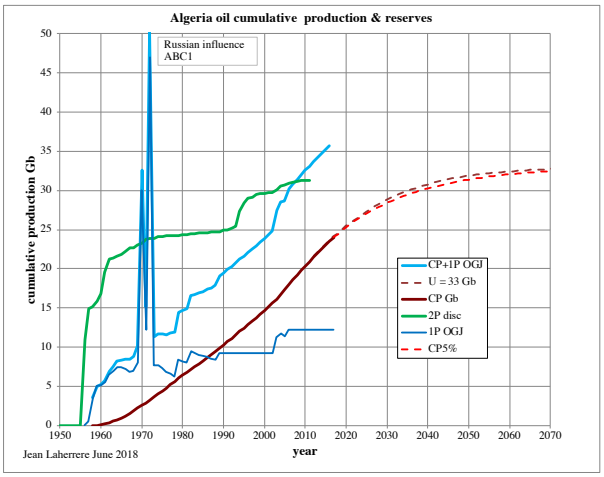
-Algeria

Algeria crude oil production peaked in 2007 at1.7 Mb/d (crude oil +NGL at 2 Mb/d)
Creaming curve trends towards 33 Gb, which is in line with the HL of oil production for the period 2005-2017.
1P OGJ reserves were drastically high around 1970 for few years, because a Russian influence, confusing with ABC1 (in fact 3P) reserves.

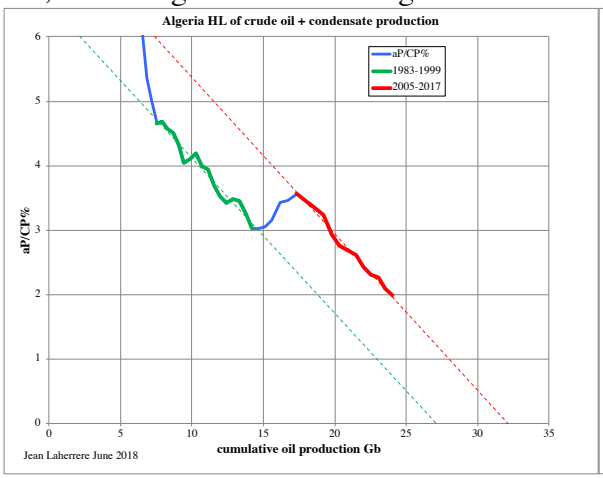


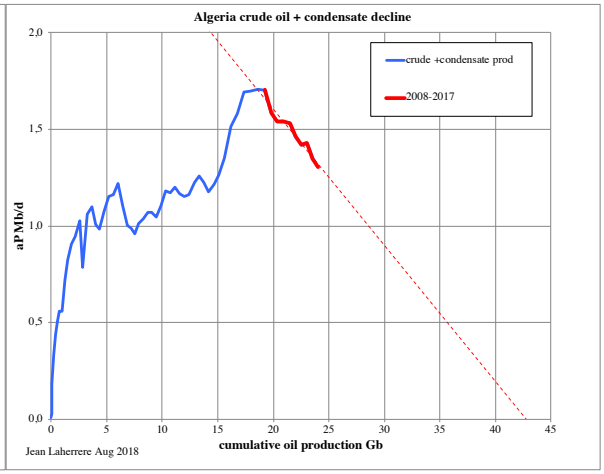




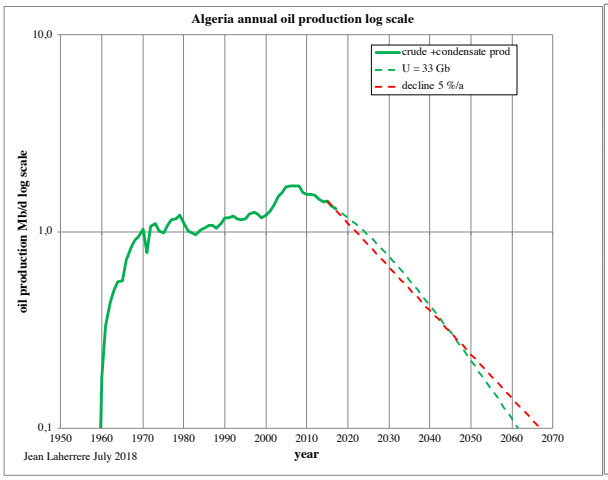


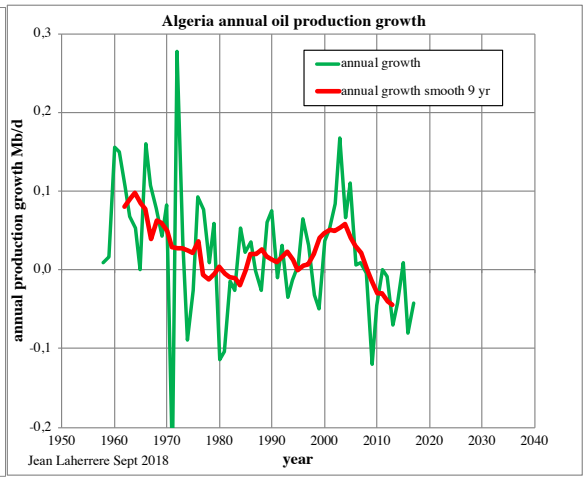
HL 2005-2017 is parallel to HL 1983-1999 and same slope as rise 1999-2005
HL 2005-2017 is extrapolated towards 32 Gb, when OD 2008-2017is extrapolated towards 43 Gb, 11 Gb higher than HL : huge difference!



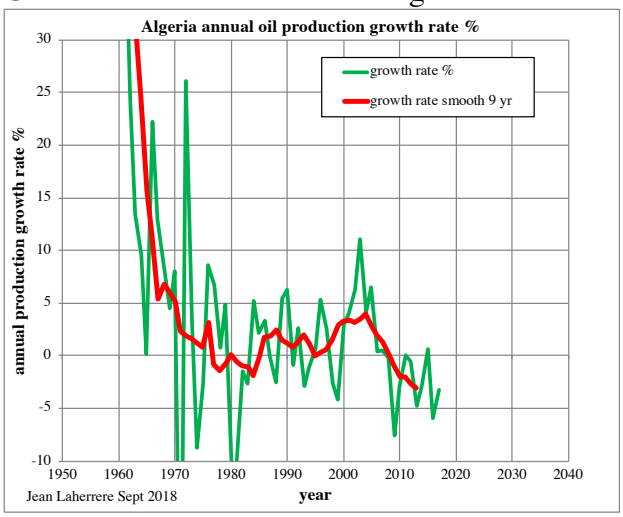


Algeria crude oil production is declining at 5%/a since 2015 until the end for U = 33 Gb
Algeria crude oil production growth has crossed the zero line in 2007 and will go to a low.



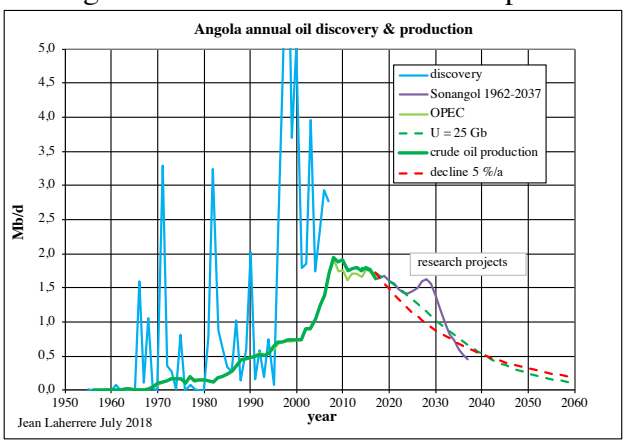


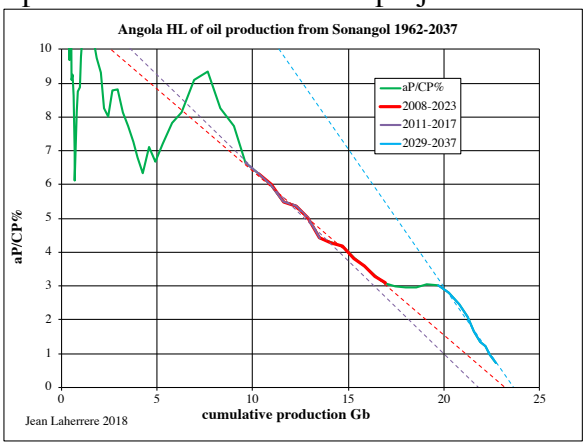
Growth rate in % does not change much.



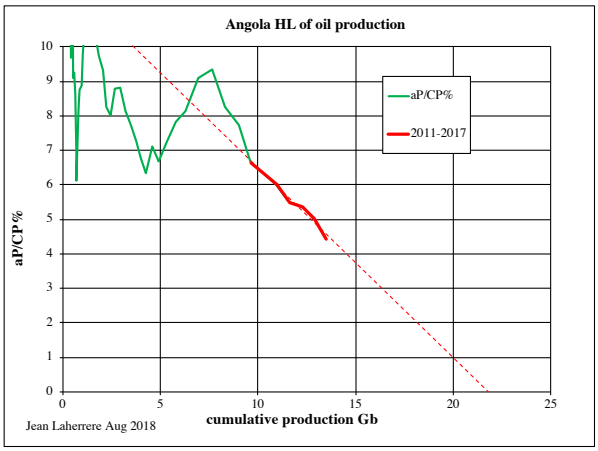
-Angola

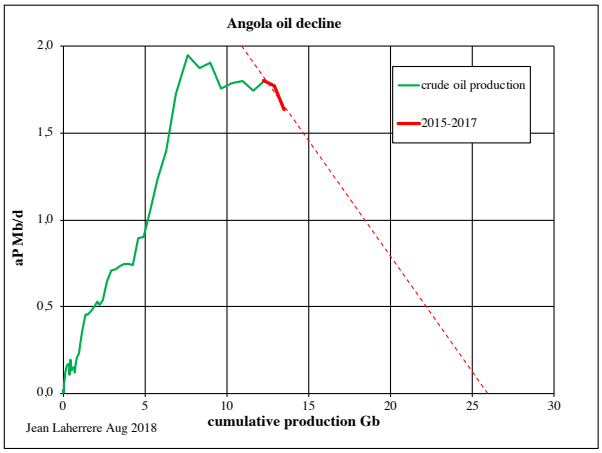
Angola crude oil production peaked in 2008 at 2 Mb/d.
Sonangol 2018 forecasts 1962-2037 hope a minor peak in 2028 with research projects





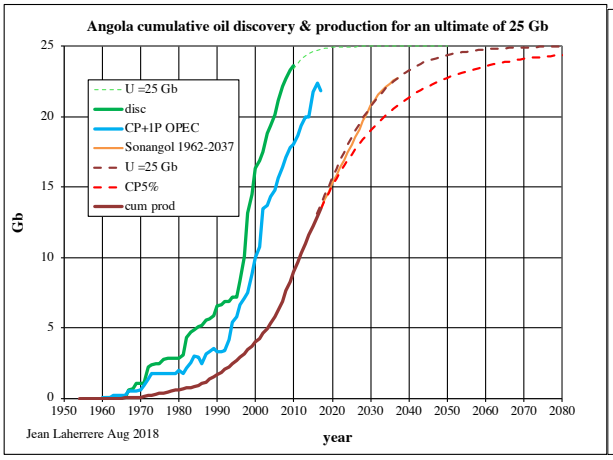
HL (2011-2017) trends towards 22 Gb when OD (2015-2017) trends towards 26 Gb

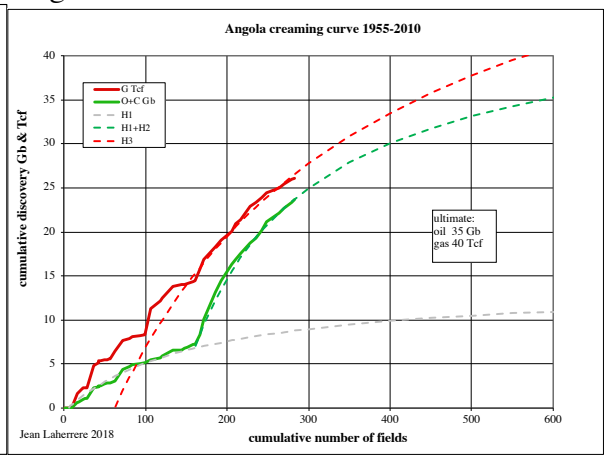




Ultimate is chosen as 25 Gb, despite that the creaming curve trends towards 35 Gb, because the Sonangol forecast up to 2037 fits such 25 Gb ultimate.

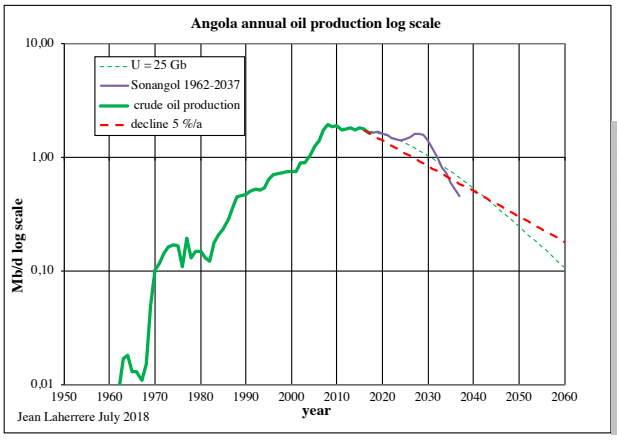
Sonangol 1962-2037 GAD201801-DGH0001-1

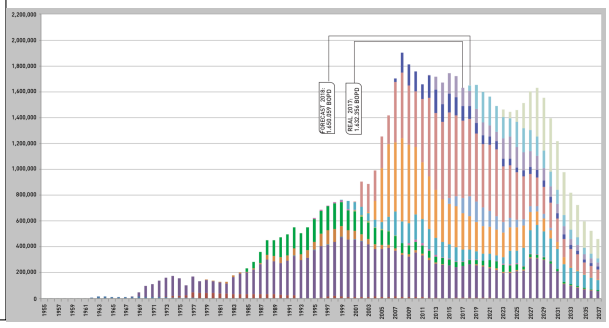




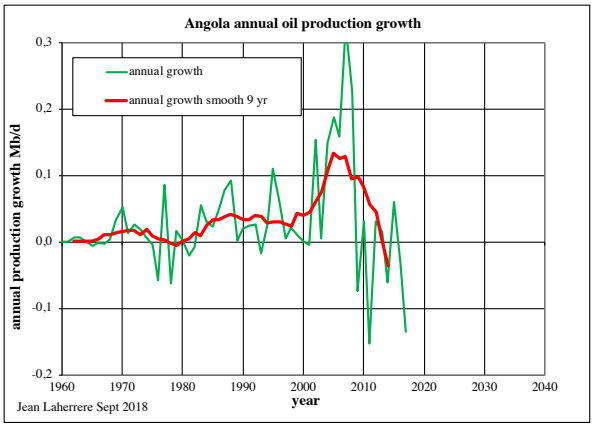
For an ultimate of 25 Gb crude oil production is declining at 5 %/a since 2016 to end

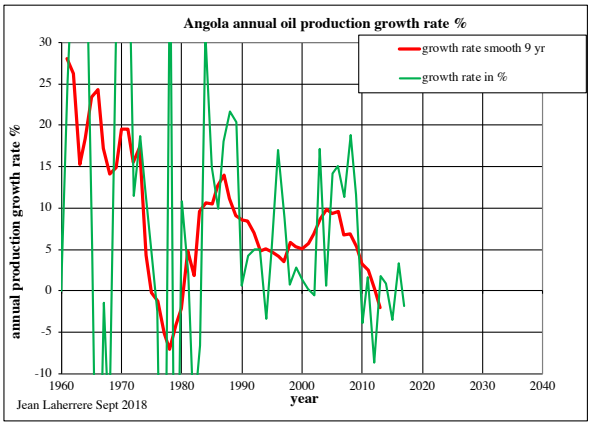
Sonangol 2018 forecast 1962-2037





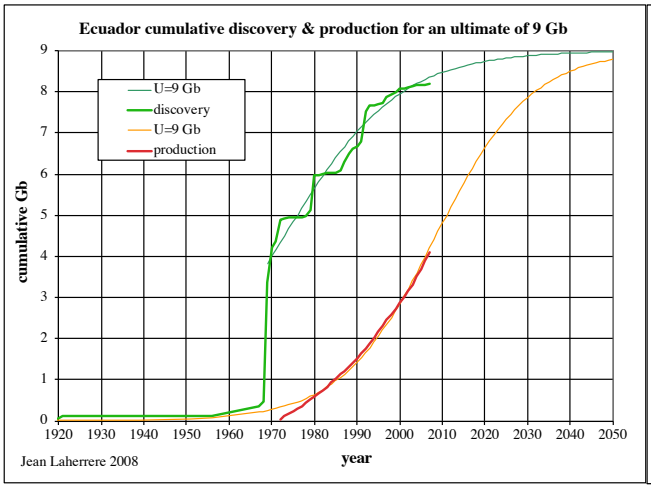
Angola crude oil production growth has just passed the zero (peak). Growth rate in % displays a different pattern. .

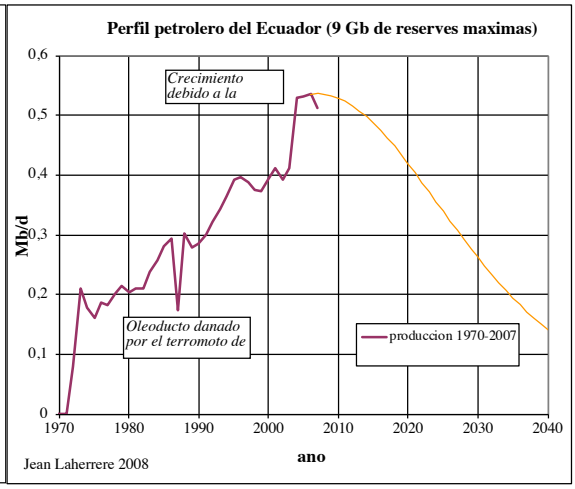




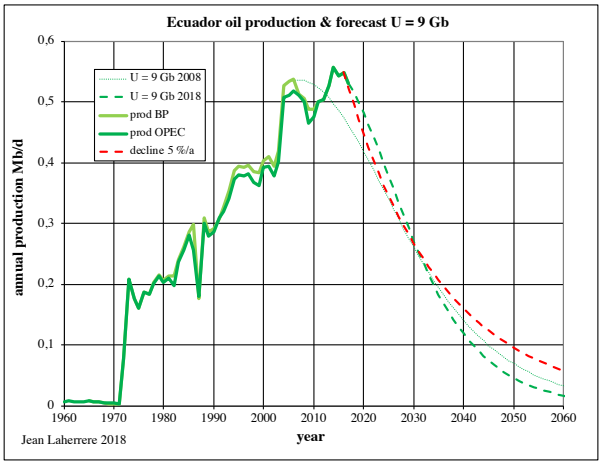
-Ecuador

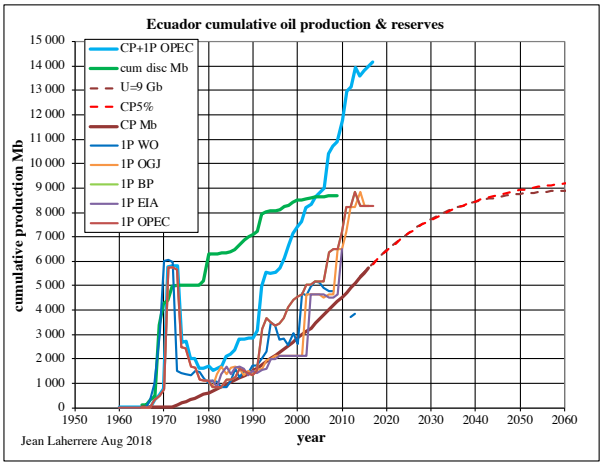
Forecast in 2008 for an ultimate of 9 Gb from CC



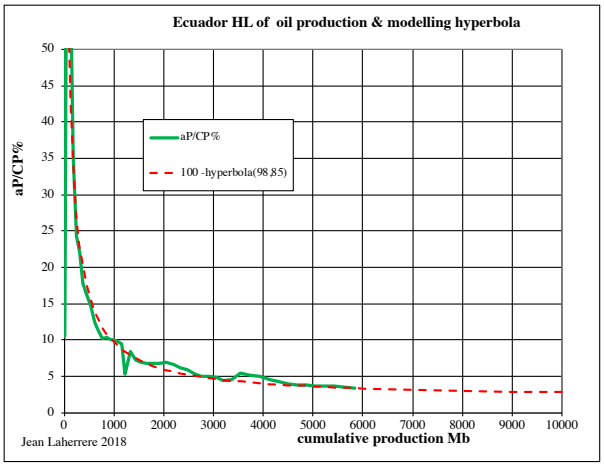


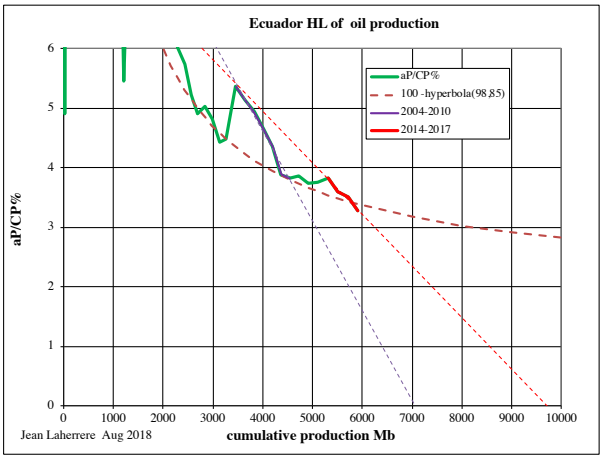
Ecuador crude oil production peaked in 2014 at 0.5 Mb/d and is declining at 5 %/a since to end for an ultimate of 9 Gb (already estimated in 2008). But CP+1P is at 14 Gb in 2017, overestimated.



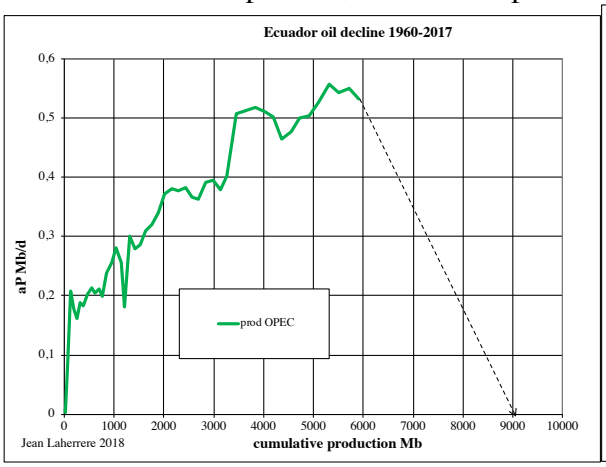


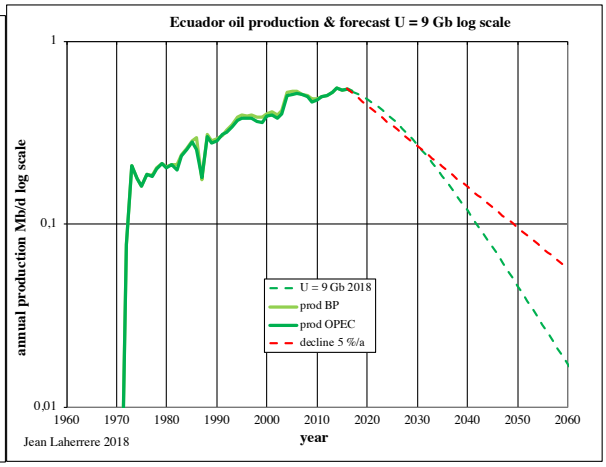
HL trends towards 9.5 Gb for the period 2014-2017, against the hyperbolic model, which fits aP/CP from 1971-2017. HL for the period 2004-2010 trends towards 7 Gb. HL is not too reliable



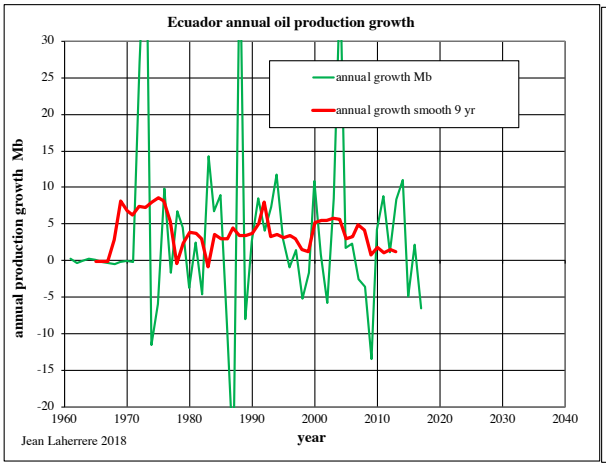


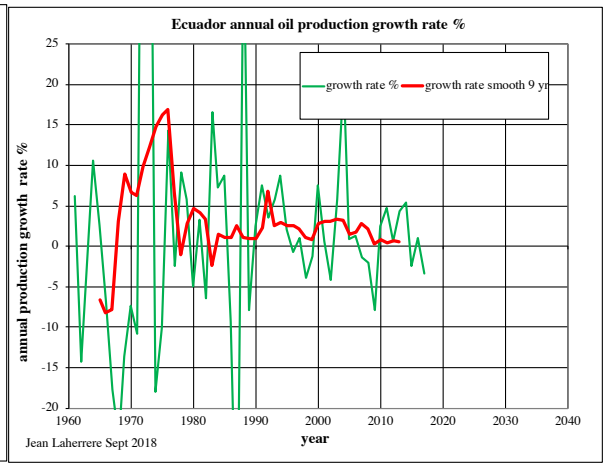
OD cannot be extrapolated, too close to peak.





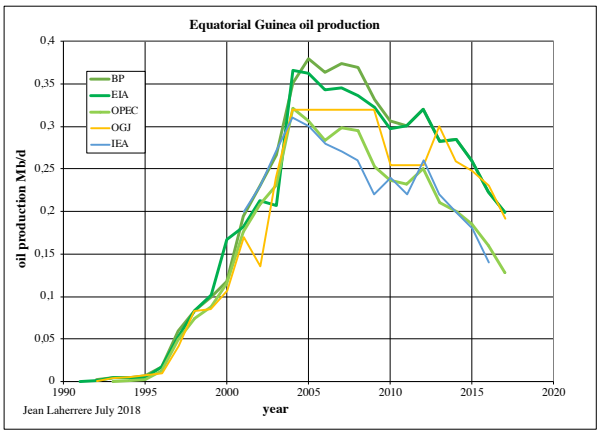
Ecuador crude oil production growth has just passed the zero (peak). Growth rate in % is similar

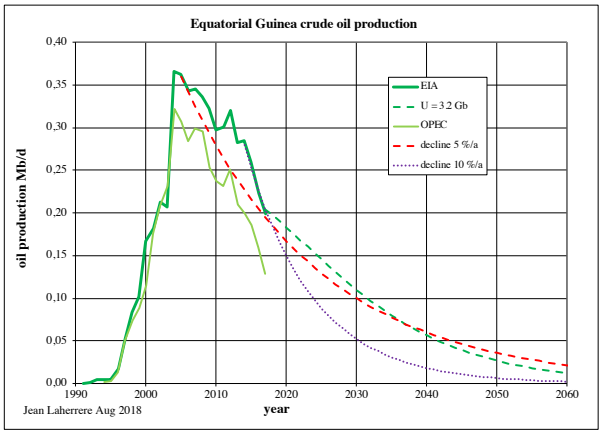




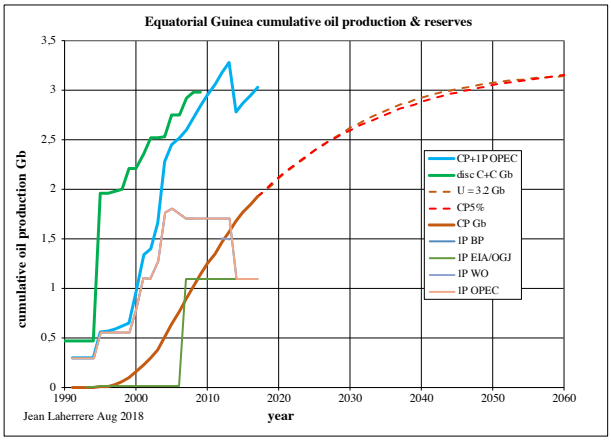
-Equatorial Guinea

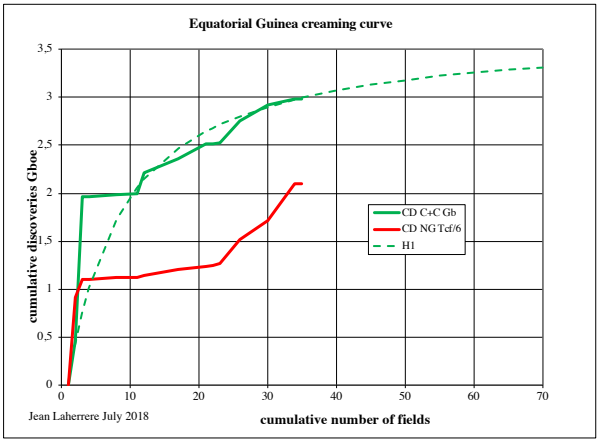
Equatorial oil production peaked in 2004, but data varies with source.
Since 2005 a decline rate of 5 %/a fits 2017 data and future production for an ultimate of 3.2 Gb, chosen from CC ads HD and OD are unreliable



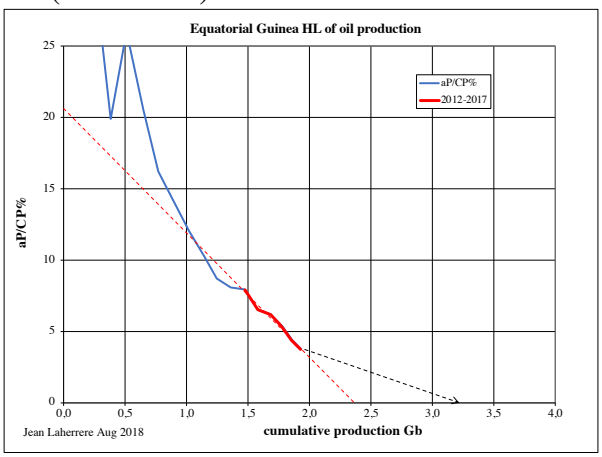


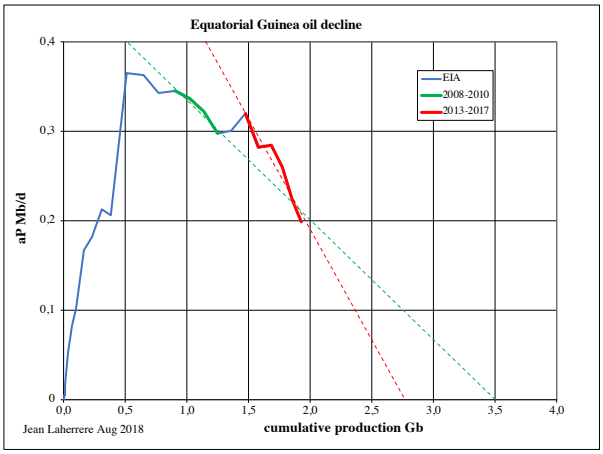
CC trends towards 3.2 Gb (for 60 fields) and CP+1P is 3 Gb in 2017.



