

Graphs JHL 2024

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-Introduction

My previous paper on the subject was in French "Graphiques JHL 3e édition" mars 2022
<https://aspofrance.org/2022/03/31/graphiques-jhl-mise-a-jour-de-mars-2021-3e-edition/>

Beware that my excel graphs display the French use of a comma before decimals (and not a dot). The SI = International System of unit is legal in every country except US and Liberia. *SI 10.5.3 Grouping digits: Because the comma is widely used as the decimal marker outside the United States, it should not be used to separate digits into groups of three. Instead, digits should be separated into groups of three, counting from the decimal marker towards the left and right, by the use of a thin, fixed space.*

The goal of my paper is to give the reader a complete graph to make his own opinion on many subjects.

“A picture is worth a thousand words” https://en.wikipedia.org/wiki/A_picture_is_worth_a_thousand_words

Napoleon Bonaparte said "A good sketch is better than a long speech"

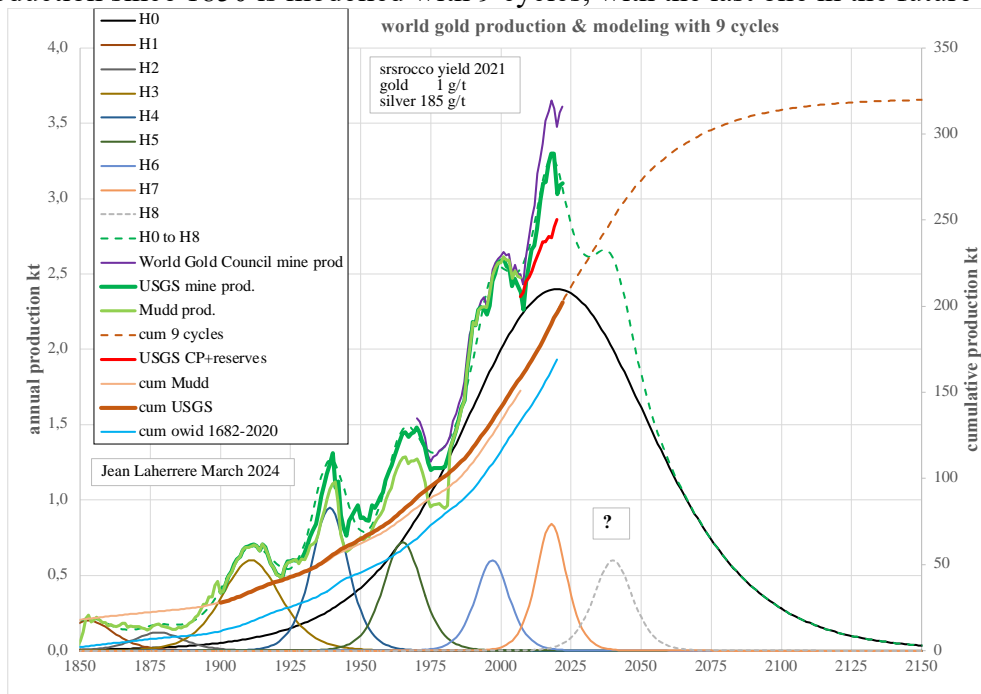
-metal

The best source of metal production data is USGS and BGS. Unfortunately, both agencies do not provide historical series and it is necessary to consult every annual report with sometimes discrepancy. It is a pity that official agencies as USGS, BGS or INSEE (except for deaths) do not report historical series; their report are signed by individuals who do not care to report the past which is not in their study!

Any historical series should start at zero or at the beginning of measures.

-gold

Gold production since 1850 is modelled with 9 cycles, with the last one in the future



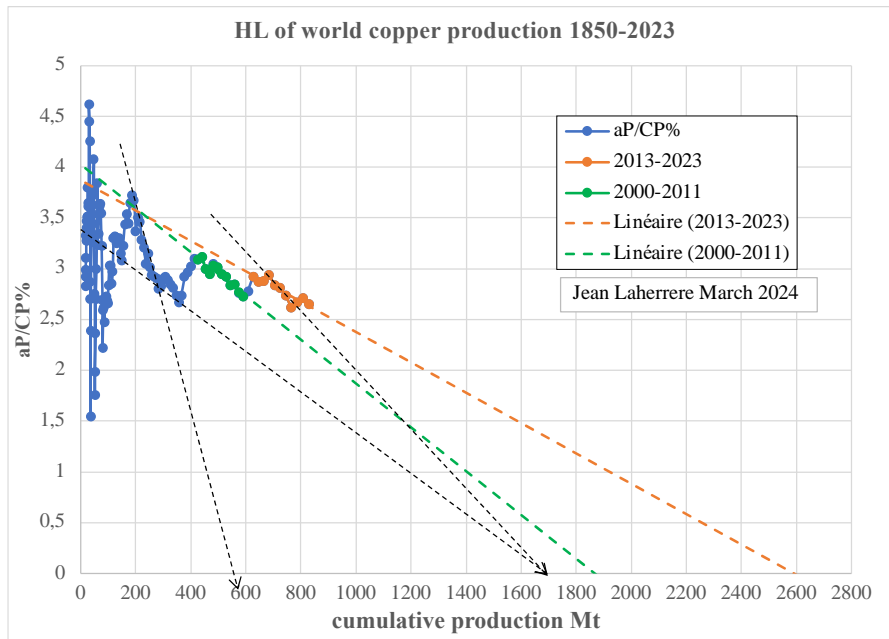
Gold mine production data varies with source: USGS value being lower than World Gold Council, which is assumed to be more reliable!

Gold production has peaked in 2019 with 3.3 kt for USGS or in 2018 with 3.7 kt for World Gold Council

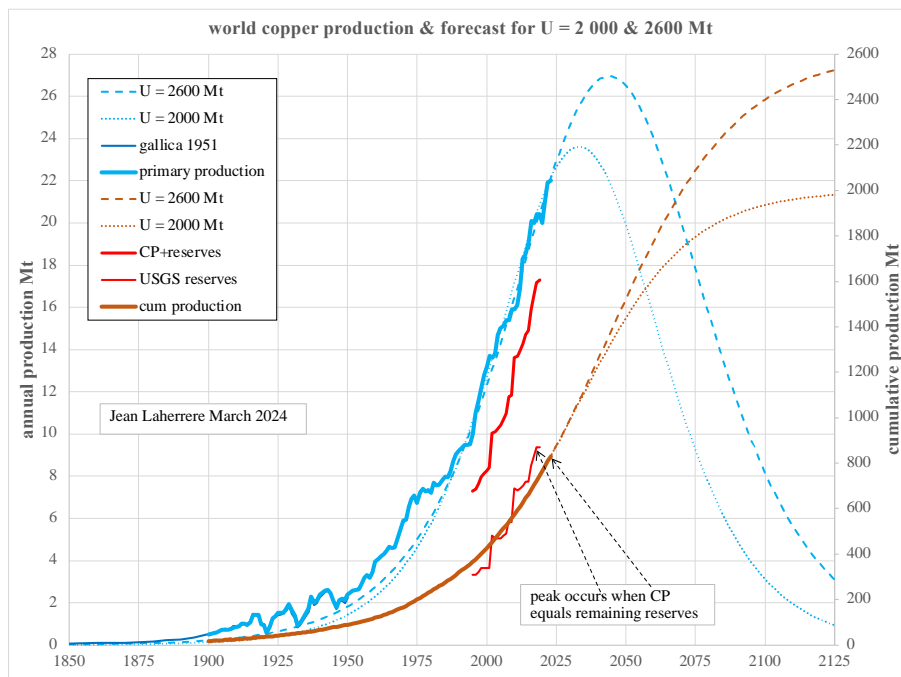
-copper

HL (Hubbert Linearization) of world copper production trends towards an ultimate of 2600 Mt for the period 2013-2023 and towards 2000 Mt for the period 2000-2011.

CP + reserves are sharply rising being at 1600 Mt in 2023

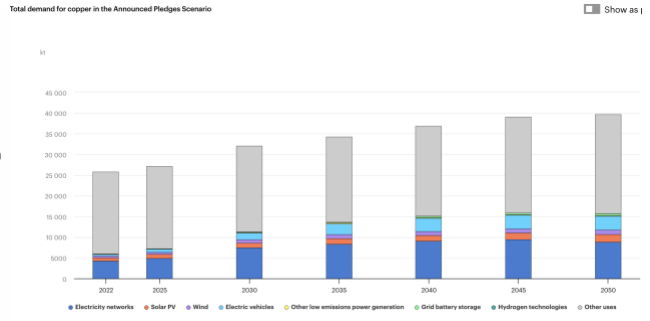
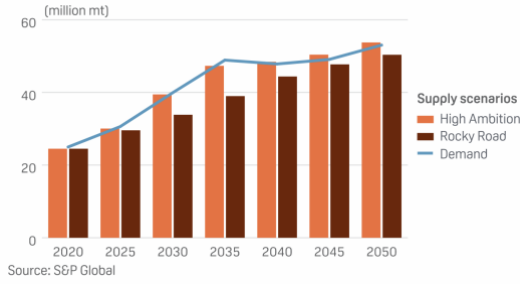


Copper production will peak at 27 Mt around 2040 for U= 2600 Mt and around 2030 for U= 2000 Mt



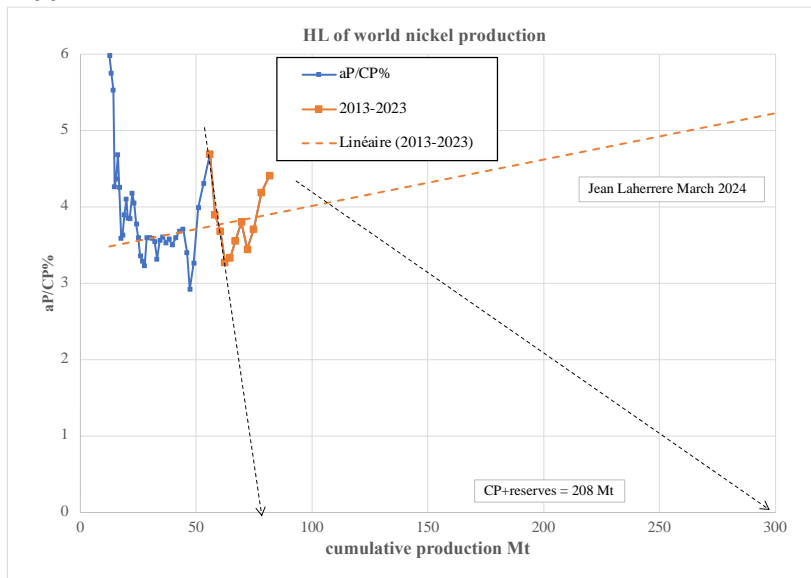
An electric car needs 4 times more copper than a thermal car.
 S&P forecasts 2050 copper demand about 50 Mt and IEA about 40 Mt, well above my peak of 27 Mt!

GLOBAL COPPER SUPPLY SCENARIOS AND DEMAND

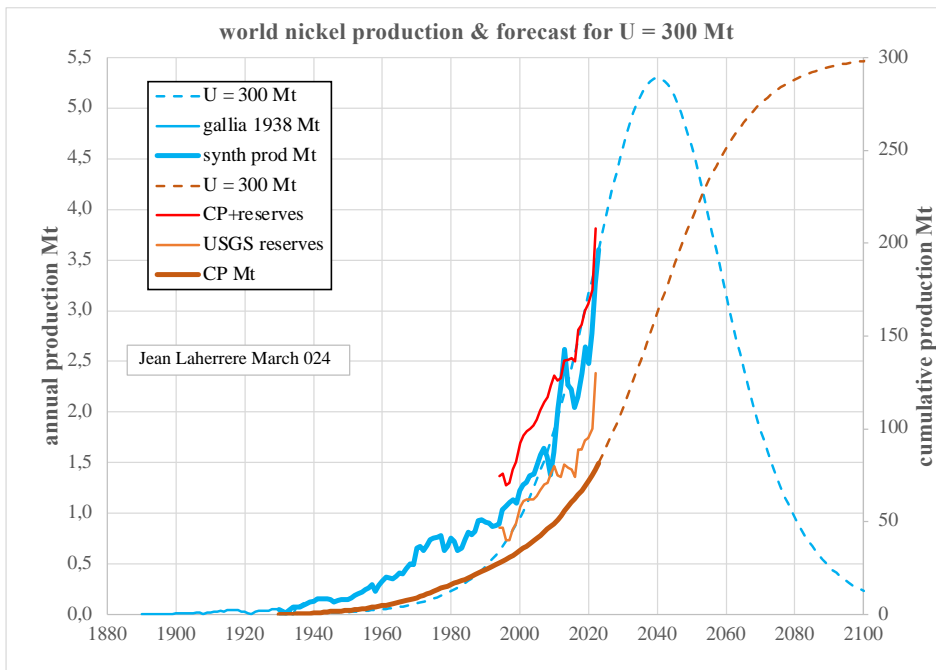


-nickel

HL of world nickel production is useless and an ultimate of 300 Mt is chosen as over a CP + reserves above 200 Mt



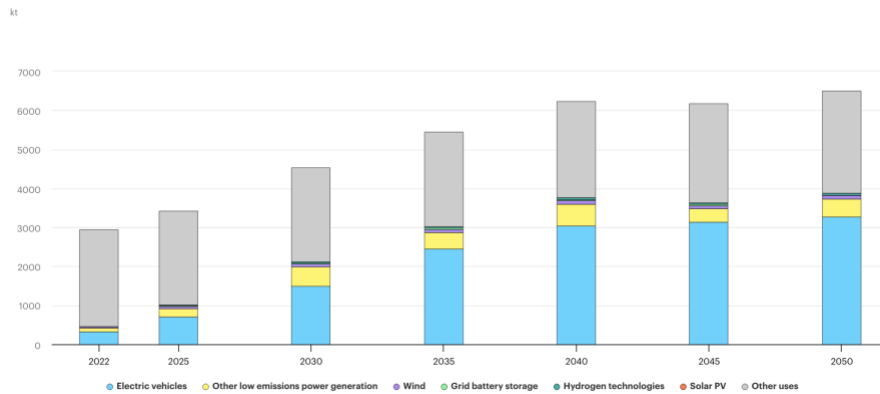
For an ultimate of 300 Mt, world nickel production will peak around 2040 at a value of less than 5.5 Mt



IEA forecasts 2050 nickel demand at 6.5 Mt when my forecast is 4.5 Mt

Total demand for nickel in the Announced Pledges Scenario

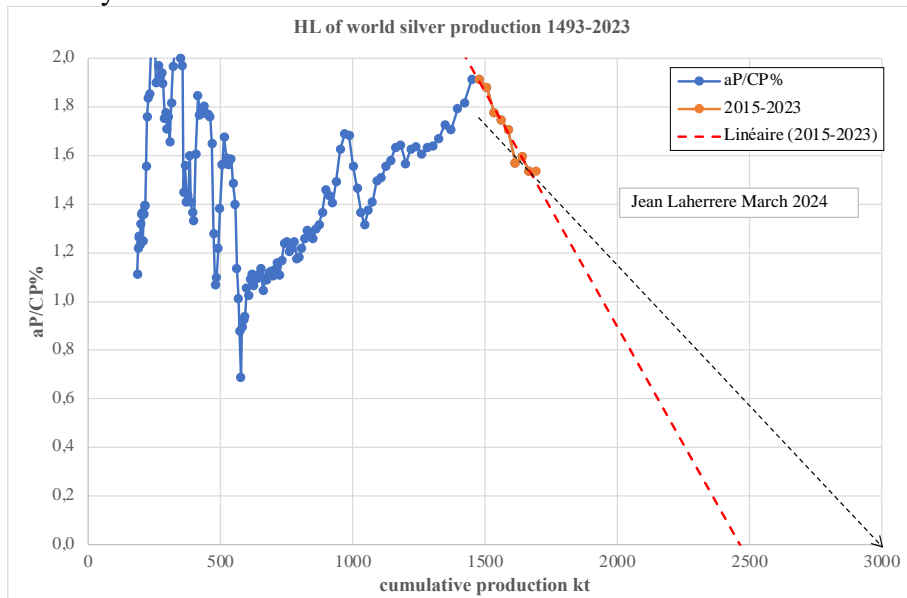
Show as



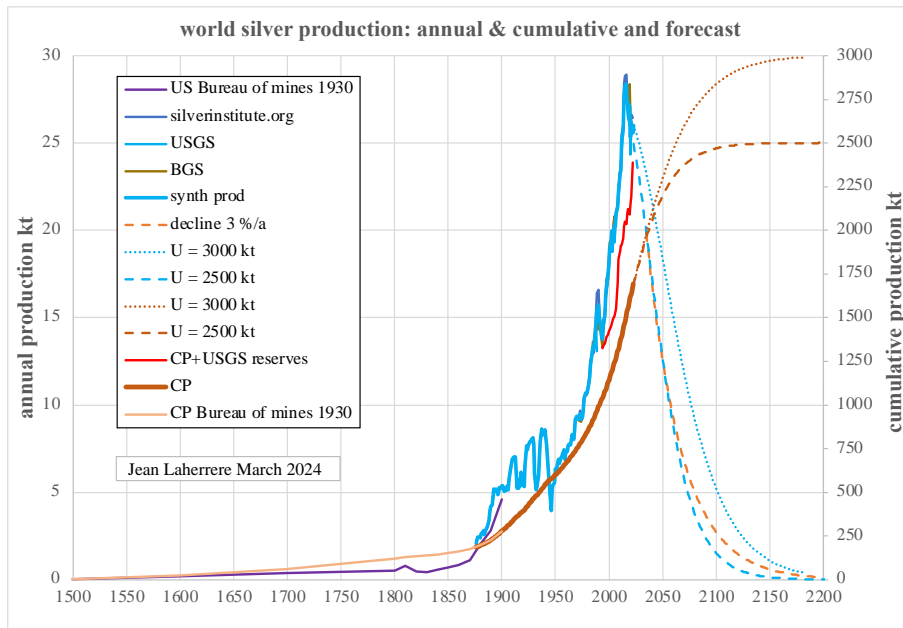
Nickel is more abundant in the crust than copper (80 against 50 ppm) but its production and reserves are 6 to 8 times less. But copper is the first metal used by man as easy to work and found native, when nickel was identified only in 1751 (confused before with copper) and is used mainly to fight corrosion (stainless)

-silver

HL of world silver production trends for the period 2015-2023 towards 2.5 Mt, but higher to 3 Mt for the last few years.



For an ultimate of 2.5 Mt world silver production has peaked in 2015 and will decline as sharply as its rise. Silver production in 2050 would be about the same as in 2000.



-world oil production forecasts

World oil production data varies with sources and definitions.

Today world oil production varies roughly from 60 Mb/d for conventional (?) crude, to 80 Mb/d for crude (?) and 100 Mb/d for all liquids.

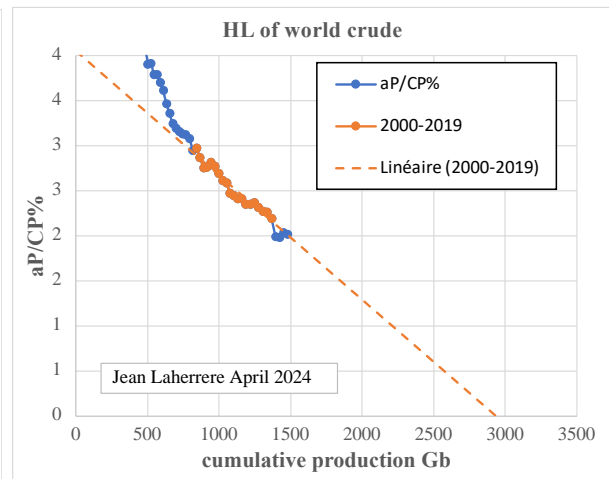
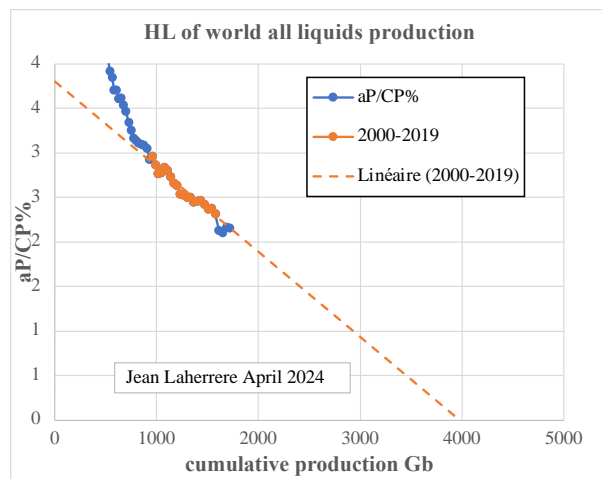
Condensate can be classified as crude or NG liquids by IEA depending upon its sale: it is confusing!

In the football game there are rules, umpires, and red cards, but in the oil market there is no consensus on rules: only competition. The only rule is that it is very cheap to transport oil and there is only one oil market when there are at least three NG markets because NG transport costs ten times more than oil transport.