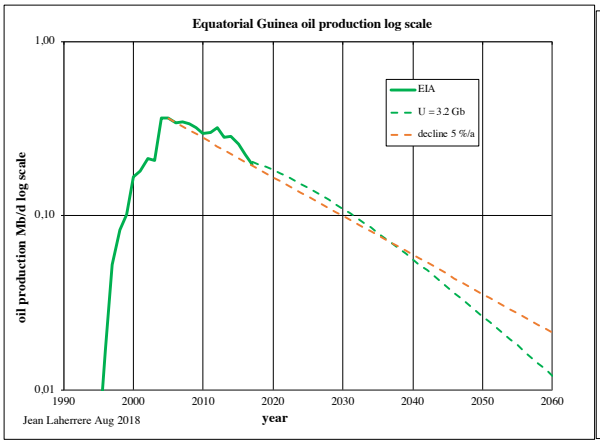


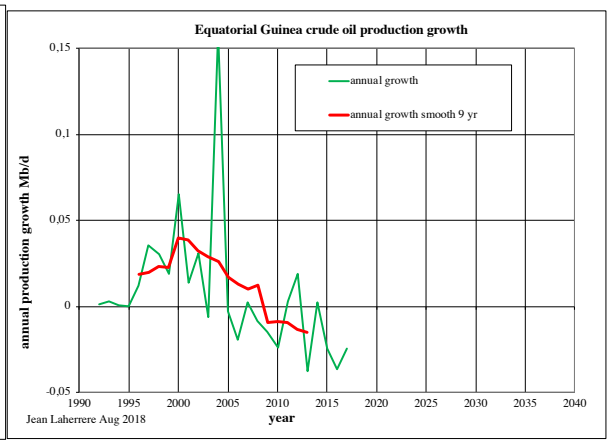
Hl (2012-2017) trends towards 2.4 Gb, but an ultimate of 3.2 Gb fits with its past curve.
OD (2013-2017) trends towards 2.8 Gb when 2008-2010 trends towards 3.5 Gb = unreliable



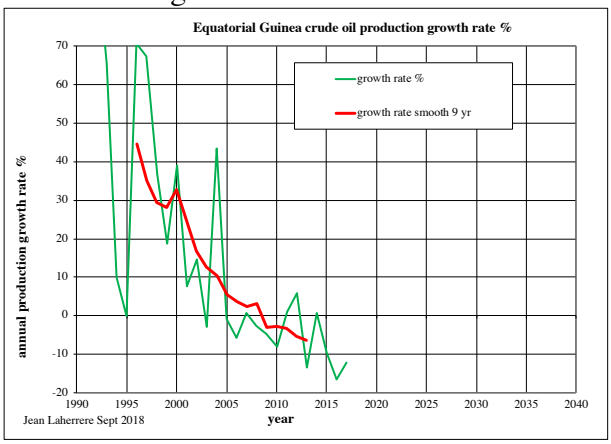


Future production for U= 3.2 Gb will decline at 5 %/a.
Annual oil production growth (blue) has crossed the zero line (peak) twice, but the 9 yr smooth (red) only once and will later return to zero (end)



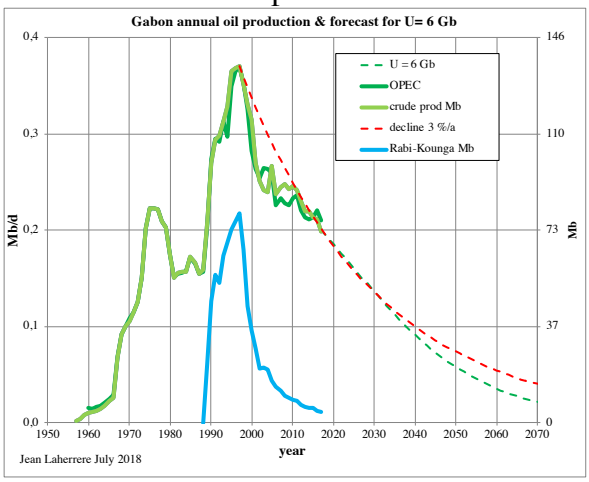


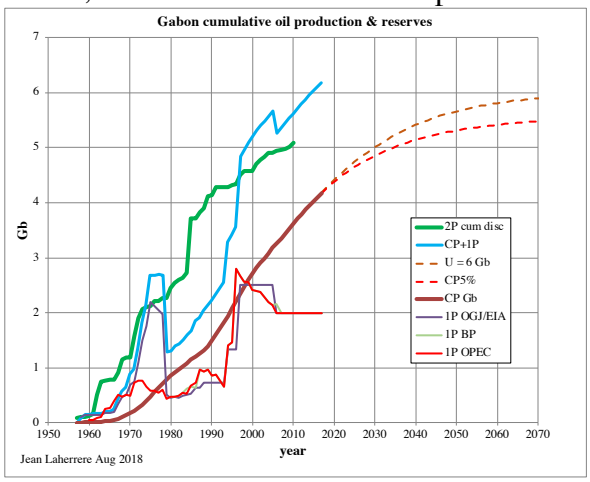
The trend of growth rate in % looks better.



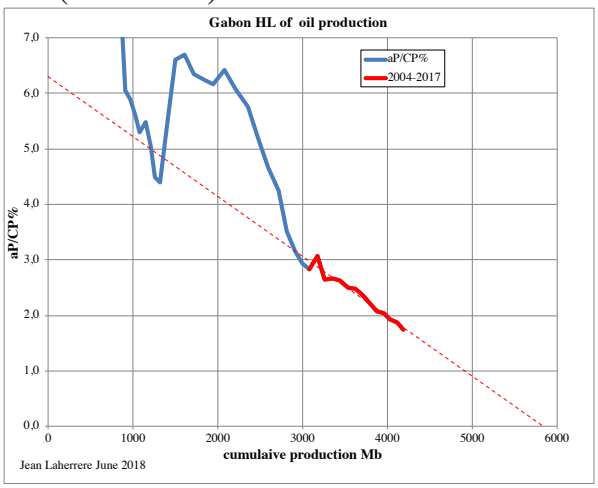
-Gabon

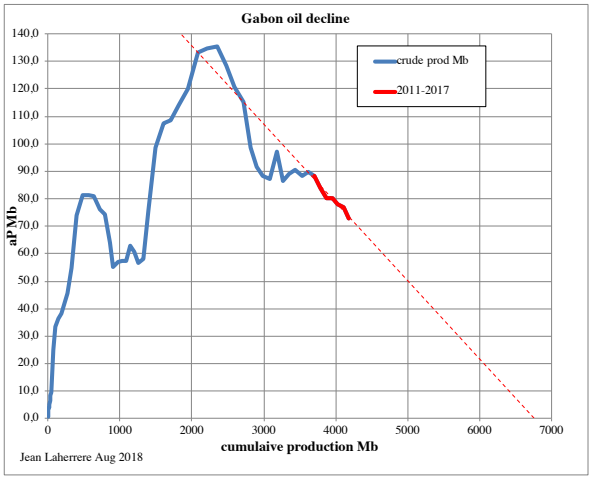
Gabon crude oil production peaked in 1997 at 0.37 Mb/d. The ultimate is chosen at 6 Gb, from the CC. Future production will decline at 3%/a, which is the rate from the peak to 2017.

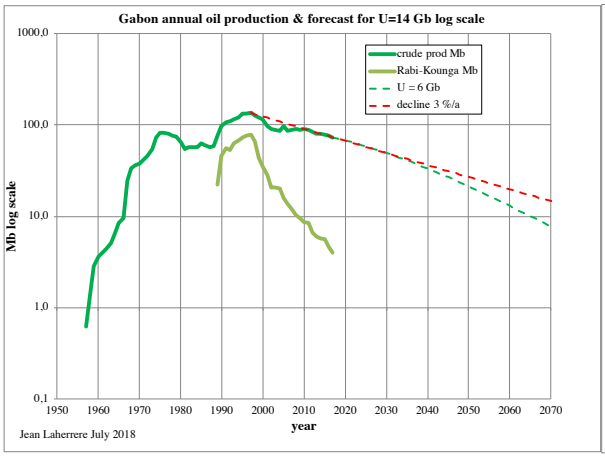


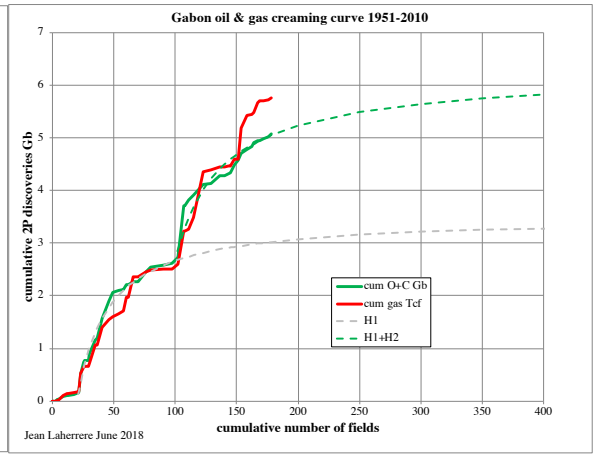


HD (2004-2017) trends towards 5.9 Gb when OD (2011-2017) trends towards 6.8 Gb.

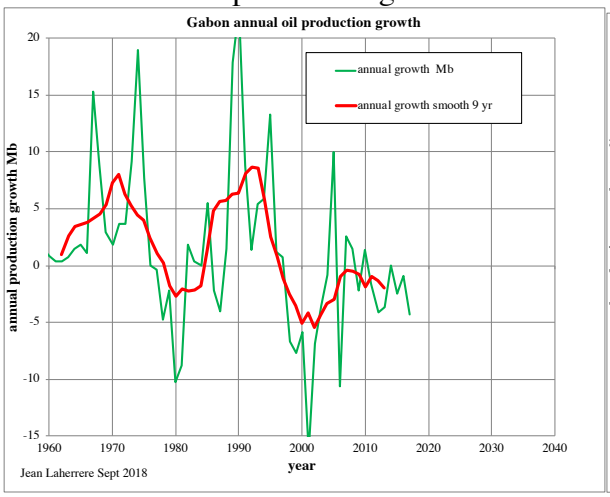


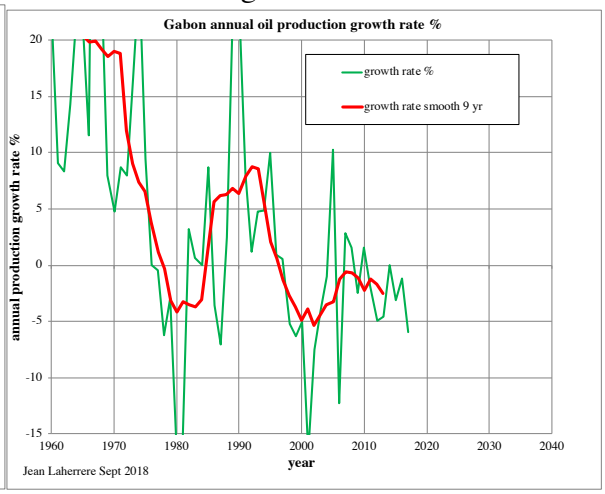






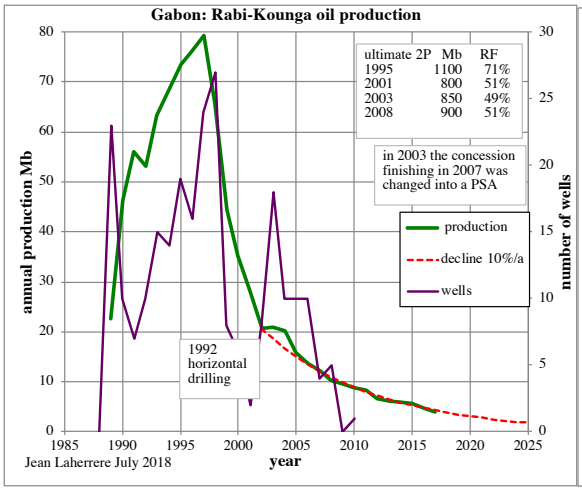
Gabon annual oil production growth is rather chaotic. Same with growth rate in %

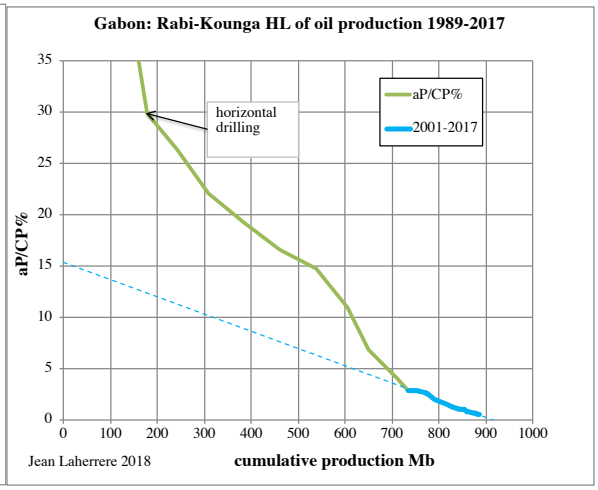




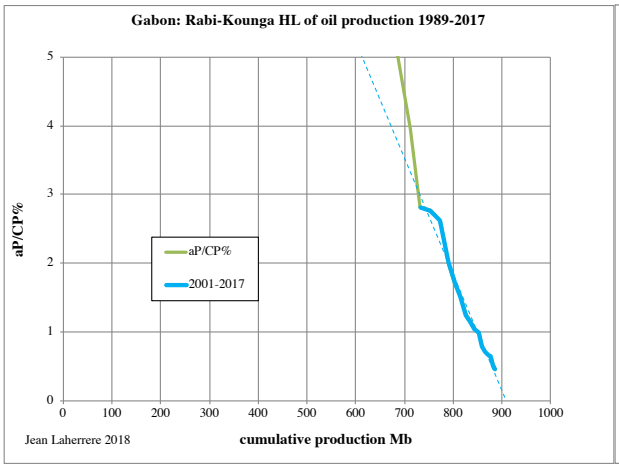
-Rabi-Kounga

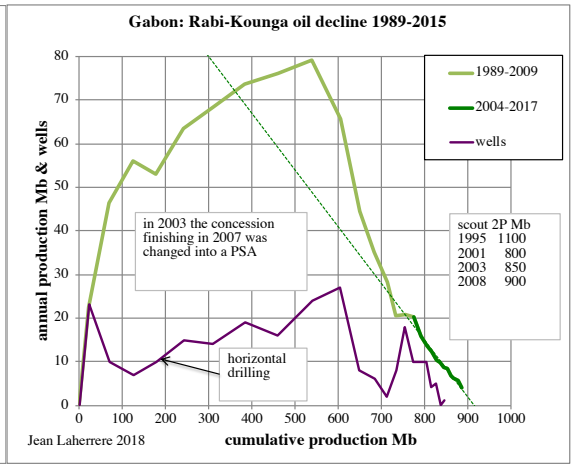
Rabi-Kounga the largest oilfield in Gabon peaked in 1997, busted by the operator Shell with horizontal wells from 1992 because the concession was terminating in 2007, but on 2003 the concession was changed in a PSA (production sharing agreement). But the sharp rise (1992-1997) was followed by a sharp decline 1997-2004 and from 2004 to 2017 a smaller 10 % decline

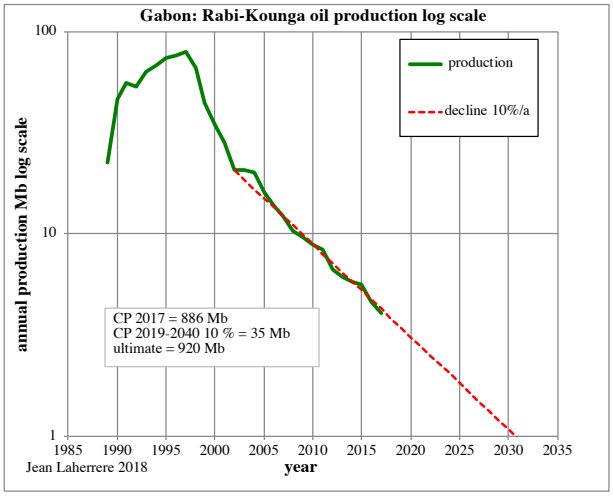




2P reserves were changing : 1100 Mb in 1995, 800 Mb in 2001, 850 Mb in 2003 and 900 Mb in 2008. In 2017 CP is 886 Mb, the field is almost depleted the remaining is 35 Mb and the ultimate 920 Mb.

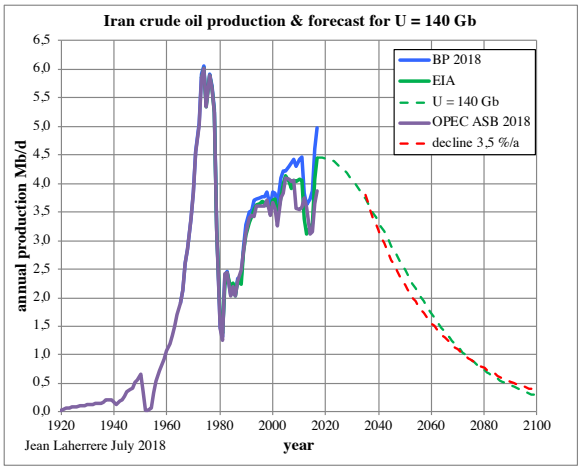


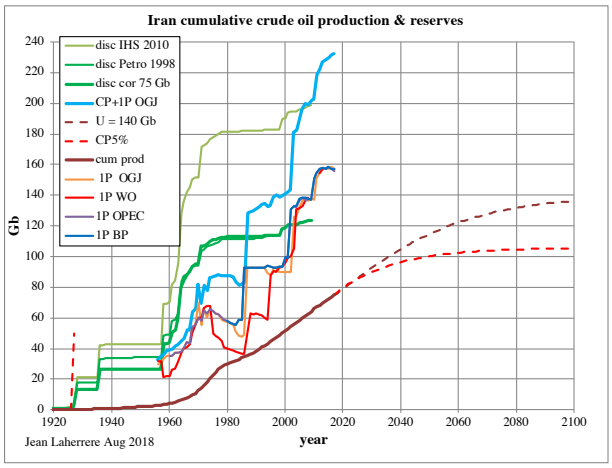




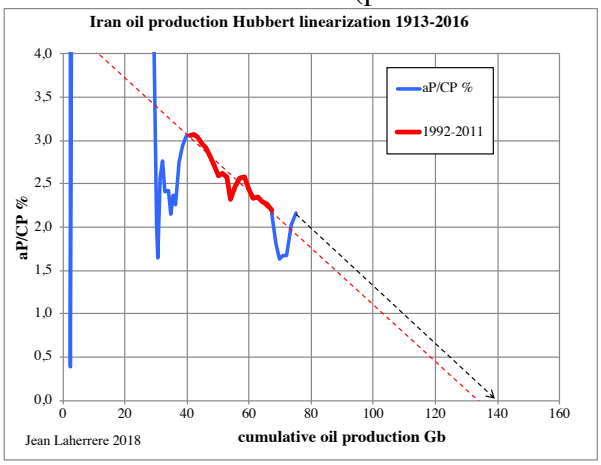
-Iran

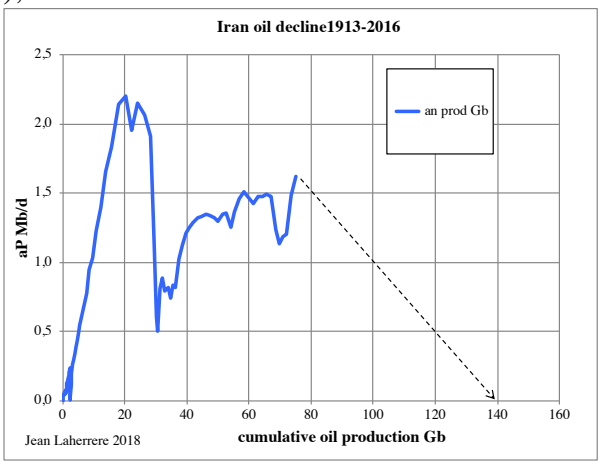
There is a large discrepancy for production in 2017 between BP = 5 Mb/d, EIA = 4.4 Mb/d and OPEC= 3.9 Mb/d. Our reference is EIA. Iraq oil production will peak again



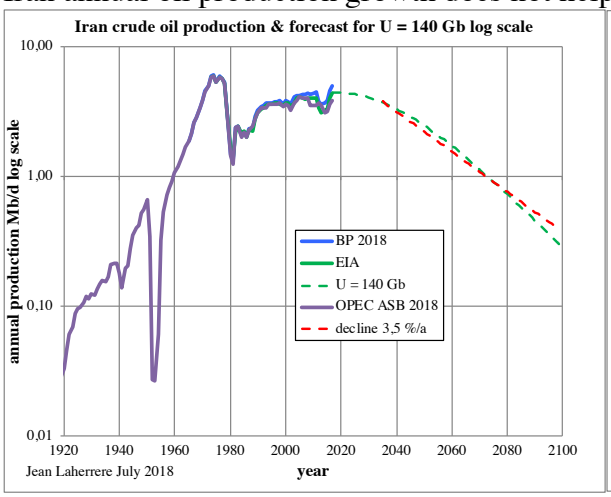


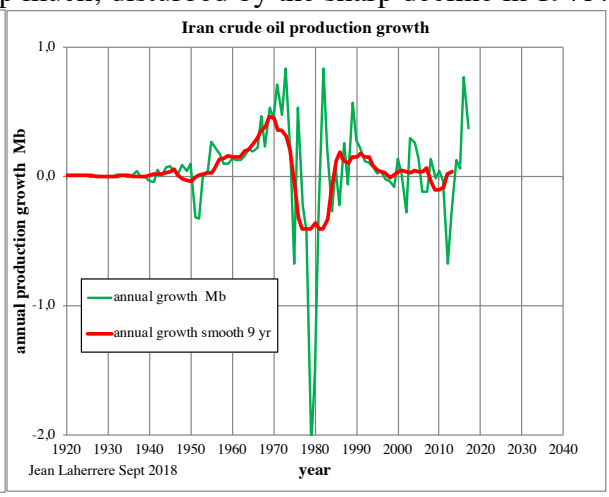
IHS 2010 data was corrected by 75 Gb to fit Petroconsultants 1998 data
The corrected creaming curve trends towards 140 Gb
HL trends towards 140 Gb (parallel 1992-2011), when OD is useless



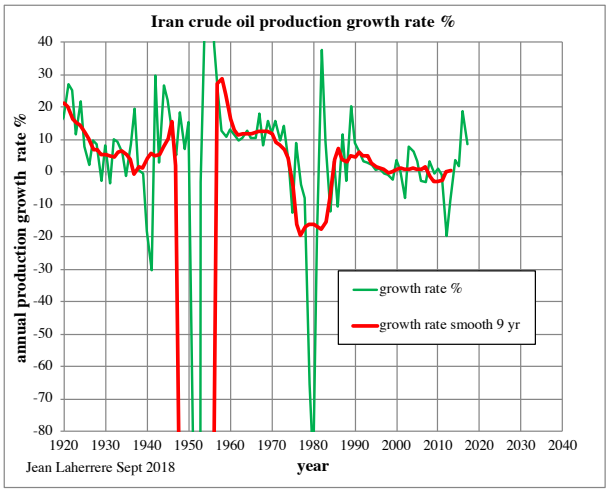


Iran oil production for an ultimate of 140 Gb will decline at 3,5 %/a after 2035
Iran annual oil production growth does not help much; disturbed by the sharp decline in 1975.



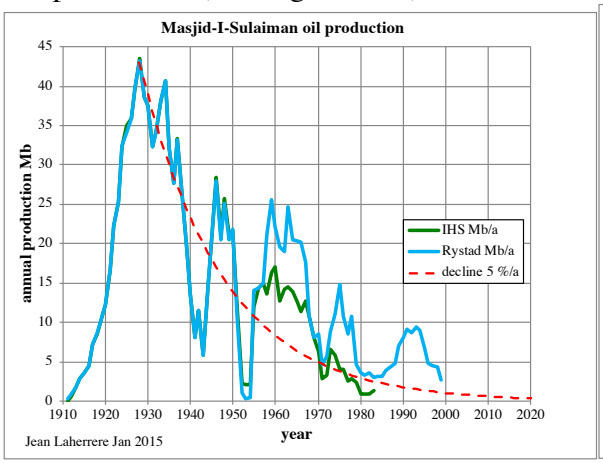


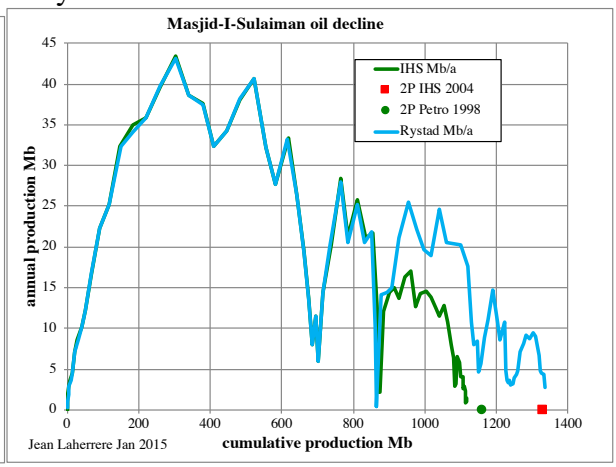
Growth rate in % is disturbed by events around 1950.



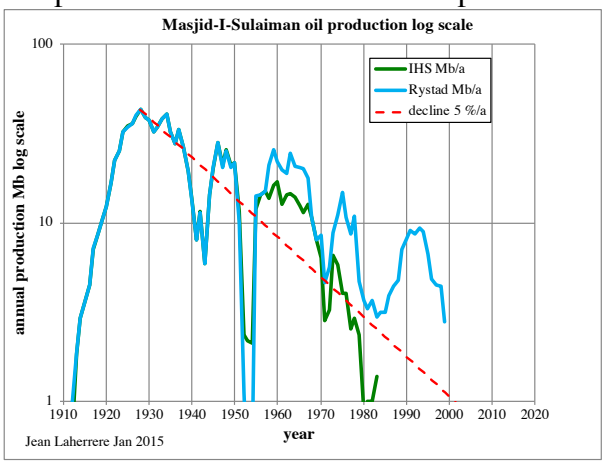
-Masjid-I-Sulaiman

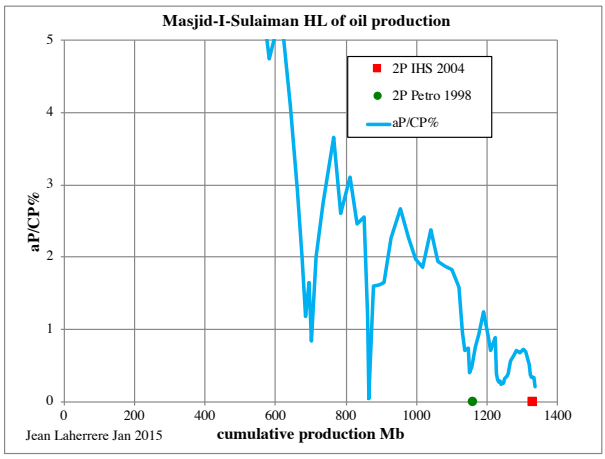
This field was discovered in 1908 on Bakhtiari land by Bakhtiari Oil Company (1909), which was changed into Anglo-Persian Oil Company and later in BP.
Oil production (starting in 1911) data differs wildly between scout sources



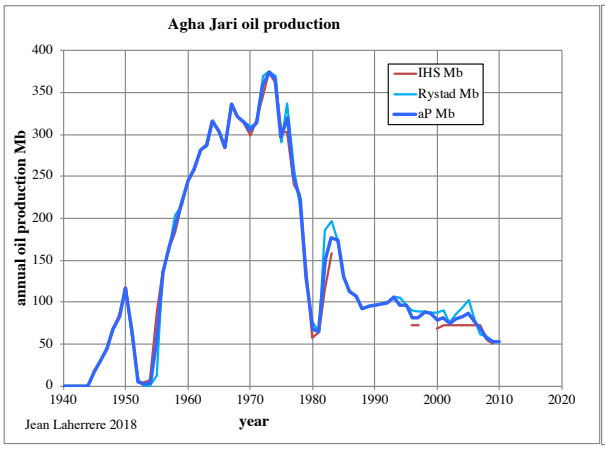


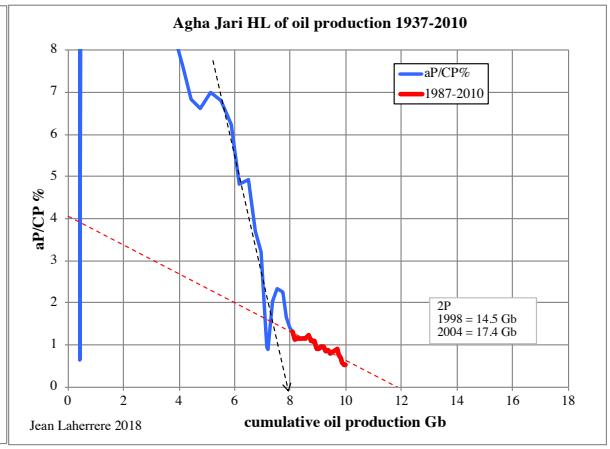
HL plot is chaotic and hard to extrapolate before end.