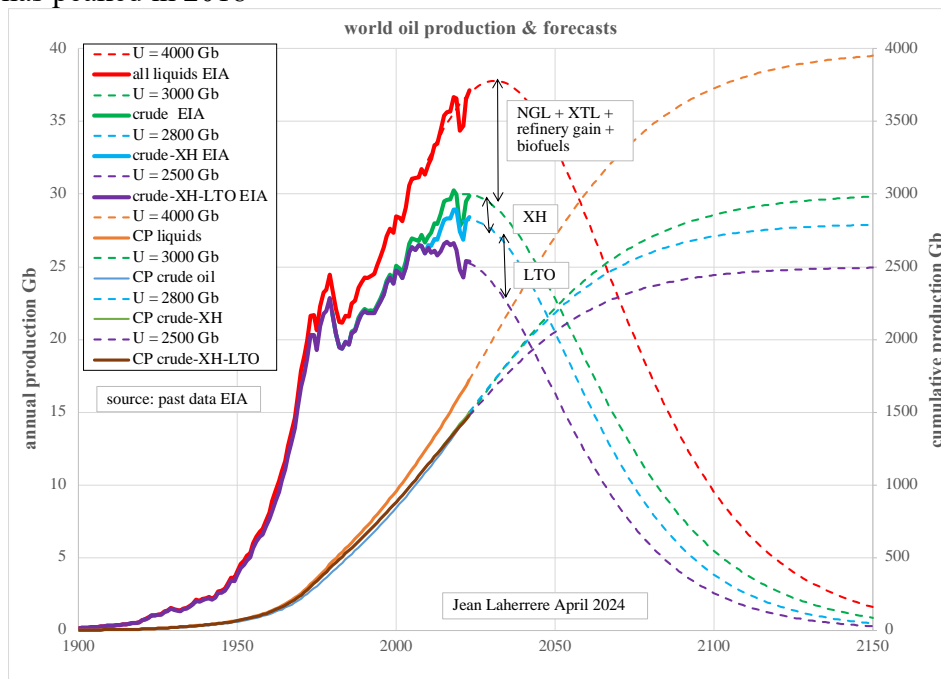
Oil losses occur, being internal use on site, leaks, theft (Nigeria = 0.3 Mb/d, but also in Russia, Iraq) and a part of the US military forces oil consumption overseas, when not going through customs is omitted, disappearing from statistics (0.35 Mb/d Sohbet Karbuz

<http://www.energybulletin.net/node/13199>).

HL (2000-2019) of world liquids production trends towards 4000 Gb and towards 2800 Gb for crude



For those ultimates world liquids production will peak around 2030 when crude oil production has peaked in 2018



The 2022 paper Jean Laherrère, Charles Hall, Roger Bentley "How much oil remains for the world to produce? Comparing assessment methods, and separating fact from fiction" was more optimistic with higher ultimates and later peaks!

J. Laherrère et al.

Current Research in Environmental Sustainability 4 (2022) 100174

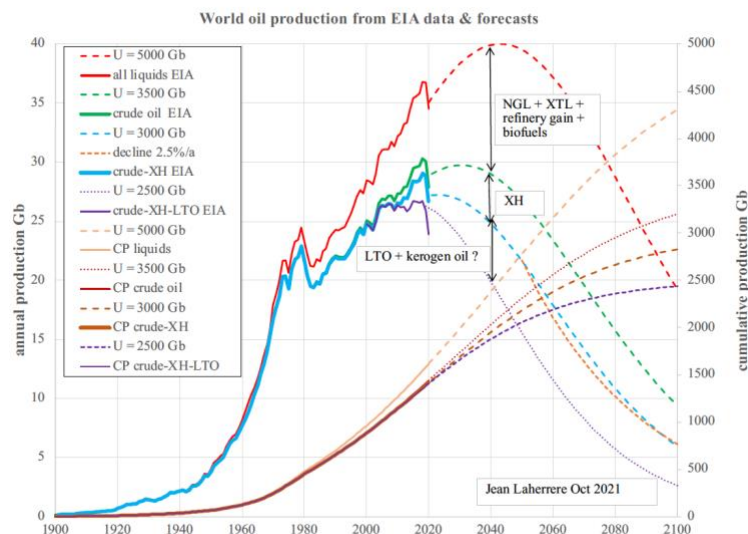
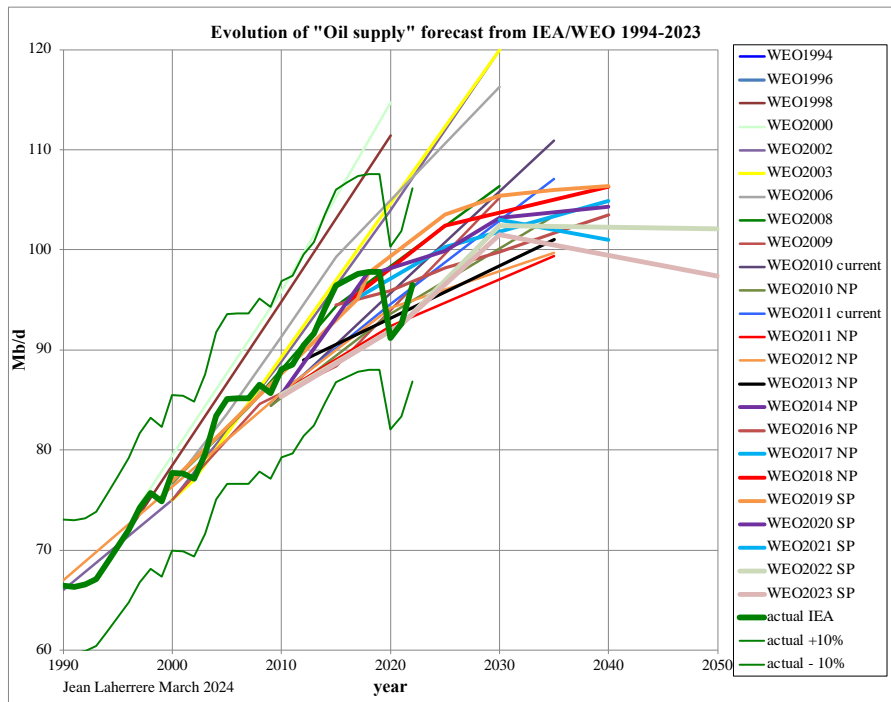


Fig. 7. Forecasts to 2100 of production of four aggregations of classes of oil, based on HL estimates of URR from Fig. 6.

My old forecasts were not very good. But IEA/WEO world oil supply forecasts (1994-2023) were not very good either, with a large range of past forecasts: > 10%. IEA forecast for 2050 is 94.5 Mb/d for WEO2023 against 103 Mb/d for WEO2021 = 9% less! IEA world oil production forecasts in the past were more optimistic than pessimistic.



-world oil discovery & production

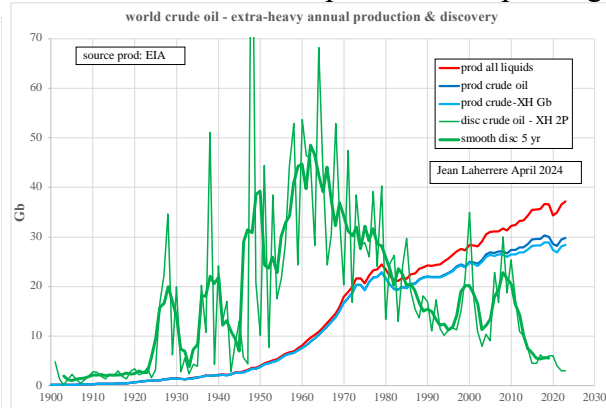
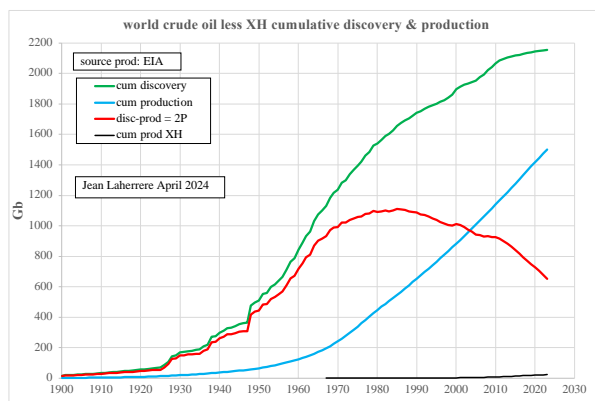
Extra-heavy oil (API<10°, density >1) (XH), heavier than water is trapped close to the surface, hardly able to move, and produced differently from conventional oil field capped over a water plane under impermeable sediments.

XH is produced in Canada = oilsands of Athabasca being bitumen, needing mining or steam to be produced and in Venezuela = Orinoco belt = largest oil accumulation in the world, which is similar in nature (and age) but warmer then less viscous and able to be produced without steam (lower recovery).

Bitumen is one of the rare products where there is a world consensus on definition because approved by Unitar in 1982: bitumen is when the viscosity is above 10 000 centipoise (mPa.s) XH needs upgraders or diluent to be moved.

So, it is normal to study crude oil less XH, being more homogeneous than crude!

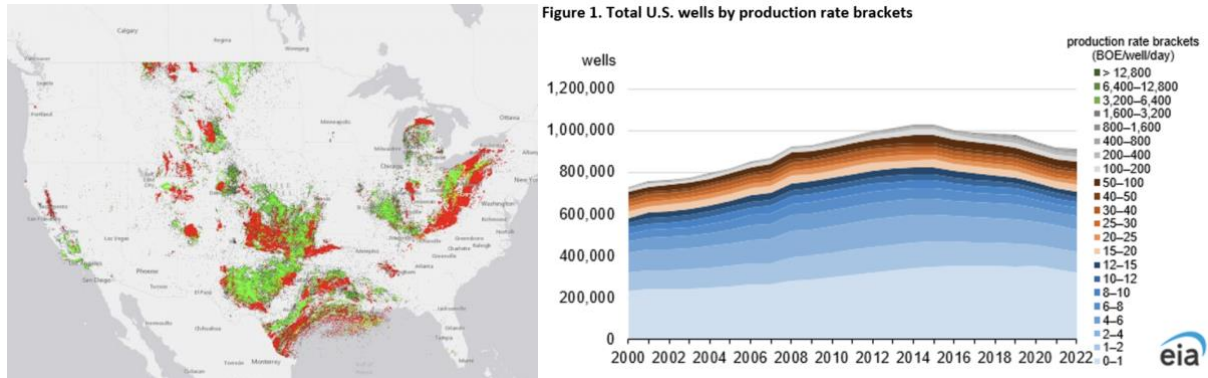
World crude oil less XH discovery has peaked around the 1960s and its production is peaking.



Since the 1980s world crude oil less XH production is larger than discovery and remaining 2P reserves decline.

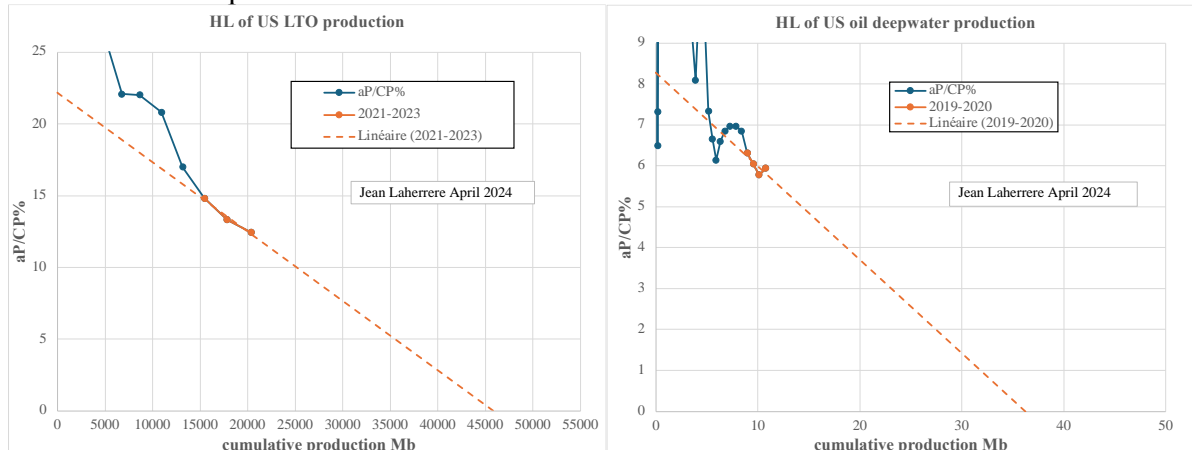
-US oil production forecast

Because the too many USL48 oilfields (> 30 000 oilfields in 1989 = Ivanhoe & Leckie) with about one million producing oil wells (most below 15 b/d in blue), EIA oil production data are not precise measures but estimates (form 914).

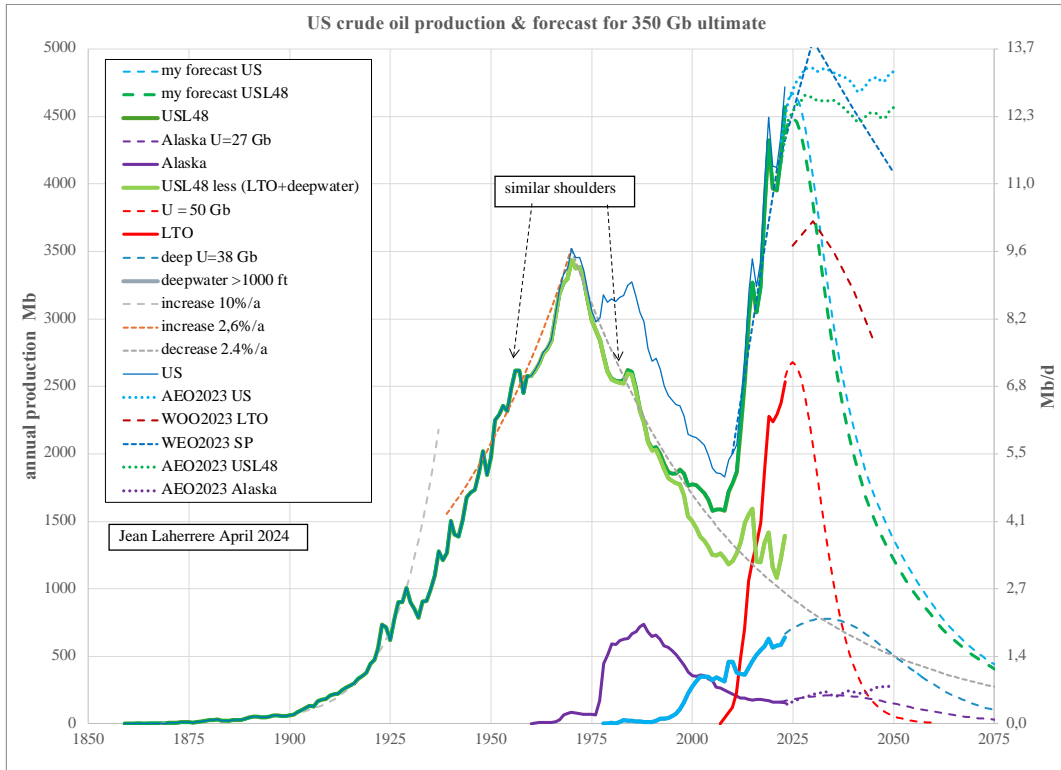


Most of US's data comes from EIA, except the Gulf of Mexico (GOM) and Alaska!
 EIA reports 1P reserves for US when BOEM reports 2P reserves for the GOM.
 EIA forgets that their I = information!
 Estimates are not the best information when measures exist!
 Estimates could be used for recent data, not for historical series

HL of US LTO production trends poorly towards 50 Gb and HL of US deepwater oil production poorly towards 38 Gb
 HL of Alaska oil production trends towards 27 Gb

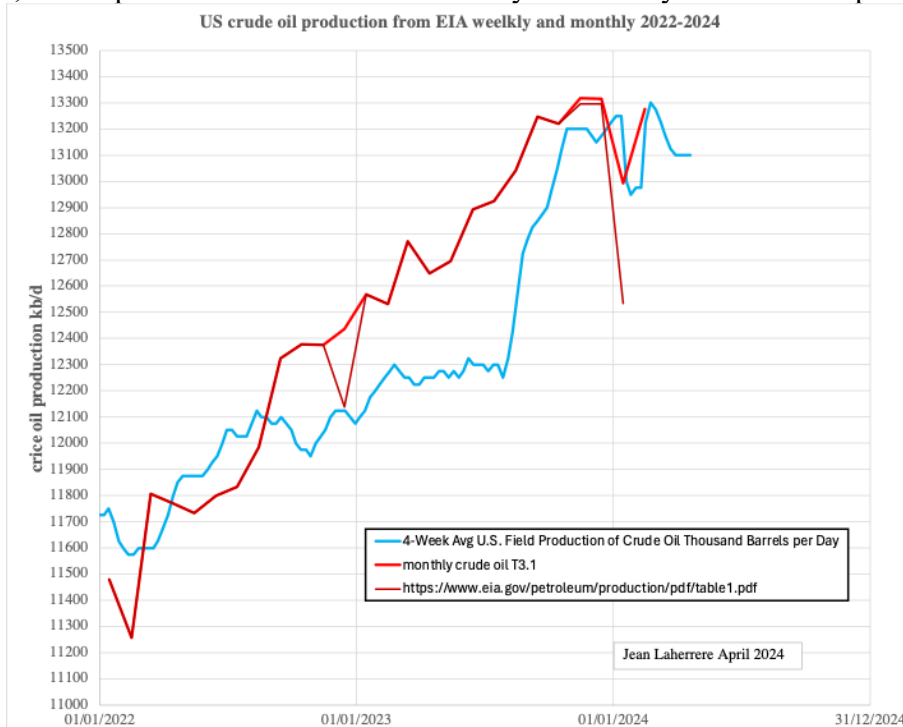


US crude oil production will peak around 2025 and the ultimate is about 350 Gb.
 US deepwater oil will peak around 2030, Alaska oil has peaked in 1988.

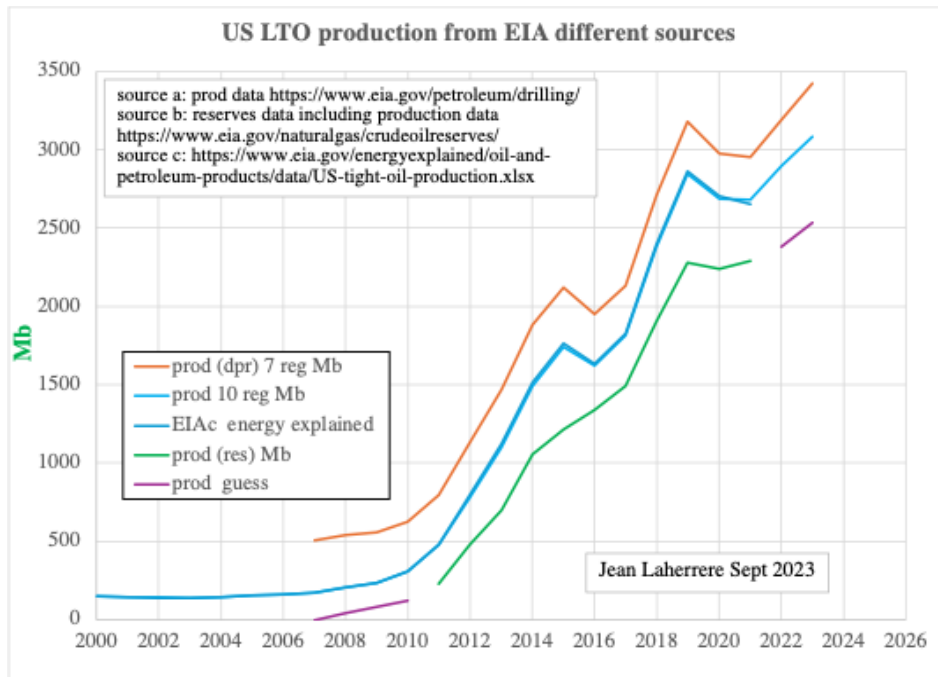


EIA data is not reliable because it is not measures but estimates with form EIA-914
EIA collects data from a sample of less than 500 out of 13,000 currently active operators of oil and natural gas wells. These operators account for about 90% of crude oil, lease condensate

Furthermore, EIA reports different data from weekly or monthly US crude oil production

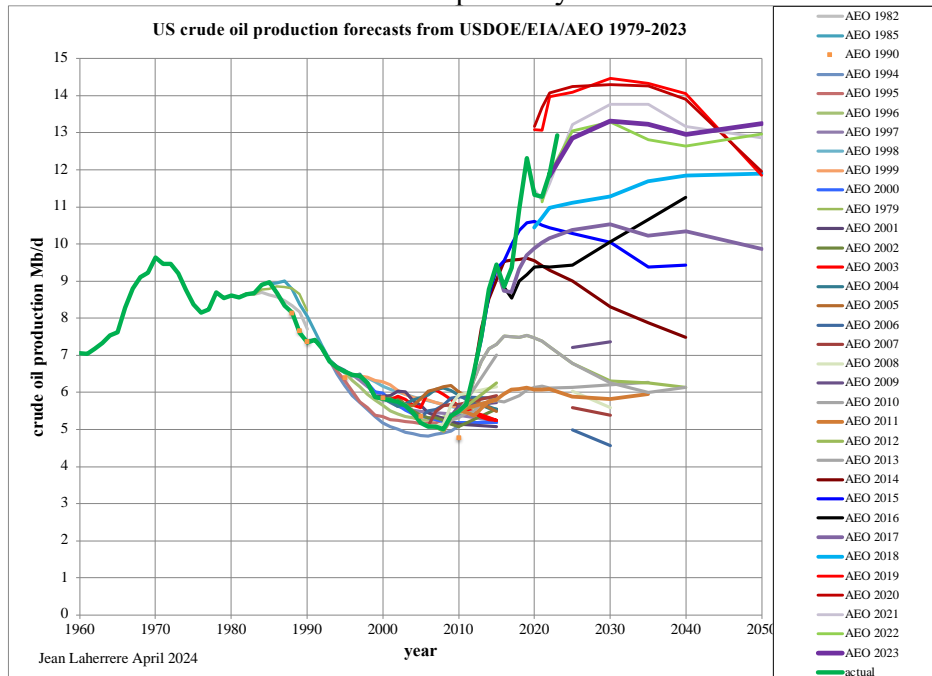


It is the same with US LTO production with 3 different EIA sources



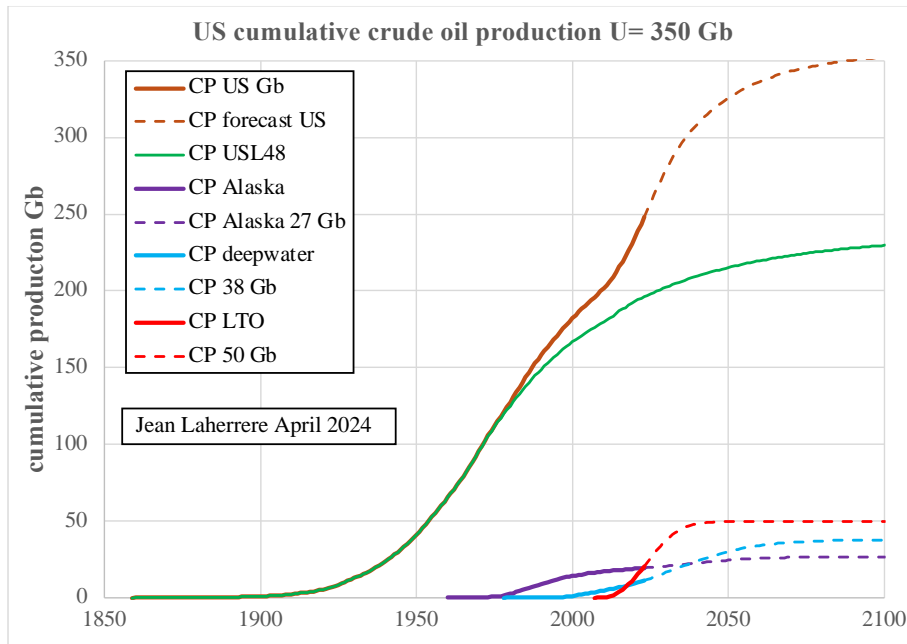
EIA was very poor in forecasting US crude oil production from AEO 1979 to AEO2023. AEO2011 forecasted for 2021 a production of 6 Mb/d which is half of real data! AEO2023 forecasts US crude over 13 Mb/d in 2050: they believe in Santa Claus! US LTO fields have a strong decline, dropping to negligible production within few years, and need a constant drilling of new locations but new locations are coming rare!

The evolution of EIA/AEO forecasts from 1979 to 2023 shows that the LTO was badly forecasted, and it still is with AEO2023 with a peak beyond 2050!

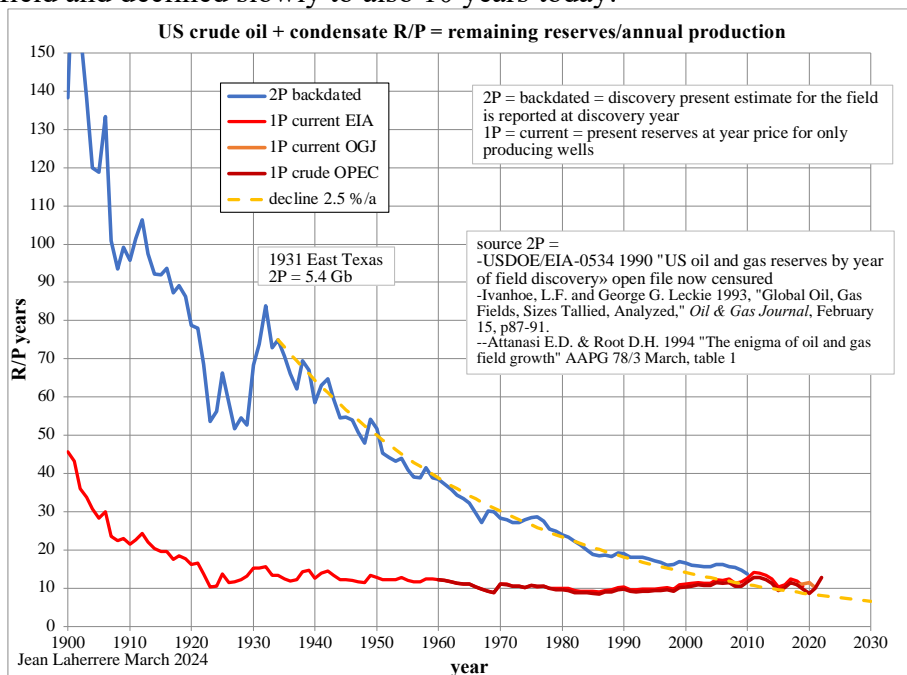


AEO2011 forecasted 6 Mb/d for 2023 against 13 Mb/d in reality!

US cumulative crude oil production is displayed, with the breakdown of Alaska, deepwater and LTO and the forecast gives an ultimate of 350 Gb

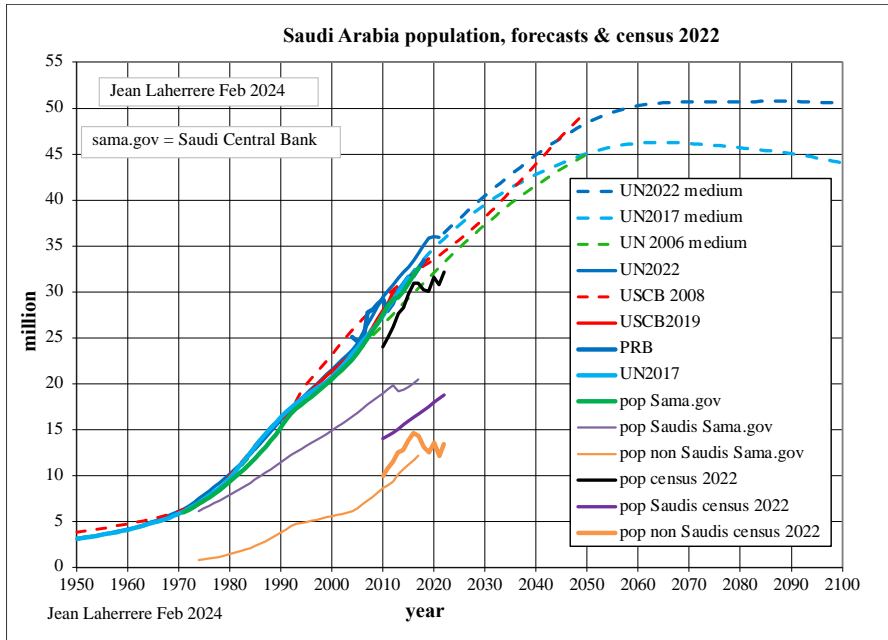


In the past, without seismic data US proven oil reserves were estimated by multiplying by ten the annual production: the R/P was taken as 10 years. The present R/P is close to ten since one hundred years, when it was 40 in 1900. The backdated 2P reserves is taken from a 1990 EIA open file 0534 which is censured today. R/P for 2P was 80 years in 1931 with the discovery of East Texas field and declined slowly to also 10 years today:

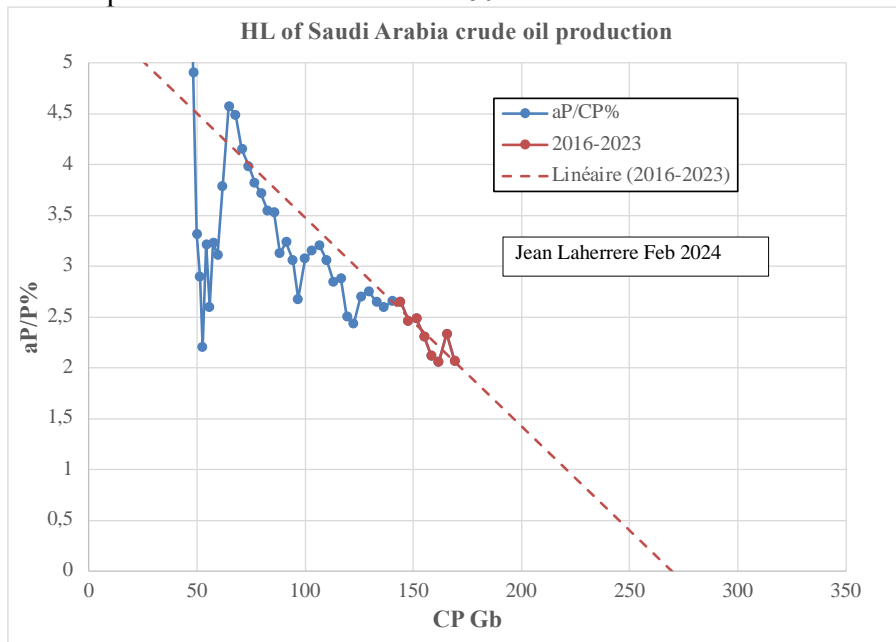


-Saudi Arabia oil production forecast

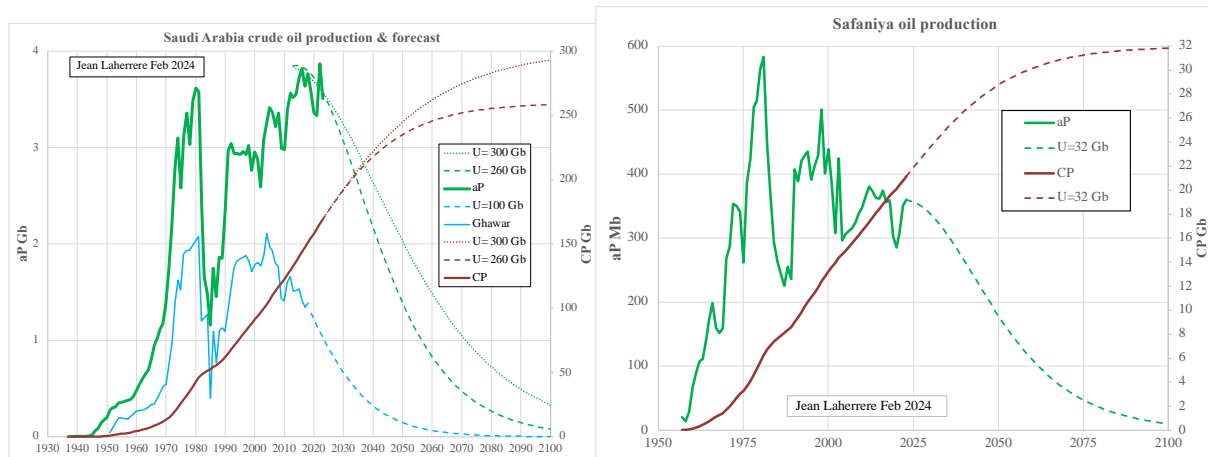
Saudi Arabia population data was wrong before the 2022 census, showing the importance of reliable data and the needs of real measures and not just estimates.



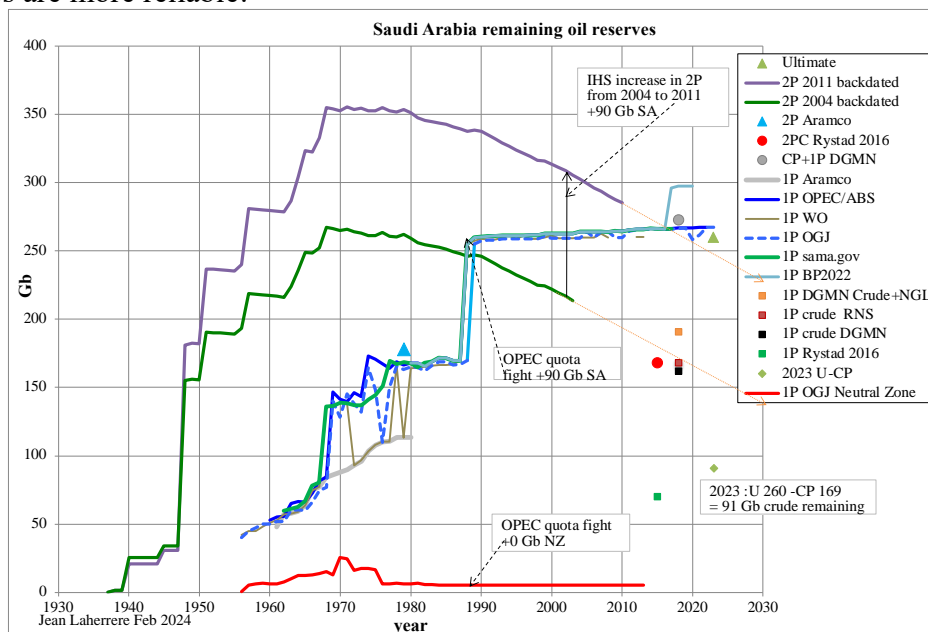
HL of SA crude oil production trends towards 260 Gb



SA crude oil production has peaked in 2022 and will decline in the future: SA claim to increase production in future looks unreliable.
Ghawar production is largely on decline, as the world largest offshore oilfield Safaniya

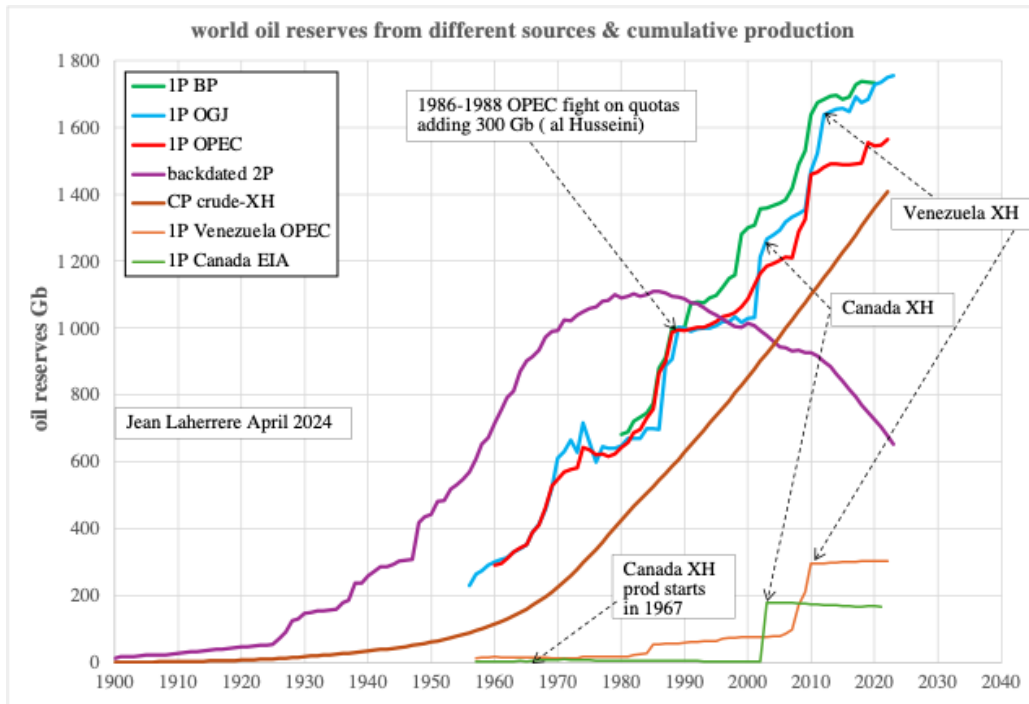


SA oil proven reserves are unreliable, being about 260 Gb for the last 30 years, meaning that for the last every 30 years SA finds the same quantity of oil than it produces: it is unrealistic for such a long period! SA is lying as most OPEC countries because OPEC oil quotas! NG reserves are more reliable!



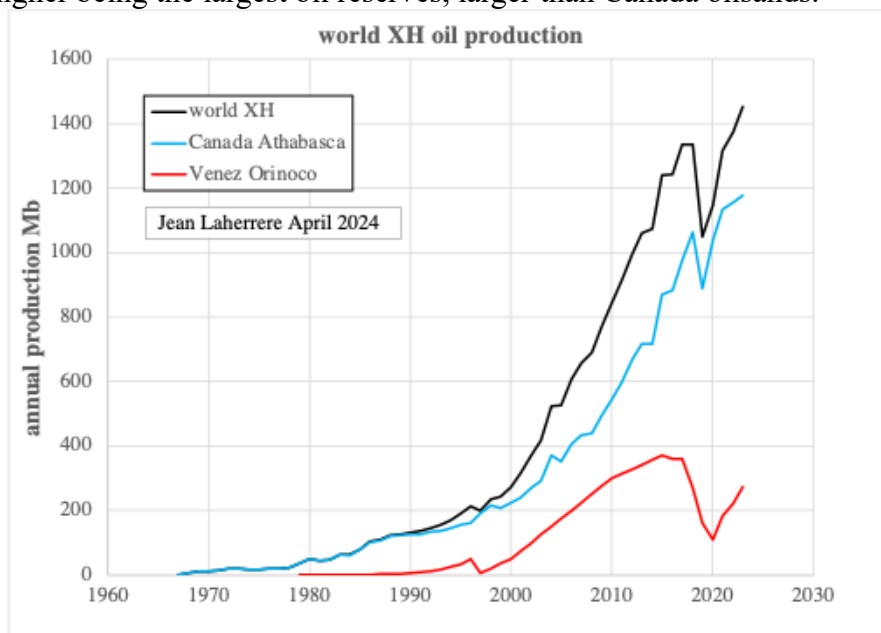
-world oil reserves

World oil reserves vary with sources, classification (see page 14) and definition: proven 1P reserves are current (and include XH), when proven +probable = 2P (excluding XH) are backdated (present estimate is backdated to the year of discovery): 2P are given by the difference between cumulative discovery (excluding XH) and cumulative production of crude less XH.

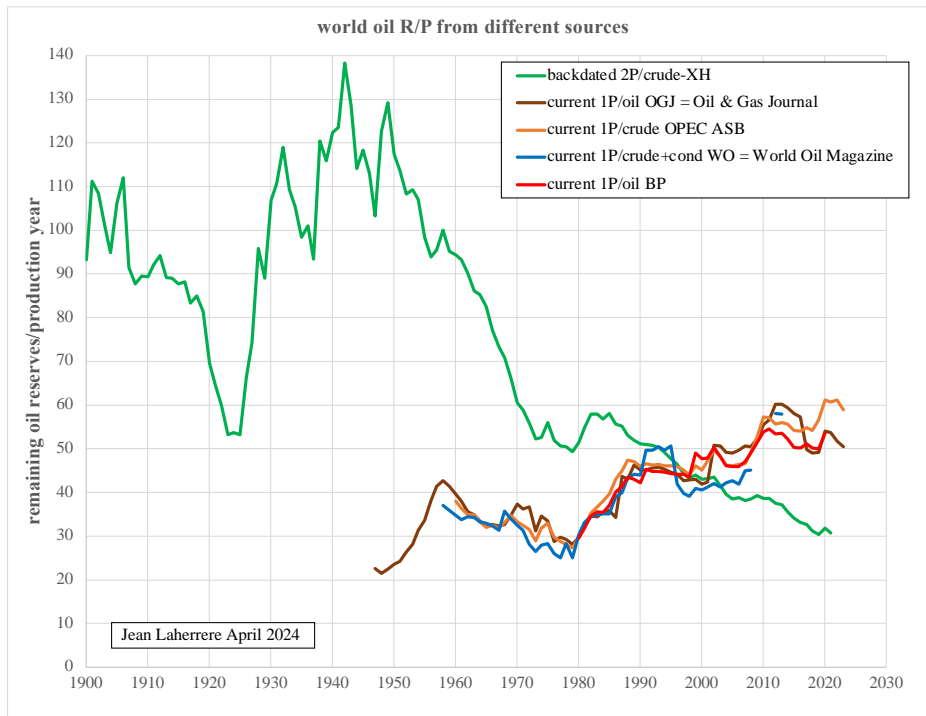


2P is peaking in 1980s (as discovery) when current 1P vary with sources, always rising. The 1P sharp jumps are first OPEC quotas fight in 1988, then Canada XH in 2002 and last Venezuela XH in 2010. But the rise in 1970 was real conventional discoveries

XH production started in Canada in 1967 and in Venezuela in 1979: Venezuela XH present poor production is political, due to Chavez and Maduro policy: it should be higher being the largest oil reserves, larger than Canada oilsands.