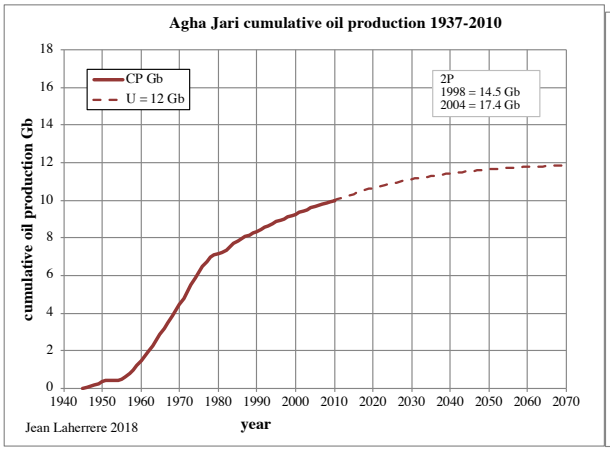


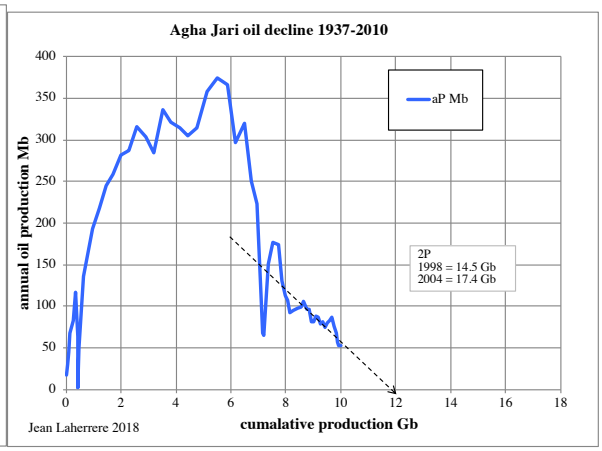


-Agha Jari

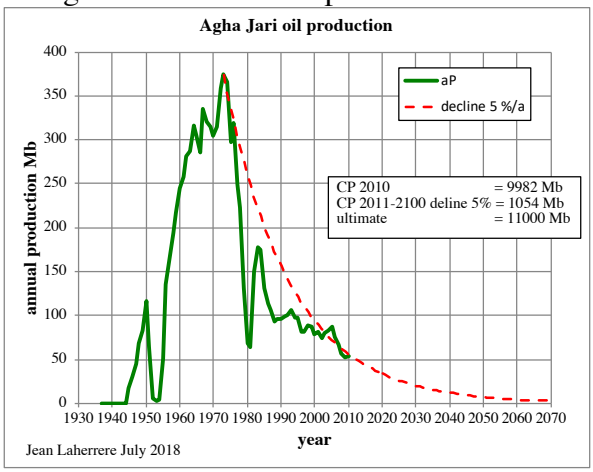


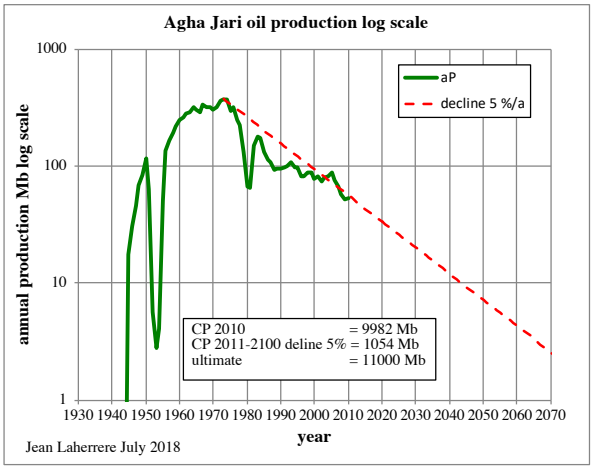




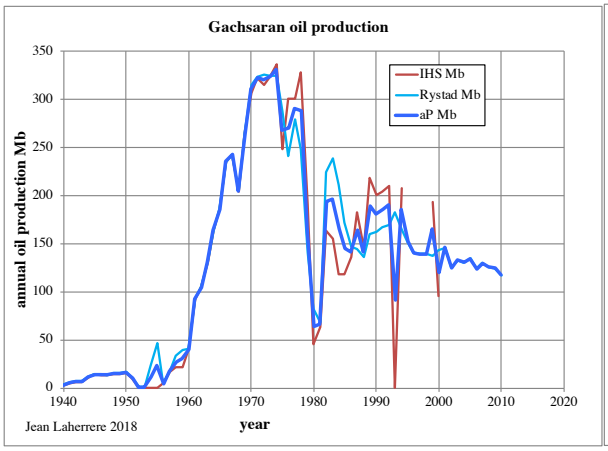


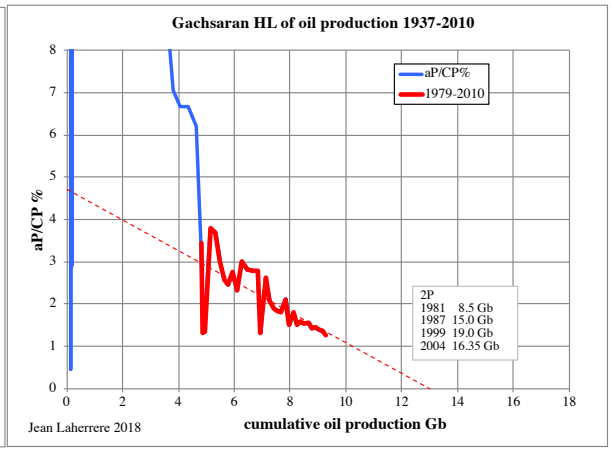
Using two sources of oil production

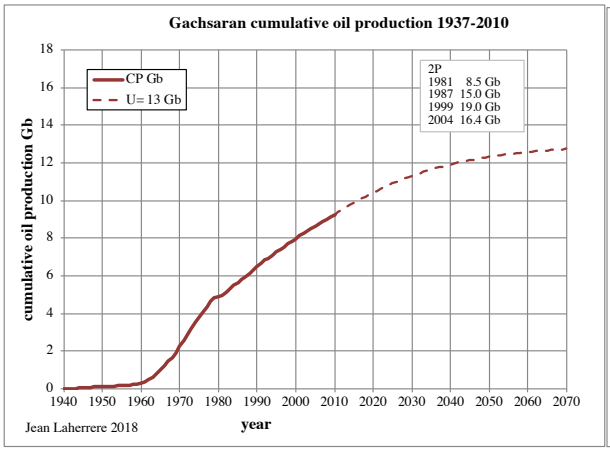


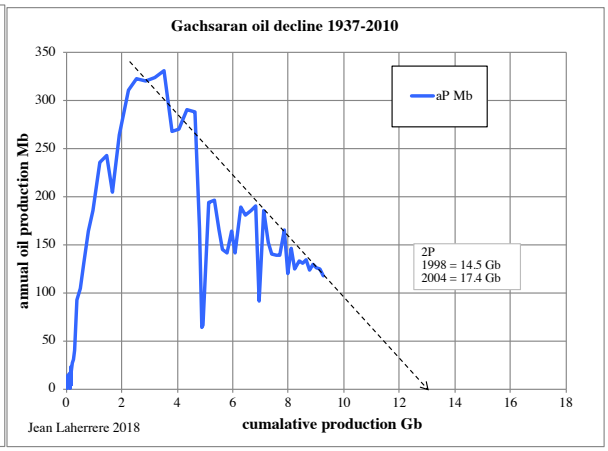


-Gachsaran

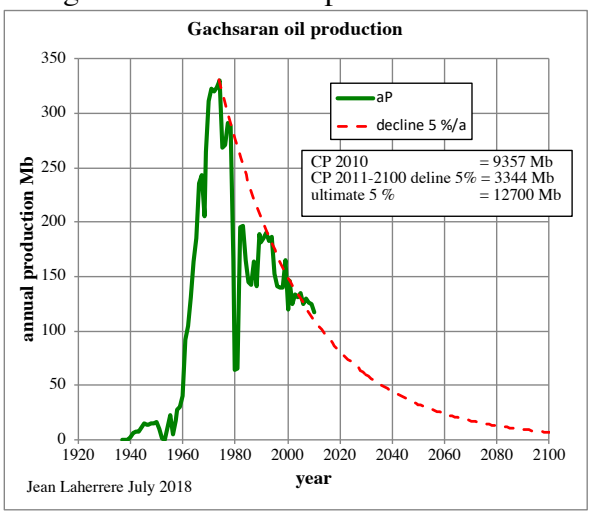


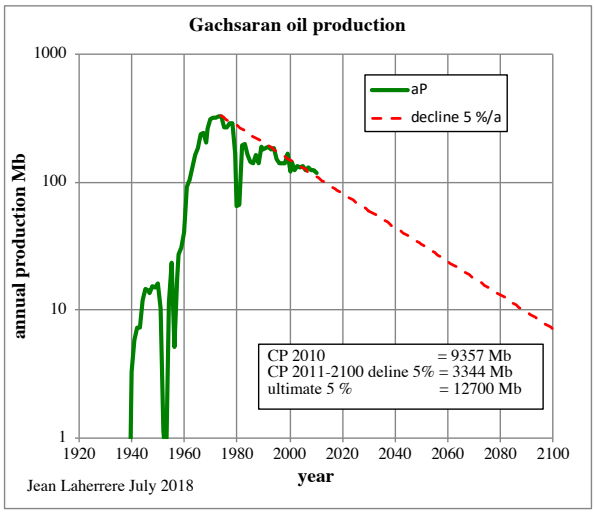




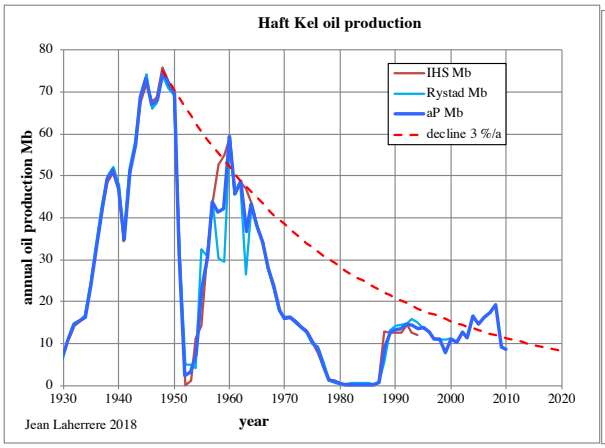


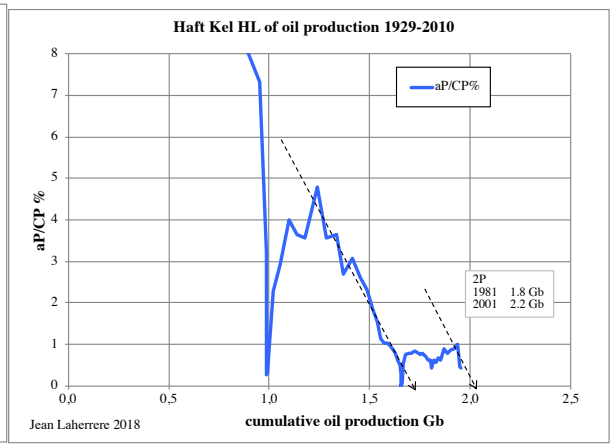
Using two sources of oil production

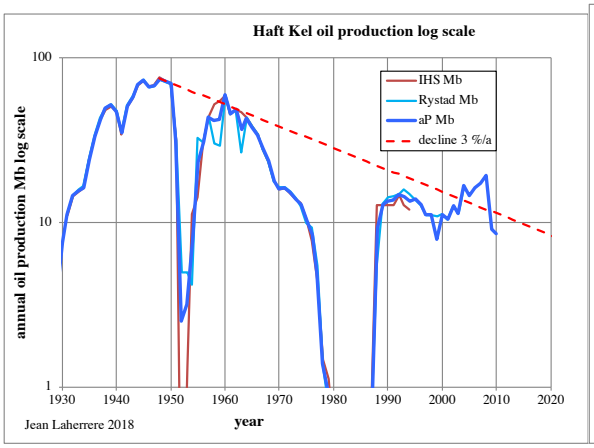


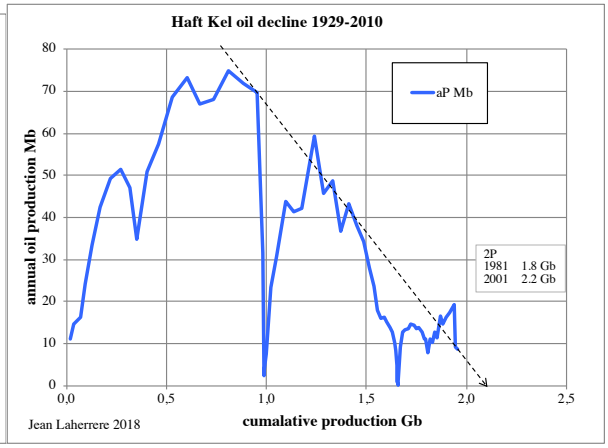


-Haft Kel







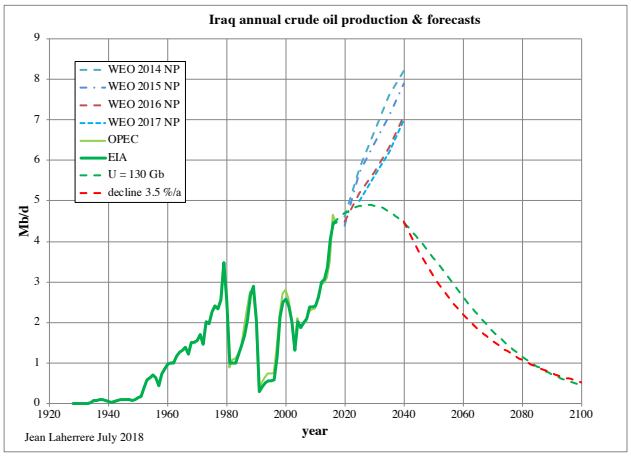


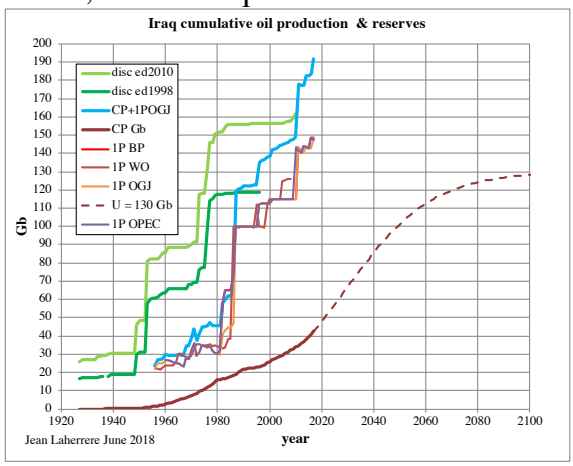
Twenty Years of Gas Injection History into Well-Fractured Haft Kel Field (Iran) Ali M. Saidi 1996 https://www.onepetro.org/conference-paper/SPE-35309-MS:
Haft Kel field is located in the foot hills of the Zagros mountain some 100 km east of Ahwaz city and on the east side of the Dezful embayment. The first oil producer well in Haft Kel was completed to a depth of 3363 ft in 1928 with an initial production rate of about 5700 b/day. A plateau rate of about 200 000 b/d was maintained for several years, before the field was shut down during 1950 to 1954. Its production dropped to about 14 000 b/d in 1976. Gas was injected in this field in June 1976, at a rate of 400 million cf/d.
Since then several old watered out oil producers have worked over and some new wells have been drilled. The present field production is over 35 000 b/d from several wells, with a fairly constant oil column thickness.
Haft Kel field is probably one of the best example of oil producing well-fractured reservoirs in the world. Its 68 years of history with several years of shut in period, well documented fairly uniform areal and vertical pressures, fluid levels, gas and oil productions, and gas injection histories with each water and gas invaded zone of about 1000 ft, is a desirable and interesting example in reservoir simulation study.

CO2 IOR Potential in Naturally Fractured Haft Kel Field, Iran Alavain et al 2005
We present results studying the IOR potential for CO2 injection in the naturally-fractured Haft Kel field, Iran, based on detailed compositional simulations of the matrix-fracture system. Oil recoveries from CO2 injection consistently range from 80-90% for reservoir pressures 1400 psia and higher (i.e. at and above current reservoir pressure of 1500-1800 psia). This compares with 15-25% recoveries reported for gas cap expansion and/or injection of hydrocarbon gas.

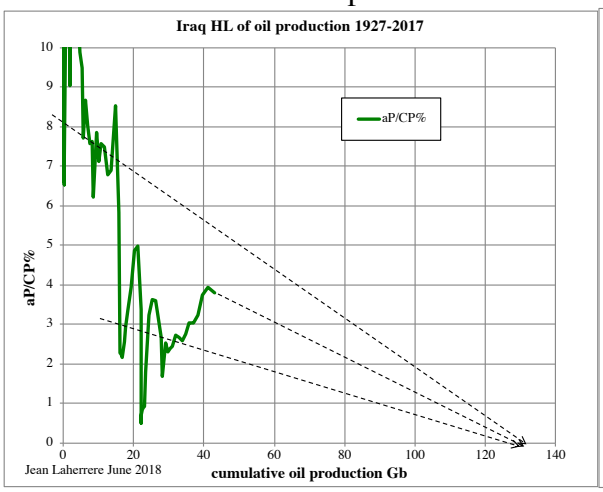
-Iraq

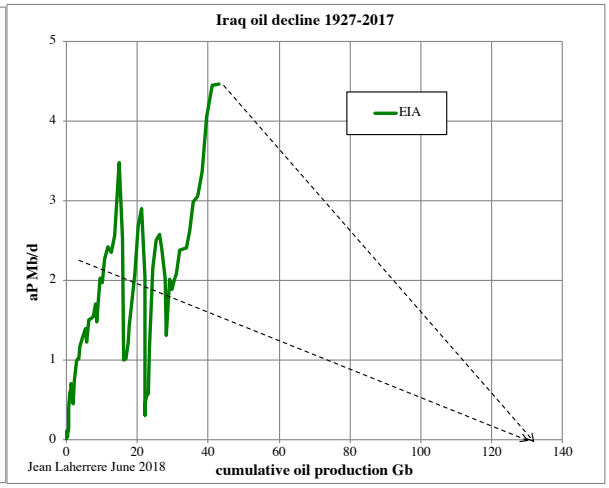
Three cliffs: 1980 = Iran-Iraq war, 1990 = Desert storm, 2003 = Iraq war



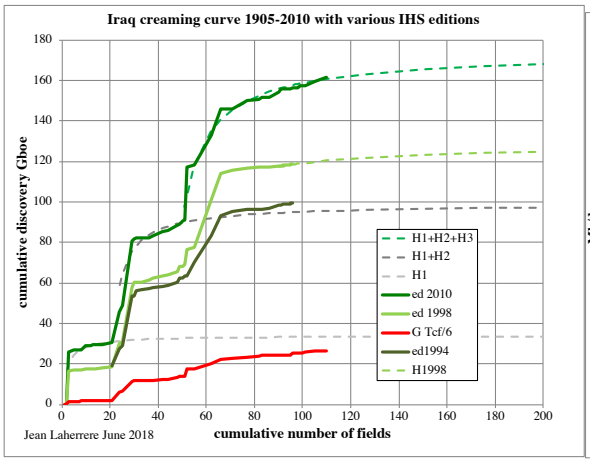


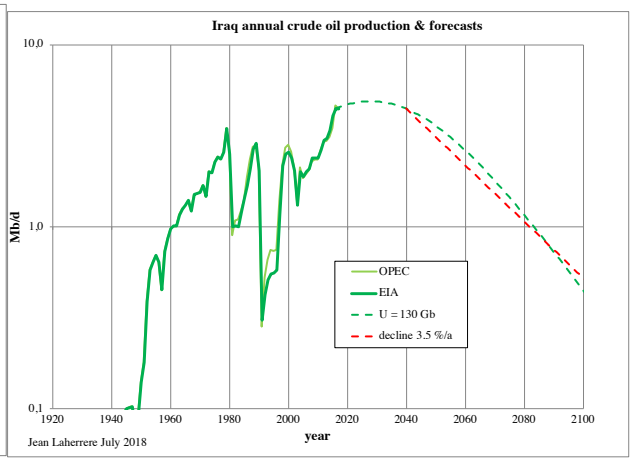
HL is useless with the sharp increase 2010-2017, and also for OD, which is worse.



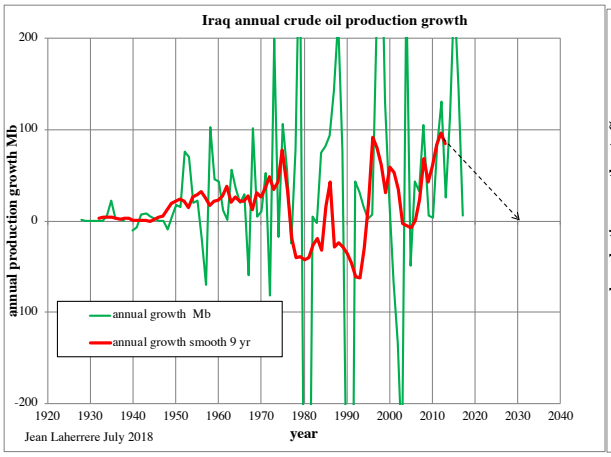


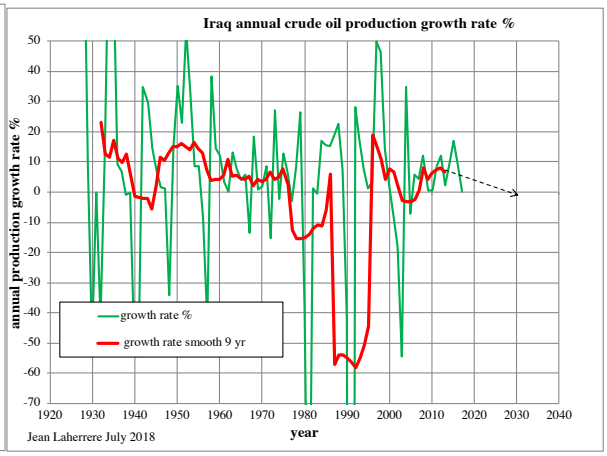
Iraq ultimate is chosen as 130 Gb using the creaming curve of earlier Petroconsultants data (1998), before OPEC members fight on quotas.





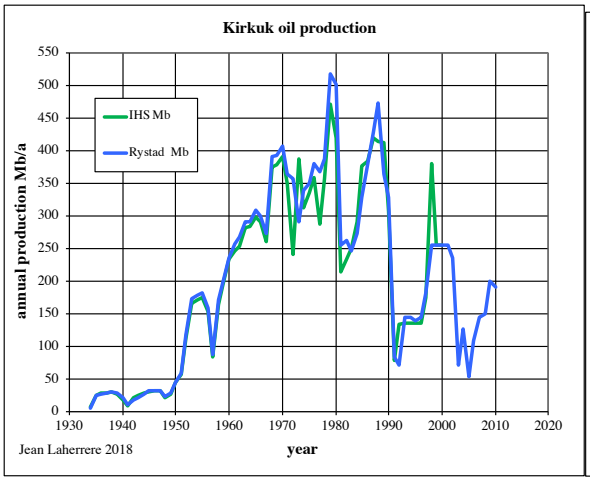
Iraq crude oil production growth is chaotic crossing several times the zero, the next could be around 2030 growth rate in % displays a better trend despite the wars

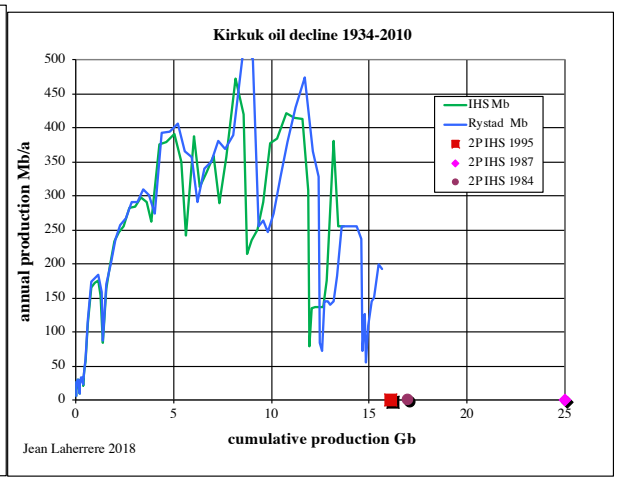


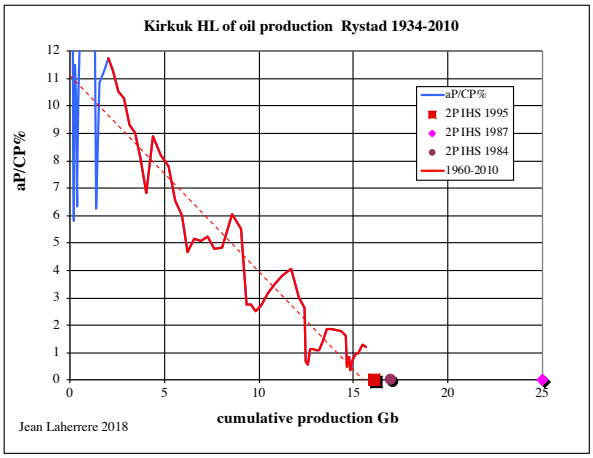


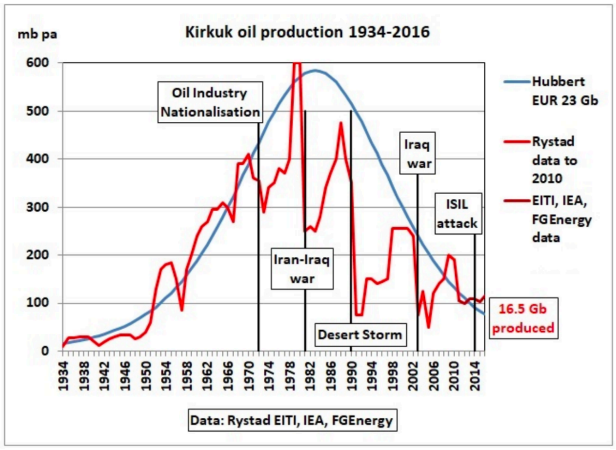
See the graphs of Matt Mushalik
http://crudeoilpeak.info/the-fight-for-northern-iraqs-remaining-oil

-Kirkuk









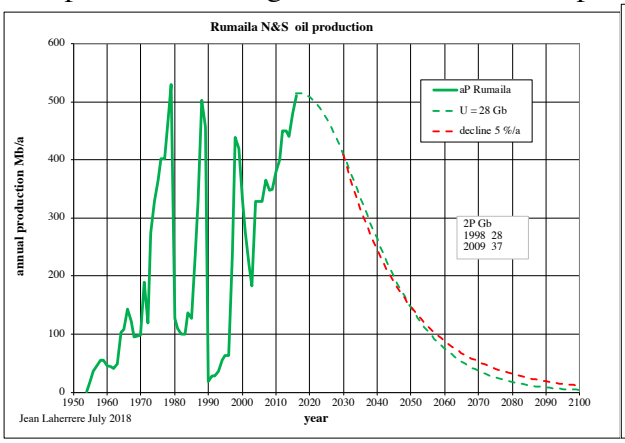
May 7, 2018
Iraq, BP sign Kirkuk oilfield development contract, official says. Under the deal, BP will boost output capacity from six fields in the Kirkuk region to a total of more than 1 million barrels per day (bpd), three times today's capacity in the region.

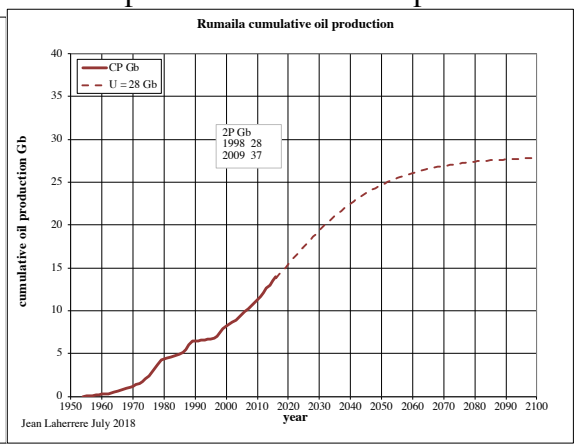
https://oilprice.com/Latest-Energy-News/World-News/BP-Iraq-Sign-Deal-To-Triple-Kirkuk-Oil-Production-To-1-Million-Bpd.html
Kirkuk is estimated to hold some 9 billion barrels of recoverable oil remaining, according to BP.
Kurds in October along with the fields of Havana, Bai Hassan, Jambu and Khabbaz.
Read more at https://www.channelnewsasia.com/news/business/iraq-asks-bp-to-study-developing-kirkuk-oilfields-9950186
A sixth oilfield, Khurmala, remains under Kurdish control, but Luaybi insisted it belongs to Iraq's state-owned North Oil Company.
The Iraqi government first approached the supermajor in 2014, with a request for it to study the development of two Kirkuk fields, Baba Gurgur and Havana
Iraqi Oil Minister Jabbar al-Luiebi (R) and BP President for Middle East Michael Townshend sign an amended Letter of Intent for studying North Oil Company fields, in Basra on May 7, 2018.

4 June 2018 - Under the deal, Iraq will send oil from the Kirkuk fields to Iran by truck, to be refined in Iran, and Iran will send the same amount of crude it receives to Iraq's ...

-**Rumaila**

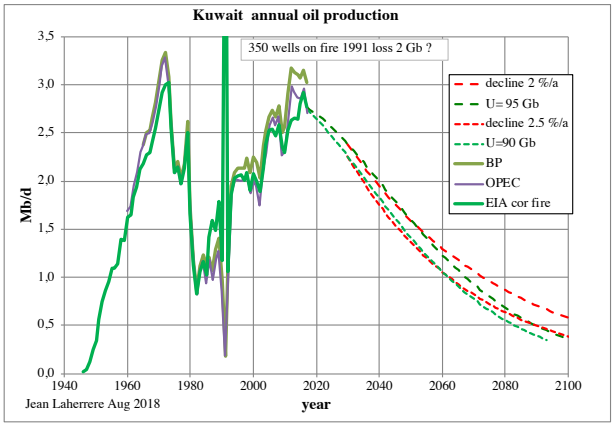
Rumaila oil production displays the three wars, being like Russian Mountains. 2P reserves were 28 Gb in 1998 and it is likely that the 2009 value of 37 Gb is overestimated. Recent oil production is reported by Arial Flores GM of Rumaila Operating Organization
http://www.rumaila.iq/english/
Past production being chaotic is useless except that 1979 peak was close to real peak

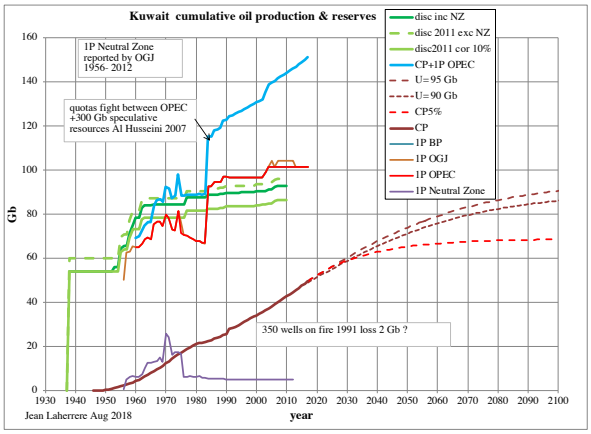




-Kuwait

Kuwait crude oil production peaked in 1973 at 3 Mb/d (1.1 Gb), but was disturbed by the war with Iraq, in 1991 350 wells were on fire for several months and about 2 Gb of oil was lost (not accounted in OPEC production : it was produced, but not sold or consumed). It peaked again in 2016 at 2.9 Mb/d and it declines since with a rate of 3 %/a for an ultimate of 95 Gb.





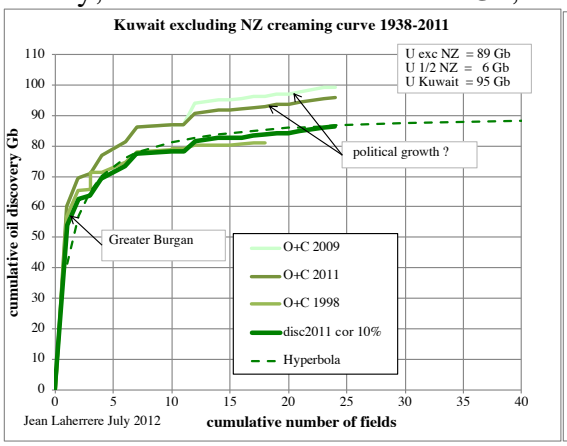
CC of Kuwait excluding the Neutral Zone (50 Kuwait, 50 SA) trends towards 89 Gb and the CC of NZ is 13 Gb (see below p 89).

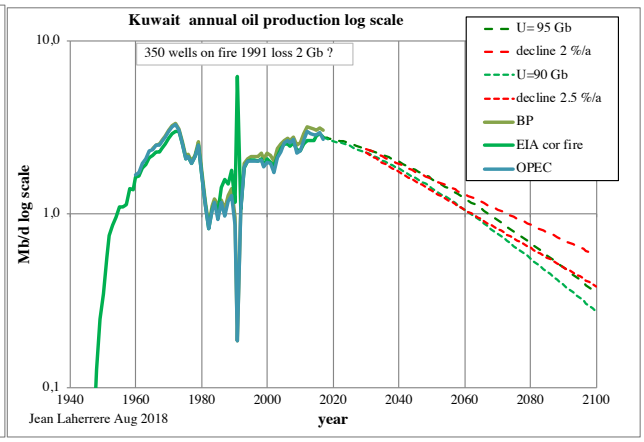
CP +1P OPEC (including NZ) is about 150 Gb o in 2017, far too high, because the fight for quotas Kuwait (excluding NZ) increased its proved reserves in 1985 but NZ did not change.

For an ultimate of 95 Gb the decline rate after 2030 is 2 %/a: it is lower than in UAE (5 %/a)

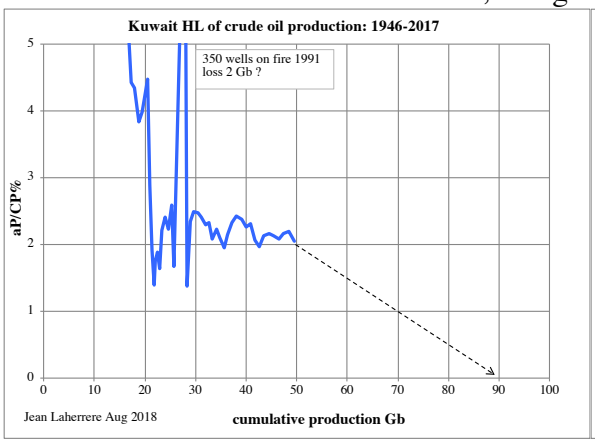
For an ultimate of 90 Gb the decline rate after 2030 is 2.5 % and is more symmetrical of the rise 1981-2010 and for me better.

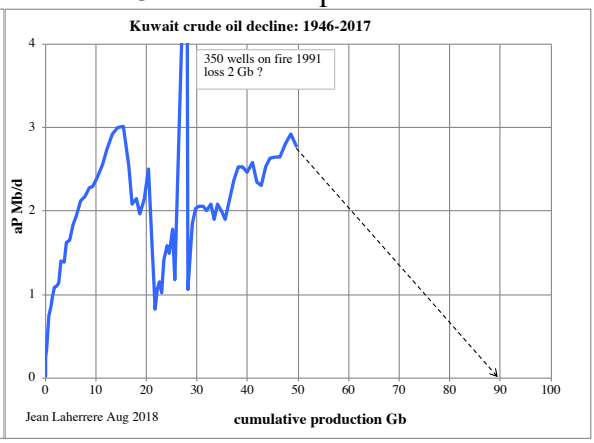
Finally, the ultimate is chosen as 90 Gb, but unreliable.



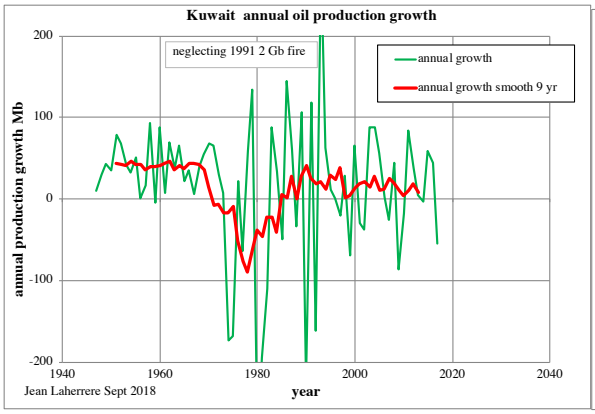


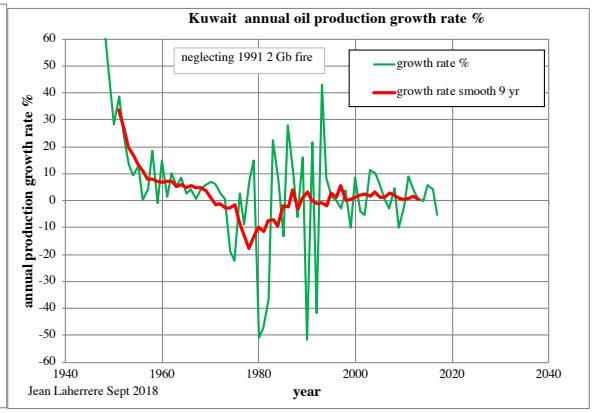
HL is useless to estimate the ultimate, being flat and as OD as the last peak is 2016.





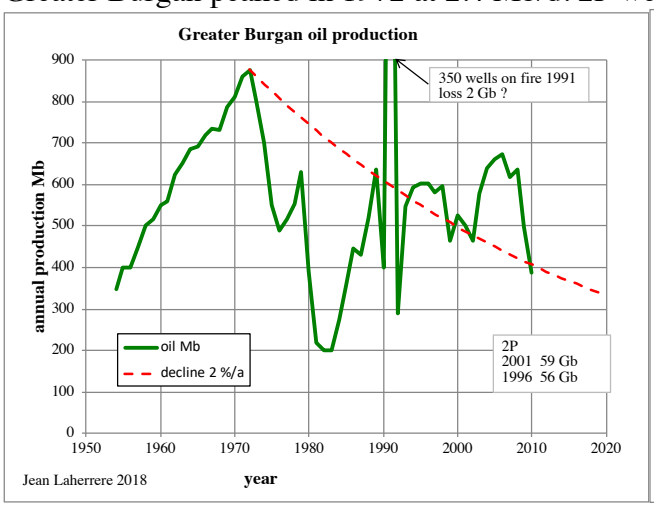
Kuwait annual crude oil production growth is almost flat, neglecting the 2 Gb fire of 1991 and does not help much. Same with growth rate in %.

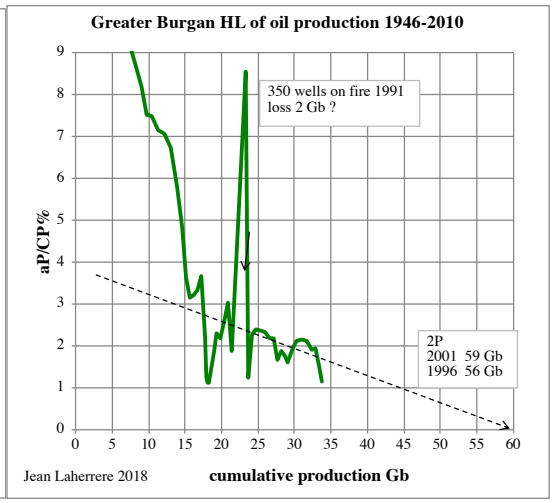




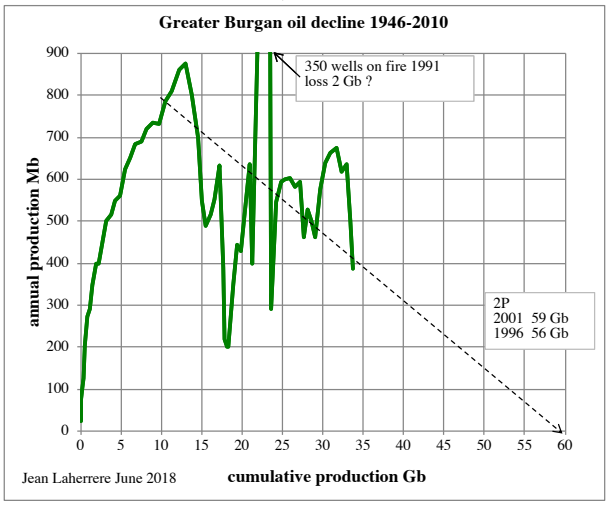
-Greater Burgan

Greater Burgan peaked in 1972 at 2.4 Mb/d. 2P were 56 Gb in 1996 and 59 Gb in 2001.



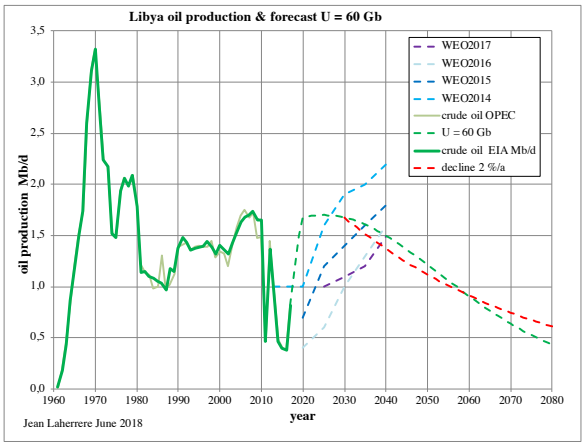


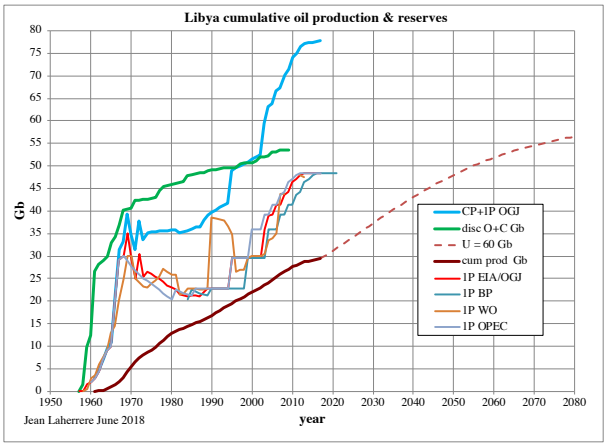
HL & OD are useless, as aP is too chaotic with wars and quotas.



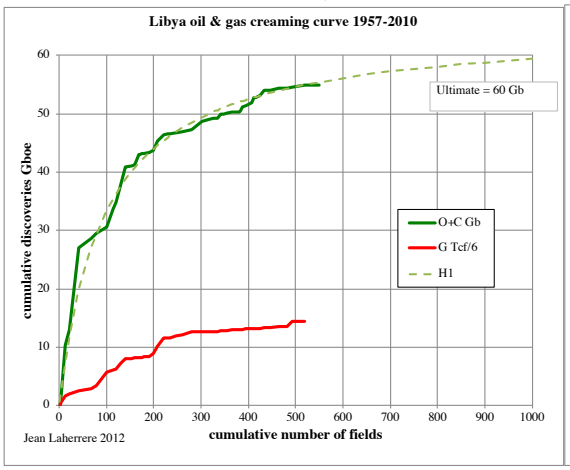
-Libya

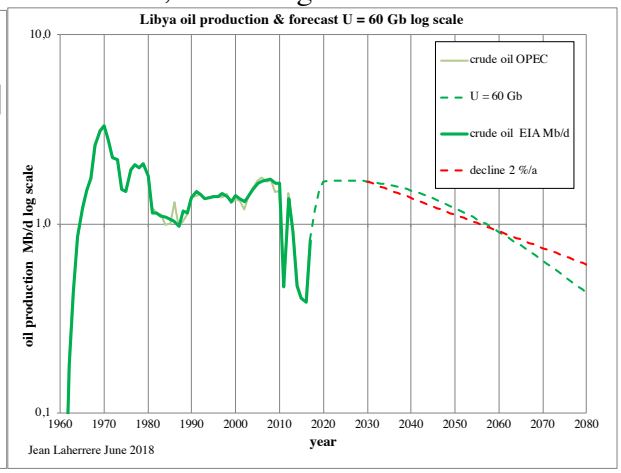
Libya crude oil production peaked in 1970 at 3.3 Mb/d, since 2010 because the war in Libya oil production is chaotic.





CC trends towards 60 Gb, when CP +1P 2017 are 78 Gb; far too high!

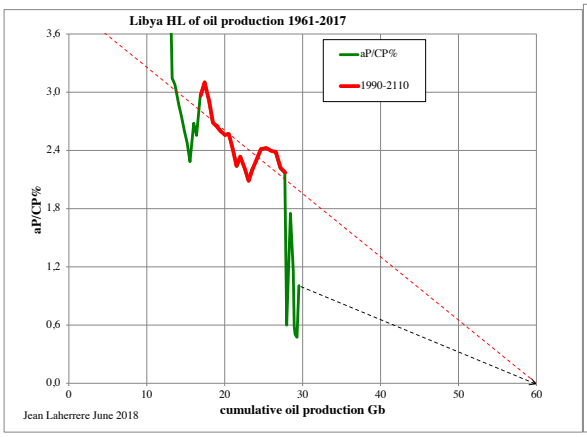


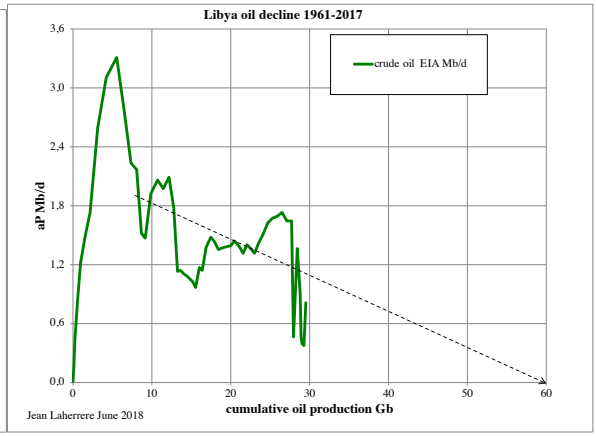


Assuming that the war is over in 2020, oil production will decline at 2 %/a after 2030 for an ultimate of 60 Gb

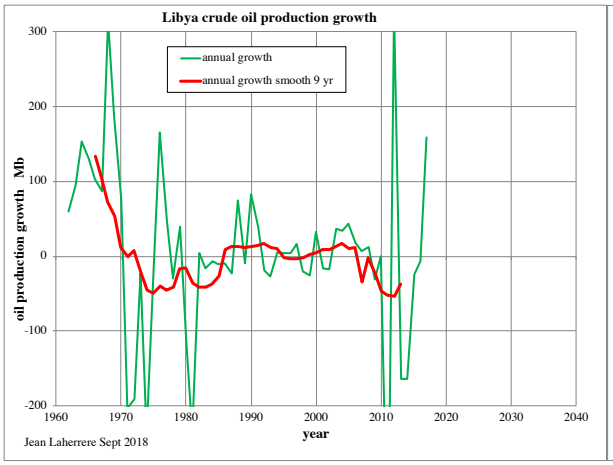
HL (1990-2010) trends towards 60 Gb, after 2010 the data is useless because of the war.

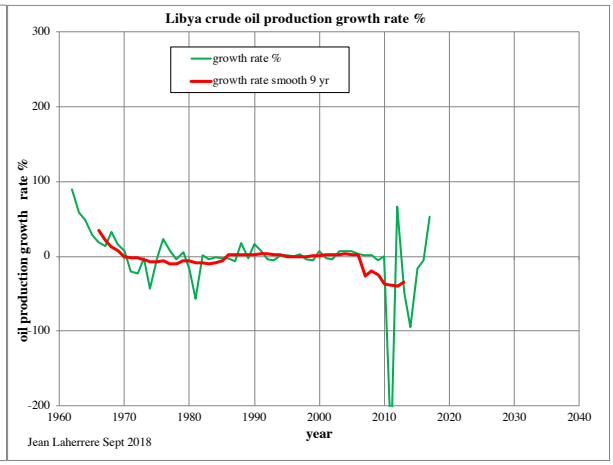
OD is useless.





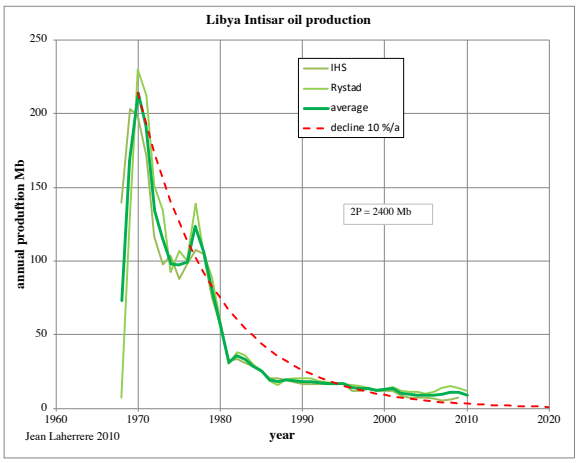
Libya crude oil production growth is almost flat at zero since 1985 and since 2010 chaotic because the war: useless. Same with growth rate in %.

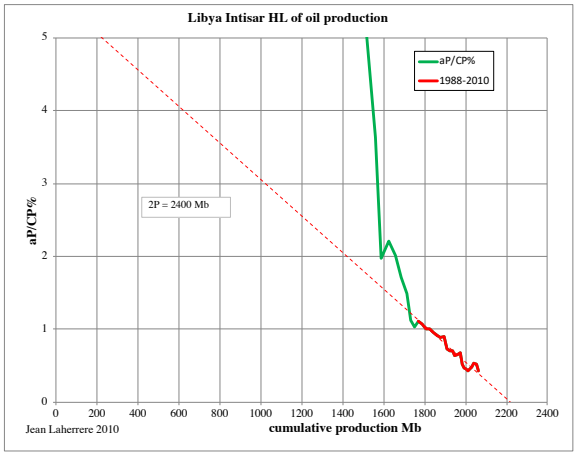


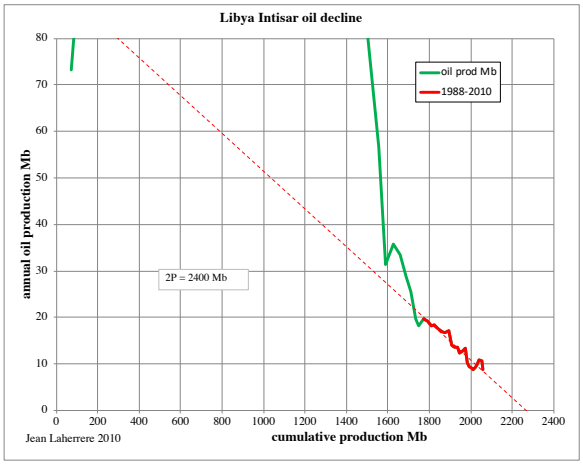


-Intisar

Intisar started production in 1968 and peaked in 1970 at 0.6 Mb/d and the decline to 2010 was about 10 %/a. 2P were at 2400 Mb and CP2010 = 2060 Mb
HL (1988-2010) trends towards 2200 Mb and OD (1988-2010) rends towards 2220 Mb, less than 2P



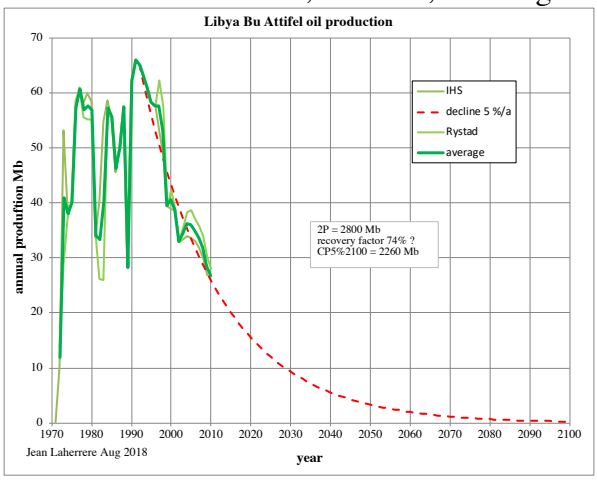


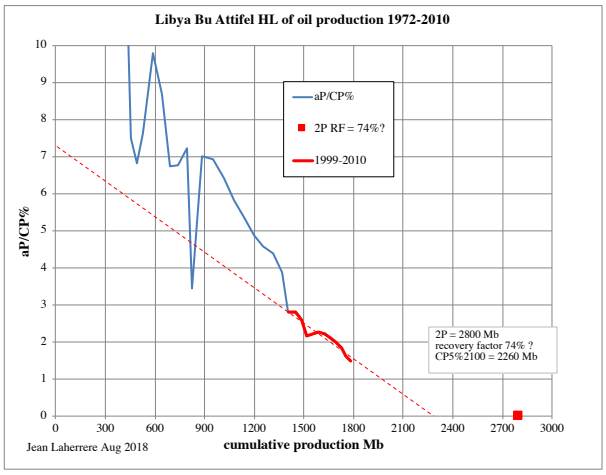


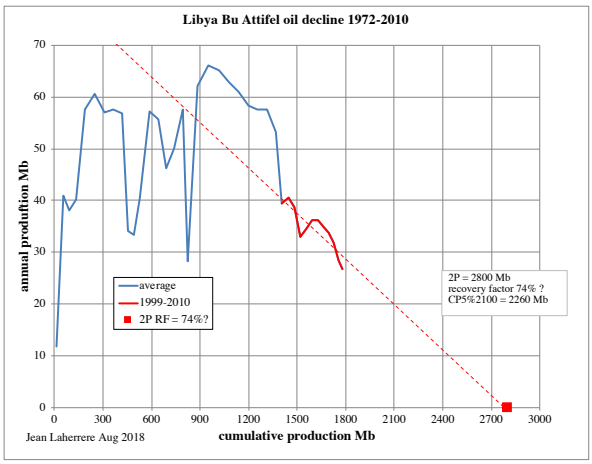
-Bu Attifel

Bu Attifel peaked in 1991 at 0.18 Mb/d. The decline rate from 1992 to 2010 is 5 %/a.
2P were 2800 Mb and HL (2000-2009) trends towards 2250 Mb when OD trends towards 2800 Mb.

CP5%2100 is 2260 Mb, like HL , meaning that HL is much better than OD

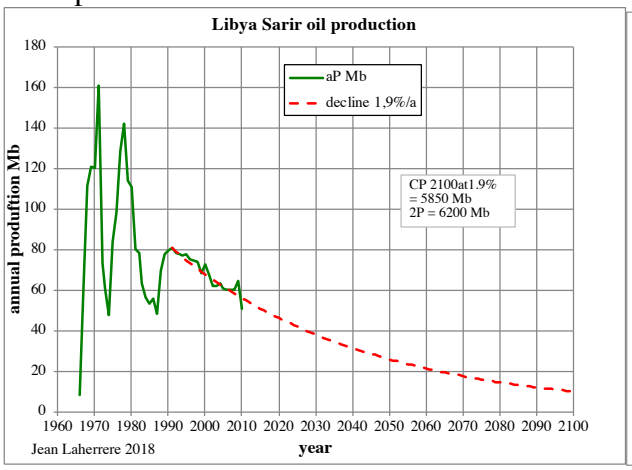


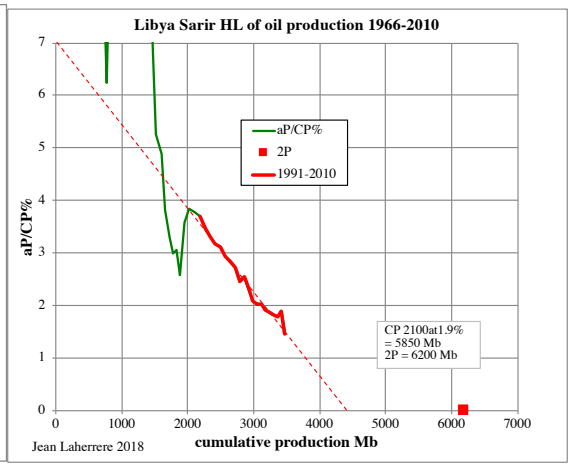




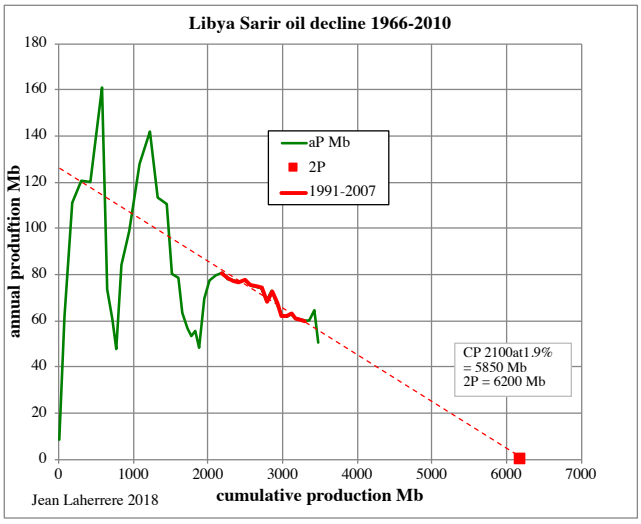
-Sarir

Sarir peaked in 1971 at 0.4 Mb/d and declined from 1991 to 2010 at 1.9 %/a.





HL (1991-2010) trends towards 4400 Mb, far from 2P = 6200 Mb
OD (1991-2007) trends towards 6200 Mb, which is 2P
CP up to 2100 at 1.9 %/a is 5850 Mb
It is hard to choose between all these estimates! A round number of 6000 Mb



-**Neutral (Divided) Zone**

Neutral (Divided) Zone is located onshore and offshore between Kuwait and Saudi Arabia: the production is shared fifty-fifty between both countries. NZ oil reserves and production were reported until 2013, now there are included into SA and Kuwait data.

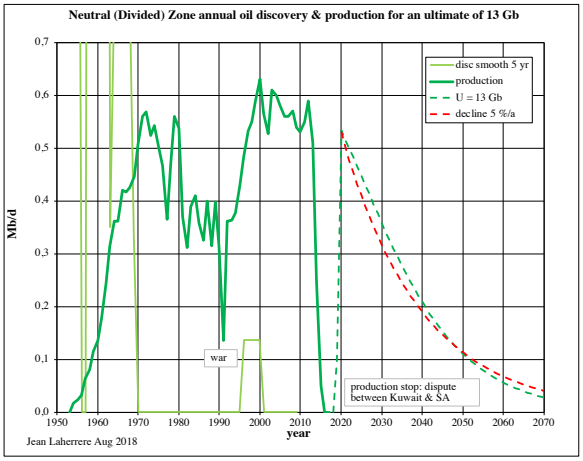
When quotas based on reserves were established on production , it was a fight between OPEC members and Kuwait increased their so called proved reserves by 50 % in 1985 followed only in 1990 by SA, but NZ reserves were not increased (see graph page 3)

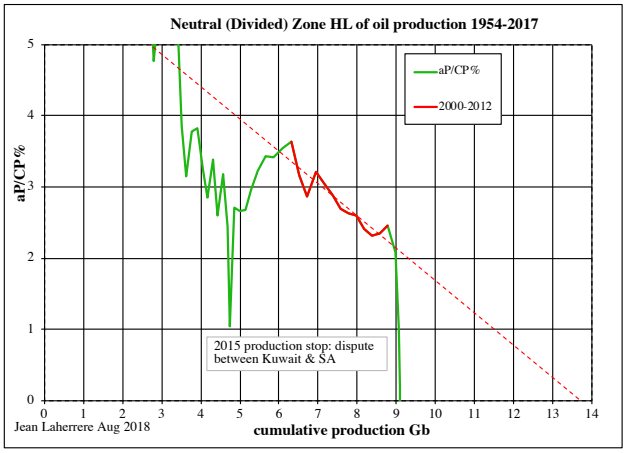
In 2010 only 9 fields have been discovered for a total discovery of 12.7 Gb and 1.7 Tcf.

NZ crude oil production peaked in 2000 at 0.6 Mb/d.

Since 2015, NZ oil production is stopped because a dispute between SA and Kuwait.

We assume that production will resume in 2020 and will decline for an ultimate of 13 Gb at a decline rate of 5 %/a.

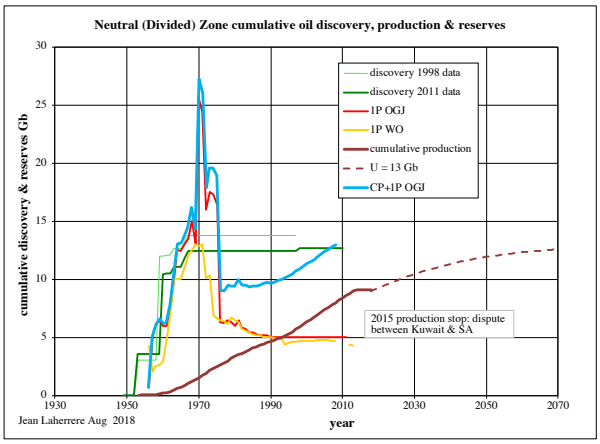


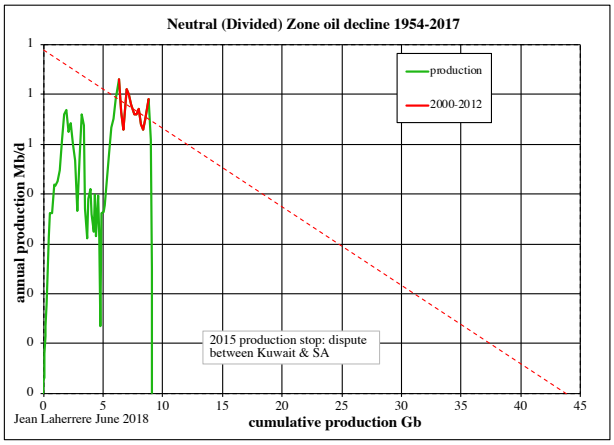


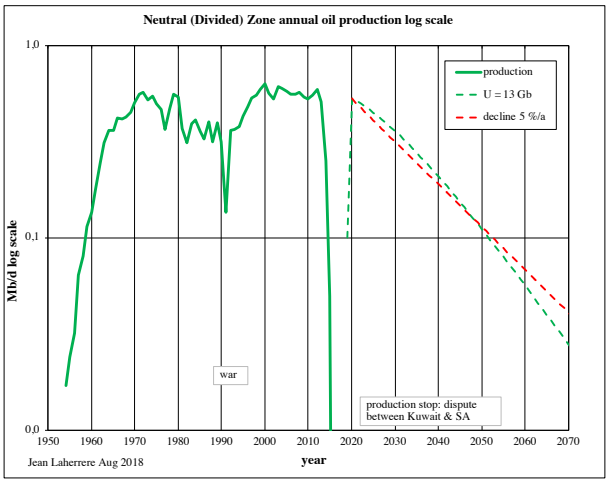
HL for the period 2000-2012 trends towards 13,5 Gb.

CP +1P OGJ is for 2012 (last data) at 18.8 Gb (like discovered 2P), but it was in 1970 over 27 Gb: obviously completely wrong.

OD for the period 2000-2012 trends towards 43 Gb, obviously wrong too close to the peak.

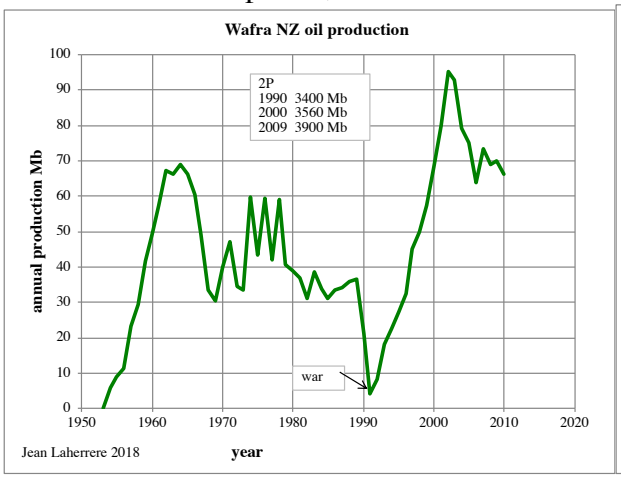


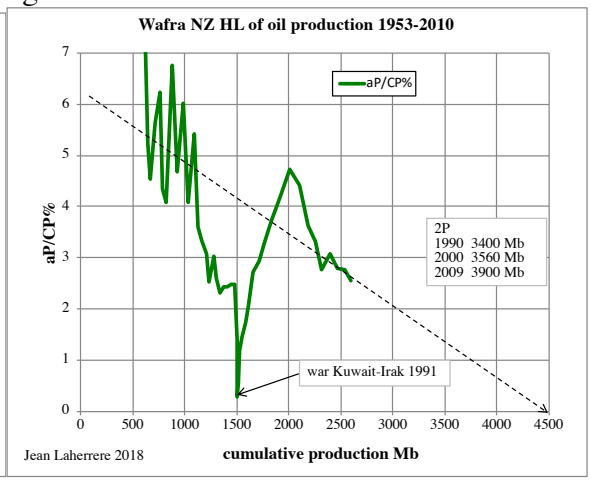


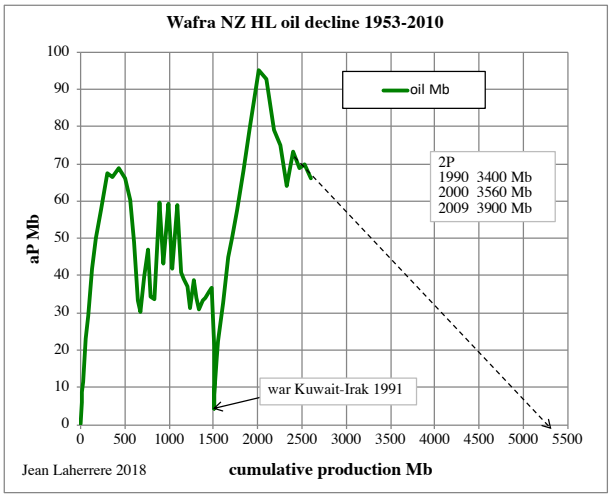


-Wafra

Wafra field is onshore NZ. It peaked in 2001
2P was in 2009 3900 Mb.
HL is hard to extrapolate, but trends towards a higher value as OD



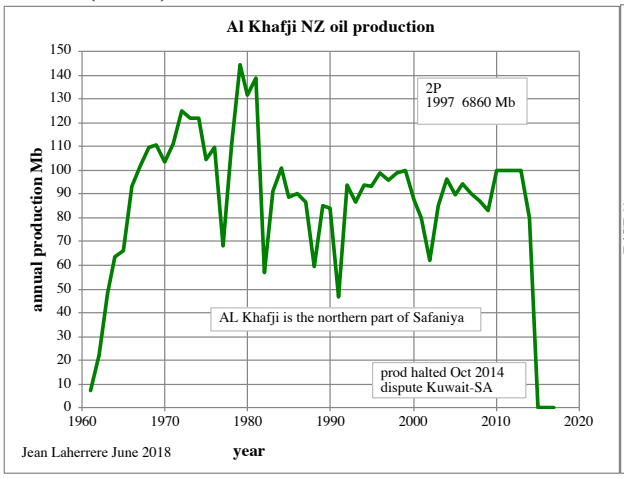


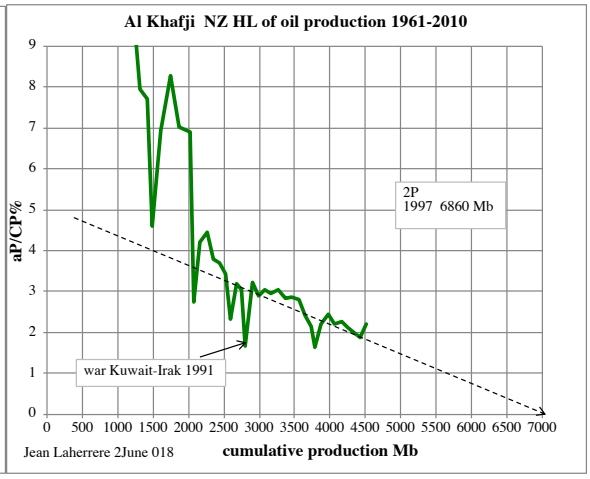


-**Al Khafji**

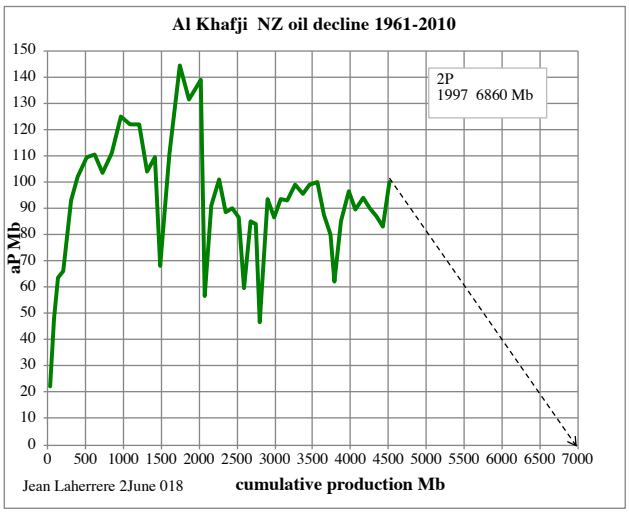
Offshore Al Khafji field is the northern part of Safanyia field in Saudi Arabia. Production was stopped in Oct 2014 after a dispute between SA and Kuwait.