World oil R/P displays an increase for 1P since 1980 from 30 years to 50 years, but a decrease in 2P



-backdating reserves

My 2016 paper “World, US, Saudi Arabia, Russia & UK oil production & reserves

-Comments on Rystad 2016 world reserves” <https://aspo.france.org/2016/08/11/world-us-saudi-arabia-russia-uk-oil-production-reserves-august-2016-jean-laherrere/>

There is no consensus on oil reserves definitions with 4 systems in use:

- *US: all energy companies listed in the US stock market are **obliged by the SEC (1978 rules)** to report only proved reserves (1P), assumed to be the minimum; **these reserves are audited.***
- *OPEC: because quotas depend upon reserves, OPEC members report proved reserves (1P), which corresponds to their wishes since **they are not audited.***
- *FSU classification: ABC1 (Khalimov 1979) reports maximum theoretical recovery, being about equal to proven plus probable plus possible (3P). Khalimov in 1993 stated that Russian reserves were grossly exaggerated.*
- *Rest of the world: SPE/WPC (1997) classification, definition and guidelines (I was a member of the task force, which introduced probability) reports reserves as proven plus probable (2P), close to the expected value used to compute the net present value of the development, when decided.*

***It is incorrect to aggregate independent proved reserves** (as they are in aggregation of countries) and SPE 2006 draft reserve definition shows that it could underestimate the real proved by about 100:*

Figure 3: Comparison of arithmetic aggregation and probabilistic aggregation from SPE 2006

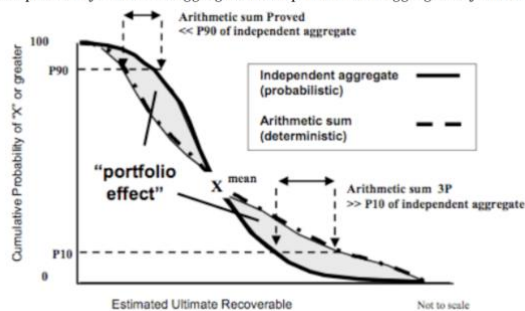
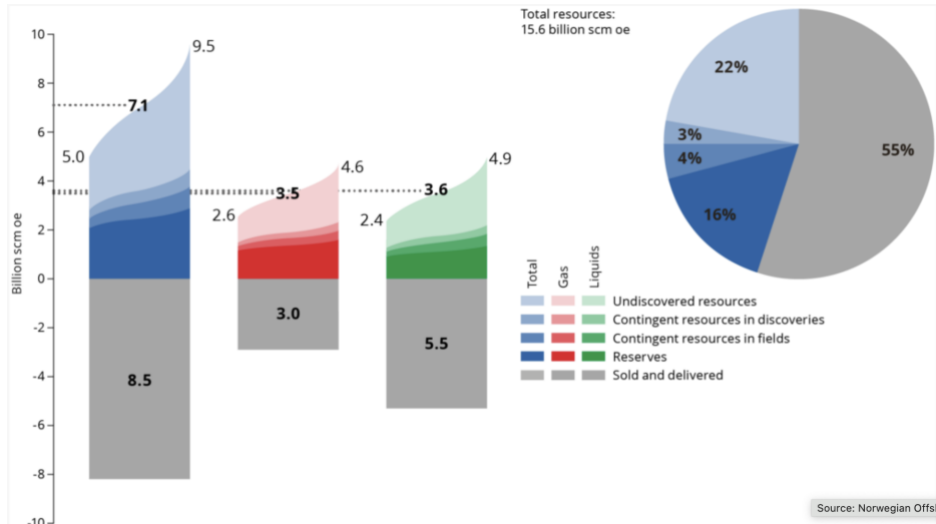


Figure 3-2: Deterministic versus Probabilistic Aggregation

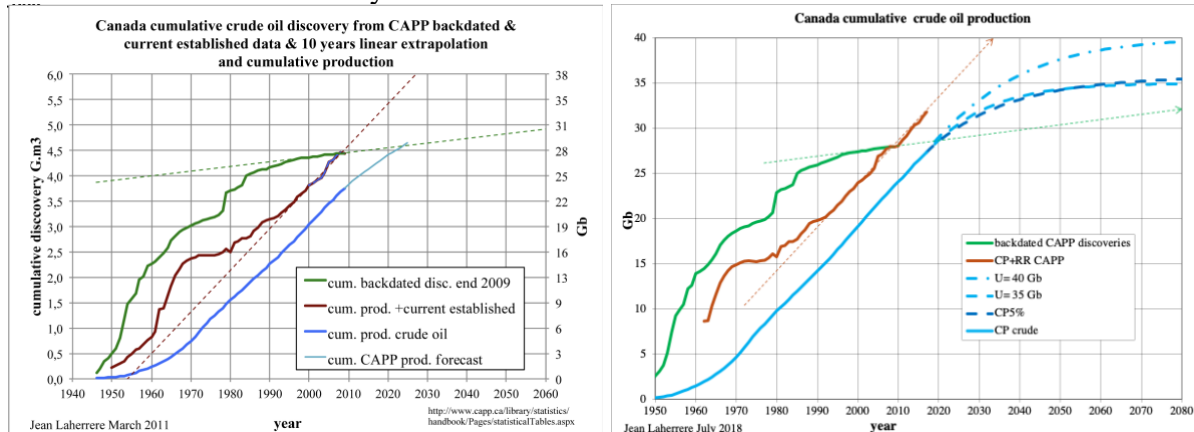
In 1996 a reserves expert Capen stated: "An industry that prides itself on its use of science, technology and frontier risk assessment finds itself in the 1990s with a reserve definition more reminiscent of the 1890s" "illegal addition of proved reserves"

In fact, in 2016 I forget to mention that Norway has its own classification (as the UN too complex in 3D) <https://www.norskpetroleum.no/en/petroleum-resources/resource-classification/>
 NPD ignores 1P or 2P and reports reserves with a range of uncertainty and reserves by field as original recoverable oil.



My 2011 paper «Backdating is the key » http://www.aspo9.be/assets/ASPO9_Wed_27_April_Laherrere.pdf
http://aspoFrance.viabloga.com/files/JL_ASPO2011.pdf displays for Canada the cumulative backdated 2P discoveries (reported by CAPP = Canadian association of Petroleum Producers) (green) and the cumulative current 1P discoveries (brown): it is obvious that the extrapolation of 1P gives a more optimistic estimate of oil ultimate than the extrapolation of proven. Then CAPP stopped to report backdated data after 2010

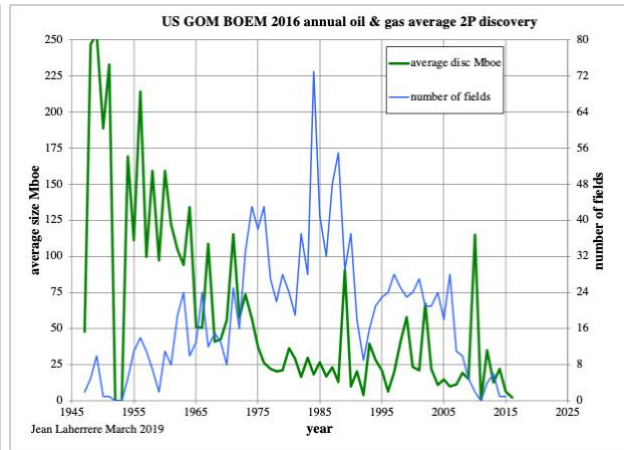
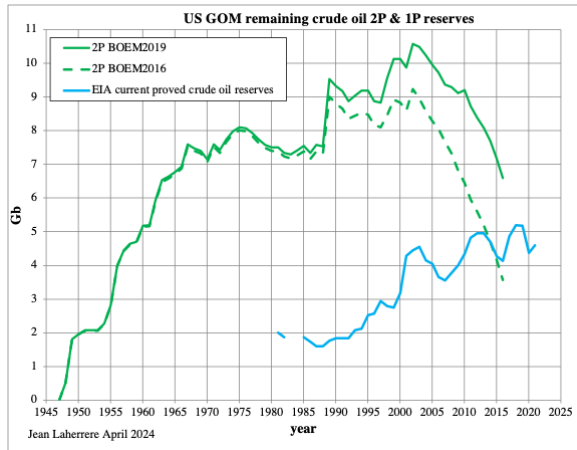
Canada cumulative discovery for backdated 2P in 2011 in 2018



In fact, Canada backdated 2P curve is too pessimistic, but the current 1P is too far optimistic
 The only country reporting field reserves as 1P, 2P and 3P is UK.

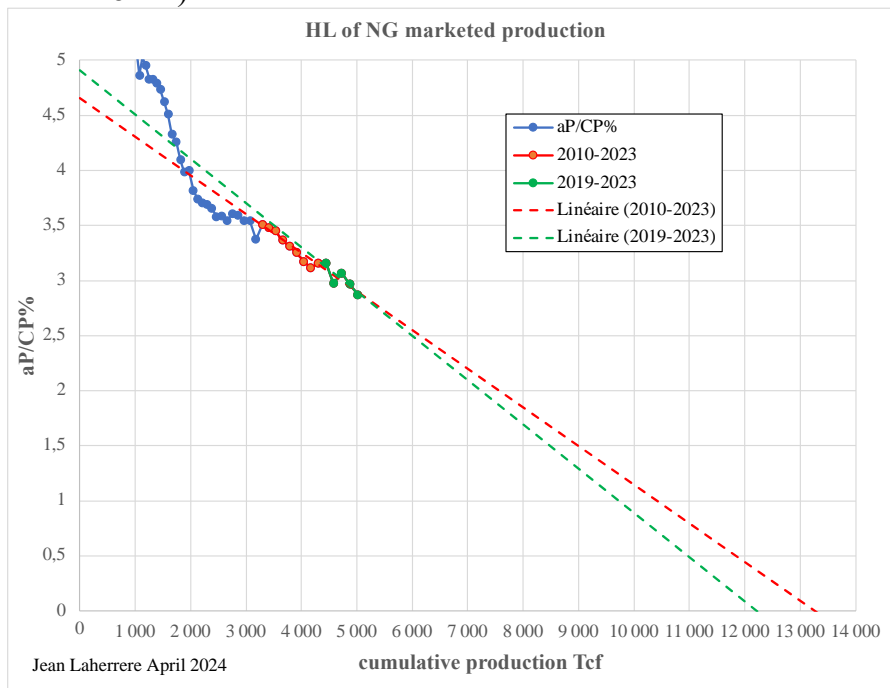
In US since 2012 BOEM (which is not ruled by the SEC) reports 2P reserves by field.
 The GOM difference between EIA 1P and BOEM 2P is striking, since 2002 GOM 2P declines and since 1988 1P increases. But 2P BOEM2019 is quite higher than 2MBOEM2016 since 1989.

BOEM has not updated the 2P data since 2019!

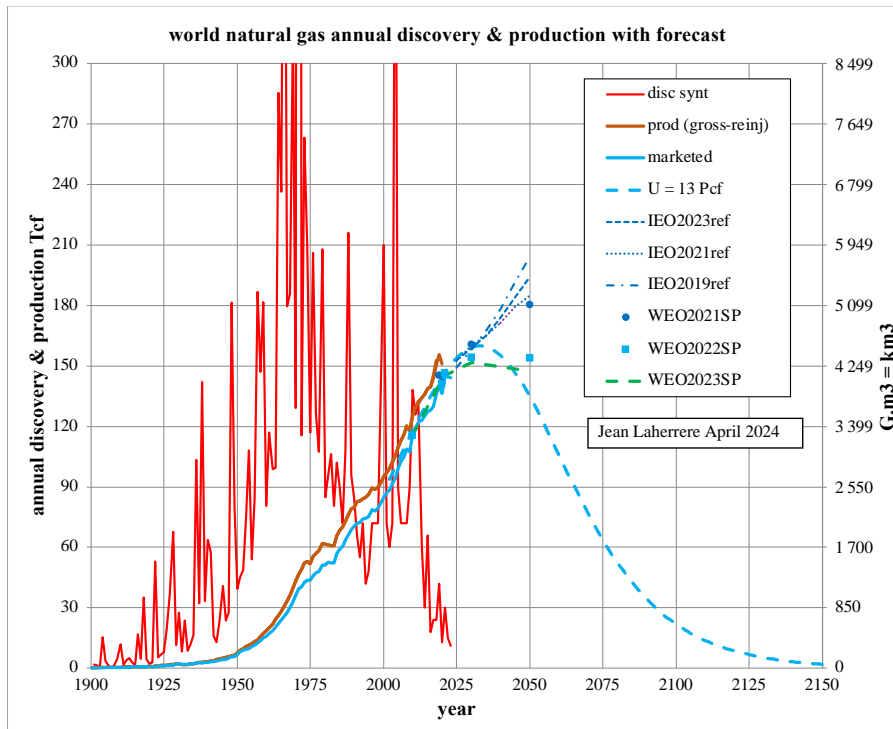


-world natural gas discovery & production

HL of world NG marketed production trends towards 13 Pcf (my previous estimate was much more optimistic at 18 Pcf)

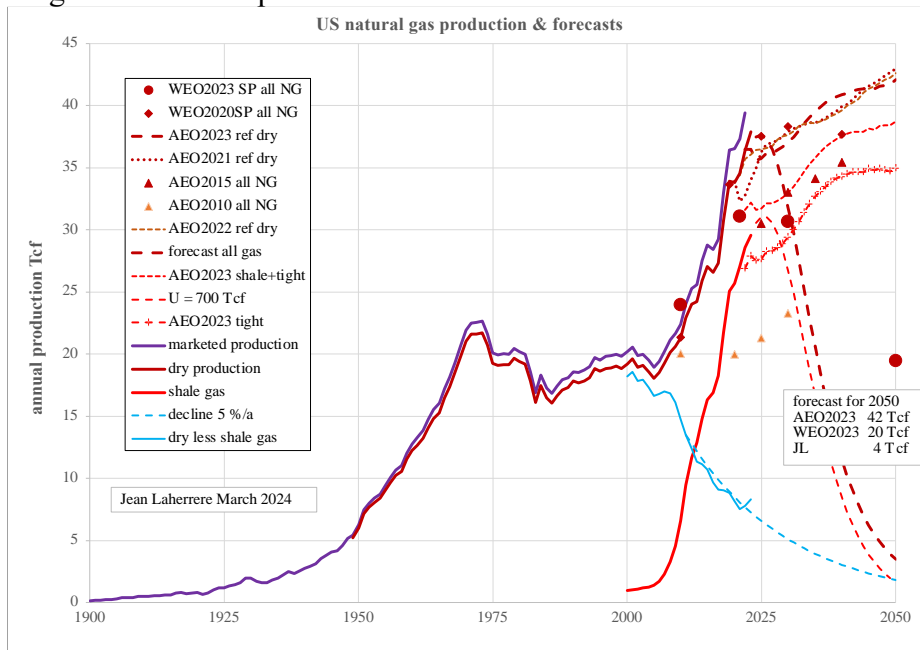


With a 13 Pcf ultimate world marketed NG production will peak around 2033 at 160 Tcf



-US natural gas production

US NG dry production will peak around 2025 and will decline sharply to about 4 Tcf in 2050 when EIA.AEO 2023 reference forecasts 42 Tcf = 10 times more and still rising!
 EIA rejects any US peak before 2050.
 IEA 2023SP forecasts for 2050 about 20 Tcf (half of EIA) with a peak around 2025
 EIA is dreaming and the wakeup will be severe!



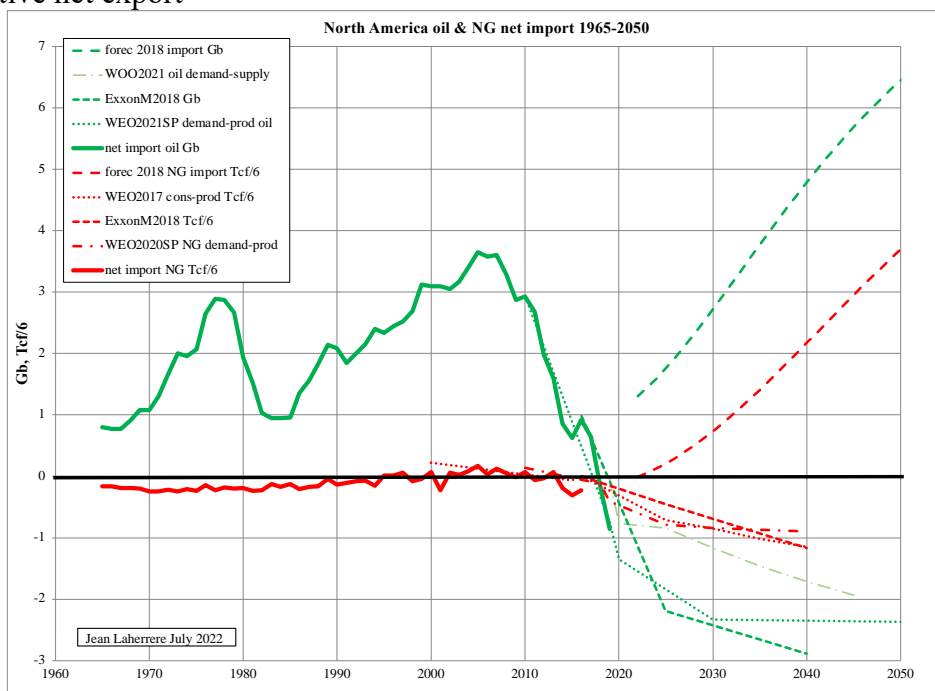
-North America oil & NG net imports

North America definition varies widely, but here it includes only US, Canada and Mexico.

Europe hopes to replace in the long-term future (2050) Russian oil and NG by North America nets imports.
 Since a long time, Canada and Mexico are connected by pipelines (green oil, blue products, red gas) to US and net imports must cover North America and not with only US.

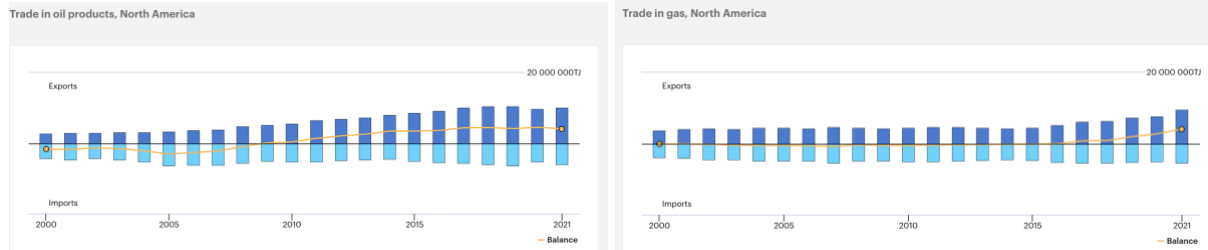


From 1970 to 2013 North America was importing more than 1 Gb of oil and in 2018 starts to have a positive net export

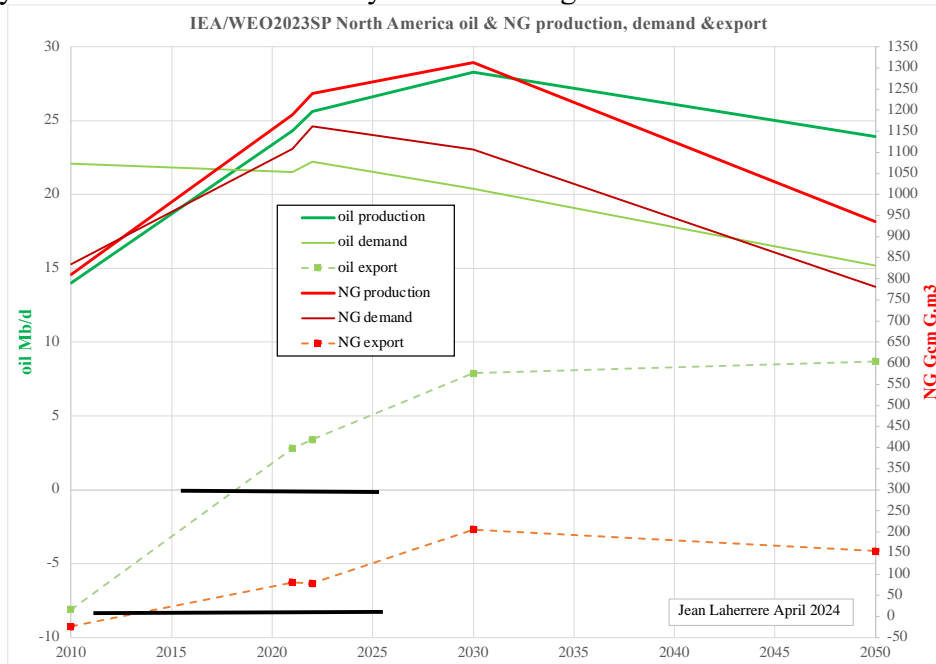


From 1965 to 2014 North America NG was self-sufficient and starts to export liquified gas

IEA graph 2000-2021 on oil & NG trade



IEA/WEO2023SP forecasts for North America in 2030 a net import of 6 Mb/d and 200 Gcm, significantly more than in 2022 when my forecast is negative!