Its 2P (1997) is 6850 Mb and HL trends towards 7000 Mb



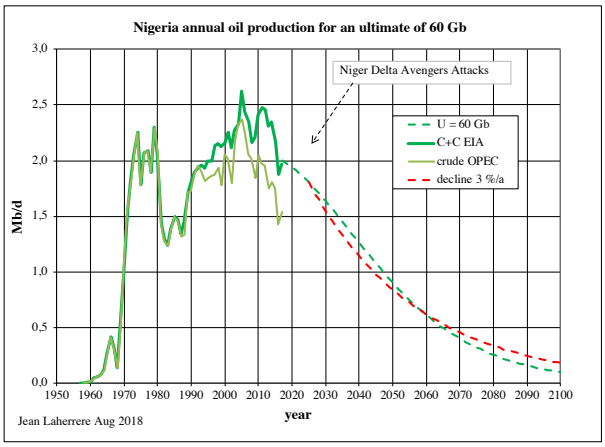


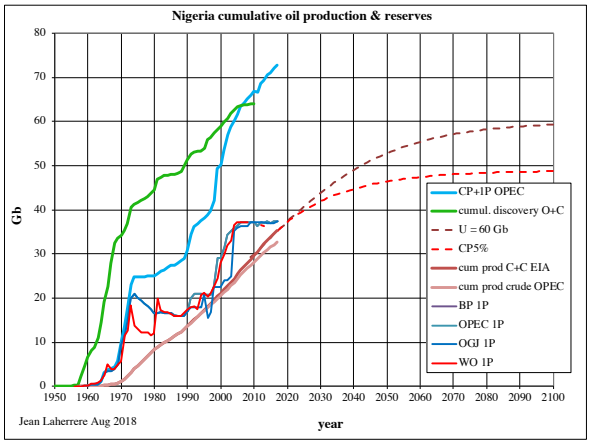
OD is useless



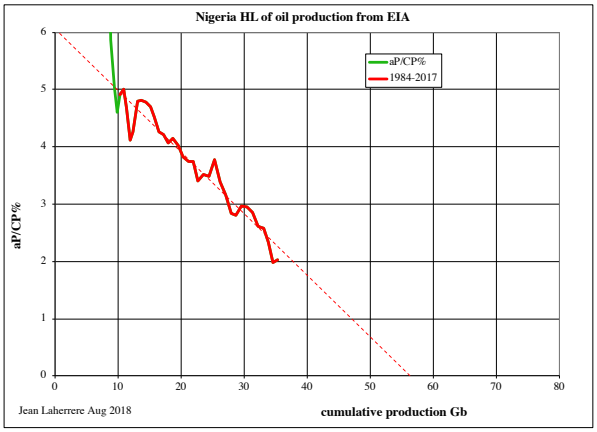
-Nigeria

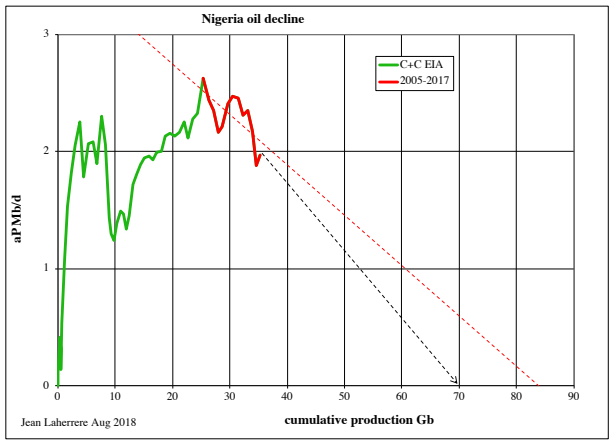
Nigeria has peaked in 2005 above 2.5 Mb/d and the present production is in decline below 2 Mb/d because the Niger Delta Avengers attacks.
HL is trending towards less than 60 Gb, CC trends towards 70 Gb, high compared to CP5% which is about 50 Gb, and the 2P of the fields below looks too optimistic,
An ultimate of 60 Gb was chosen, but it is questionable.
CP+1P OPEC 2017 is 73 Gb. Libya like the Middle East OPEC members has increased its reserves to get a better quota.
With such ultimate of 60 Gb, Nigeria oil production could continue to decline and its rate de decline will be 3% since 2025



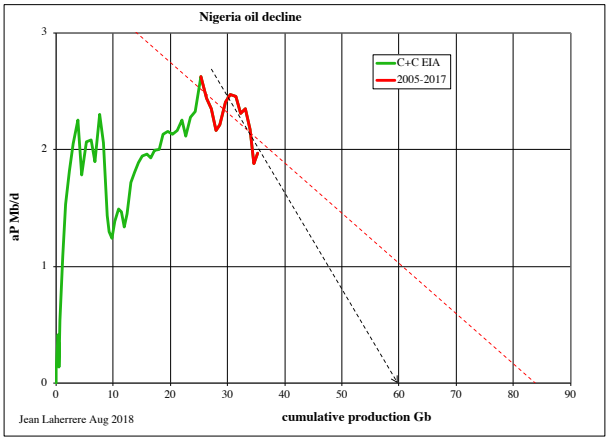


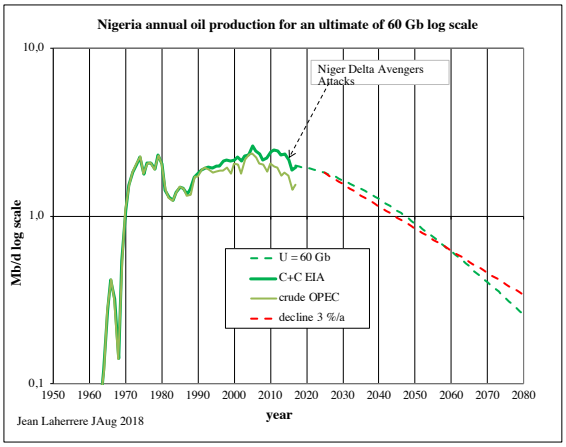
The oil production data is disturbed by the civil war and HL (1994-2017 trending towards 56 Gb and OD (2005-2017) trending towards 83 Gb is not reliable





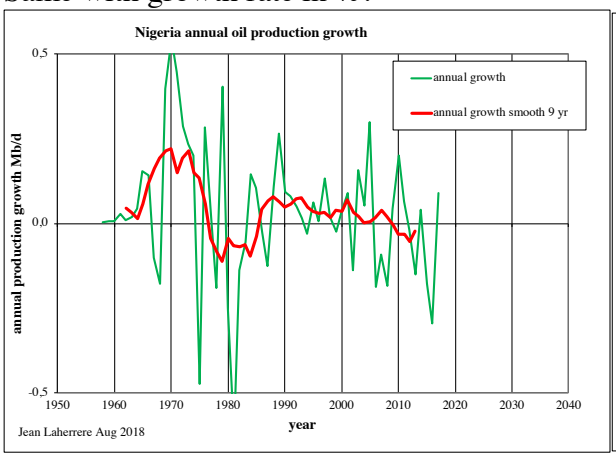
Nigeria oil production will decline at 5 %/a after 2040

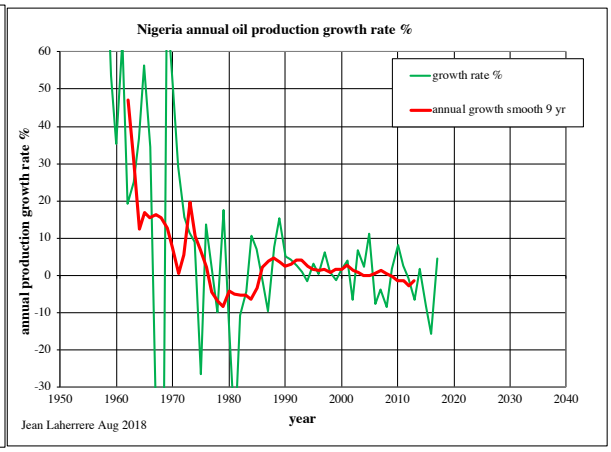




The 2P of the following fields looks too high compared to HL and OD.

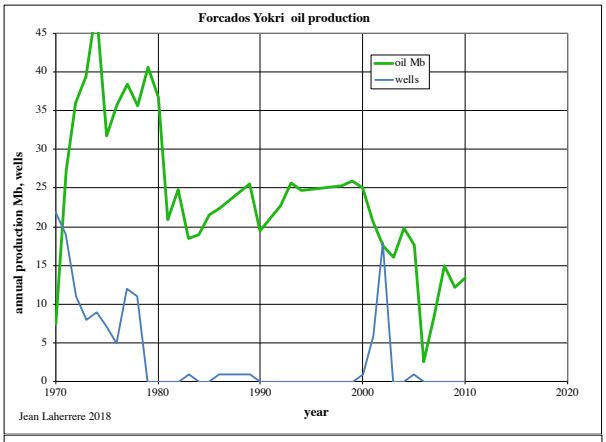
Nigeria annual oil production growth is also useless because the civil war and is almost flat
Same with growth rate in %.

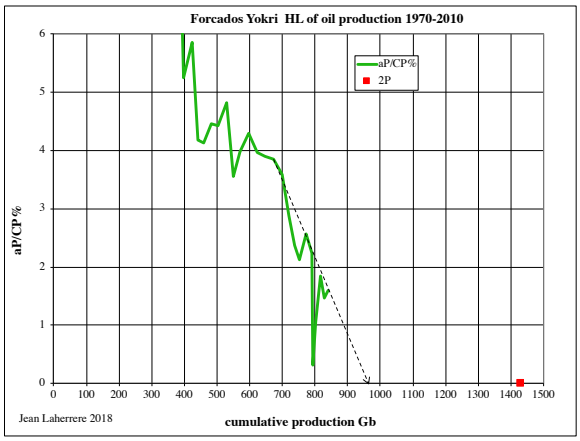


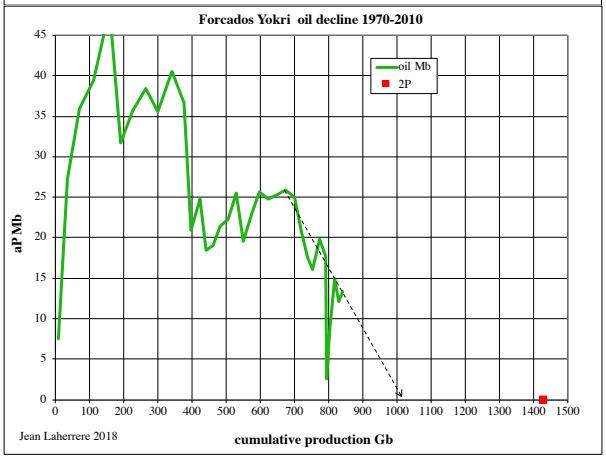


Forcados Yokri

Nigeria oil field production were disturbed by civil wars and the largest field Forcados displays a chaotic annual production after the peak in 1974
HL as OD trends towards about 1000 Mb when 2P is 1430 Gb.

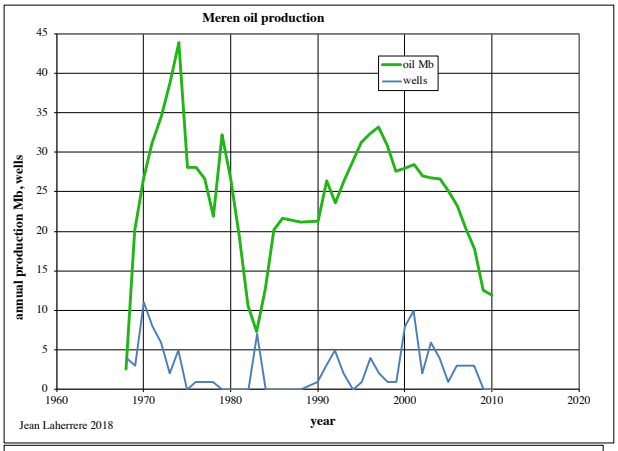


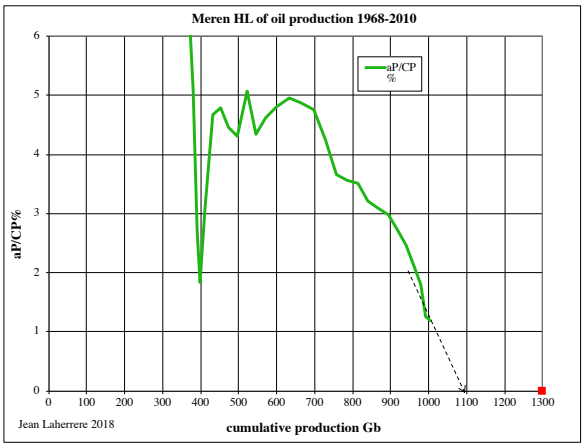


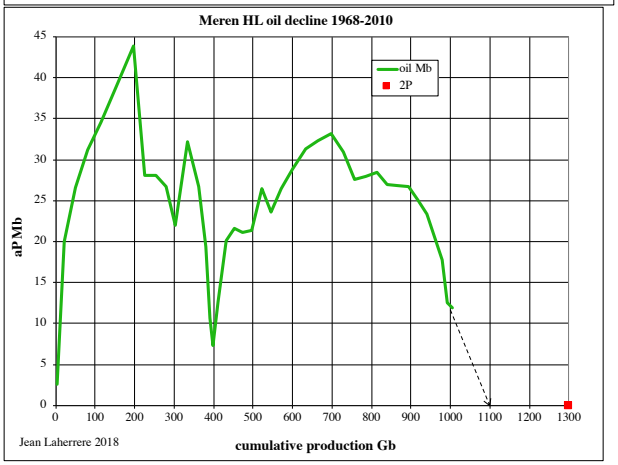


-Meren

Same for Meren, which peaked in 1974? HL and OD was poor but trending towards less than 2P = 1300 Gb

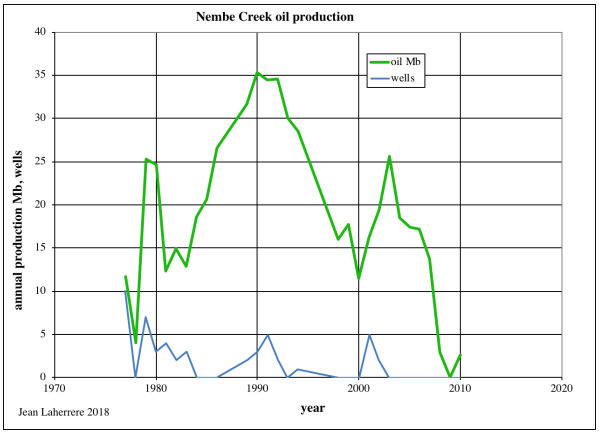


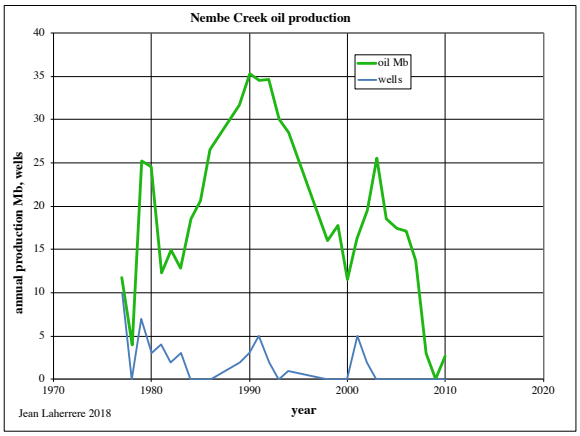


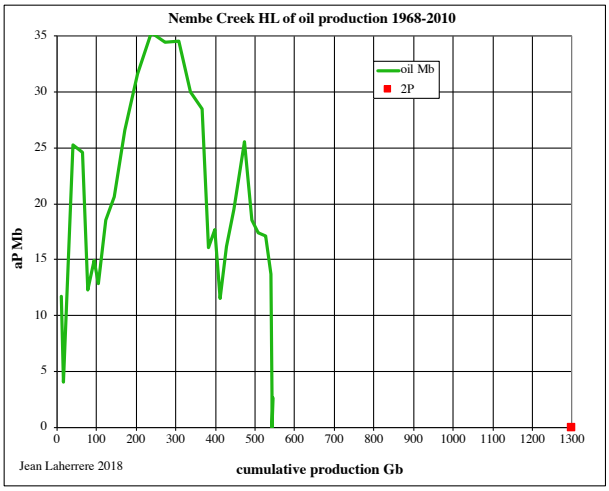


-Nembe Creek

Same for Nembe Creek





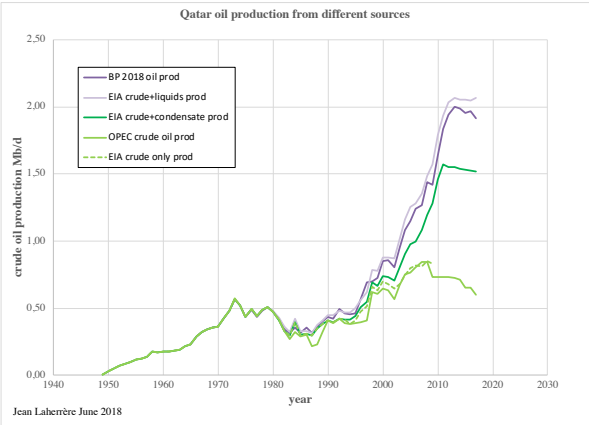


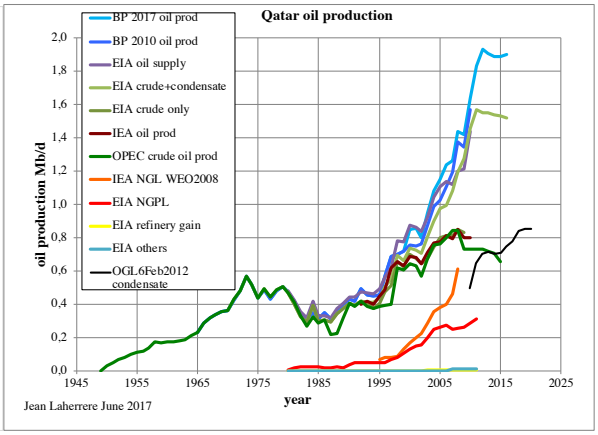
-Qatar

The problem of Qatar oil data is the importance of condensate and NGL, higher than crude oil production in volume. Condensate, as NGL, is badly reported by OPEC and IEA, and recently by EIA (in the past condensate was reported in US with crude oil) : there is a discrepancy of 2 Mb/d between EIA and IEA historical world NGL.

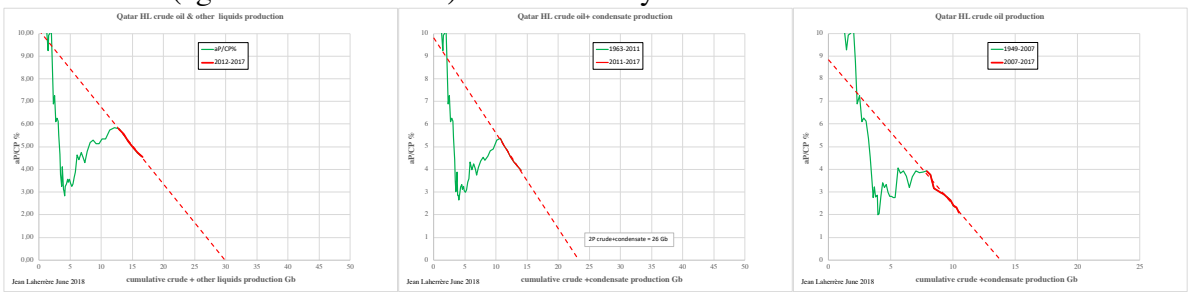
North Field 2P reserves are 1000 Tcf of NG and 26 Gb of condensate (2P Qatar crude +condensate = 41 Gb). North Dome (North Field Qatar 2/3 and South Pars 1/3 Iran) 300 Gboe reserves are much larger than Ghawar.

As condensate is not subject to quotas OPEC deals only with crude oil production . But OPEC does not report the detail of NGL per country. There is a large discrepancy between IEA NGL production and EIA NGPL production



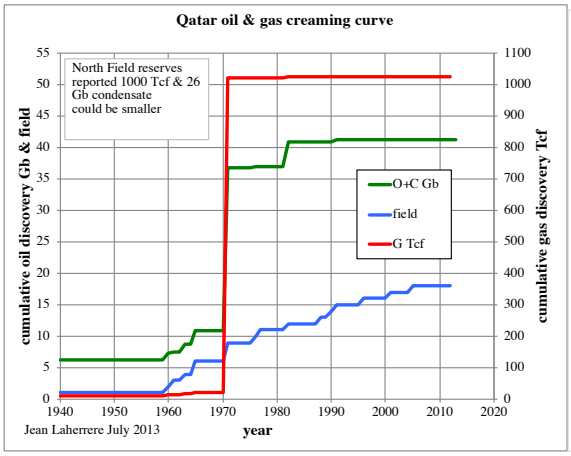


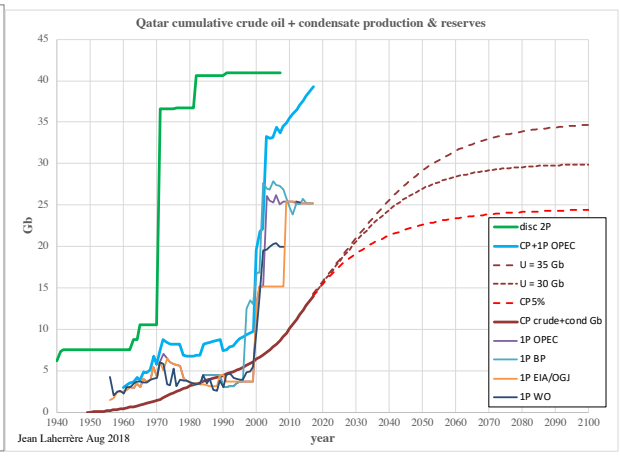
HL of past production trends towards 30 Gb, 23 Gb & 14 Gb for crude +liquids, crude +condensate (against 26 Gb for 2P) and crude only ultimates



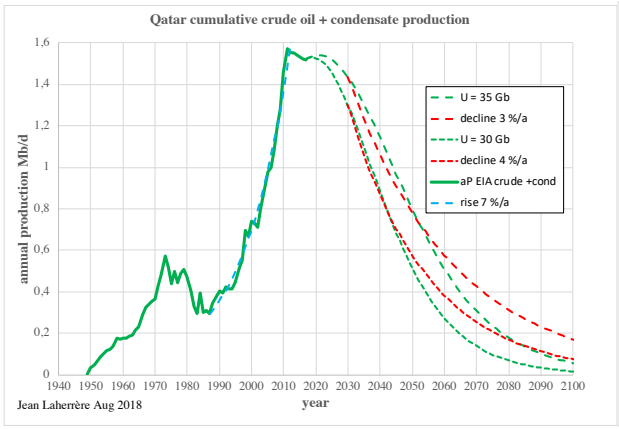
Condensate & NGL reserves are larger than crude oil, but the problem is that their production is connected to those of NG and NG production is limited by the different phases of NG development. Also, their reserves

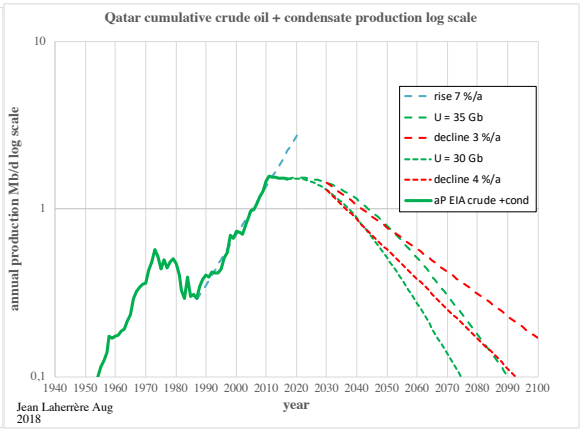
The problem is to choose the production of the item considered in the reserves, but all reserves data are similar in contrary with the annual production . Qatar 2P oil reserves is questionable being old estimates in 2002, when the fields were in early production. I do not have more recent estimates. But the reserves of North Field were rumored to be overestimated after the drilling of a dry hole in the field. We estimate the crude oil+ condensate ultimate to be about 35 Gb



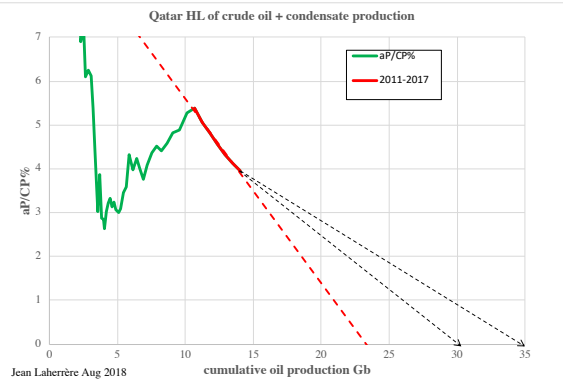


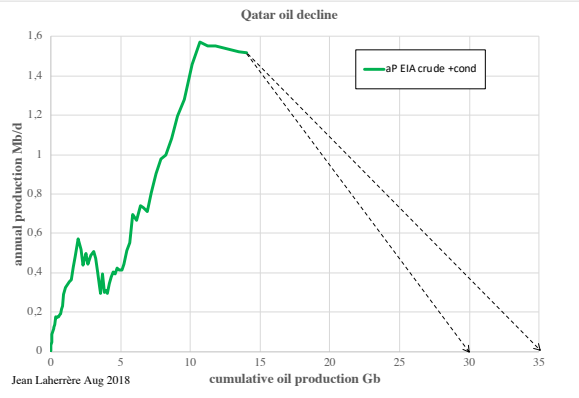
Qatar crude +condensate production has a 7% rise rate from 1987 to 2011 = peak and will have a decline rate of 3 %/a after 2030



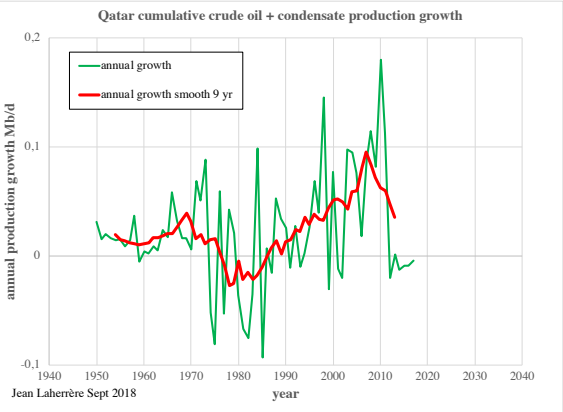


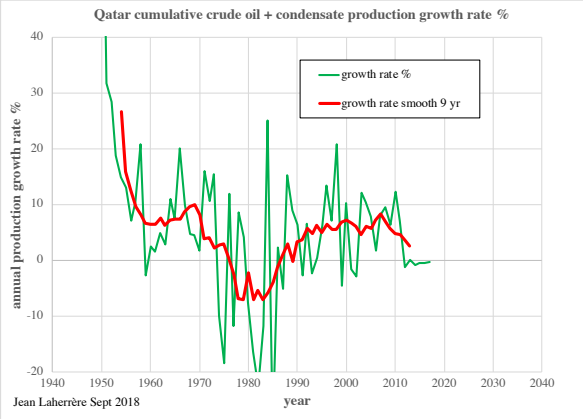
HL (2011-2017) trends towards 23 Gb too short, compared with the creaming curve. And CP+1P? OD is useless. But another guess with 30 Gb looks possible and in fact it looks better more symmetrical with the past rise





Qatar crude +condensate annual production growth is of little use for forecasting the future: same for growth rate in %





-Saudi Arabia

The main oilfield of SA is Ghawar, largest oil field in the world (but smaller in oil equivalent to the North Dome Iran + Qatar), but Ghawar crude oil production and reserves data has been always confidential. After Matt Simmons' book "Twilight in the desert" Aramco (Baqi & Saleri CSIS 2004) released some production data

HL of past production (2005-2017) trends towards an ultimate of 350 Gb, meaning a peak in 2016 and a decline after 2020. OD is useless.

This 350 Gb ultimate is confirmed by the creaming curve using discoveries estimated in 2004 (discoveries in 2011 are overestimated by 90 Gb to please Aramco)

The 1P reserves staying at 260 Gb since 1989 (quotas fight) is ridiculous as if SA has found each year exactly during 28 years the same amount as its production: it is a joke!

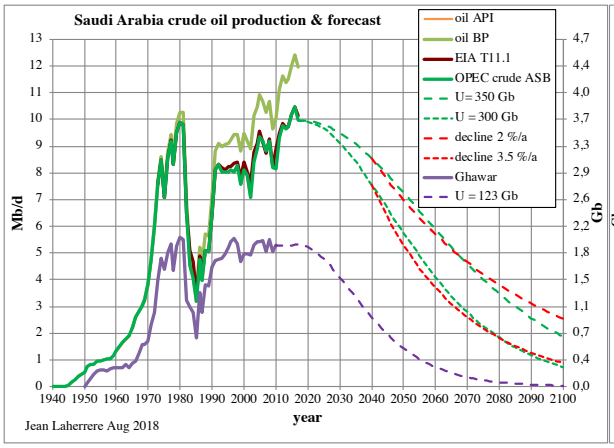
It is not remaining reserves! It is what they wish.

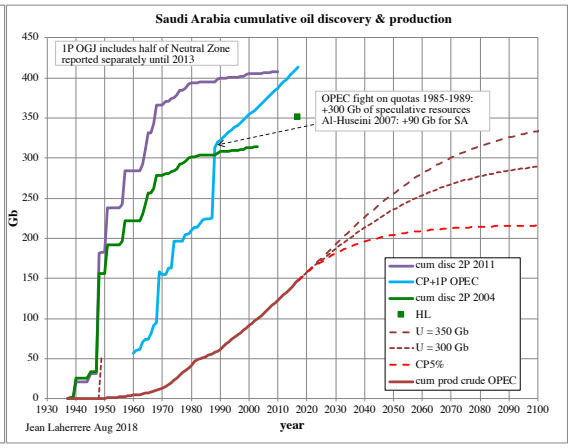
In fact, 260 Gb in 1989 represents about the remaining 2P reserves, but since the cumulative production 1990-2017 = 86 Gb.

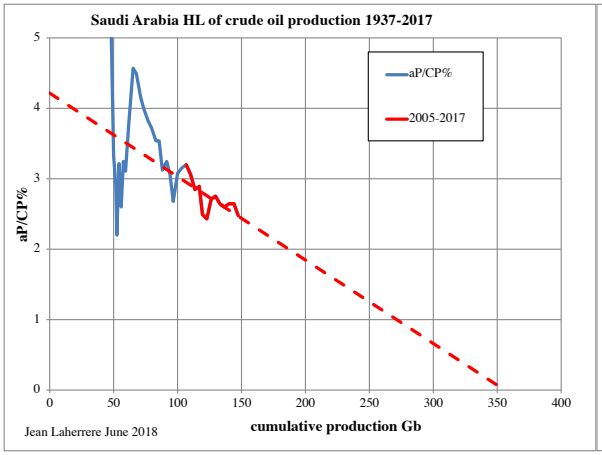
With an ultimate of 350 Gb the future decline since 2040 should be only 2 %/a: such decline rate looks low compared to the future rates around (Kuwait 2%, Iraq & Iran 3% UAE 5%) and questions the value of 350 Gb as ultimate.

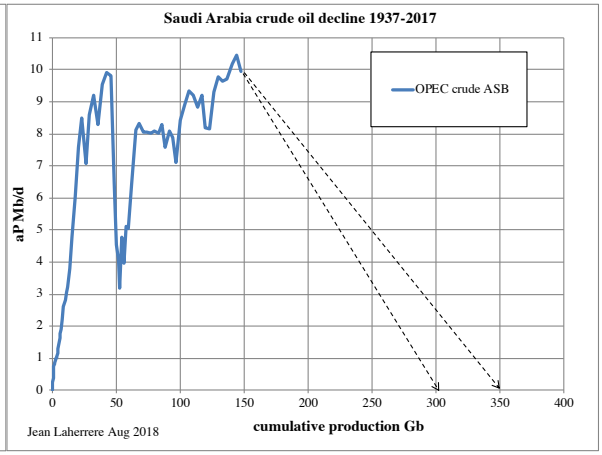
An ultimate of 300 Gb gives a decline rate since 2040 of 3.5 %/a, more in line with the countries around and displaying a more symmetrical decline with the rise 2000-2016.

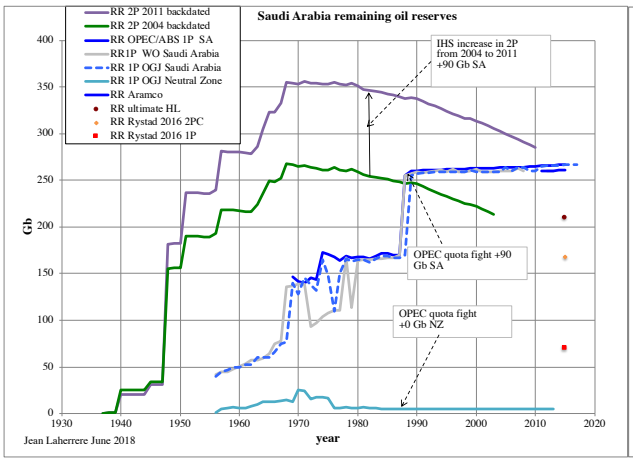
The 350 Gb ultimate is kept in table 1 (despite we prefer 300 Gb) to stay in line with HL.

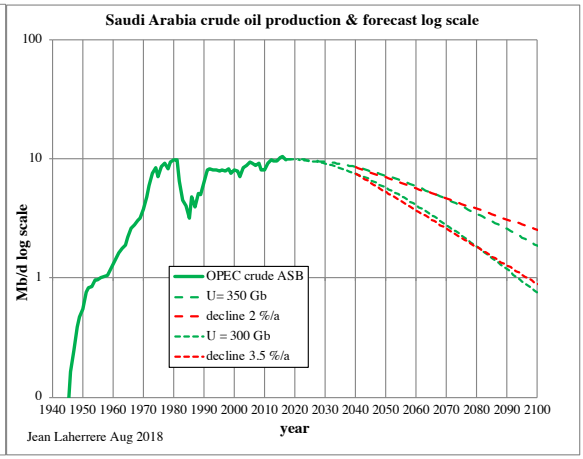




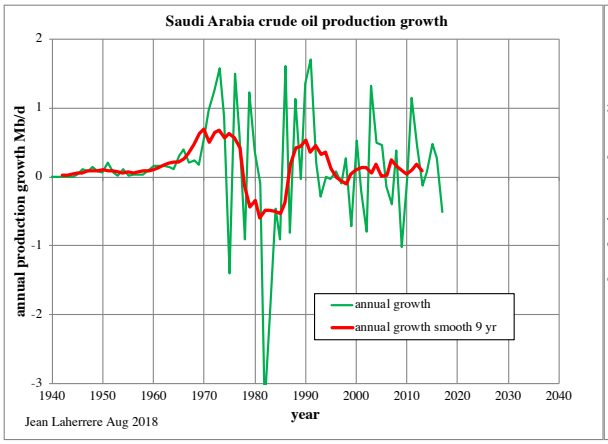


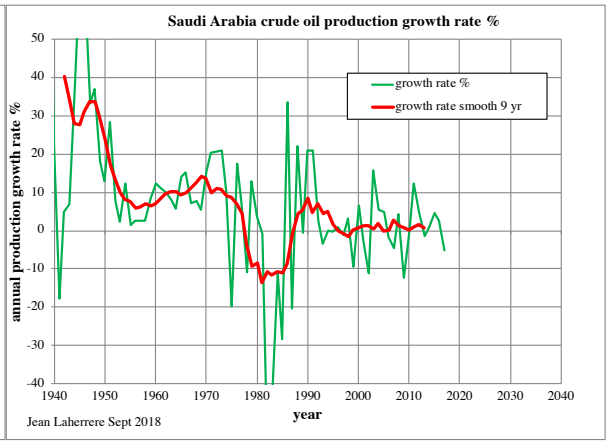






SA crude oil production growth is almost flat close to zero since 1996: no help for forecast: same with growth rate in %, which is similar:



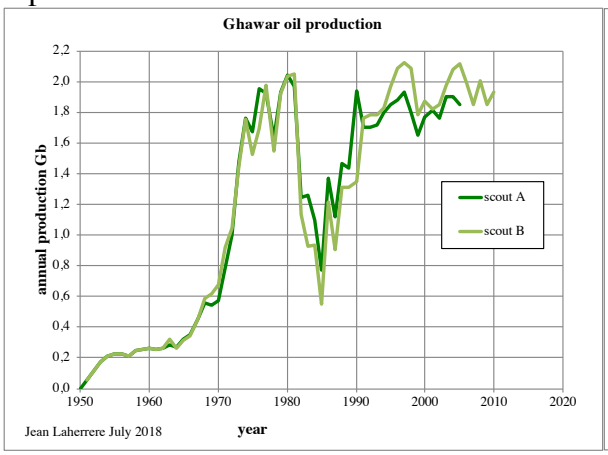


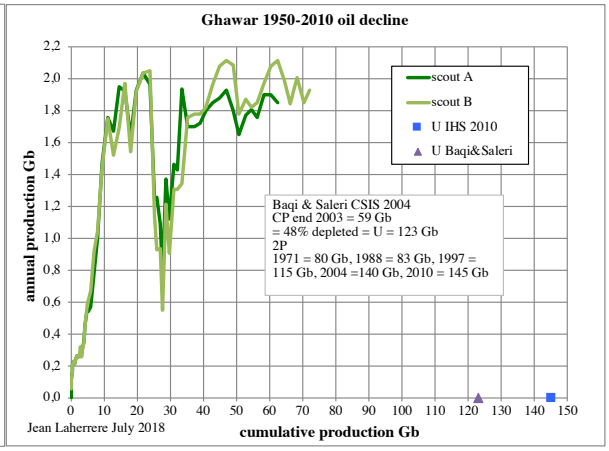
The recent release in view of the proposed IPO (now assumed dead) that two US audits (Dallas-based DeGolyer and MacNaughton, and Gaffney, Cline and Associates, part of Baker Hughes) have estimated remaining reserves at 270 Gb , higher than Aramco value, confirmed my view of the poor quality of audits paid by the producer. Enron bankruptcy led in 2001 to the fall of Arthur Andersen for poor audits.

-Ghawar

Baqi & Saleri CSIS 2004 released some data on Ghawar: end 2003 CP= 59 Gb & depletion = 48% : meaning that ultimate is 123 Gb.

Production from two scouts displays discrepancies, showing the poor reliability of the reported data

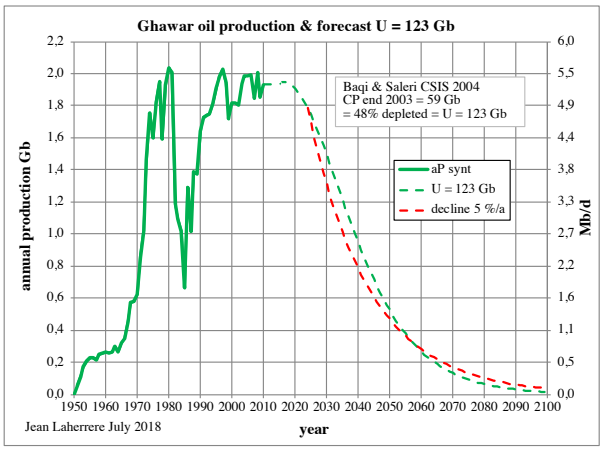


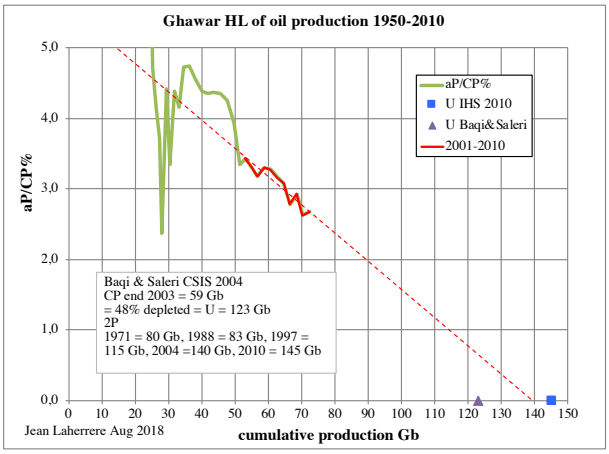


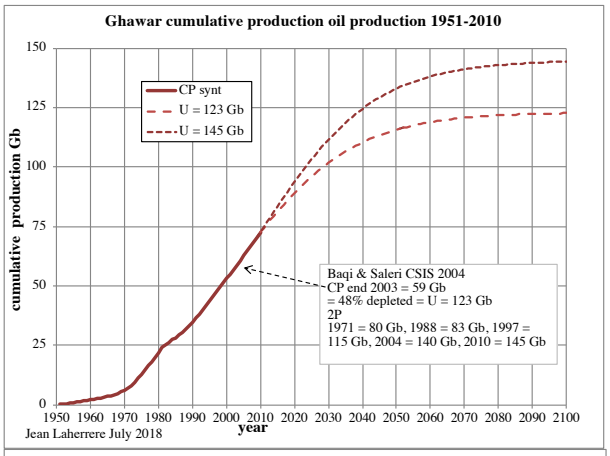
Ghawar cumulative crude oil production (average 2 scouts) is plotted up to 2010 and modeled for U = 123 Gb (Aramco 2004 estimate) and for U = 145 Gb = 2P2010

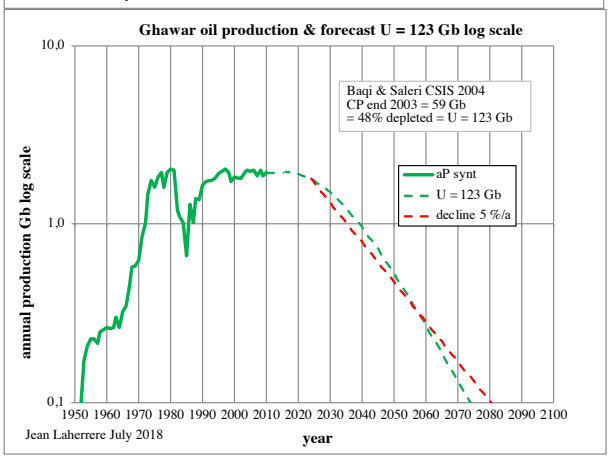
For U = 123 Gb, Ghawar will start decline after 2018 and in 2040 be reduced to 2.5 Mb/d (almost half of today) and from 2025 its decline rate is 5 %/a

HL trends towards 140 Gb, but Ghawar production is hard pushed by the drilling of many horizontal wells: end 2015 more than 3000 injector and production wells and Halliburton has a contract to drill 185 wells by year in 2009. As for LTO, end of drilling will mean sharp decline.





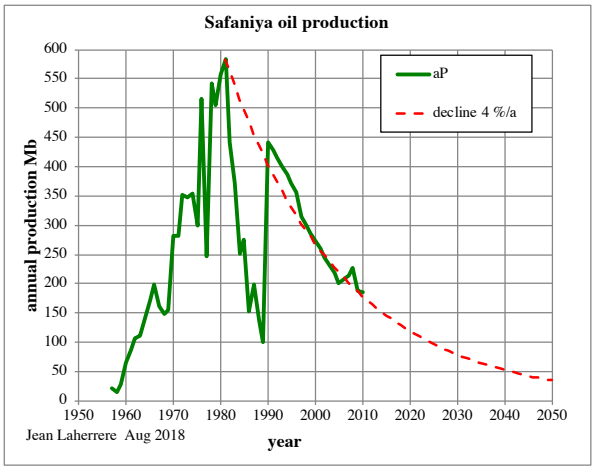


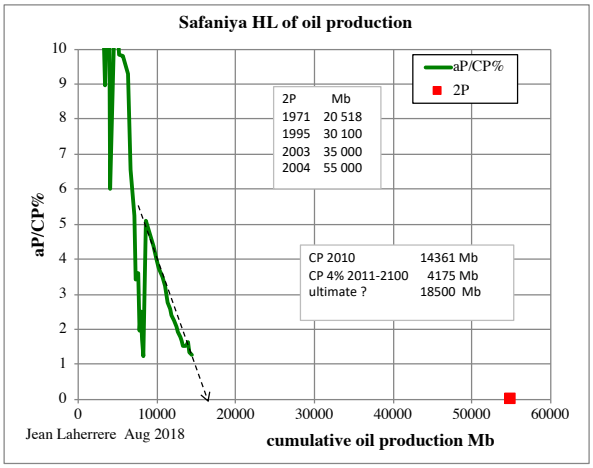


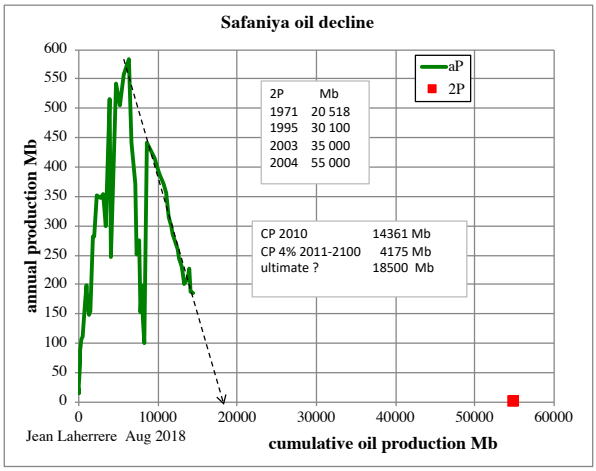
-**Safaniya**

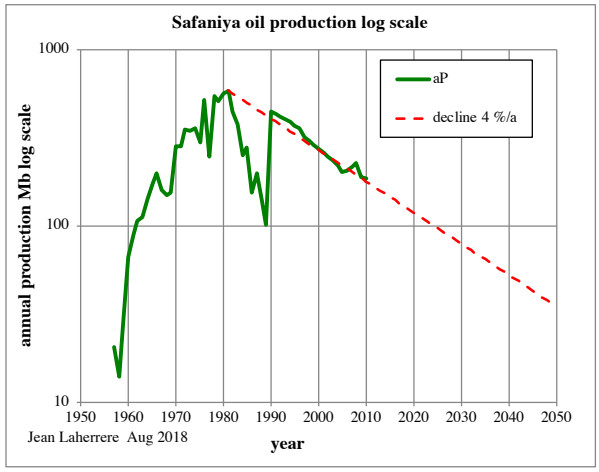
HL for 1990-2010 trends towards 16 Gb very far from 2P (20 Gb in 1971, 55 Gb in 2004) e and oil decline trends towards 18 Gb

Oil decline rate looks to be 4 %/a since the peak of 1981 and the cumulative production up to 2100 with 4 % rate is 18.5 Gb

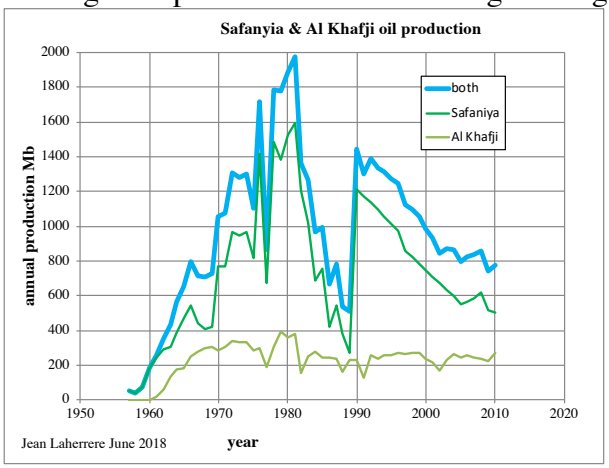








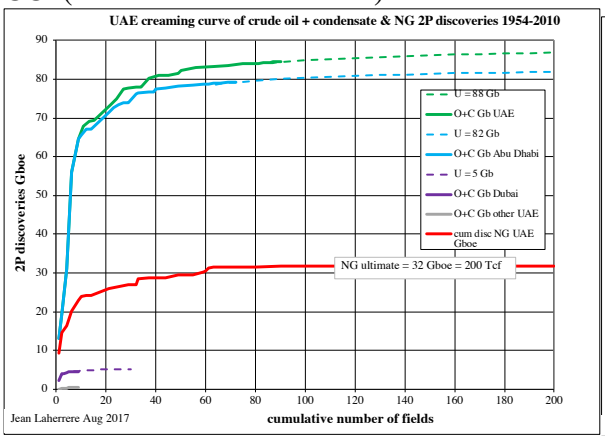
Al Khafji in the Neutral Zone is the northern extension of Safanyia
Adding both production does not bring nothing new

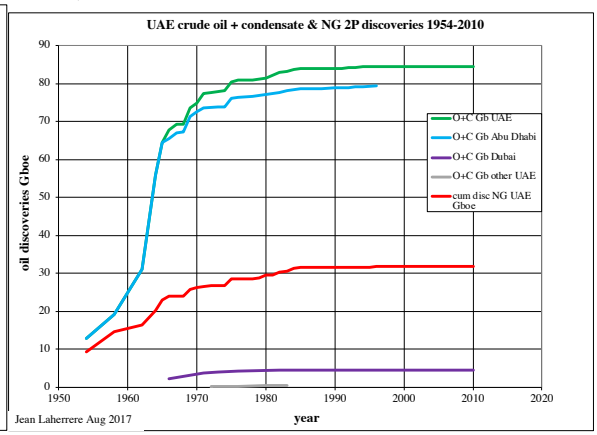


-UAE = United Arab Emirates

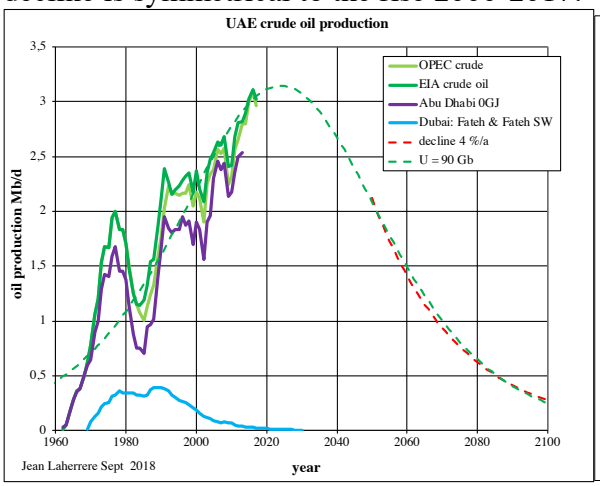
UAE oil production started in 1962 and the first oil discovery was Bab in 1954.
In 1959 the town of Abu Dhabi has no real hard building as shown by this picture of the corniche, compared to the view in 2010 with skyscrapers.

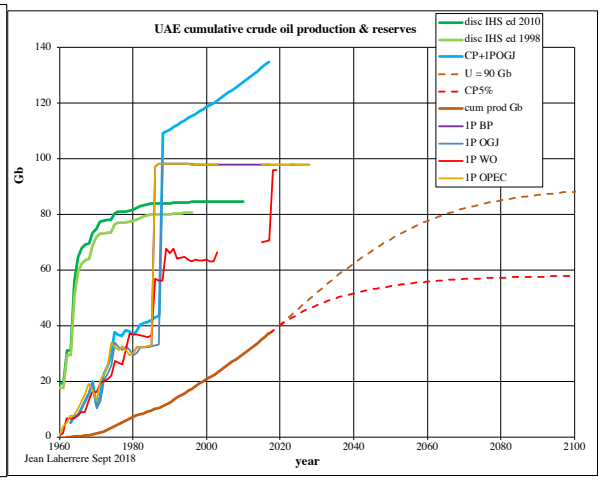
CC (Petroconsultants values) trends towards 80 Gb, but most was discovered before 1970



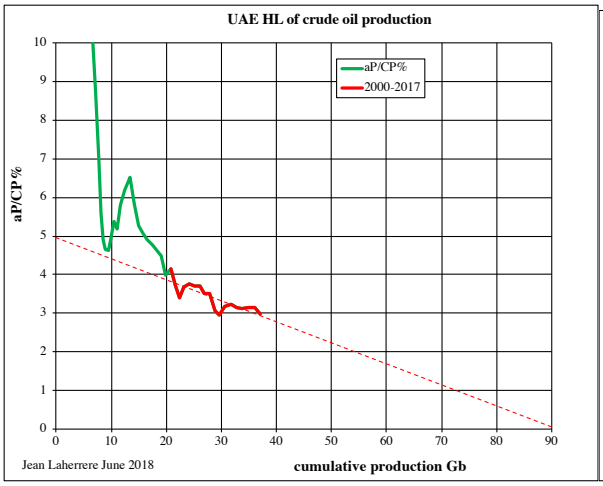


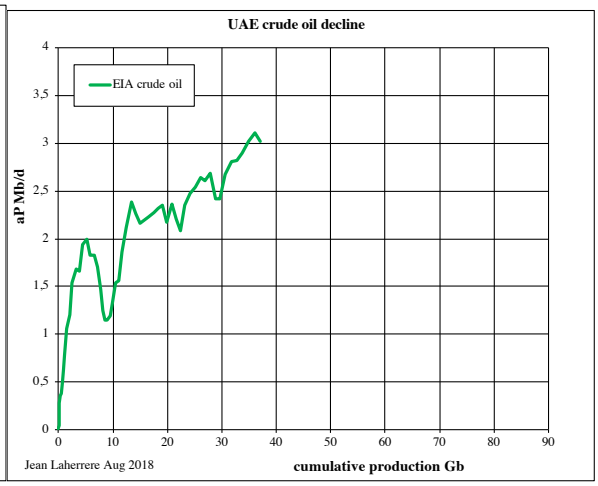
UAE is one of the few producers (7 see table 2) to have not yet reached peak.
HL 2000-2017 trends towards 90 Gb which is the ultimate from the creaming curve
For an ultimate of 90 Gb, crude oil production will peak at 2024 around 3.2 Mb/d and will decline after 2050 at 4 %/a. The 90 Gb model fits the data since 2000; it means that the decline is symmetrical to the rise 2000-2017.



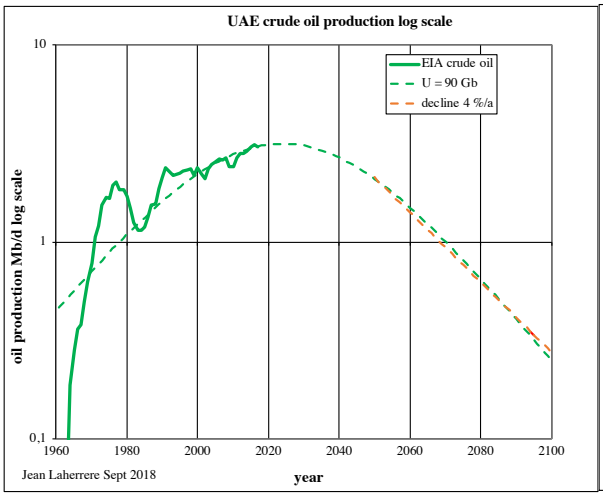


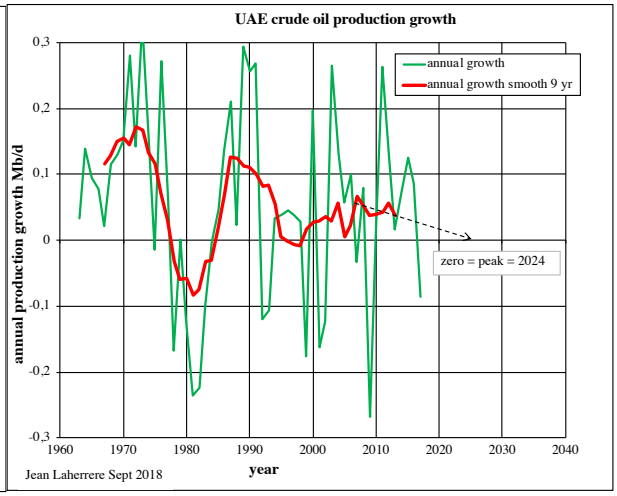
CP +1P 2017 is 135 Gb: 1P reserves at end 2017 from all sources are overestimated by 45 Gb. The sharp increase of 1P occurs in 1986 during the fight between OPEC members on quotas.
HL (2000-2017) trends towards 90 Gb. OD is useless before peak



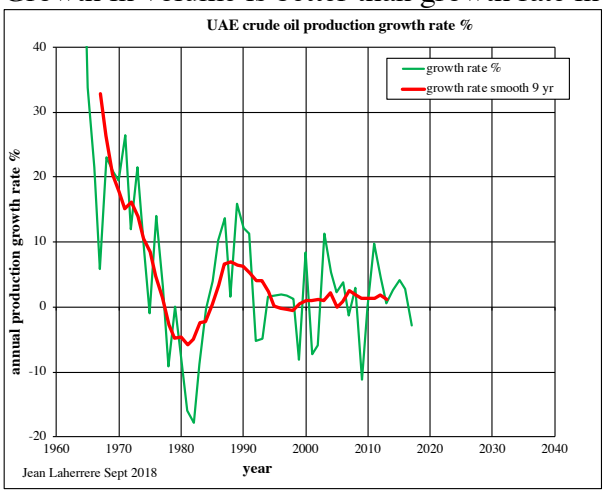


UAE annual production growth 9yr smooth is extrapolated towards 2024 in line with the fit of adjusting the ultimate of 90 Gb. The forecast was changed from one month ago without this curve.





Growth in volume is better than growth rate in % to forecast future peak.

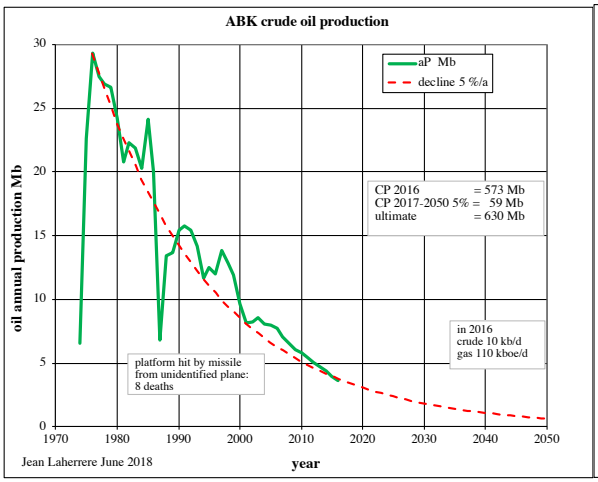


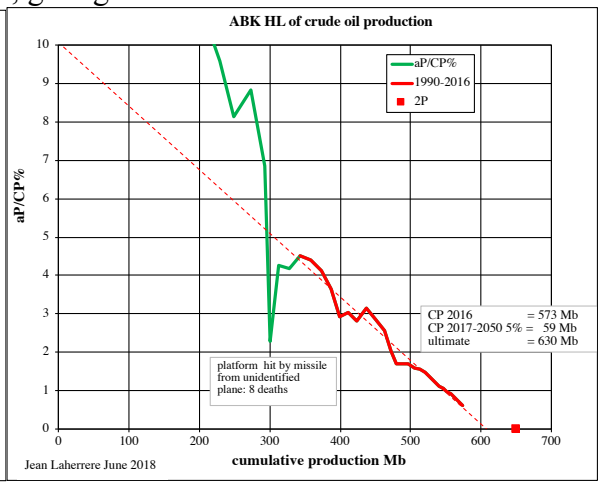
-Abu Al Bukhoosh = ABK

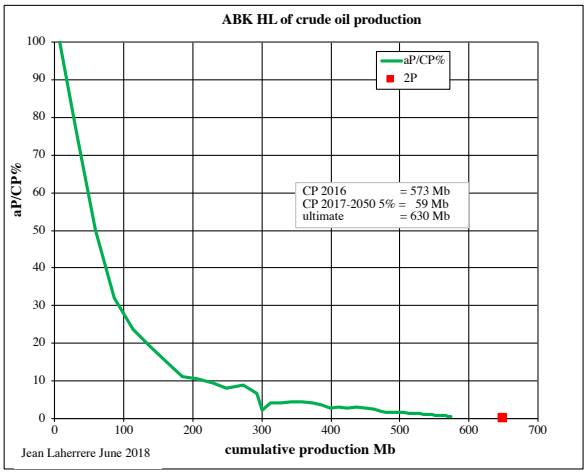
ABK is located offshore near the boundary with Iran and is operated by Total, starting production in 1974. Its production has peaked in 1976, and, but in 1987 the platform was hit by a missile from an unidentified plane (8 deaths)

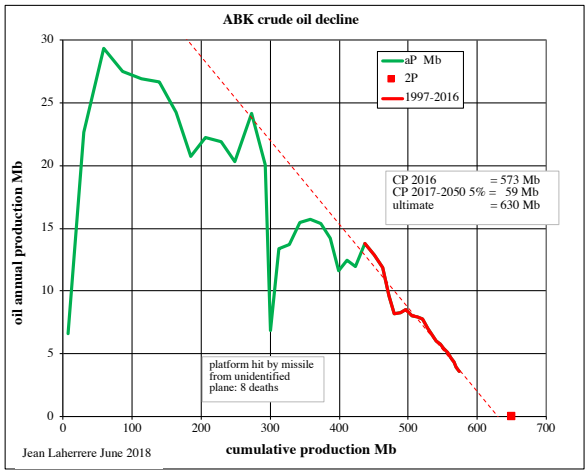
Since the peak of 1976 to 2016; oil decline rate is 5 %/a and likely to continue.

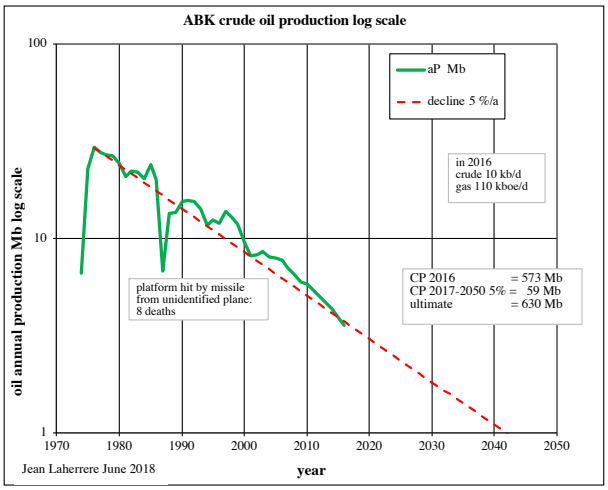
HL for then period 1974-2016 is well curved, but for the period 1990-2016 is linear and trends towards 600 Mb. OD trends towards 620 Mb. CP up to 2016 is 573 Mb and CP from 2017 to 2050 at decline rate of 5 %/a is 59 Mb, giving an ultimate of 630 Mb.









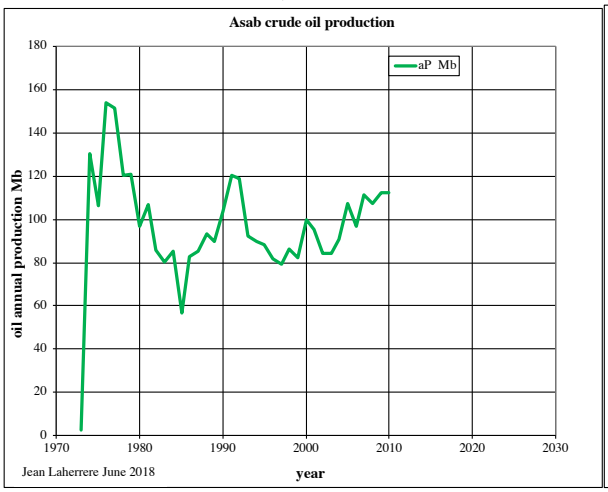


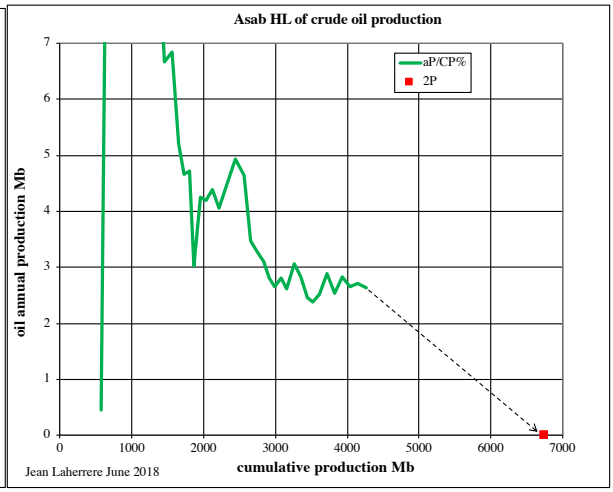
The next three fields have production rising from 2000 to 2010 (2008 higher), which is a bad condition for a reliable extrapolation to the ultimate

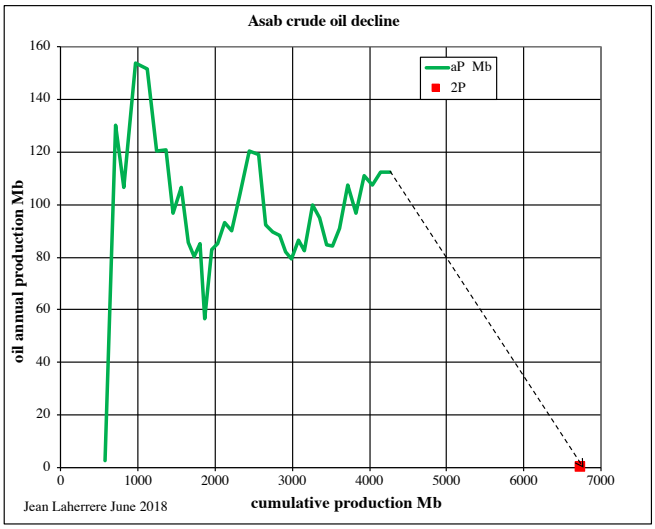
-**Asab**

Asab peaked in 1977, and again in 1991 and again still rising in 2010.
CP2010 = 4260 Mb and 2P = 6750 Mb

HL is flat and useless, like OD .

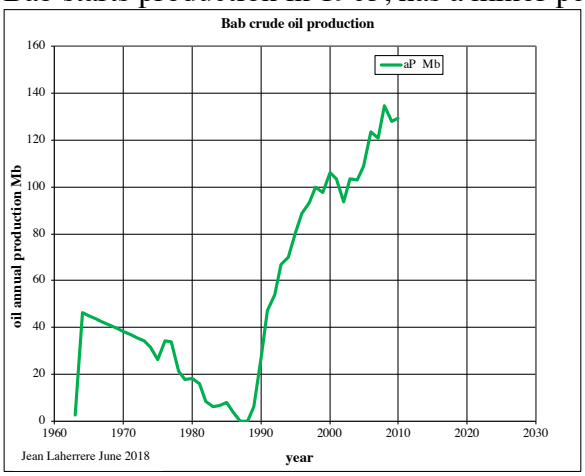


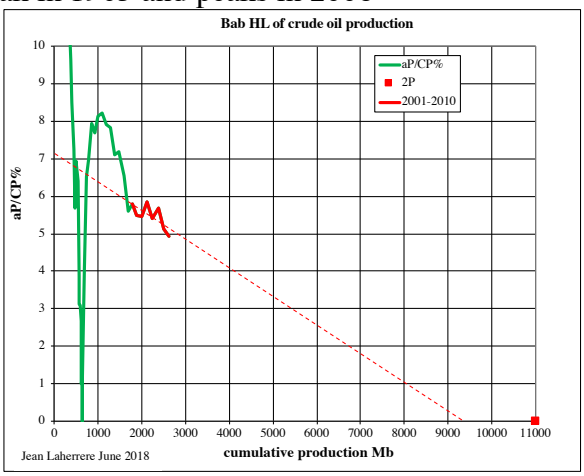




-**Bab**

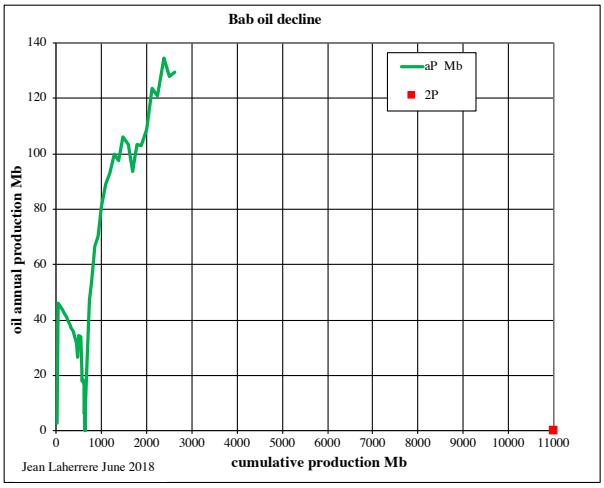
Bab starts production in 1963, has a minor peak in 1965 and peaks in 2008





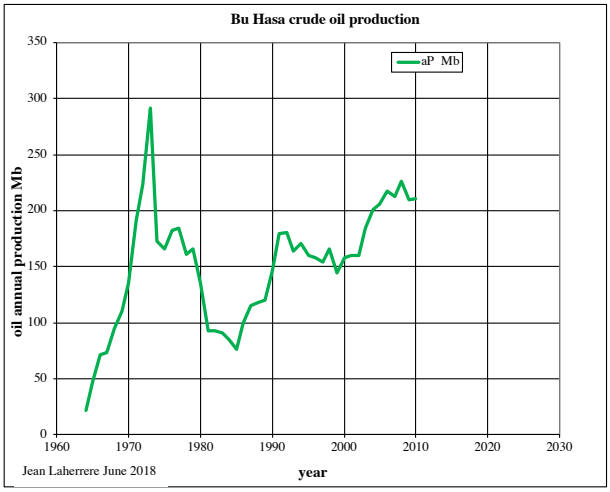
CP2010 is 2630 Mb and HL (2001-2010) trends towards 9200 Mb.