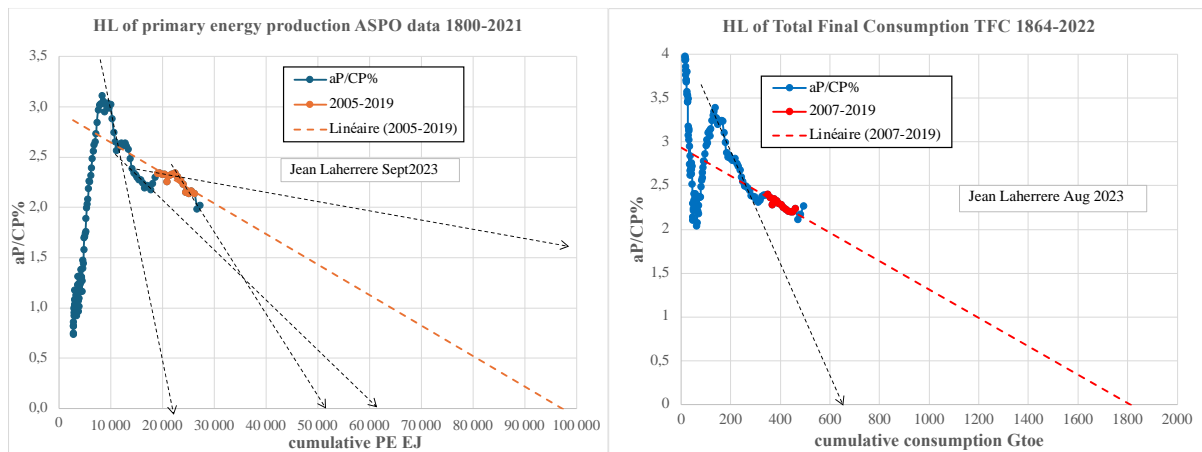
Europe is counting today and in 2050 on US shale gas LNG to replace Russian gas. I doubt very much as US shale gas should be gone by 2050!

-world primary energy & final consumption

Primary Energy refers to first form of energy encountered, as raw resources collected directly from energy production, before any conversion or transformation of the energy occurs.

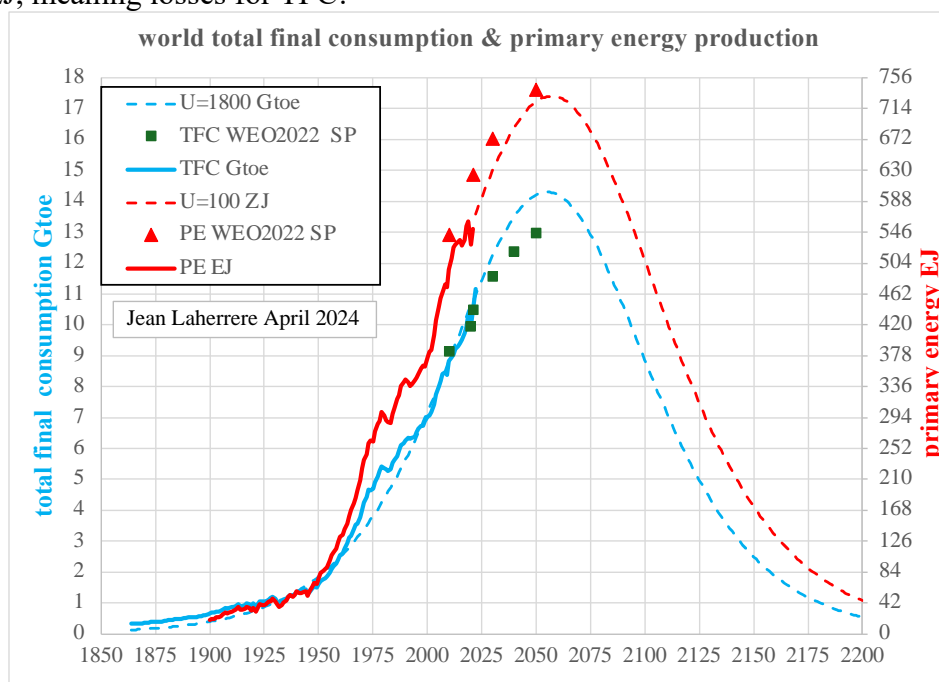
Total final consumption is the worldwide consumption of energy by end-users or total energy supply is total energy demand and thus also includes what the energy sector uses itself and transformation and distribution losses.

HL of world primary energy trends poorly towards 100 ZJ and world final consumption fairly towards 1800 Gtoe



World primary energy production PEP will peak around 2050 as world total final consumption TFC.

WEO2023SP agrees with my forecast for primary energy but it is lower for final consumption This graph agrees with the equivalence 1 Gtoe = 42 EJ, but the two curves will coincide for 1 Gtoe= 52 EJ, meaning losses for TFC!



World final consumption looks simpler than primary energy and easier to forecast.

World final consumption is less discussed and forecasted when it should be preferred to primary energy production!

World primary energy will peak around 2050 when reducing CO2 emissions will need a lot of energy

CCS technology has been going for 50 years and many projects have failed and continued to fail – like Western Australia's Gorgon – with only a handful working.

The International Energy Agency says annual carbon capture capacity needs to increase to 1.6 billion tons of CO2 by 2030 to align with a net-zero by 2050 pathway.

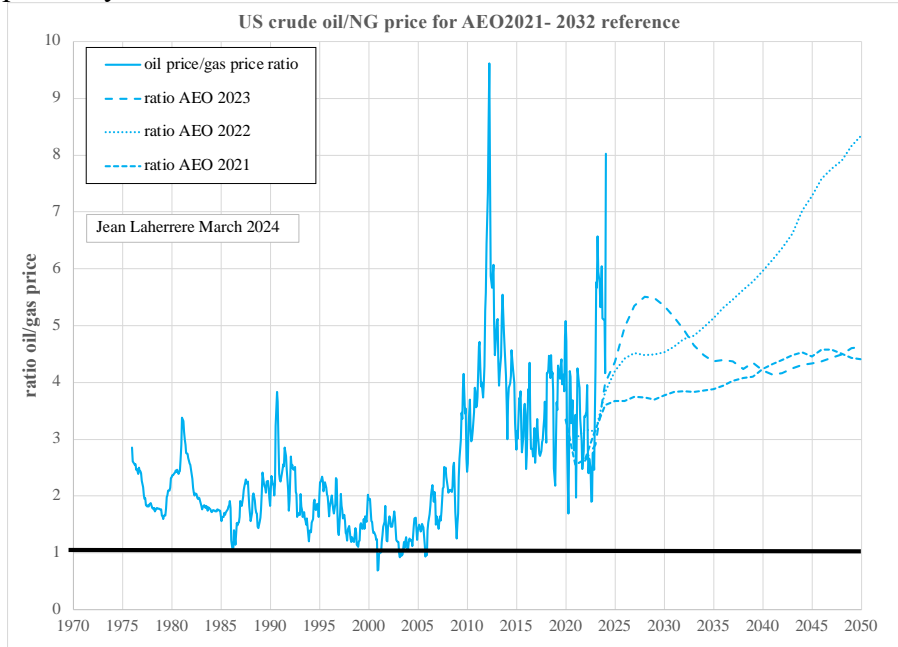
According to IEEFA, about nearly three-quarters of all CO2 captured annually by multi-billion-dollar CCUS facilities, roughly 28 million tons (Mt) out of 39Mt total capture capacity globally, is reinjected and sequestered in oil fields to push more oil out of the ground.

CCS present capture is one thousandth CO2 fuels emissions!

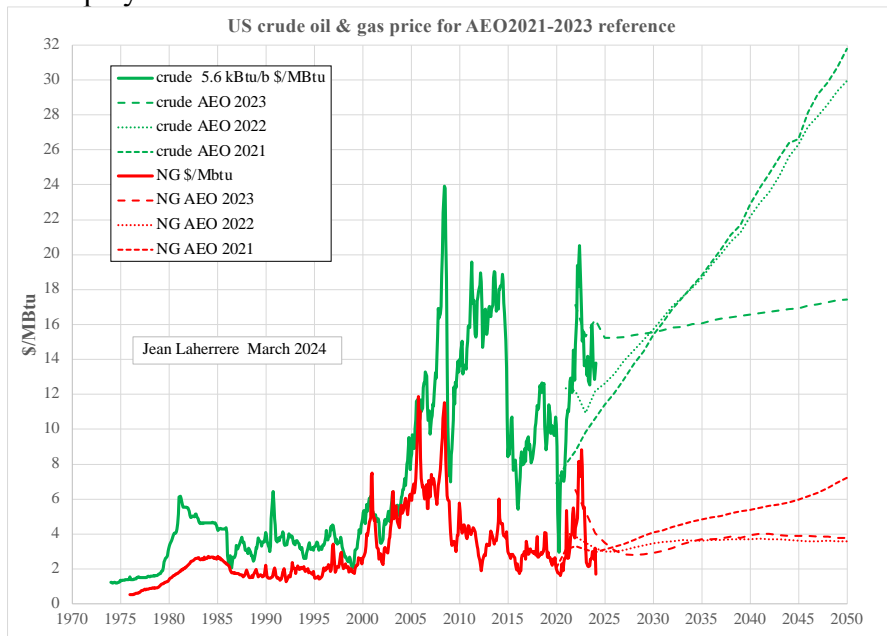
Net zero CO2 emissions by 2050 is unrealistic!

-US oil/gas price ratio

US crude oil/NG price ratio has varied a lot since 1976, being only three times at equality in the 2000s : presently it is above 5 and AEO2023 forecasts above 4 in 2050



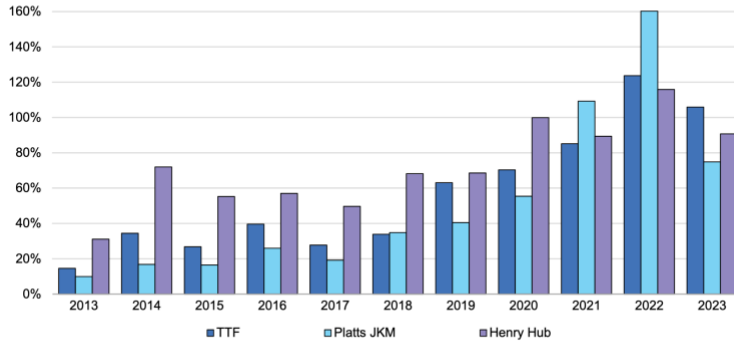
The US price forecast for oil and gas, which were close from 1975 to 2005, diverge after because the shale play



Price gas volatility is high from IEA

Heightened price volatility lingered into 2023 amid tight supply fundamentals

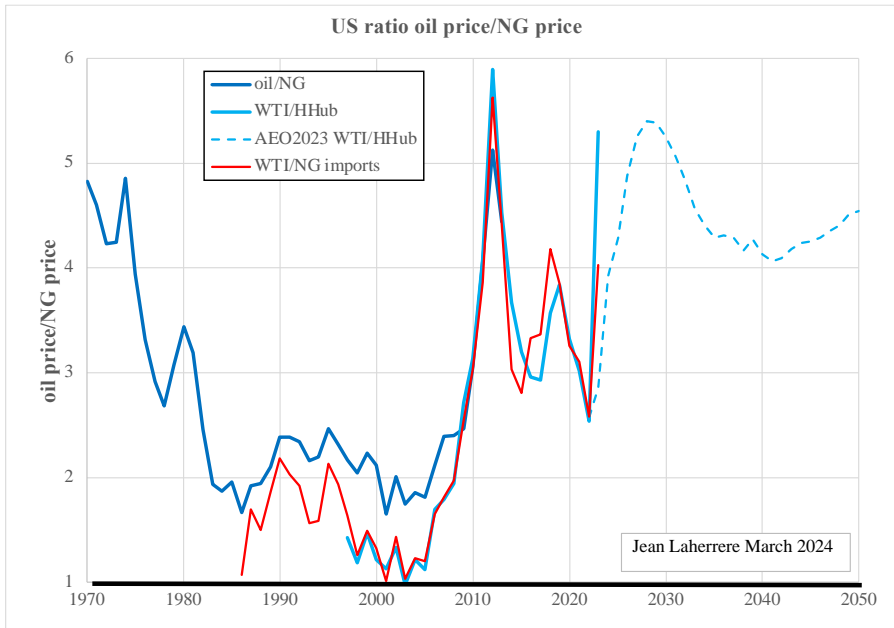
Annual average of historical price volatility across key gas markets, 2013-2023



IEA, CC BY 4.0.

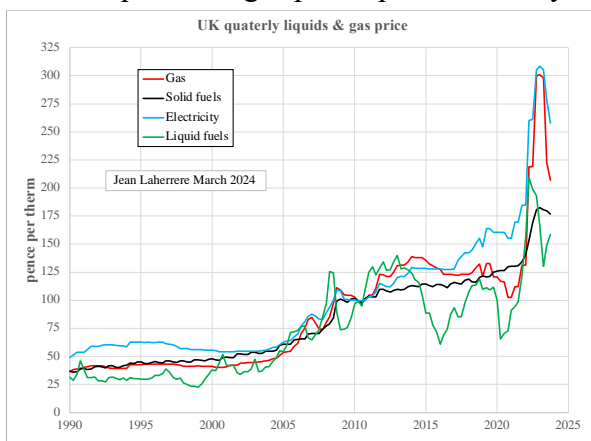
Sources: IEA analysis based on CME Group (2023), Dutch TTF Natural Gas Month Futures Settlements; CME Group (2023), LNG Japan/Korea Marker (Platts) Futures Settlements; EIA (2023), Henry Hub Natural Gas Spot Price; ICIS (2023), ICIS LNG Edge; Powermex (2023), Spot Market Data.

US oil price versus NG price ratio was high in 1970, low, but in fact normal (1 = normal equivalence) in 2005, very high in 2012, low at 2.5 in 2021 and high in 2023: EIA/AEO2023 reference forecasts a ratio of 4.5 in 2050!

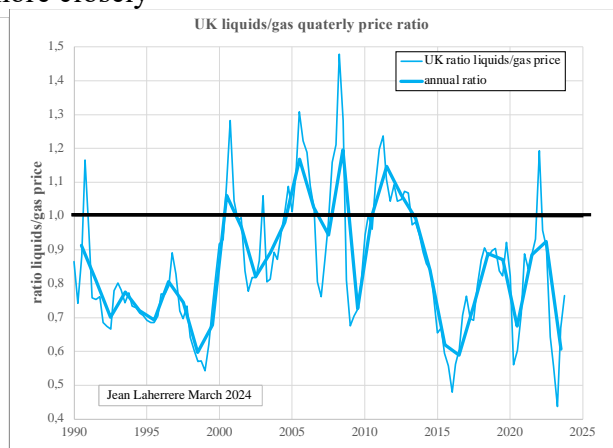


Jean Laherrere March 2024

In UK liquids and gas prices per therm vary more closely

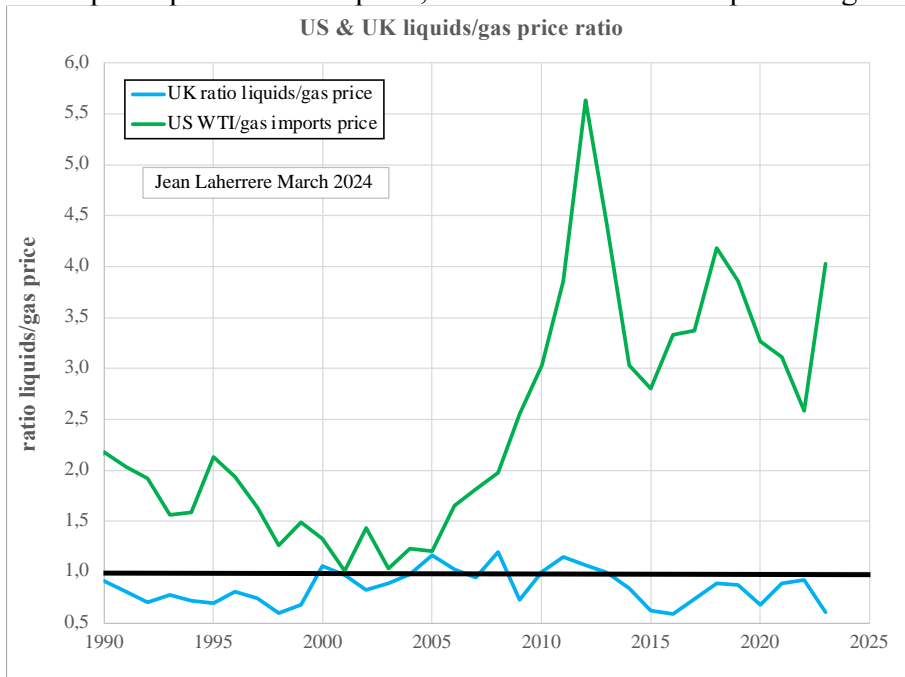


Jean Laherrere March 2024



Jean Laherrere March 2024

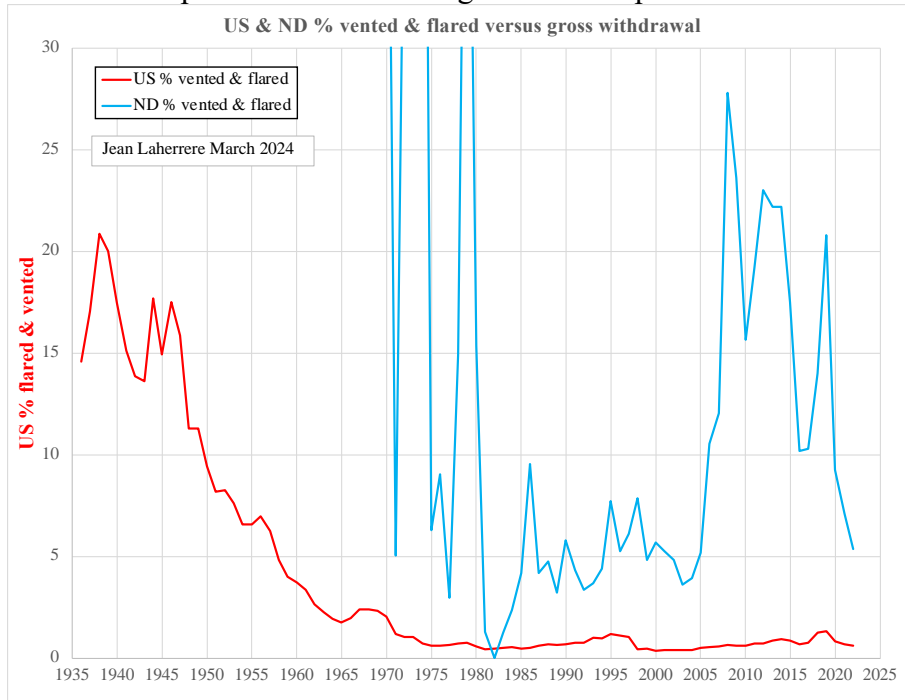
US gas is too cheap compared with oil price, when in UK oil is cheaper than gas



US and UK liquids/gas ratio were similar only from 2000 to 2005

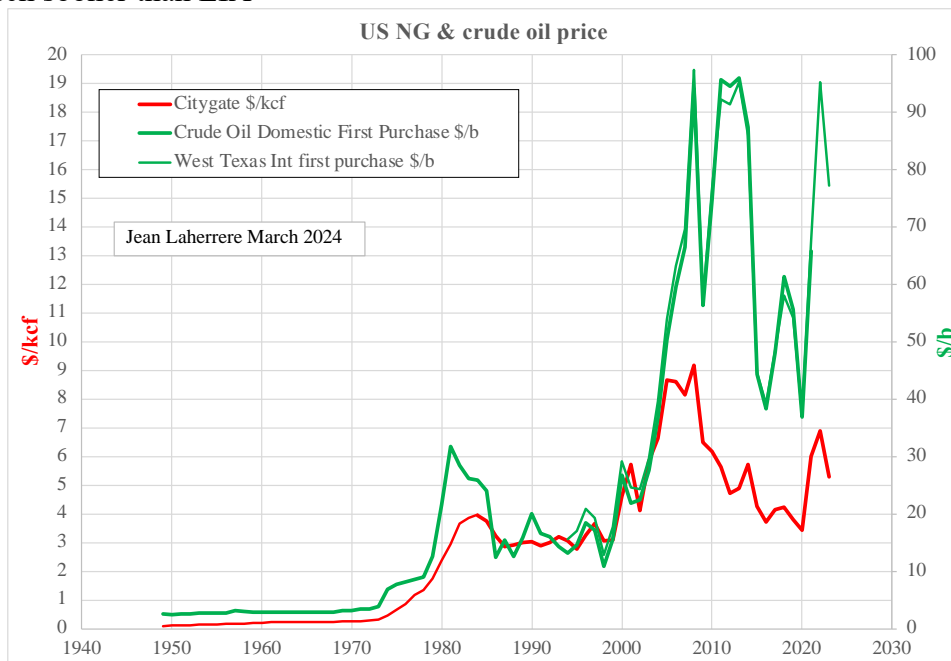
In 1950 15% of US NG production was flared: over 20% of North Dakota NG was flared from 2008 to 2015: what a waste of energy!