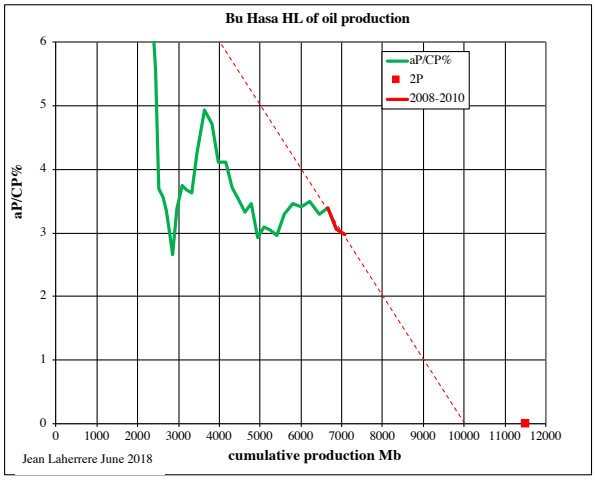
OD is useless



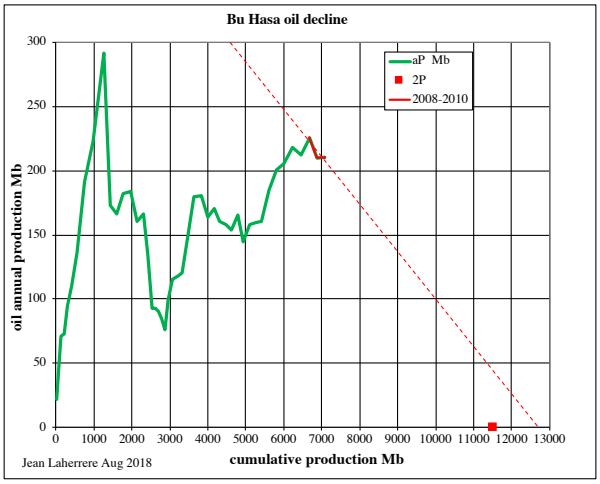
-Bu Hasa

Bi Hasa peaked in 1973, again in 1992 and again in 2008
CP 2010 is 7000 Mb and HL 2008-2010 trends towards 10 000 Mb



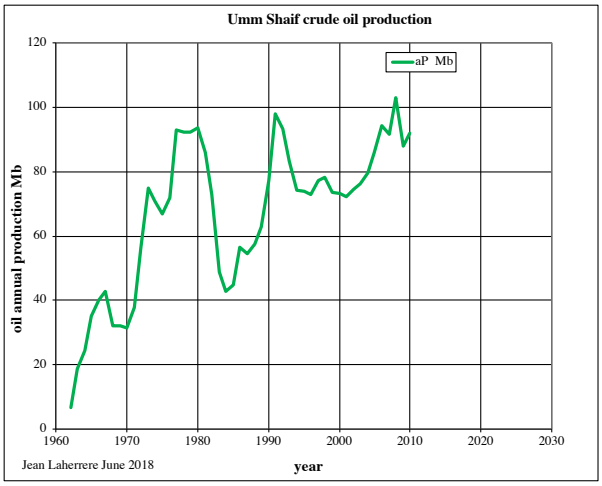


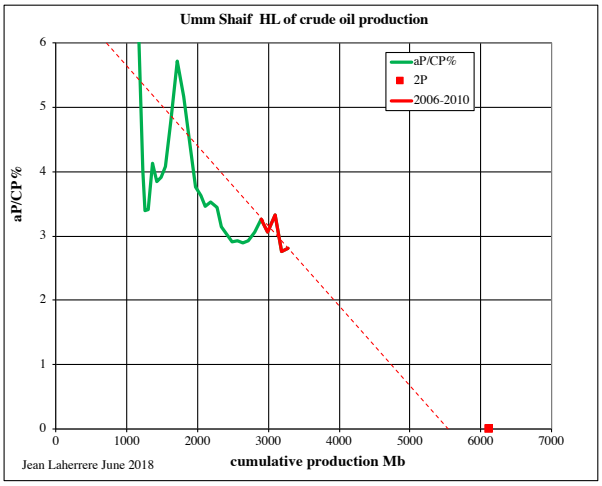
OD 2008-2010 trends towards 12500 Mb



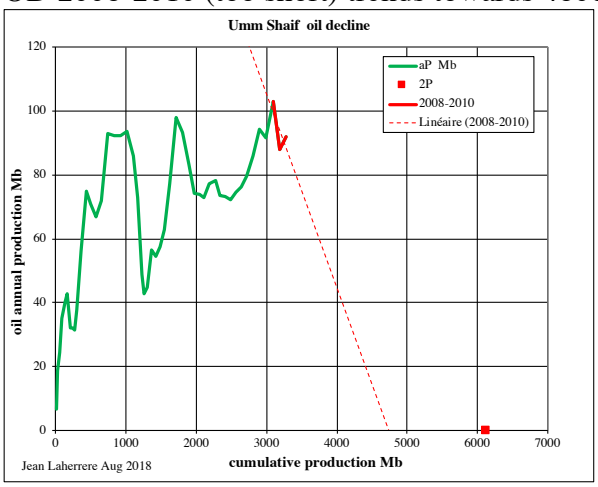
-Umm Shaif

Umm Shaif, after minor peaks in 1980 & 1991, peaked in 2008
CP 2010 is 3270 and 2P 6120 Mb
HL 2008-2010 trends towards 5500 Mb and OD 2008-2010 towards4800 Mb





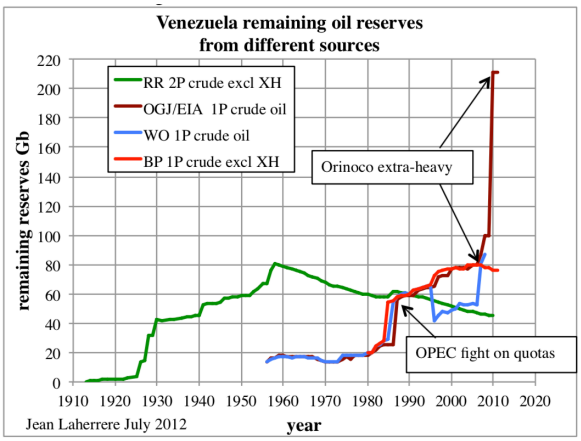
OD 2008-2010 (too short) trends towards 4800 Mb

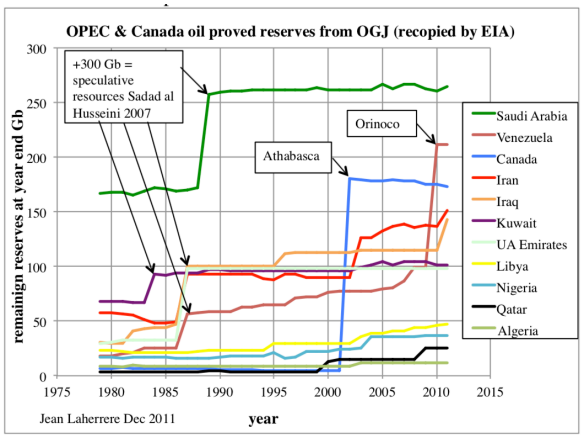


-Venezuela

Venezuela is, fill of oil and tar seeps and first discovery was found in 1883 and first production in 1917. Exploration and production were carried out by international companies. Nationalization occurred in 1976 (14 companies reduced to 4 associated to the national company PDVSA) = Lagoven (Exxon), Maraven (Shell), Meneven (Gulf) & Corpoven (all taken over by PDVSA in 1997) and in 2007 (ExxonMobil & ConocoPhillips)
Venezuela crude+ extra-heavy (Orinoco XH) oil peaked in 1970 at 3.7 Mb/d followed by a minor peak in 1998 at 3.1 Mb/d. In 2017 at 2 Mb/d, oil production is in sharp decline because the political situation. If Venezuela succeeds to return to a normal situation and to attract again the majors which have been nationalized, maybe in 2020, then crude and XH will return to normal production.
Orinoco extra-heavy oil (discovered from 1936 to 1939 with2P = 215 Gb) has the same gravity as Athabasca, but the temperature of the reservoir is 55 °C for Orinoco which is liquid, when 5°C for Athabasca which is viscous and is bitumen. Athabasca XH is hard to produce and needs steam, when Orinoco is easy to produce with pumps without steam (but less recovery) but needs diluent to be transported or to be upgraded.
As Athabasca, Orinoco resources are huge, but reserves are hard to be estimated
It is hard also for crude less XH oil reserves.

My paper -Laherrere J.H. 2012 « Production of crude less extra-heavy oil in Venezuela » 24 July http://aspofrance.viabloga.com/files/JL_Venezuela2012.pdf displays these 2 graphs





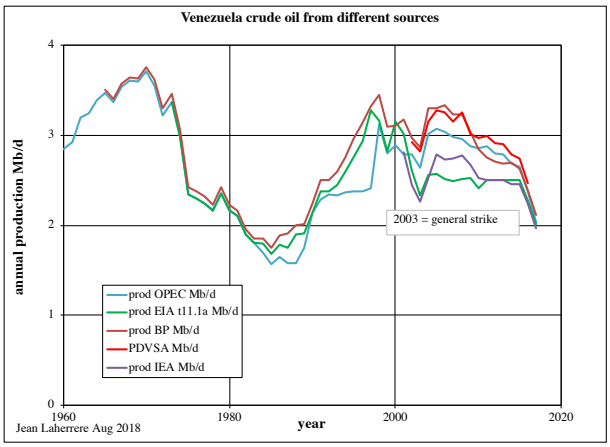
In 2018

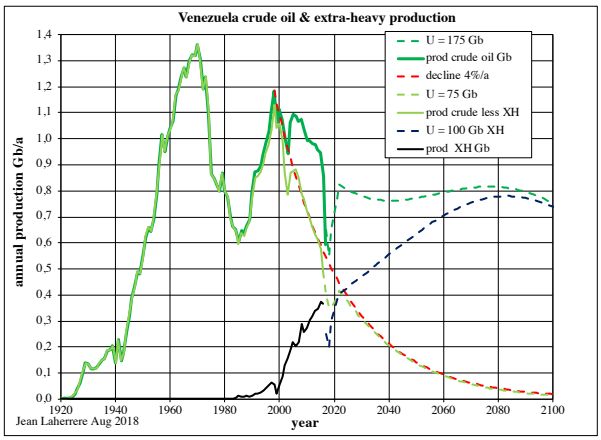
-**crude oil and extra-heavy (XH = Orinoco) oil**

The first problem is the discrepancy of crude oil production data from five different sources: PDVSA, OPEC, IEA, EIA and BP. An average is taken.

Venezuela oil production peaked in 1970 and 1998. The present political situation is a mess and the national operator NDVSA was demolished. The oil production is falling like a stone. It is assumed that the oil production will return to normal in 2022 (quite optimistic) and for an ultimate of 175 Gb, the crude less XH will have a decline rate of 4 %/a from 1998 to 2100, except for the period 2016-2021, which is just guess for return to normal production.

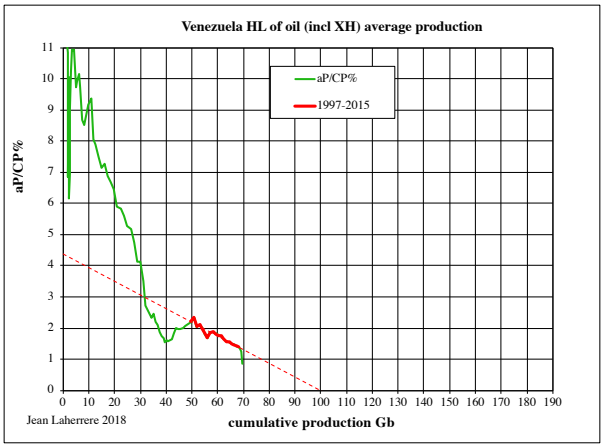
From 2020 to 2100 the crude including XH will be about flat at 0,8 Gb/a (~2 Mb/d)

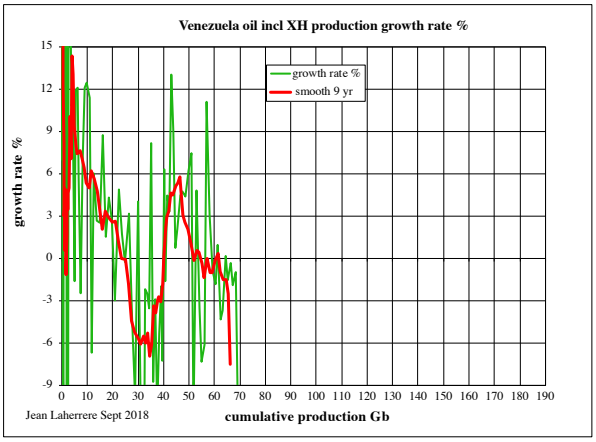




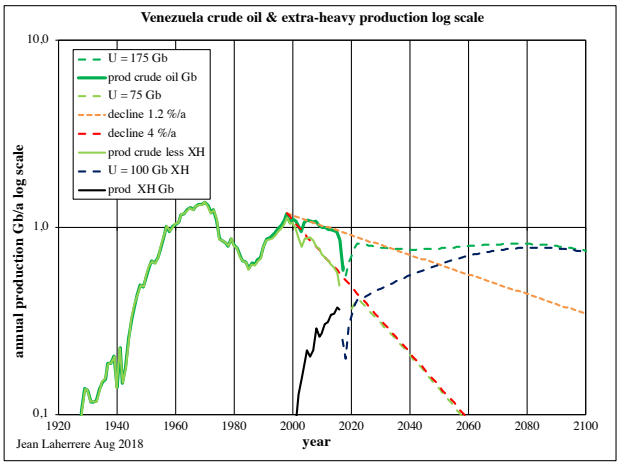
HL of crude (including XL) for 1997-2015 trends towards 100 Gb, which is too low as we feel that it should be 175 Gb, as the ultimate for crude -XH is estimated at 75 Gb and for XH at 100 Gb.

The oil production growth rate in % crossed twice the zero line as there are two peaks but cannot say more for the future.



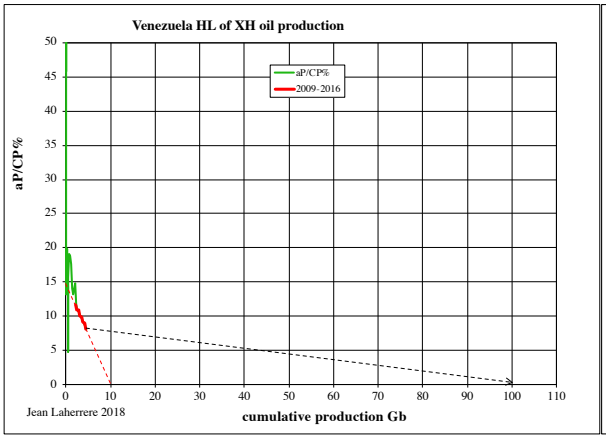


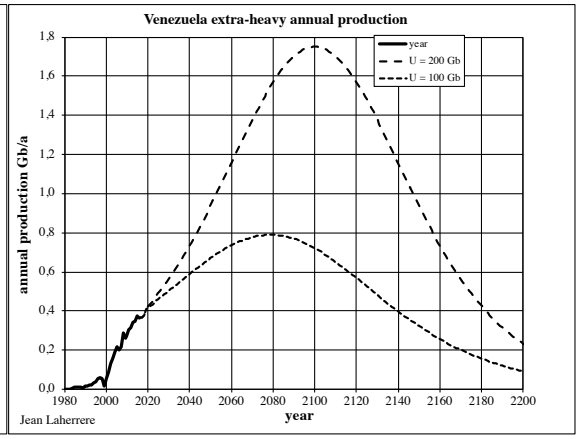
The log plot shows that crude-XH production has declined at 4 %/a since 1998 and will continue in the future, when the crude including XH w had declined at 1.2%/a since 1998 until 2015 and will resume this decline from 2022 to 2040.



-Orinoco production = XH

Orinoco XH production data is hard to get because now PDVSA reports extra heavy with heavy. Then value for 2017 is taken as 0.88 Mb/d as found on the web. The resources are huge but the 2P reserves of 215 Gb found between 1936 and 1939 looks too optimistic, in front of the political situation of Venezuela. A value of 100 Gb looks more realistic than 200 Gb.



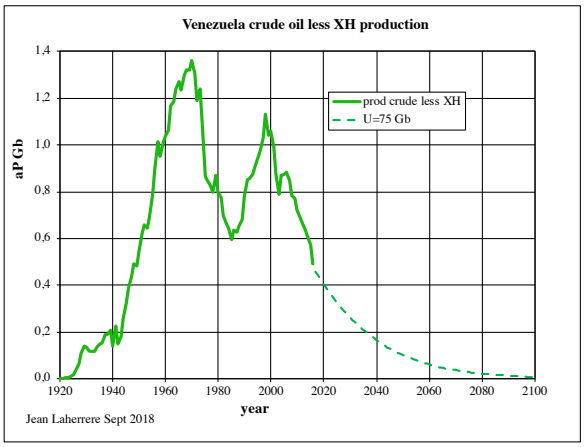


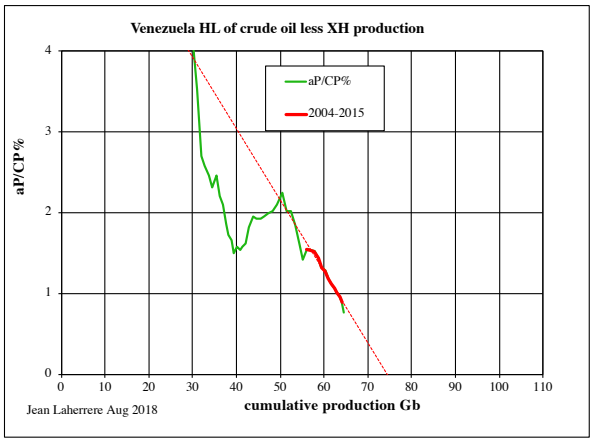
Present XH production is handicapped by the lack of light oil to use as diluent to transport XH and by the heavy debt of PDVSA to many oil companies and services, as to States (Russia and China)

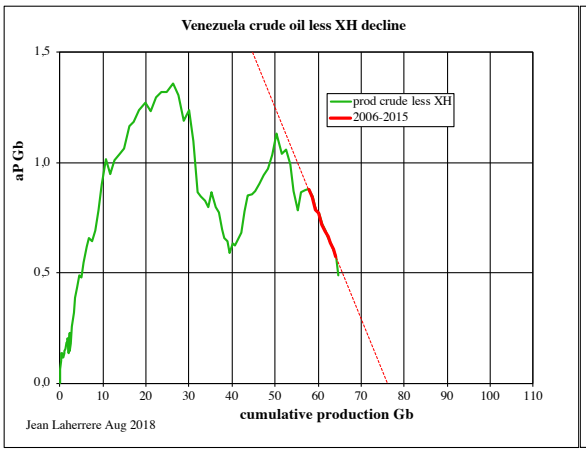
-excluding extra-heavy oil = XH

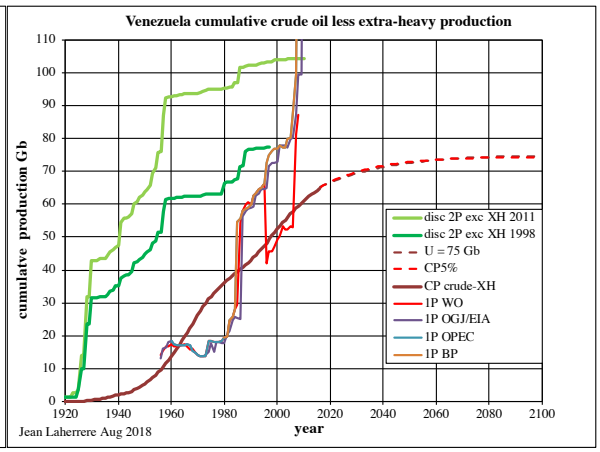
HL of crude-XH trends for the period 2004-2015 towards 75 Gb. OD for the period 2006-2015 trends also towards 75 Gb.

2P discoveries (excluding XH = 251 Gb between 1936 and 1939) have sharply increased between the edition of 1998 (Petroconsultants) and the edition of 2011 (IHS): it is the case of most OPEC countries: spy companies want to please their customers. We rely on the old version which is in line with HL and OD.









Proven reserves 1P have increased sharply first in 1985 during the OPEC quota fight and second in 2006 including Orinoco reserves (already in production since 1979).

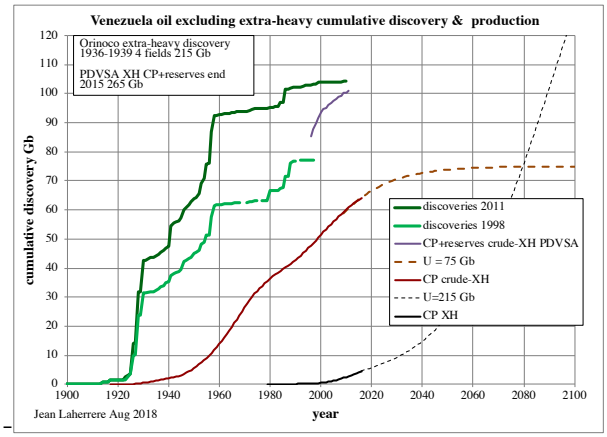
These values are political and should be forgotten, relying on older reserves estimate and on estimates from past production.

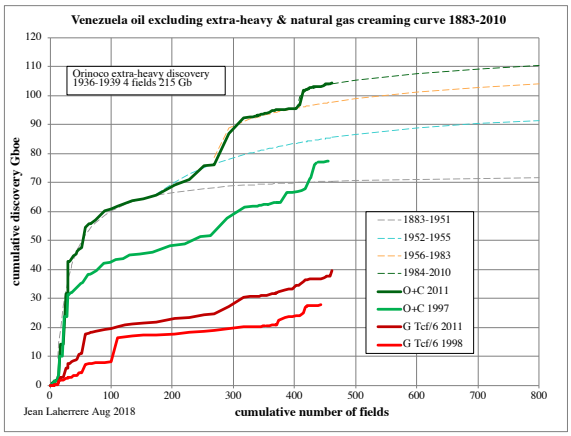
HL of crude oil less XH 2003-2015 trends towards 75 Gb, leaving only 25 Gb for XH; which is too low compared to the resources but HL of XH trends towards 10 Gb

OD of crude oil less XH trends towards 75 Gb

CC (creaming curve) of crude oil less XH trends towards 110 Gb for the 2011 edition but there is the overestimation of OPEC ,as in the Middle East and Nigeria.

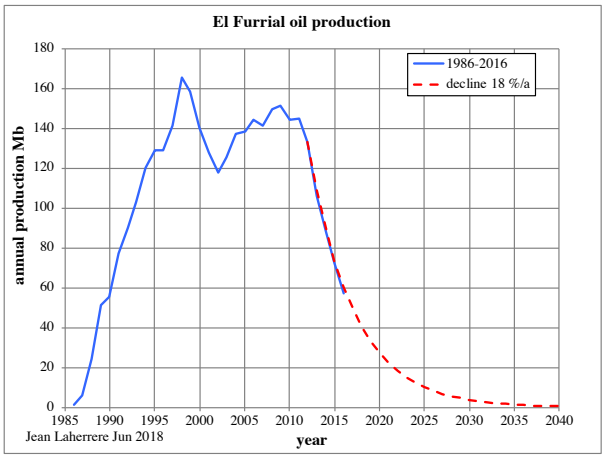
CC from 1998 data (Petroconsultants) trends towards 80 Gb and Petroconsultants is considered more reliable.

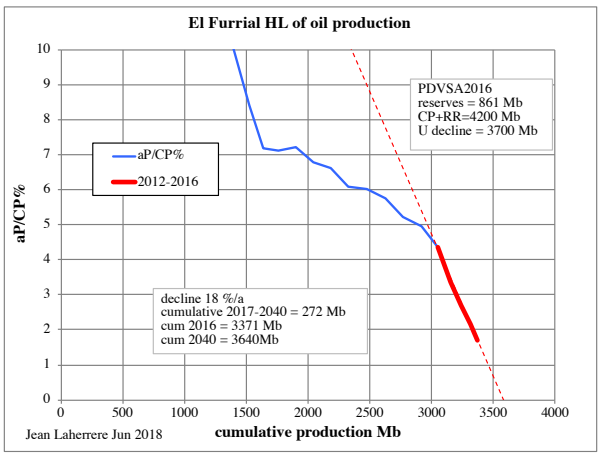




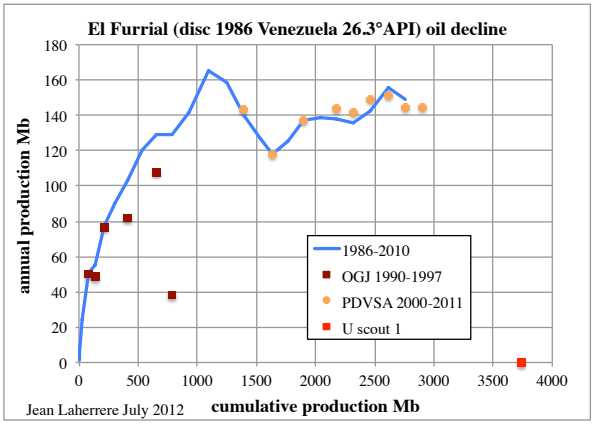
-El Furrial

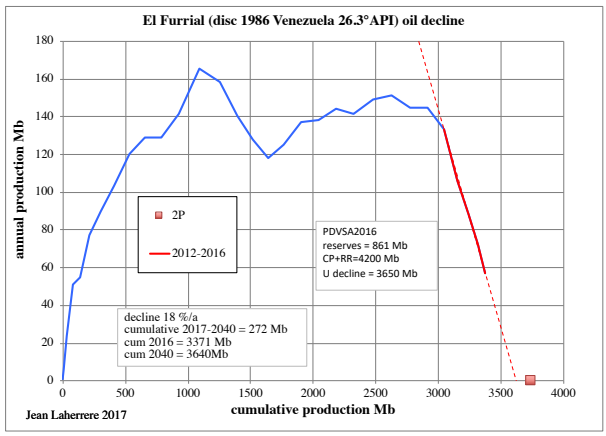
El Furrial is one of the last giant found in Venezuela by Lagoven. It started production in 1986 and peaked in 1998 and again lower in 2009, since 2011 it declines at 18 %/a.
PDVSA reports in 2016 CP = 3371 Mb remaining reserves 861 = ultimate = 4200 Mb
2P reserves were 3640 Mb in 2003, 3313 Mb in 1998, 3124 Mb in 1997 and 3400 Mb in 1990.

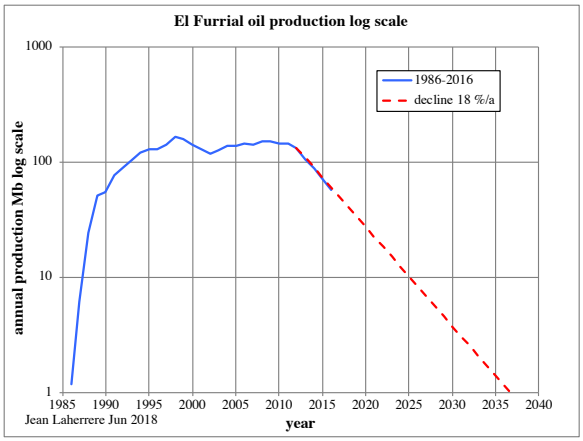




HL (2012-2016 trends towards 3600 Mb
OD in 2012 and OD 2017 trends towards 3600 Mb
The cumulative production up to 2040 with z decline rate of 18 %/a is 3640 Mb







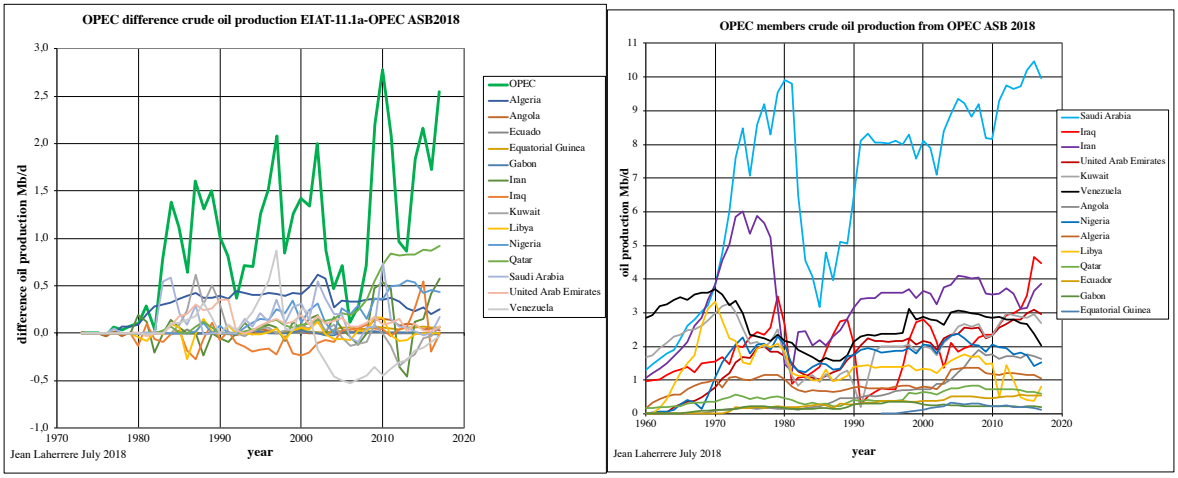
-synthesis OPEC

OPEC ASB 2018 reports the 14 OPEC members annual and cumulative crude oil production since 1960, but the problem is that their data does not always agree with EIA T11.1a, (Equatorial Guinea is missing) because the problems of defining condensate often added with crude.

The discrepancy between EIA and OPEC is chaotic and can be over 2 .5 Mb/, the highest is for Qatar producing a large volume of condensate and NGL.

The best should be to deal only with crude +NGL, which differs less but production has to be matched with reserves and if crude oil reserves are reported there is no report for NGL.