US shale gas has disturbed the production when associate gas from oil shale has no pipeline available: oil can be transported with truck not gas: NG transport costs 10 times oil transport.



US oil and NG price per volume (barrel and cubic feet) since 1949 displays a huge change in 2005 with shale plays.

It is interesting to think what will happen with the end of shale oil and shale gas which I forecast much sooner than EIA



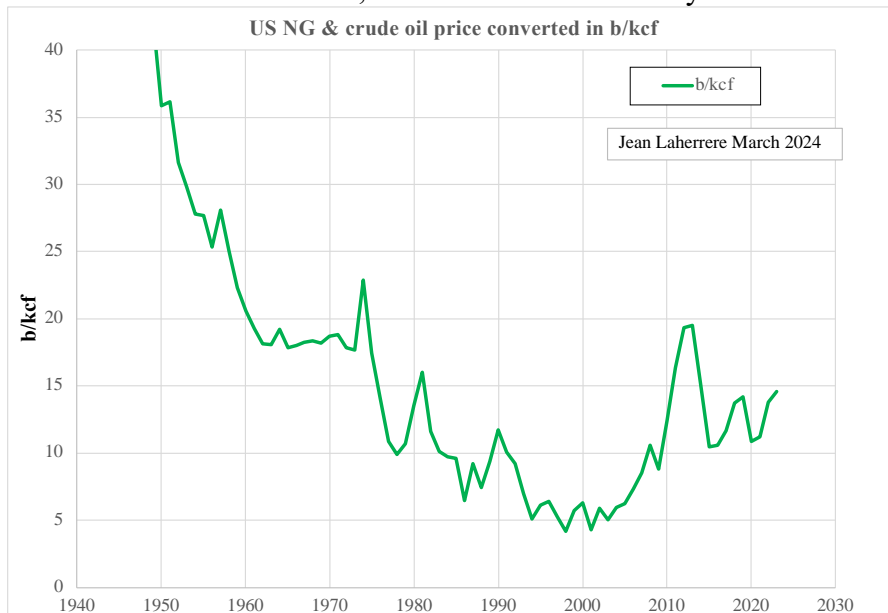
On the graph crude and NG price correlate from 1985 to 2005 for 1 b = 5 kcf

The equivalence is taken as 1b = 5.6 kcf

Since 2005 NG price is too low because shale production.

US industry is privileged compared with Europe because low NG price

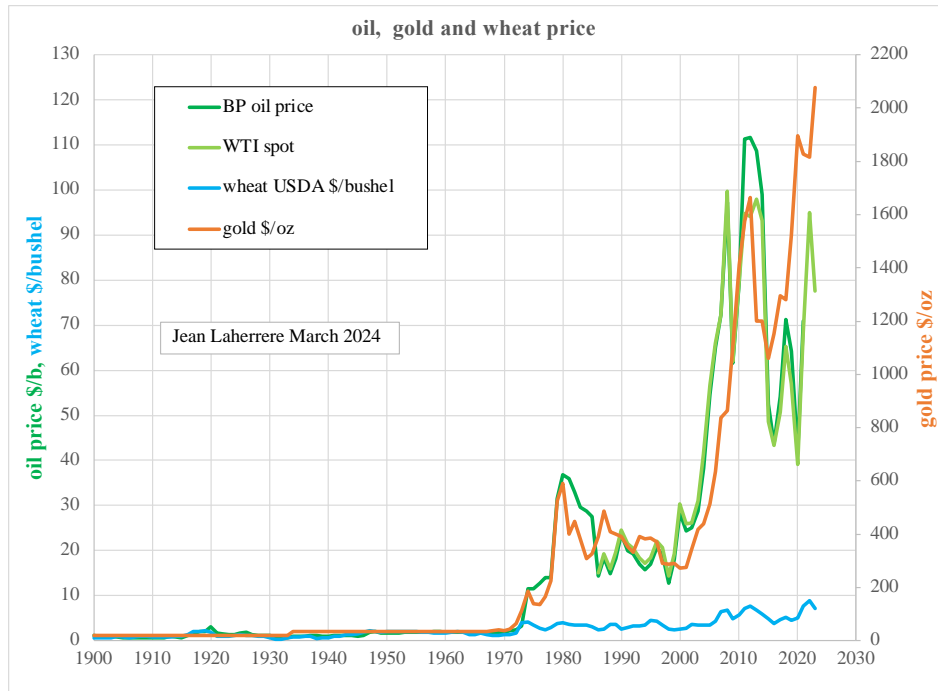
There is only one world oil market because oil is cheap to transport when gas transport is 10 times more expensive and there are several gas markets: North America, Europe and Pacific
 The display of NG and crude oil price converted in b/kcf declined sharply from 1950 to 2000 and was on increase from 2000 to 2010, flat with oscillation today.



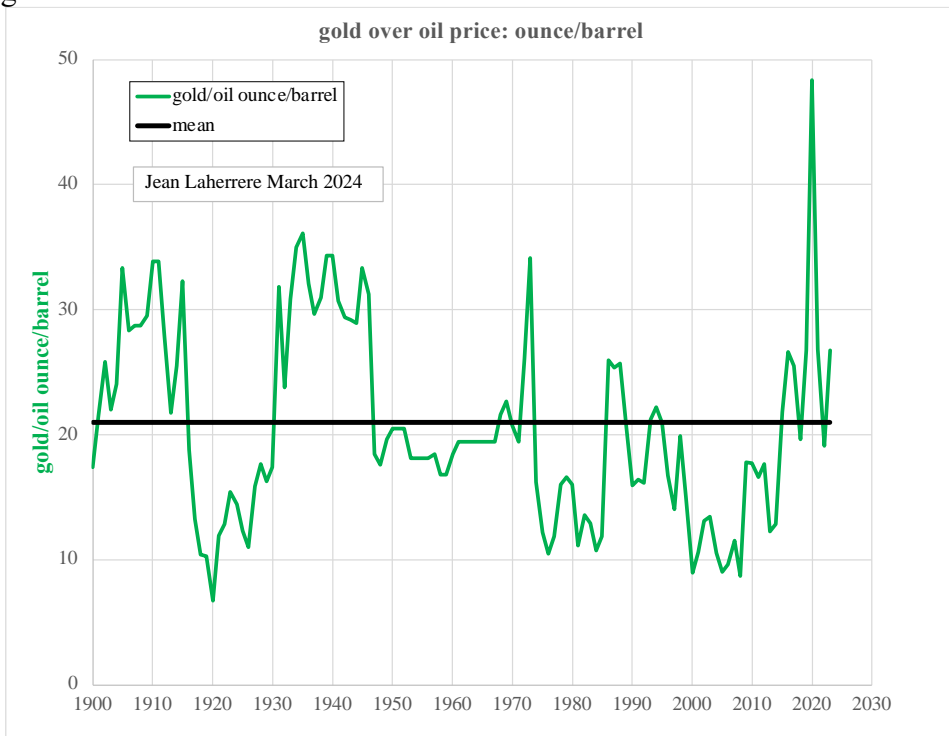
-comparison oil, gold, and wheat price

The comparison of oil, gold and wheat prices since 1900 display a big change in 1976 (oil shock)

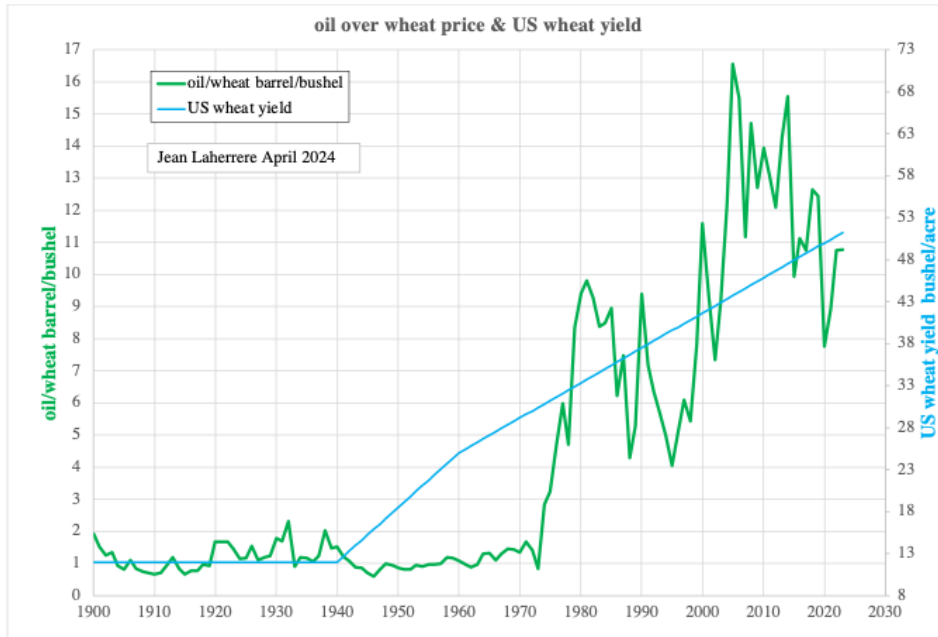
one bushel = 8 dry US gallons = 35,2 l



The gold over oil price since 1900 to 2023 oscillates from 10 to 35, with a mean of one oil barrel = 21 gold ounces.

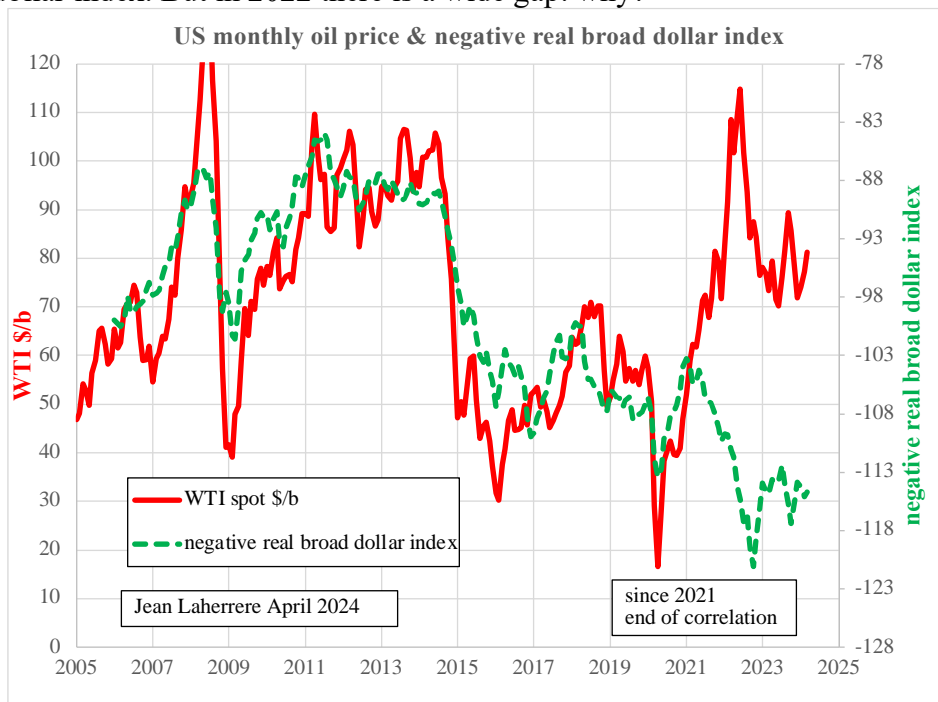


The comparison of gold with wheat price displays a huge change in 1973 with the oil shock, but the (smoothed) US wheat yield was flat from 1900 to 1940 but increases sharply since thank to fertilizers and CO2 increase: wheat yield increase compensates for the lack of price change!

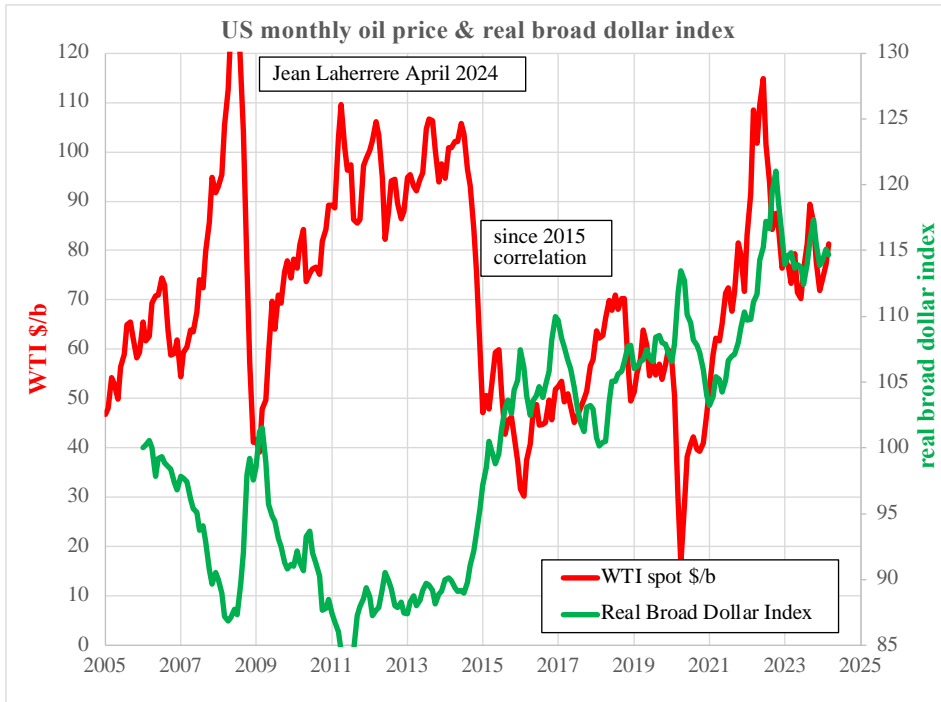


-US oil price and US dollar value

Since 2006 to 2021, there is a good correlation between US monthly oil price and negative real broad dollar index. But in 2022 there is a wide gap: why?



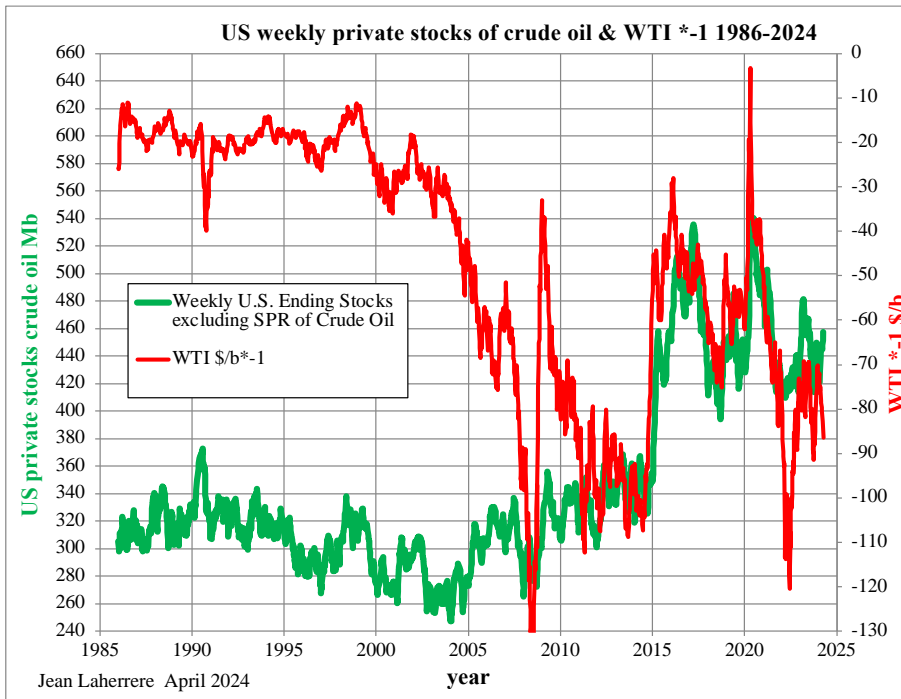
But since 2015 there is a correlation between US monthly oil price and real broad dollar value.



I am unable to explain why these two contradictory correlations, why they start, why they end!
Send me any idea!

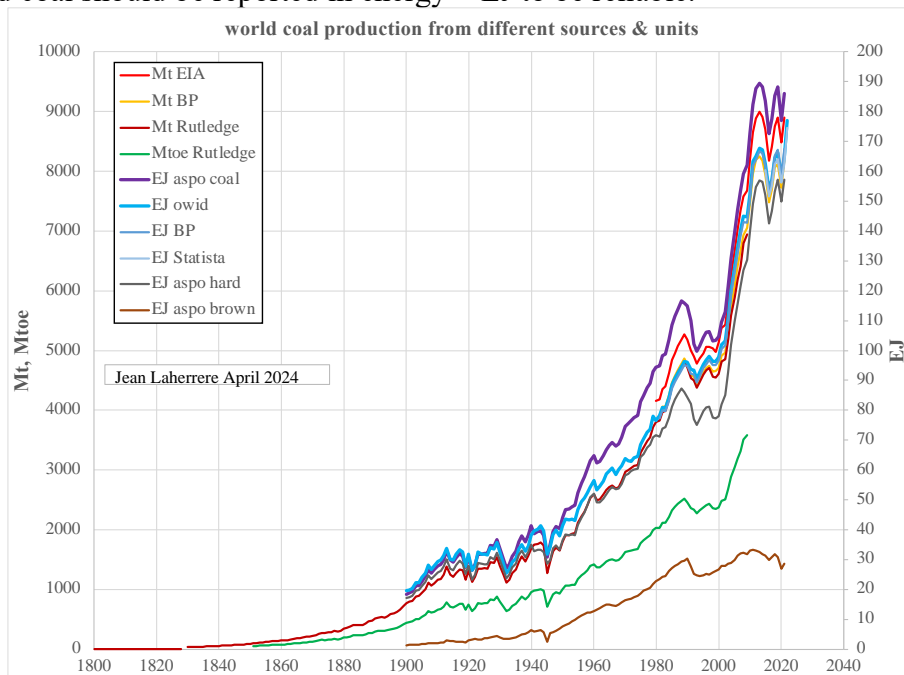
-US oil price and US private oil stocks

There is a good correlation between US weekly private oil stocks and negative oil price WTI only since 2012 when oil price was over 100 \$/b. In the 1990s negative WTI was far from crude stocks!

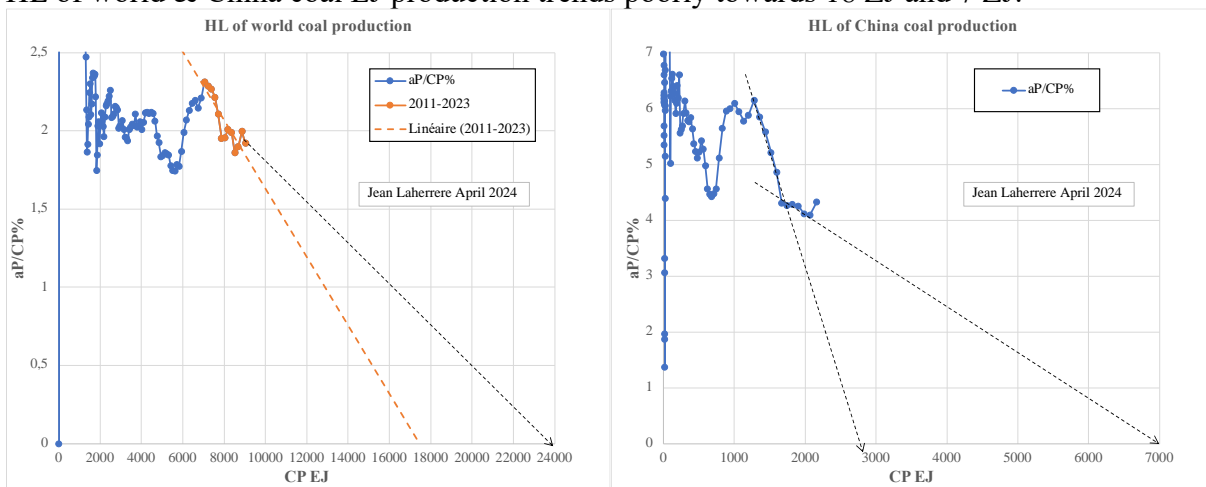


-coal production forecast

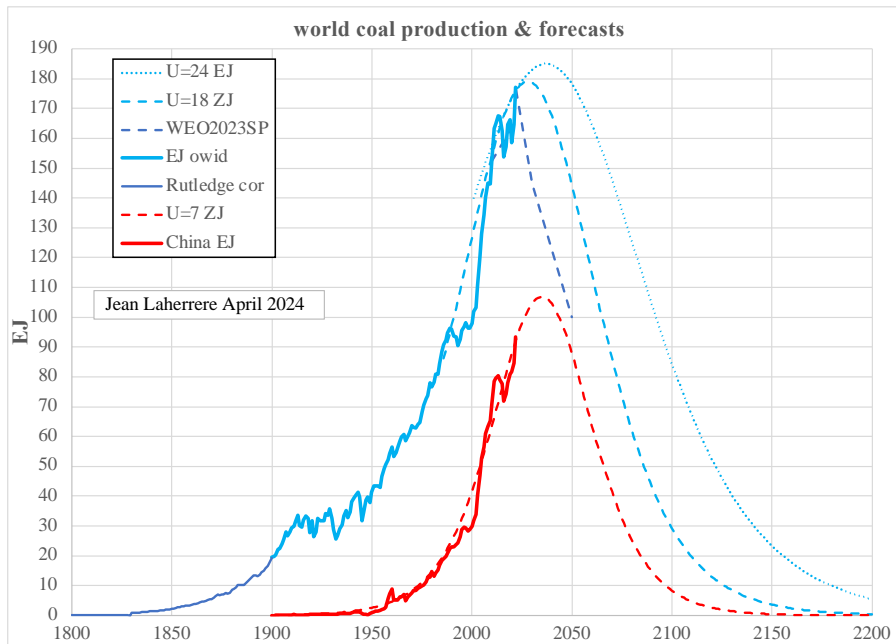
World coal production started in 1800 but there is a large difference between anthracite, hard coal and soft coal, bituminous and subbituminous and lignite with a large range of heat content from 16 to 30 MJ/kg (range 1 to 2). World coal production varies with sources and units. World coal should be reported in energy = EJ to be reliable.



HL of world & China coal EJ production trends poorly towards 18 ZJ and 7 ZJ.

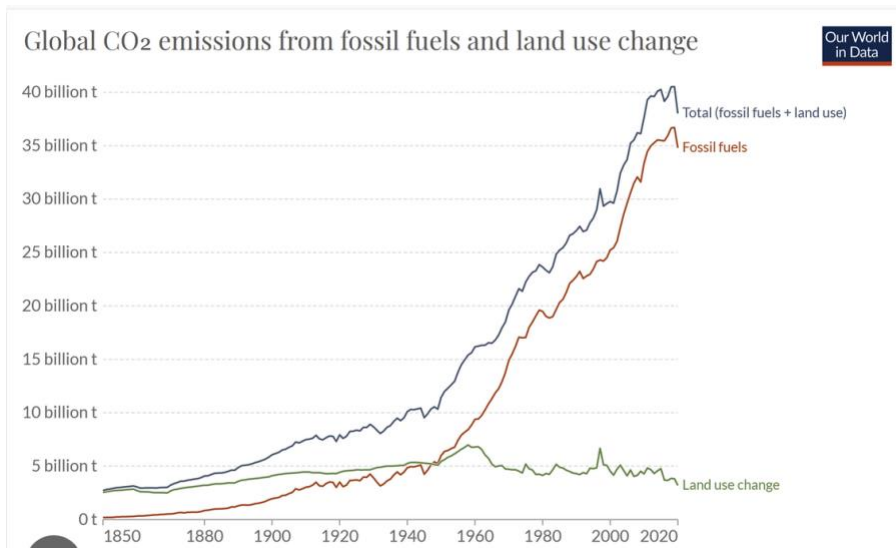


World coal production will peak around 2028 and China over 2030
 IEA/WEO2023SP peaks sooner but IEA decline forecast is parallel to mine.

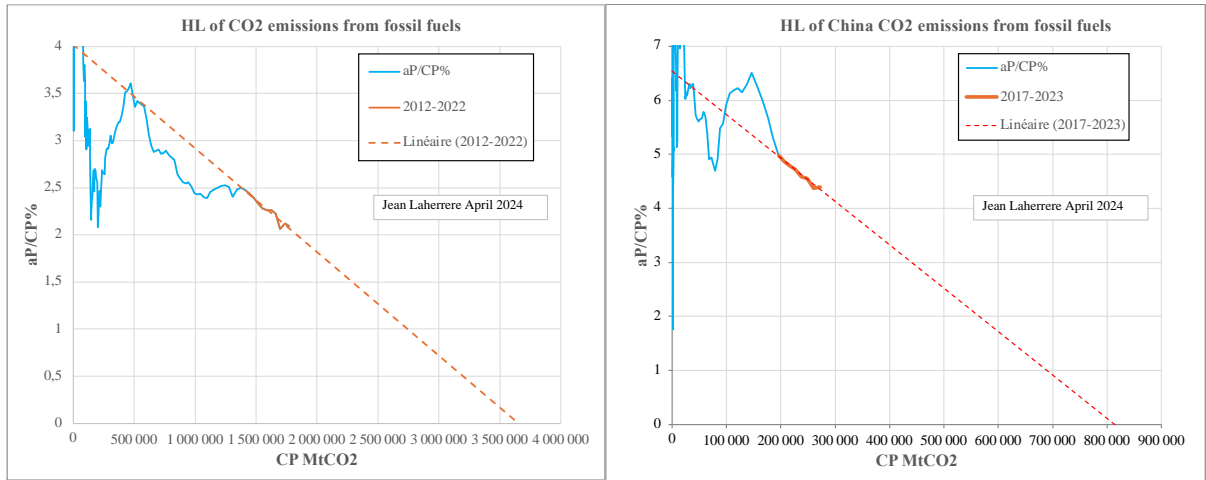


-CO2 emissions

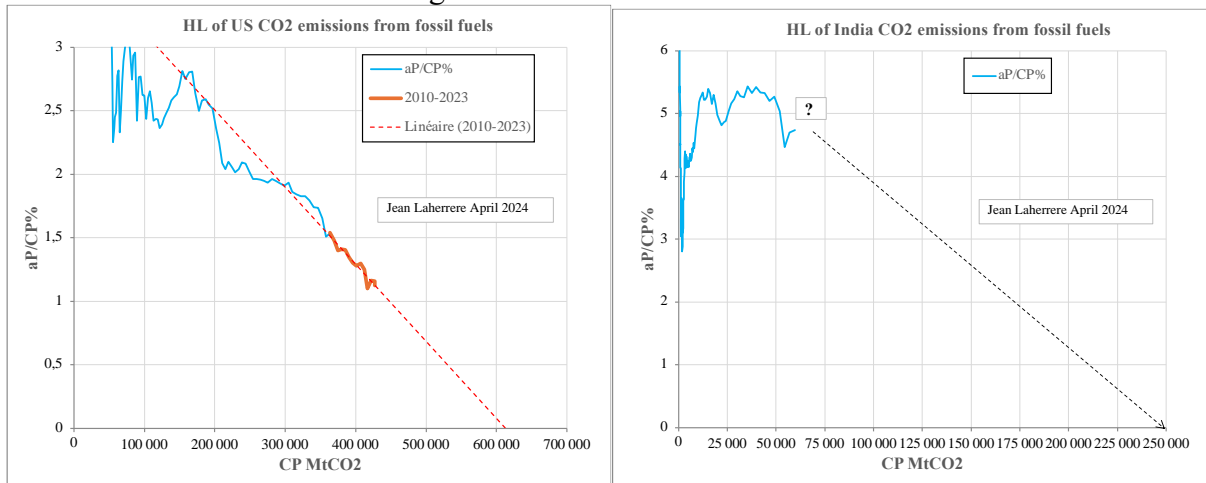
Global CO2 emissions are on the increase since 1945 because fossil fuels



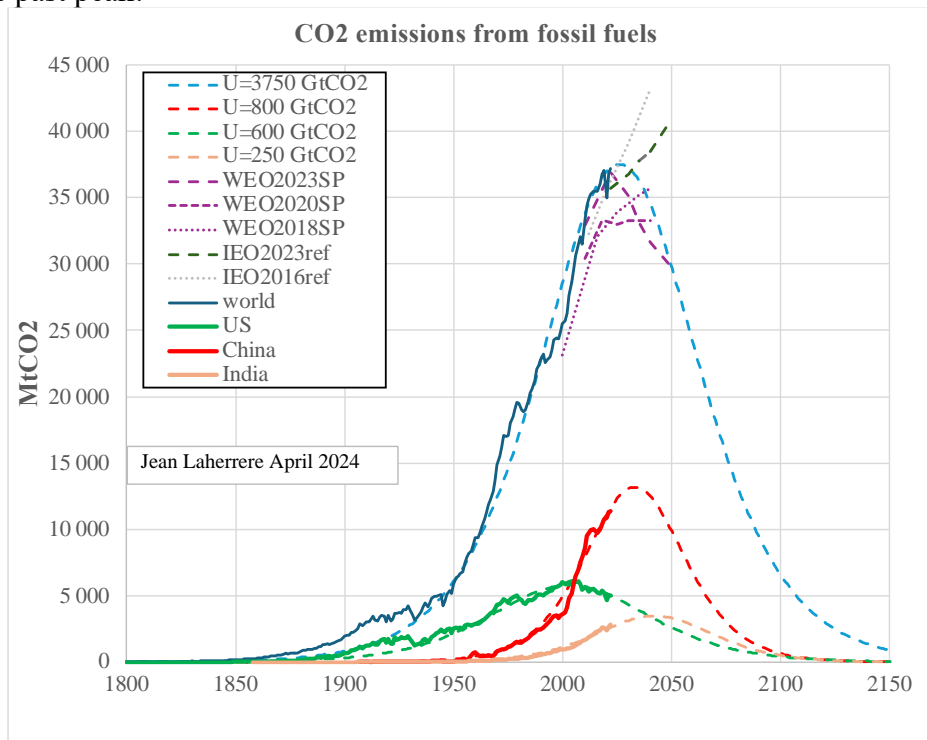
HL of global emissions trends towards 3600 GtCO₂, when for China towards 800



Towards 600 GtCO₂ for US and guess to 250 GtCO₂ for India



The forecast of CO₂ emissions is for a peak soon for the world, 2030 for China and 2040 for India. US is past peak!



EIA IEO2023 reference forecasts global CO2 emissions peak beyond 2050 when IEA WEO2023SP forecasts it much before near 2022, as WEO2018. EIA is always against any peak before 2050

Net zero emissions by 2050 is unrealistic as CCS (carbon capture & storage) needs a lot of energy.

Many international bodies and national governments are relying on carbon capture in the fossil fuel sector to get to net-zero. IEEFA claimed that it was very unfortunate since 'at this stage of the game, it simply won't work.'

Capturing CO2 emissions using direct-air-capture (DAC) technology requires almost as much energy as that contained in the fossil fuels that produced the carbon dioxide in the first place

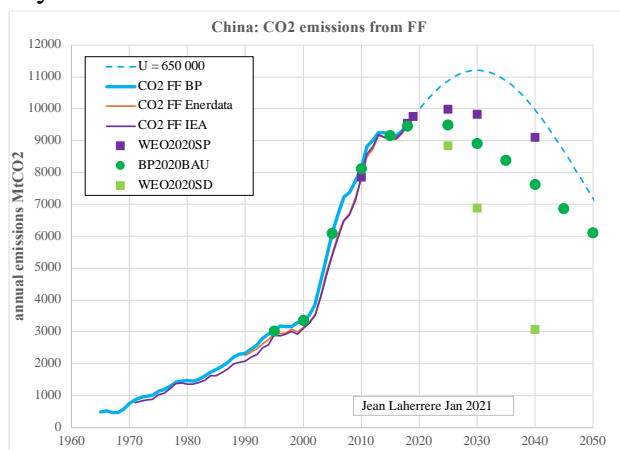
<https://www.rechargenews.com/energy-transition/the-amount-of-energy-required-by-direct-air-carbon-capture-proves-it-is-an-exercise-in-futility/2-1-1067588>

Current CCS needs about 2000 kWh = 7.2 GJ of energy to capture 1 tCO2; present world 35 GtCO2 fuels emissions would need 250 EJ to be captured, which about half of the world primary energy (550 EJ): it is completely unrealistic!

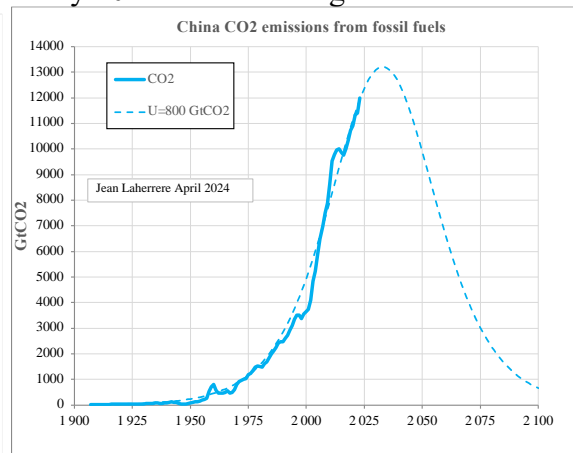
<https://www.shareyourgreendesign.com/energy-fundamentals-of-carbon-capture/>

China, the largest CO2 emitter is committed by 2015 Paris Protocol to reduce its CO2 emissions in percentage of its GDP from 1990: as GDP has sharply increased, COP21 commitment induces no constraint.

My 2021 China CO2 forecast was too low



My 2024 forecast is higher



-CO2 & temperature

Ole Humlum's graph (climate4you "the state of climate 2021") shows that CO2 (Mauna Loa green) follows temperature (HadSST3 blue): green events occur always after blue events.

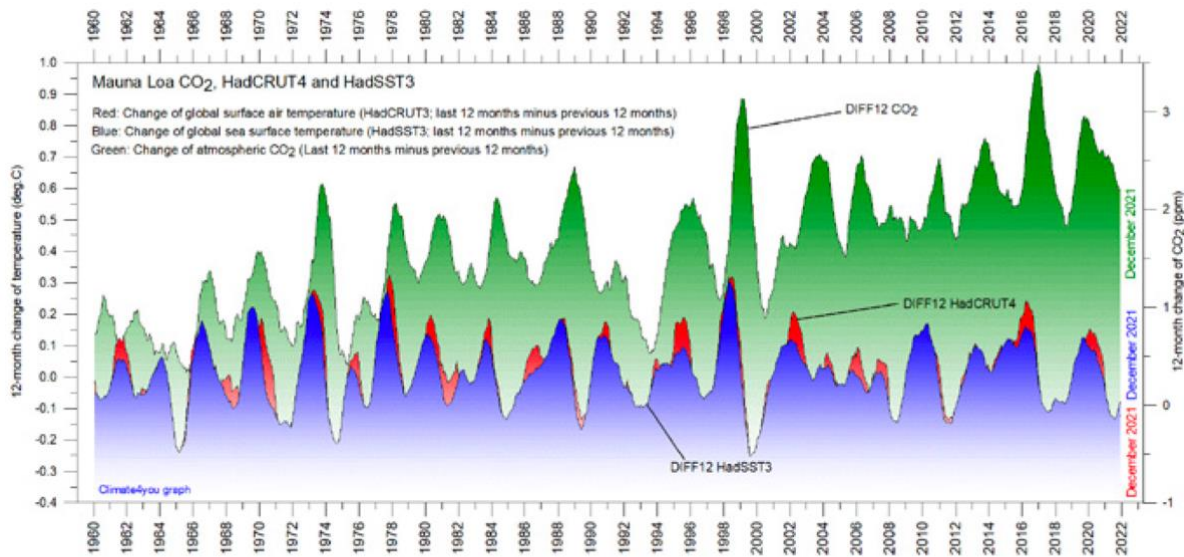
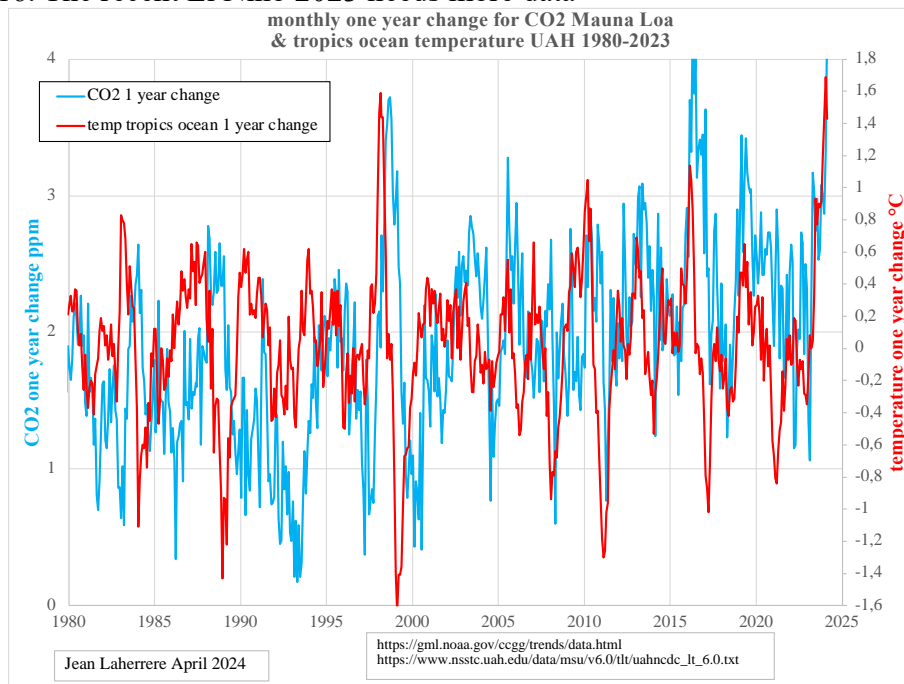


Figure 20: Correlation of carbon dioxide concentrations and temperature records.

Annual (12-month) change of global atmospheric CO₂ concentration (Mauna Loa; green), global sea surface temperature (HadSST3; blue) and global surface air temperature (HadCRUT4; red). All graphs are showing monthly values of DIFF12, the difference between the average of the last 12 months and the average for the previous 12 months for each data series.

My graph uses Mauna Loa data and satellite (UAH) monthly ocean tropics temperature and the El Nino 1998 (red) temperature change occurs obviously before CO₂ change (blue), as for El Nino 2016. The recent El Nino 2023 needs more data



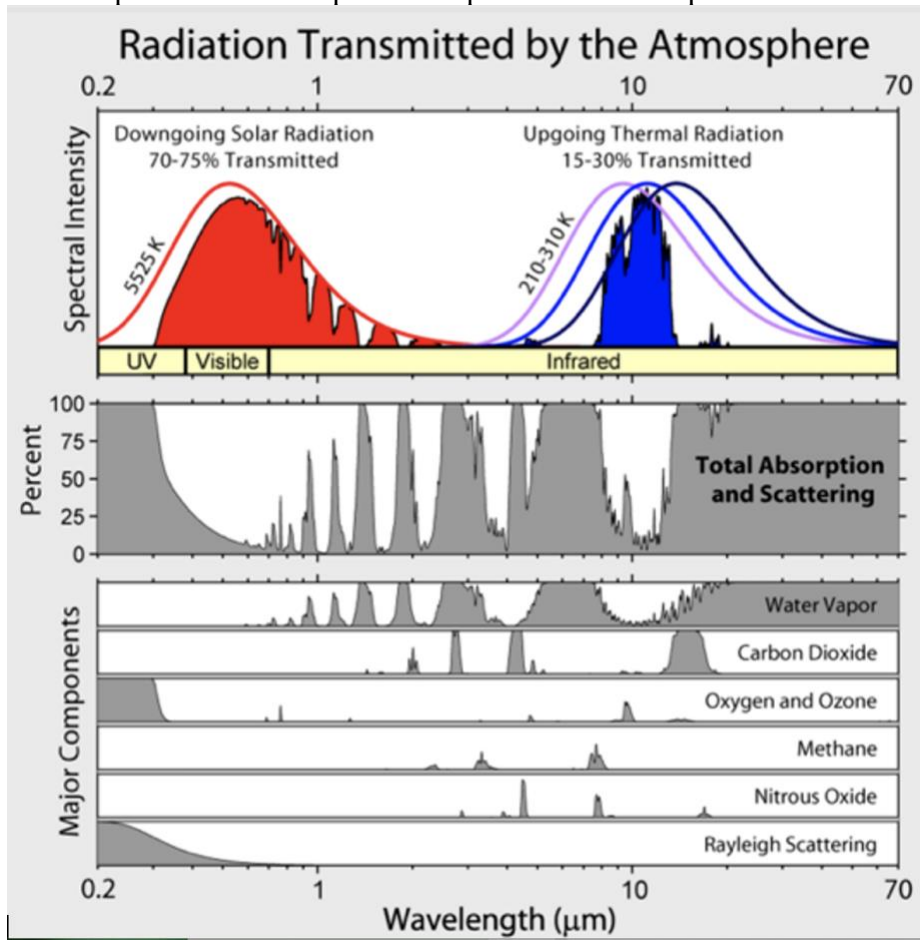
Those who believe that reducing CO₂ anthropic emissions will reduce temperature believe in Santa Claus!