So, we stay with EIA data and estimate the ultimate for each OPEC member and add the 14 members

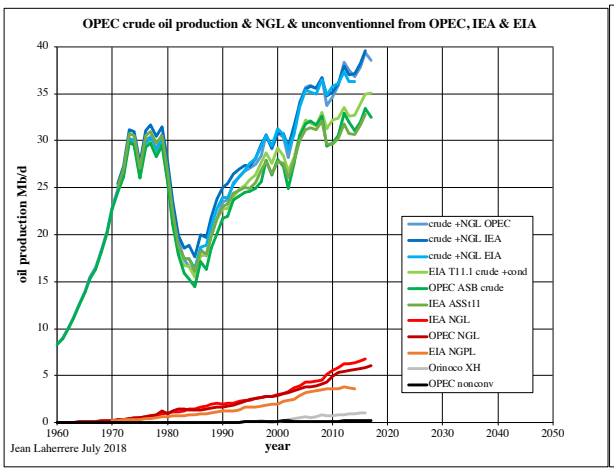


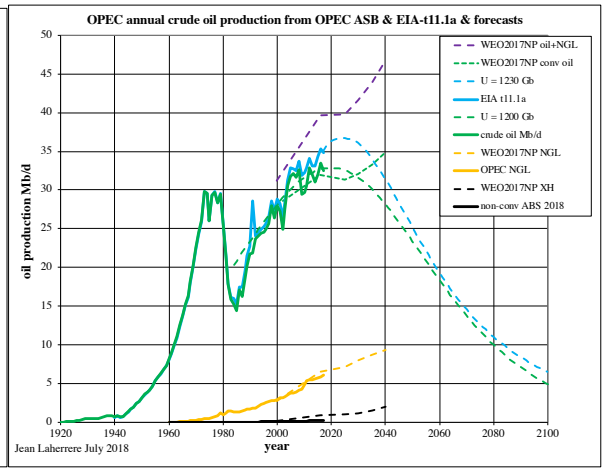
The OPEC EIA crude oil has an ultimate of 1230 Gb and will peak in 2025 about over 36 Mb/d

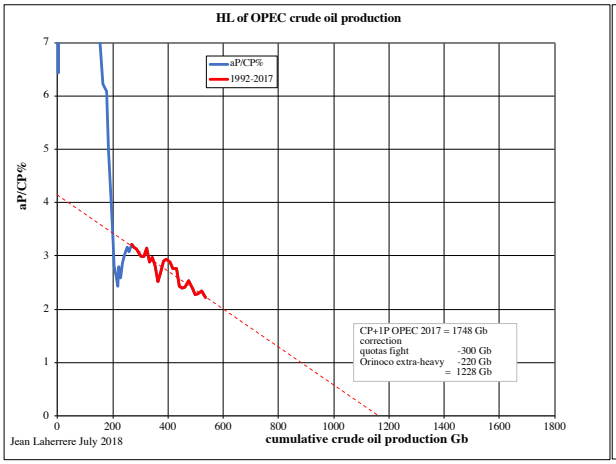
The HL of OPEC crude oil production trends towards 1200 G, which agrees with the CP +1P OPEC corrected of 300 Mb for quotas fight and 220 Gb for extra-heavy Orinoco

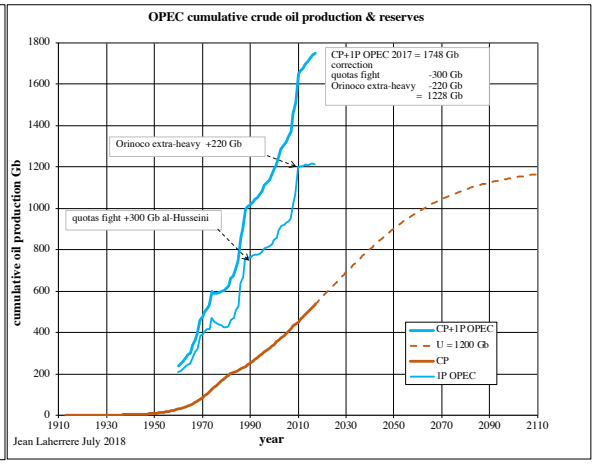
The non-conventional oil reported by ASB2018 should be Orinoco, but it is less than IEA WEO2017 data.

The OPEC crude oil production should peak also around 2025 for 33 Mb/d and will be in 2040 at 29 Mb/d declining, against a forecast of 35 Mb/d rising for WEO2017 NP.

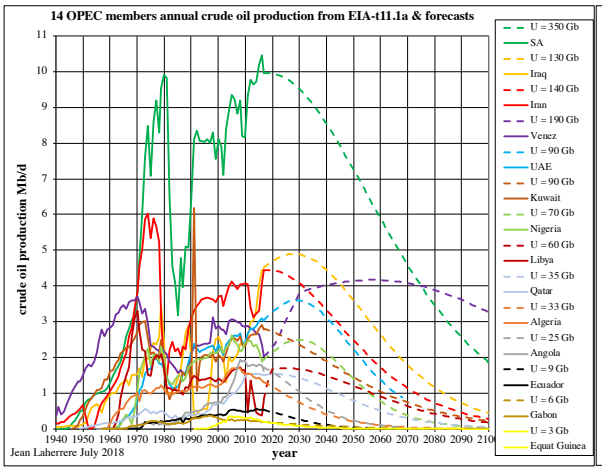


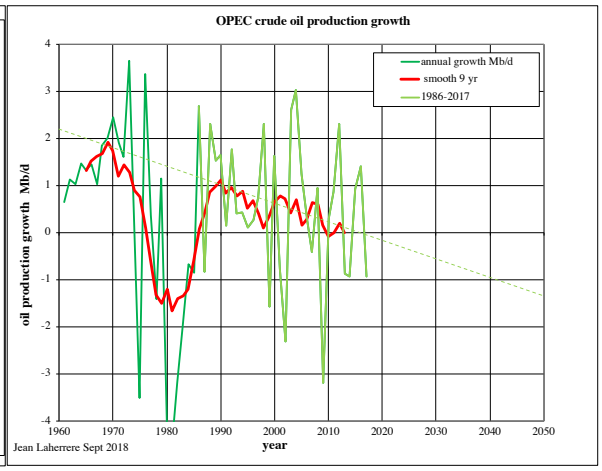






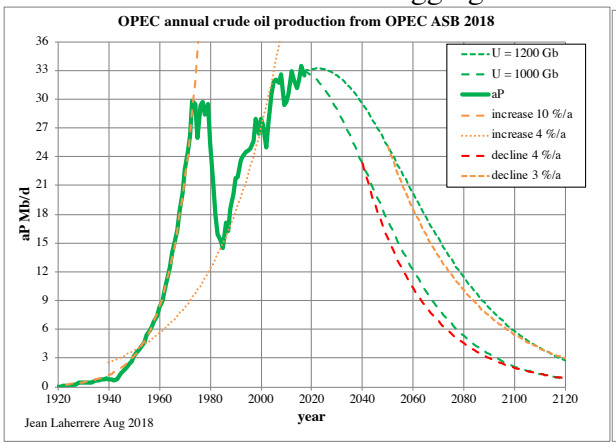
ASB2018 OPEC production data is interesting because the updated longest reported historical series, but its data on Orinoco seems poor and the lack of NGL data by country is disturbing.

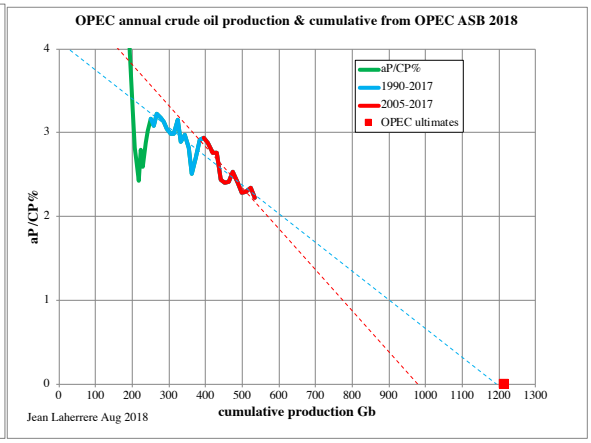




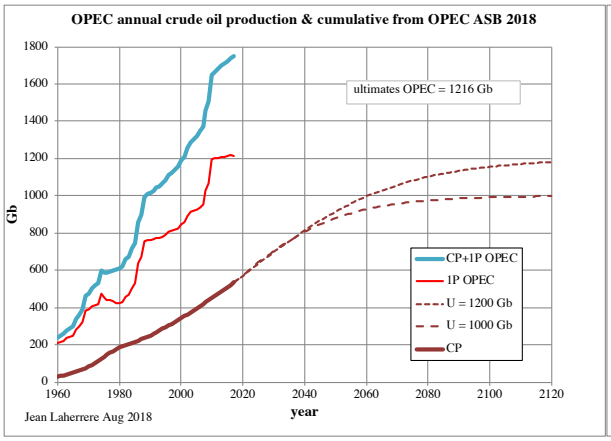
From OPEC data in ASB 2018 OPEC crude oil production has peaked in 73 at 30 Mb/d and in 2016 at 33.4 Mb/d.
OPEC annual crude oil production growth trends for the period 1986-2017 towards a peak in 2016.
HL 1990-2017 trends towards 1200 Mb but HL 2005-2017 trends towards 1000 Mb when the aggregation of my ultimates (as estimated in the previous chapters) is 1216 Mb.

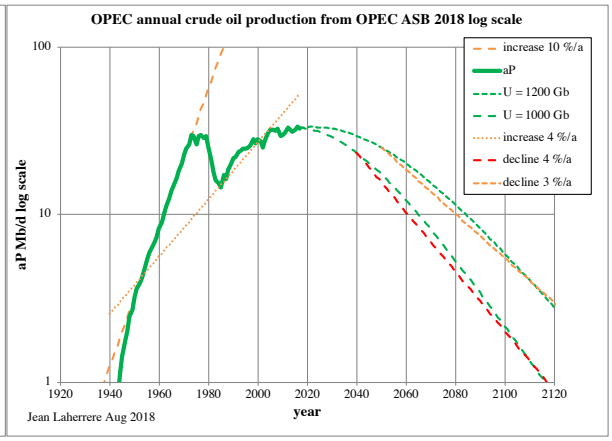
Between HL 1990-2017 and HL 2005-2017 the last one is assumed to be the most reliable, but the first one is close to the aggregation of individual ultimates



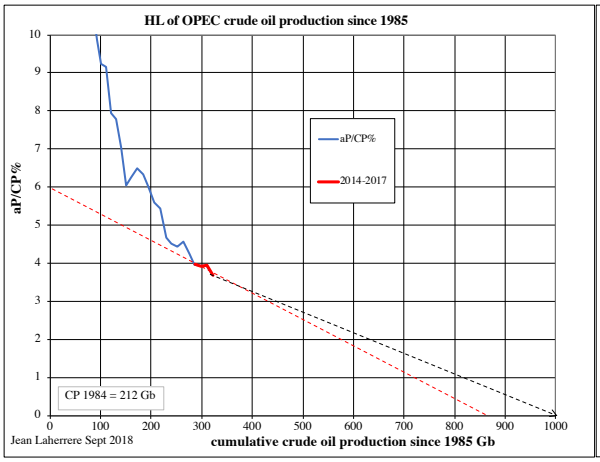


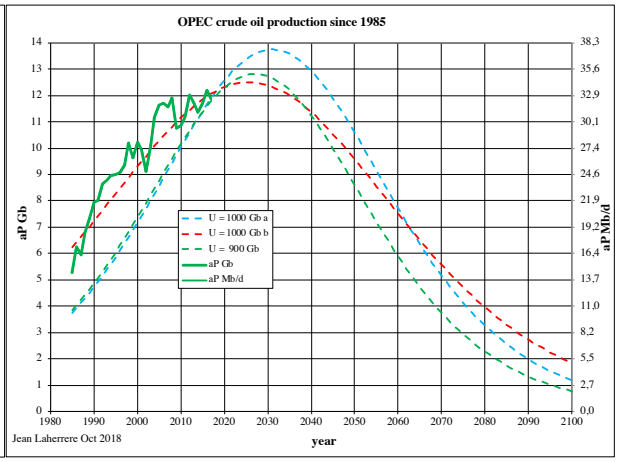
CP +1P OPEC at 2017 is 1750 Mb or 500 Mb above the OPEC ultimate. When in 2007 S. al-Husseini was talking about 300 Gb of speculative resources added by OPEC members in their fight on quotas, he was short by 200 Gb.
With an ultimate of about 1000 Gb OPEC future production will decline from 2040 to 2100 at 4 %/a. OPEC oil production has increased by 4 %/a from 1985 to 2004.
With the 1200 Gb ultimate the decline rate from 2050 is 3 %/a

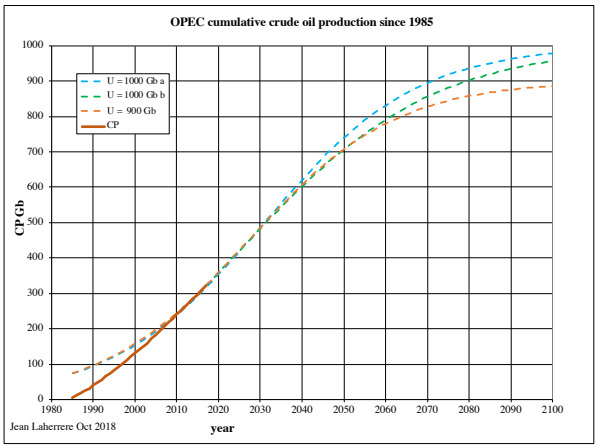




From my studies on population, I found that it is better when an historical series displays several cycles to work only on the last cycle. OPEC production displays a fast rise from 1945 to 1974 (the Thirty Glorious years), followed by a fast decrease and a new cycle starting in 1985 (called the counter oil shock).
The study of the cycle 1985-2017 gives that the HL (2014-2017) trends towards 900 Gb (since 1985), when the tangent trends towards 1000 Gb. The cumulative production 1960 to 1984 is 212 Gb
For modelling both future annual production and cumulative production for an ultimate of 900 Gb you need to find the right tm (peak time) and the right b (see equations page 9) by trying several values and looking if the model fits in time and slope the past. The fit for U = 900 Gb gives the green curve, but to get the same ultimate of 1200 Gb as used for CP since 1960, it is U = 1000 Gb which is necessary. The best fit gives the blue curve (U = 1000 Gb a), which does not fit the past. So, I try to find another solution U = 1000 Gb b, giving the red curve which fits also the past. With such solution OPEC crude oil production will peak in 2025 at 12.5 Gb or 34 Mb/d. it is close to the solution found previously on page 131
There are many solutions for annual production to fit an estimated ultimate but the one fitting the past for a long period is the best.


HL of OPEC crude oil production since 1985
aP/CP%
2014-2017
CP 1984 = 212 Gb
aP/CP %
cumulative crude oil production since 1985 Gb
Jean Laherrere Sept 2018


OPEC crude oil production since 1985
U = 1000 Gb a
U = 1000 Gb b
U = 900 Gb
aP Gb
aP Mb/d
aP Gb
aP Mb/d
year
Jean Laherrere Oct 2018


OPEC cumulative crude oil production since 1985
U = 1000 Gb a
U = 1000 Gb b
U = 900 Gb
CP
CP Gb
year
Jean Laherrere Oct 2018

Synthesis

The study is based on crude oil (EIA data

Table 1 : countries

Table 1	Mb/d	% world	Gb	% world	Gb	% world	Gb	Gb	% world	Gb	Gb	Gb	Gb		%	year	Mb/d	% world	%		
crude oil EIA	aP2017	aP2017	CP2017	CP2017	RR2017	RR2017	CP+1P	U	U	CC	HL	OD	CP5%pp	average	depletion	peak	aP2040	aP2041	decline rate	period	
Australia	0,3	0,3	8,0	0,6	2,0	0,1	5,8	**10**	0,4	14	9,5	9,3	10,0	10,7	80	2000	0,1	0,2	5	2000-2050	
Azerbaijan	0,7	0,9	15,1	1,1	5,9	0,4	22,1	**21**	0,8	22	20,0	22,5	20,3	21,2	72	2009	0,2	0,3	5	2009-2050	
Brazil	2,6	3,2	12,6	0,9	77,4	5,7	30,5	**90**	3,3	90	50-90	?	?	?	14	2040	4,3	6,7	5	2050-2080	
Canada crude	1,2	1,5	27,3	2,0	7,7	0,6	31,8	**35**	1,3	32	39	35	35,7	35	78	1973	0,4	0,6	5	2014-2050	
Canada oilsands	2,8	3,5	12,1	0,9	102,9	7,6	173,0	**115**	4,3	?	?	?	?	?	11	2045	5,5	8,6	3	2050-2070	
Canada	4,0	4,9	39,4	2,9	110,6	8,2	205	**150**	5,6	?	?	?	?	?	26	2030	5,5	8,6	3	2050-2071	
China	3,9	4,8	50,8	3,8	29,2	2,2	76,3	**80**	3,0	75	100	75	77,0	82	64	2014	1,4	2,2	5	2015-2050	
Colombia	0,9	1,1	10,0	0,7	4,0	0,3	11,6	**14**	0,5	13,5	14	14	15,8	14	71	2015	0,2	0,2	7	2017-2040	
Egypt	0,5	0,7	11,6	0,9	6,4	0,5	16	**18**	0,7	16	19	20	15,2	18	64	1987, 1994	0,3	0,5	3	2015-2050	
France	0,02	0,0	0,9	0,1	0,2	0,0	0,9	**1**	0,0	1,0	1,0	1,0	1,0	1,0	85	1966, 1989	0	0,0	3,5	2015-2050	
India	0,7	0,9	10,1	0,7	6,0	0,4	14,5	**16**	0,6	14	16	30	14,9	19	63	2012	0,3	0,5	3,5	2015-2050	
Indonesia	0,9	1,0	26,1	1,9	8,9	0,7	29,3	**35**	1,3	35	33	36	31,5	34	74	1978, 1991	0,3	0,5	5	2016-2050	
Kazakstan	1,7	2,0	13,5	1,0	21,5	1,6	43,4	**35**	1,3	35	?	?	?	?	39	2025	1,1	1,7	5	2035-2050	
Malaysia	0,7	0,8	9,1	0,7	5,9	0,4	12,7	**15**	0,6	15	15	16	13,7	15	60	2005	0,3	0,5	3	2017-2040	
Mexico	2,0	2,4	45,0	3,3	15,1	1,1	51,6	**60**	2,2	65	59	63	58,8	61	75	2004	0,7	1,1	5	2013-2100	
Netherlands	0,0	0,0	1,0	0,1	0,1	0,0	1,1	**1,1**	0,0	1,7	1,1	1,1	1,1	1,3	91	1987	0	0,0	5	1987-2050	
Norway	1,6	2,0	27,5	2,0	9,5	0,7	34,0	**37**	1,4	37	32	35	38,7	36	74	2002	0,4	0,6	5	2016-2040	
Oman	1,0	1,2	11,8	0,9	5,2	0,4	11,8	**17**	0,6	17	15	18	18,4	17	69	2001, 2016	0,2	0,3	5	2016-2030	
Russia	10,6	13,1	176,8	13,1	73,2	5,4	257	**250**	9,3	250	?	?	249	250	71	1988, 2019	2,8	4,3	8	2030-2050	
Syria	0,0	0,0	5,4	0,4	2,1	0,2	7,9	**7,5**	0,3	7,5	6,5	9,0	?	8	72	1995	0,1	0,1	3	1995-2011	
UK	0,9	1,1	27,0	2,0	4,1	0,3	29,0	**31**	1,1	40-33	30	31	32,5	23	87	1986, 1999	0,3	0,5	8	2015-2040	
US	9,3	11,5	222,0	16,4	78,0	5,8	254,0	**300**	11,1	300	300	350	286,0	309	74	1970, 2015	3,8	6,0	5	2025-2050	
Yemen	0,0	0,0	3,0	0,2	0,2	0,0	6,0	**3,2**	0,1	4	3,1	3,1	3,2	3,4	93	2001	0	0,0	10	2000-2030	
total 21 co	42	52,1	726	53,8	465	34,5	1121	**1192**	44,1	?	?	?	?	?	68	?	22	35	?	?	
OPEC																					
Algeria	1,3	1,6	19,0	1,4	14,0	1,0	36,2	**33**	1,2	33	32	43	33,0	35	58	2007	0,4	0,7	5	2015-2050	
Angola	1,7	2,1	13,1	1,0	11,9	0,9	21,9	**25**	0,9	35	22	26	24,7	27	53	2008	0,5	0,8	5	2016-2050	
Ecuador	0,5	0,7	5,9	0,4	3,1	0,2	14,2	**9**	0,3	9	9,5	?	9,5	9,3	66	2014	0,1	0,2	5	2014-2030	
Equatorial Guinea	0,2	0,2	1,6	0,1	1,6	0,1	3,0	**3,2**	0,1	3,2	2,3	2,8	3,3	2,9	49	2004	0,1	0,1	5	2005-2060	
Gabon	0,2	0,2	4,1	0,3	1,9	0,1	6,2	**6**	0,2	6,0	5,9	6,8	5,6	6,1	69	1997	0,1	0,1	3	1997-2040	
Iran	4,5	5,5	74,2	5,5	65,8	4,9	232	**140**	5,2	140	140	?	105	128	53	1974	3,3	5,2	3,5	2035-2100	
Iraq	4,5	5,5	43,5	3,2	86,5	6,4	192	**130**	4,8	130	?	?	?	?	33	2030	4,5	7,1	3,5	2040-2100	
Kuwait	2,8	3,4	47,8	3,5	42,2	3,1	151	**90**	3,3	95	?	?	69	82	53	1973, 2016	2,0	3,1	2.5	2030-2100	1991 2 Gb fi
Libya	0,8	1,0	29,4	2,2	30,6	2,3	78	**60**	2,2	60	60	?	40	53	49	1970	1,5	2,4	5	2030-2060	
Nigeria	2,0	2,4	32,7	2,4	27,3	2,0	73	**60**	2,2	70	56	83	49	65	54	2005	1,3	2,0	3	2025-2100	
Qatar	1,5	1,9	10,5	0,8	19,5	1,4	39	**30**	1,1	42	23	?	24	30	35	2011	0,9	1,4	4	2030-2050	
Saudi Arabia	10,1	12,5	147,6	10,9	202,4	15,0	414	**350**	13,0	350	350	?	216	305	42	2016	8,5	13,4	2	2040-2060	
UAE	3,0	3,8	35,5	2,6	54,5	4,0	135	**90**	3,3	90	90	?	58	79	39	2024	2,7	4,2	4	2050-2100	
Venez exc XH	0,5	0,6	64,0	4,7	11,0	0,8	?	**75**	2,8	110	77	82	72	85	85	1970, 1998	0,6	0,9	4	1998-2100	
Venez Orinoco	0,4	0,5	4,5	0,3	95,5	7,1	?	**100**	3,7	?	10	?	?	?	5	2080	1,5	2,4	?		
Venezuela	2,0	2,5	69,0	5,1	106,0	7,9	372	**175**	6,5	?	120	?	?	?	39	1970, 1998	2,1	3,3	~ 0	2022-2100	
total 14 co OPEC	35	43	534	40	667	49	1768	**1201**	44	?	?	?	?	?	44	?	28	44	?	?	
OPEC ASB data	33	40	534	40	666	49	1748	**1200**	44	?	1200	?	756	?	45	2016	18	28	3	2050-2100	
dif EIA-OPEC	3		0		1		20														
total 35 countries	77	95	1260	93	1133	84	?	**2393**	89	?	?	?	?	?	53	?	50	79	?	?	
world less XH 20	77	95	1304	97	1296	96	?	**2600**	96	?	3000	?	1834	2417	50	2016	60	94	3,5	2040-2100	
world	81	100	1350	100,0	1350	100	2832	**2700**	100	?	?	?	?	?	50	?	64	100	?	?	
% study/world	95		93		84			**89**									79				

U = ultimate = cumulative production from start to end in Gb = gigabarrel

CP5%pp = cumulative production up 2017 and beyond up to 2100 with a decline rate of 5%/a = only for post peak = pp

CC = creaming curve = cumulative backdated 2P discoveries versus cumulative number of fields

HL = Hubbel linearization = aP/CP% versus CP

OD = oil decline = aP versus CP

CP = cumulative production in Gb

aP= annual production in Mb/d = megabarrel per day

RR2017 = remaining reserves at end 2017 = ultimate less cumulative production at end 2017

CP+1P = cumulative production end 2007 + 1P reserves end 2017 = missing yet to find to be compared to ultimate

estimates are rounded to show the uncertainty , which can be about 10%

Table 2 : country before peak

Table 2
country before peak
Brazil
Canada with oilsands
Iraq
Kazakhstan
UAE
Venezuela Orinoco

Table 3 : country with 5 % decline rate since (and peak)

Table 3		
country with 5% decline rate to end since		peak
Algeria	2015	2007
Angola	2016	2008
Australia	2000	2000
Azerbaijan	2009	2009
Brazil	2050	2040
Canada crude	2014	1973
China	2015	2014
Ecuador	2014	2014
Equatorial Guinea	2005	2004
Indonesia	2016	1991
Kazkhstan	2035	2025
Libya	2030	1970
Mexico	2013	2004
Netherlands	1987	1987
Norway	2016	2002
Oman	2016	2016
US	2025	2015

Table 4 : fields

Table 4		year	Mb	year	Mb	year	year	Mb	Mb	%	Mb	Mb	%	year	
country	field	1st prod	aP	date	CP	date	peak year	2P	ultimate	depletion	HL	OD	decline rate	period	
Australia	Kingfish	1971	1,6	2009	1075	2009	1978	1100	1100	98	1100	1100	14	1978-2020	offshore
Australia	Kingfisf West	1982	1,1	2009	232	2009	1994	260	237	98	240	240	18	1994-2010	offshore
Australia	Halibut-Cobia	1970	5,6	2009	1016	2009	1971	1060	1050	97	1040	1040	10	1985-2030	offshore
Colombia	Cusiana	1994	0,7	2017	640	2017	1999	700	645	99	640	640	23	1999-2020	
China	Daqing	1960	247	2017	17 000	2017	1996	23 500	23 500	72	23 500	23 500	3	2000-2050	
France	Parentis	1954	0,6	2017	226	2017	1964	232	240	94	234	234	4,5	1998-2050	
France	Chaunoy	1983	0,4	2015	82	2015	1988	83	87	94	92	92	5	2000-2050	
France	Lacq	1955			9 Tcf	2013	1967	9 Tcf	9 Tcf	100			8	1995-2013	
India	Mumbai High	1976	80	2010	3190	2010	1984	4028	4000	80	3900	?	8	2008-2040	offshore
India	Ankleshwar	1961	0,9	2011	500	2007	1970	566	520	96	520	520	10	1979-2020	offshore
Indonesia	Handil	1975	7,4	2009	858	2009	1977	930	930	92	930	930	10	1981-2030	offshore
Mexico	Cantarell	1979	0,1	2017	13 900	2017	2004	18 300	14 000	99	14 000	14 000	25	2013-2030	offshore
Netherlands	Schoonebeek	1943	0	2017	264	1995	1957	373	280	94	280	280	11	2014-2050	
Netherlands	Groningen	1963	0,8 Tcf	2017	81 Tcf	1976	1976	100 Tcf	84 Tcf	96	86 Tcf	87 Tcf	20	2014-2030	
Oman	Yibal	1969	34	2013	1 883	2013	1999	2 100	2 100	90	2 000	2 100	15	2015-2030	
Russia	Samotlor	1964	200	2015	20 000	2015	1980	26 122	22 000	91	20 800	22 500	10	2016-2050	
Russia	Romashkino	1949	116	2016	17 000	2016	1971	18 500	18 500	92	18 000	18 500	9	2020-2050	
UK	Brent	1976	0	2017	2016	2016	1999	2010	2016	100	2015	2015	25	1996-2016	offshore
UK	Forties	1975	12	2017	2766	2017	1980	2663	2900	95	2850	2850	7	2009-2030	offshore
UK	Thistle	1978	1,4	2017	426	2017	1982	446	430	99	425	430	28	2015-2030	offshore
UK /NW	Frigg	1977			6,8 Tcf	2004	1981	6,8 Tcf	6,8 Tcf	100			17	1985-2004	offshore
US	East Texas	1931	3,5	2015	5428	2015	1933		5470	99	5430	5430	5	2003-2030	
US	Midway-Sunset	1901	22	2017	3207	2017	1991		3630	88	3500	3600	5	1995-2070	
US	Wilmington	1936	11	2017	2789	2017	1969		3000	93	3100	3000	5	1969-2050	
Gabon	Rabi-Kounga	1989	4	2017	886	2017	1997	900	920	96	910	910	10	2002-2040	
Iran	Masjid-I-Sulaiman	1911	1,3	2000	1269	2000	1928	1329	1300	98	1450	1400	5	1928-2000	
Iran	Agha Jari	1937	10	2010	10 000	2010	1973	17 400	11 000	91	12 000	12 000	5	1973-2100	
Iran	Gach Saran	1937	9,4	2010	9400	2010	1974	16 350	12 700	74	13 000	13 000	5	1974-2100	
Iran	Haft Kel	1939	9	2010	1950	2010	1948	2200	?	?	2100	2100	3	1948-2000	
Kuwait	Greater Burgan	1946	388	2010	33 800	2010	1972	59 000	?	?	2220	?	2	1972-2010	
Libya	Intisar	1968	9	2010	2060	2010	1970	2400	2250	92	2300	2210	5	1970-2010	
Libya	Bu Attifel	1972	26,8	2010	1781	2010	1991	2800	2800	64	2250	2800	5	1992-2030	
Libya	Sarir	1966	51	2010	3473	2010	1971	6200	6000	58	4400	6200	1,9	1991-2100	
Saudi Arabia	Ghawar	1951	1930	2010	72240	2010	1980	145 000	123 000	59	123 000	?	5	2025-2100	
Saudi Arabia	Safaniya	1957	185	2010	14 360	2010	1981	55 000	18 500	78	16 000	18 000	4	1981-2050	offshore
UAE	ABK	1974	3,6	2016	573	2016	1976	650	630	91	605	625	5	1976-2030	offshore
UAE	Asab	1973	112	2010	4262	2010	1976	6750	?	?	?	?	?		
UAE	Bab	1963	129	2010	2626	2010	2008	11 000	?	?	9 300	?	?		
UAE	Bu Hasa	1964	210	2010	7087	2010	1973	11 500	?	?	10 000	?	?		
UAE	Umm Shaif	1962	92	2010	3271	2010	2008	6120	?	?	5500	?	?		offshore
Venezuela	El Furrial	1986	57	2016	3371	2016	1998	3738	3640	93	3600	3650	18	2012-2040	

-**Conclusion**

There is confusion in forecasting future production because of the numerous problems:
-confusion in the definition of the product: crude oil or crude and condensate or crude and natural gas liquids or all liquids
The IEA is guilty to use a poor definition for condensate (following Norway practice), which can be classified either as crude oil if sold with crude oil or as NGL if sold with NGL, changing with sale agreements. Only crude oil +NGL is reliable. But OPEC members are always fighting between themselves on quotas and quotas are only for crude oil, not for condensate, it is why OPEC ASB historical series on production and reserves since 1960 is only for crude oil, when EIA data on OPEC production on T11.1a reports since 1973 different values for crude oil. OPEC reports condensate globally in NGL for the whole OPEC.
Since more than 10 years I complaint about the discrepancy of 2 Mb/d between IEA and EIA world NGL production, but bad practice continues, as I am the only one to complaint.
All the production graphs should be for crude +NGL but because the lack of data on NGL reserves (NGL production depends upon the way NG is treated in gas plants, removing or not the wet content), the graphs are for crude oil, dealing with different data if reported by OPEC or by EIA (which was up to 2014 the best data source, as BP statistical data is unreliable, varying with time. The problem with crude oil +NGL is that oil reserves and NG reserves are involved. It is why my study is limited with crude oil.
-unreliable production data in particular for OPEC members
-bad definition and practice of reserves: 1P (current reserves estimated with the annual oil price, meaning that if oil price increases 1P will increase), incorrect aggregation of 1P, financial value if obliged to follow the poor SEC rules (most western operators), political value for OPEC members because of the quotas = 300 Gb of speculative resources added between 1985 to 1989 stated in 2007 by former Aramco VP al-Husseini (in fact it is 500 Gb). The correct way to estimate reserves is the PRMS 2P.
Proved world reserves reported by OGJ and copied by EIA is a joke, as the result of a survey in the fall for the coming first of January, done before the study is carried out and most of agencies do not reply and no reply is taken as no change, as if the country has discovered exactly the same as produced. Furthermore, it is incorrect to add mathematically proved field reserves to get country proved reserves and proved country reserves to get world proved reserves, but nobody cares as it is done by everyone. There are several classifications of reserves but proved SEC reserves are audited but financial, when proved OPEC reserves are unaudited and political.
To forecast future discoveries reserves, 2P values should be used and backdated (present estimate reported at discovery year). 2P is assumed to take care of the real oil price during the life of the field. 1P varies with current oil price.
In brief 1 P data should be discarded and only 2P values should be used but only few countries report officially 2P = first UK. The use of expensive scout data is then necessary. But the problem is that 2P have increased more to please the buyers of such data than to represent new technology. It is then necessary to use older editions of 2P estimates.
The result is that there is no consensus on the definition of oil or on the definition of reserves. Everybody prefers confusion in order to tell what he wants
Everybody is not lying, but not telling the truth.
2P reserves were in the past reliable but the pressure of clients on scout companies are such that present data is unreliable, demonstrated by the discrepancies between different sources. To get the truth, older edition of scout data should be used.

The main conclusion of this study is:

-only 6 countries have not yet reached peak: Brazil, Canada oilsands, Kazakhstan, Iraq, UAE, Venezuela Orinoco
-17 countries (out of 35) have or will have a decline rate of 5 %/a
It means that, excluding the 6 countries before peak, the best and the simplest way to forecast future production is to decrease present production by 5 % per year. It is simpler and better than using published data.
Outside the political statements, future production is forecasted using the estimate of remaining reserves or future drilling with the present EUR per well. It appears that using the past production data is a more reliable way.
The extrapolation of the annual production versus cumulative production is good only for country with declining production.
The extrapolation of the percentage aP/CP versus CP is only linear for the last years and the reliability of the estimate depends upon the length of the last linear period.
The extrapolation of aP versus CP works only after its peak.
Annual production growth in volume or in % allows to forecast coming peak.
No one method is perfect.
It is why several methods should be used and the choice of the ultimate could be a straight average or a weighted average depending the quality of each approach.
Our approach can be criticized, but it gives all the detail of the forecast and until the end, which is not the case for most of official forecasts.

NB Sorry for my broken English, but the text is not important, it is the graphs. Correcting my English will lose energy and time: it is not worth it.
You have to make your own conclusions from the graphs
Sorry, this paper is too long but
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