Those who dream about a world without carbon forget that life on earth is based on carbon: herbivores eat plants = carbon and carnivores eat herbivores!

An increase in ambient CO₂ to 800-1,000 ppm can increase yield of C₃ plants up to 40%-100% percent and C₄ plants by 10%-25% while keeping other inputs at an optimum level.

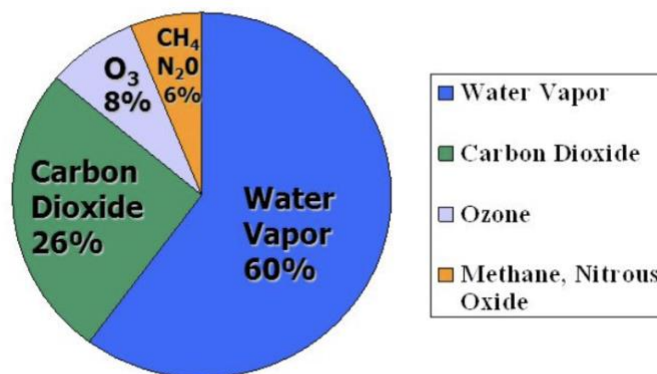
<https://extension.okstate.edu/fact-sheets/greenhouse-carbon-dioxide-supplementation.html>

CO2 has a minor impact in the atmosphere compared to water vapor as shown on this table



There are few tables giving the impact of CO2 as a greenhouse gas, the best known is by Kiehl & Trenberth 1997, where, **by clear sky**, CO2 represents only 26% compared with water vapor 60%, no data for cloudy sky!

The Natural Greenhouse Effect: clear sky



Clouds also have a greenhouse effect

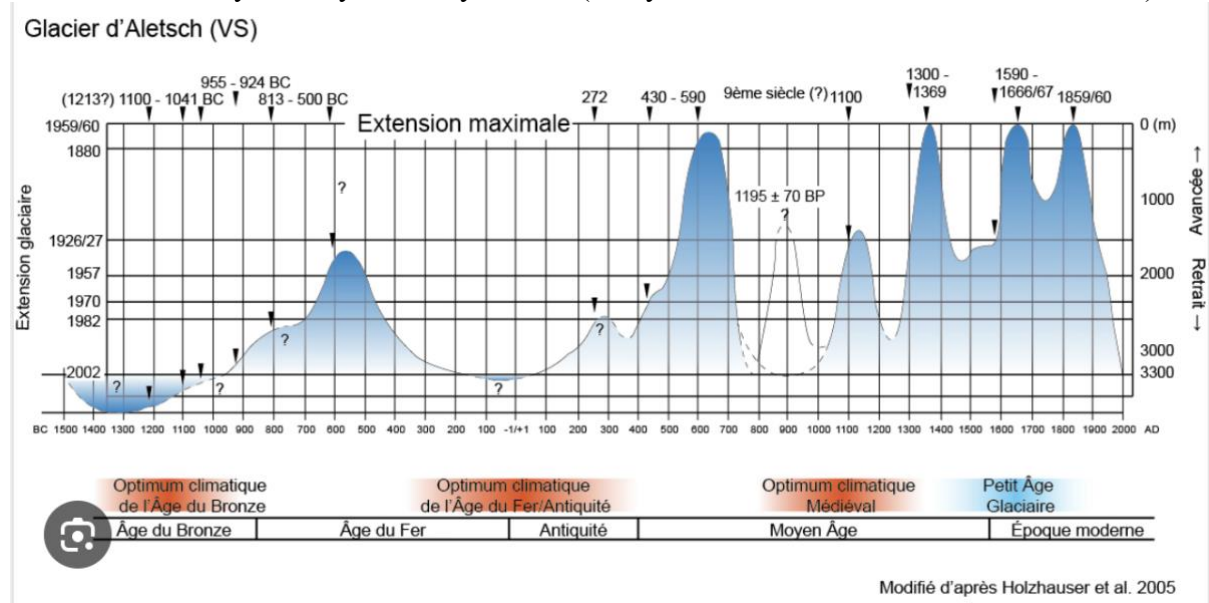
Kiehl and Trenberth 1997

In climate change run (only one point each 150 km) it is easier to model CO2 than cloud!

Many people believe that today we are in a climate deregulation, but the only rule of climate is to change

Temperature can be measured only for the last 300 years, but the change in glaciers extension can be measured and dated on a longer period.

The largest Alps glacier Aletsch extension is measured since the Bronze age, which was much warmer than today, as on year 1 or year 900 (vineyard in London and cows in Greenland)

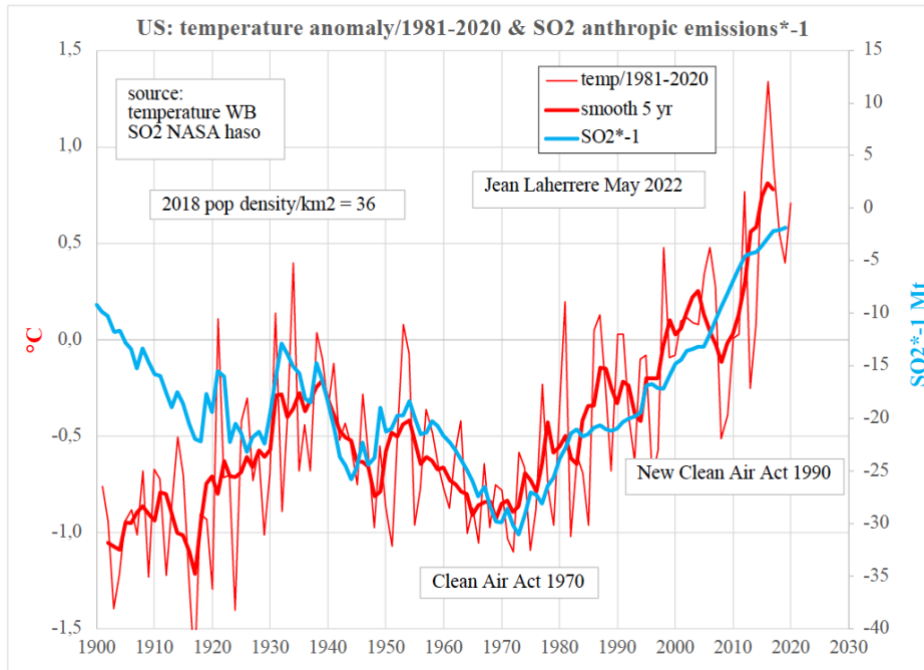


Climate Intelligence (clintel.org) is an independent foundation informing people about climate change and climate policies. Clintel was founded in 2019 by emeritus professor of geophysics Guus Berkhout and science journalist Marcel Crok.

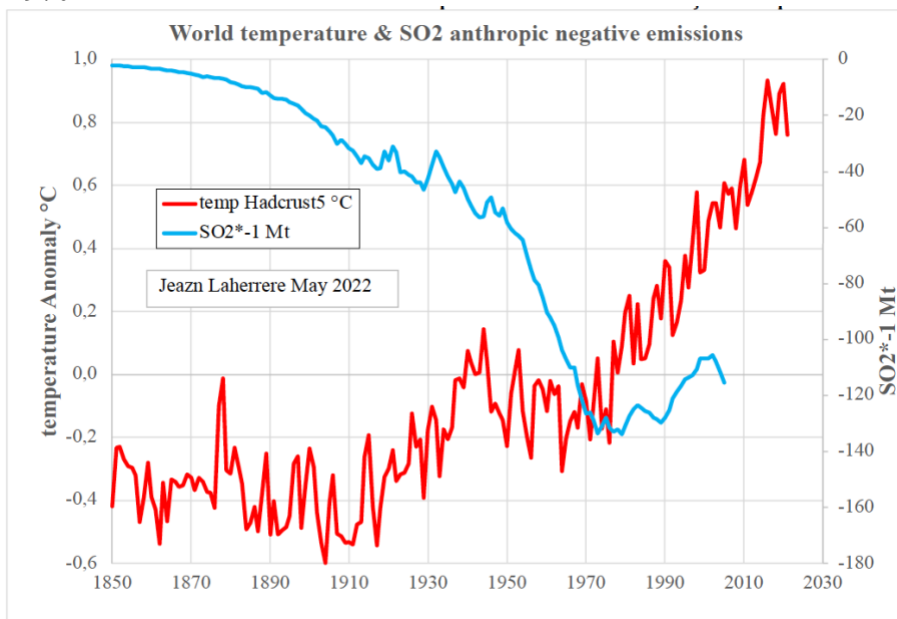
*John F. Clauser, winner of the 2022 Nobel Prize in Physics for his work on quantum mechanics, has decided to sign the World Climate Declaration of Clintel with its central message “**there is no climate emergency**”. Clauser is the second Nobel Laureate to sign the declaration, Dr. Ivar Giaever was the first. The number of scientists and experts signing the World Climate Declaration is growing rapidly and now approaching 1600 people.*

-SO2 & temperature

In my 2022 paper “France et le monde: temperature, population & SO2” this graph shows a very good correlation in US between temperature 1925-2020 and negative SO2 emissions



It is well known that SO2 emissions cool the atmosphere
 The world temperature starts to increase sharply from 1970 when SO2 emissions stopped
 because the 1970 Clean Air Act and the removal of sulfur in fuels



Central England temperature started to increase in 1970 when SO2 emissions started to decline

f

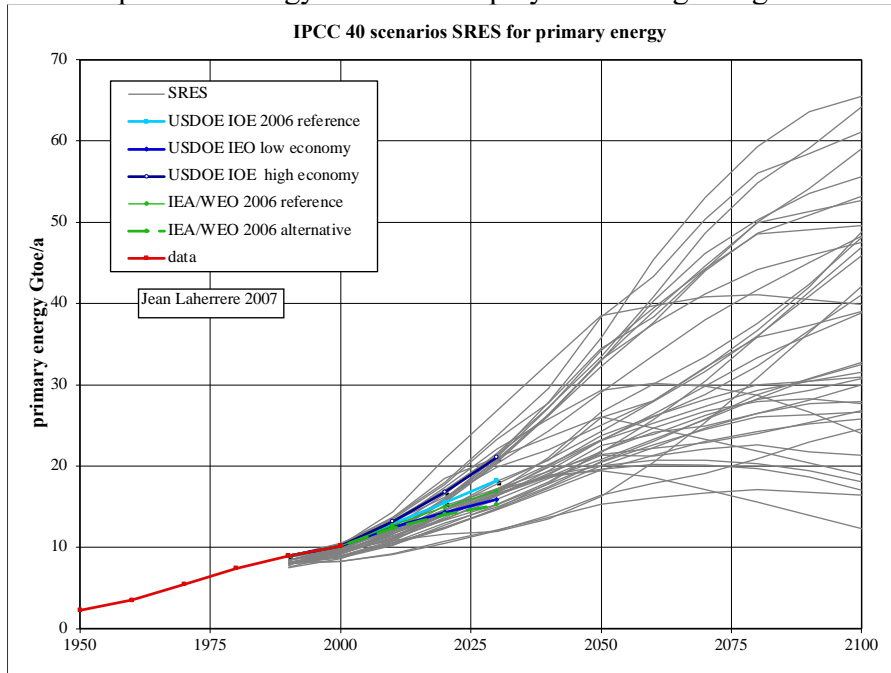
Atmosphere can be cooled by spraying SO2 particles into the stratosphere, more than 12 miles above the earth's surface to reflect sunlight back into space.

-IPCC AR6 scenarios

IPCC 6 reports are 1990, 1995, 2001, 2007, 2014, 2019.

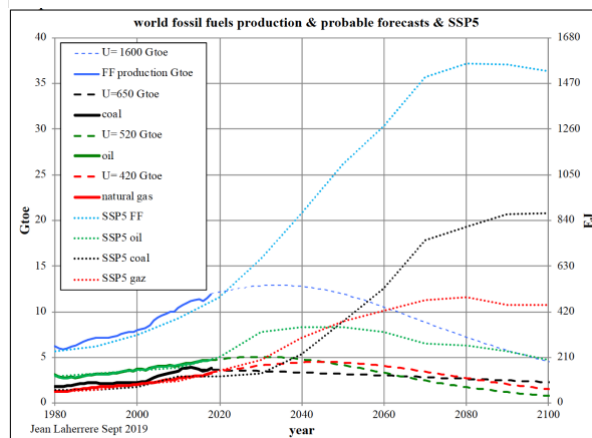
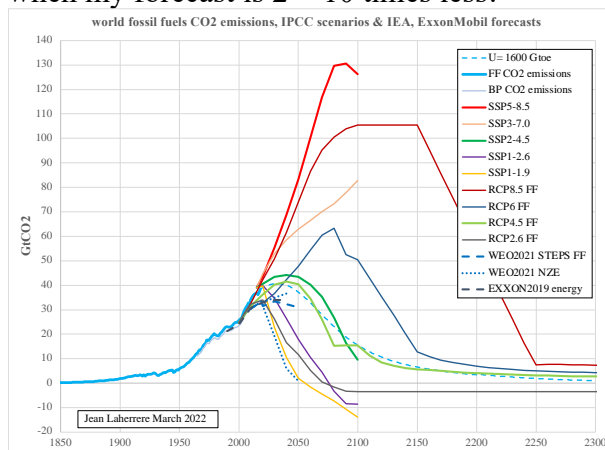
My 2019 paper "Are there enough fossil fuels to generate the IPCC CO2 baseline scenario?"

<https://aspofrance.files.wordpress.com/2019/08/ipccco2rcp.pdf> indicates that IPCC scenarios were designed before 2000 by IIASA led by Dr Nakicenovic who describes them as “storylines but not forecasts”
 For the first IPCC reports 40 energy scenarios display with a large range in 2050:



IIASA economists designed IPCC 40 energy scenarios without bothering to compare their “storylines” to real forecasts estimated by energy experts as IEA.

IPCC last report AR6 scenarios are reduced to 5 “shared socioeconomic pathways” SSP 1 to 5, but most are unrealistic. SSP5 (fossil fuels development) forecasts in 2050 to emit 126 GtCO₂ (38 in 2019) when SSP2 forecasts only 10 GtCO₂, and to consume >20 Gtoe of coal when my forecast is 2 = 10 times less!



IPCC SSP5 forecast of an increase of >4°C in 2100 is unrealistic, based on crazy scenarios!

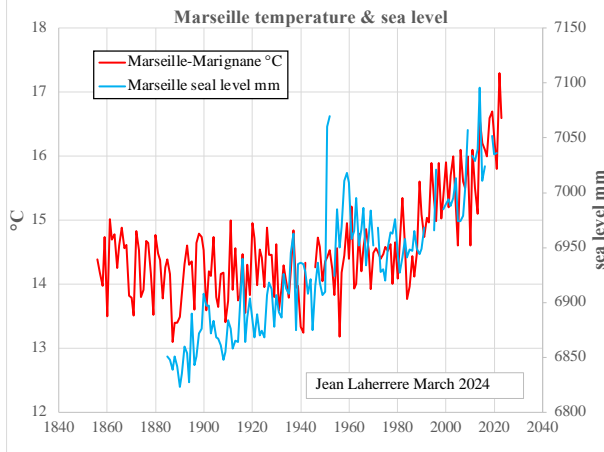
SSP	Scenario	Estimated warming (2041–2060)	Estimated warming (2081–2100)	Very likely range in °C (2081–2100)
SSP1-1.9	very low GHG emissions: CO ₂ emissions cut to net zero around 2050	1.6 °C	1.4 °C	1.0 – 1.8
SSP1-2.6	low GHG emissions: CO ₂ emissions cut to net zero around 2075	1.7 °C	1.8 °C	1.3 – 2.4
SSP2-4.5	intermediate GHG emissions: CO ₂ emissions around current levels until 2050, then falling but not reaching net zero by 2100	2.0 °C	2.7 °C	2.1 – 3.5
SSP3-7.0	high GHG emissions: CO ₂ emissions double by 2100	2.1 °C	3.6 °C	2.8 – 4.6
SSP5-8.5	very high GHG emissions: CO ₂ emissions triple by 2075	2.4 °C	4.4 °C	3.3 – 5.7

SSP1 is also unrealistic!

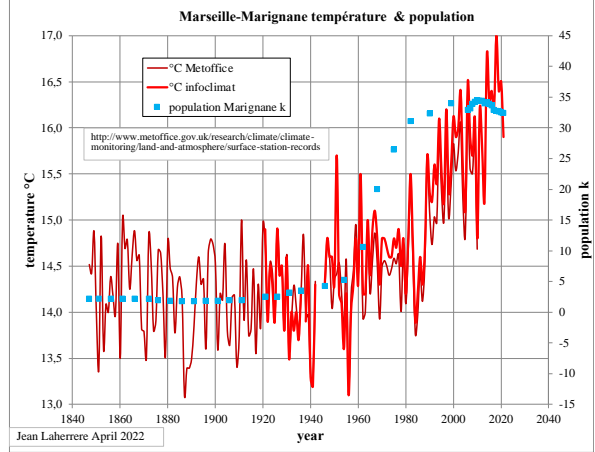
-temperature & sea level

Marseille

Temperature & sea level



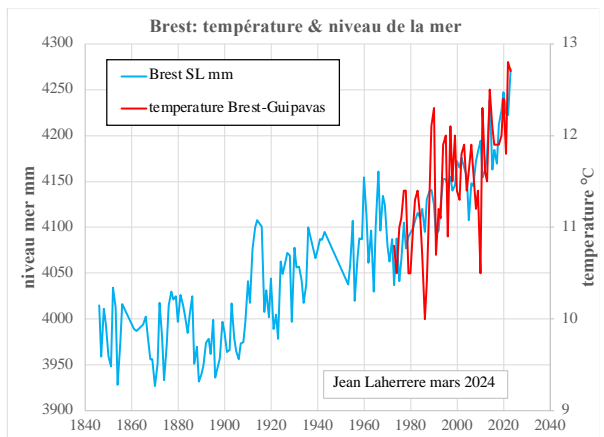
Temperature & population



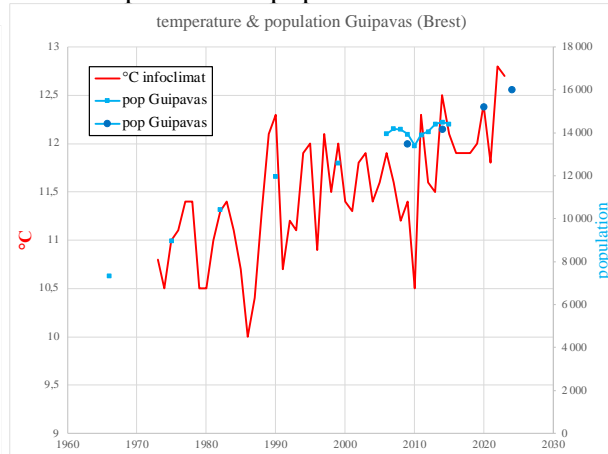
Temperature & sea level correlate well since 1930

Brest

Temperature & sea level



Temperature & population



World

Temperature and sea level

Global sea level 1900-1920 displaying waves in 1940

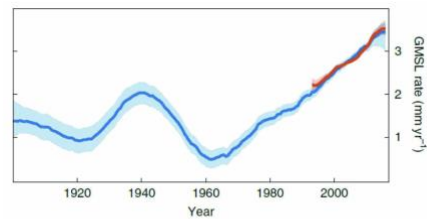
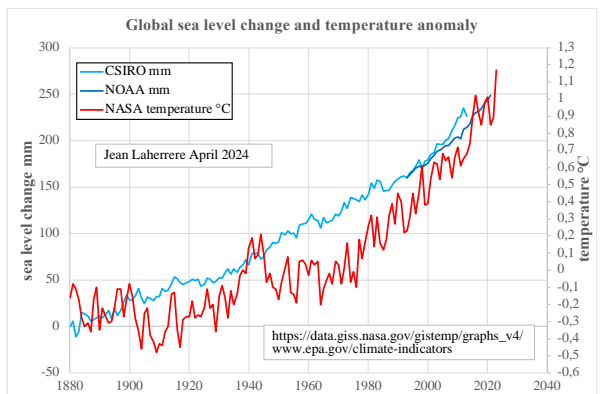
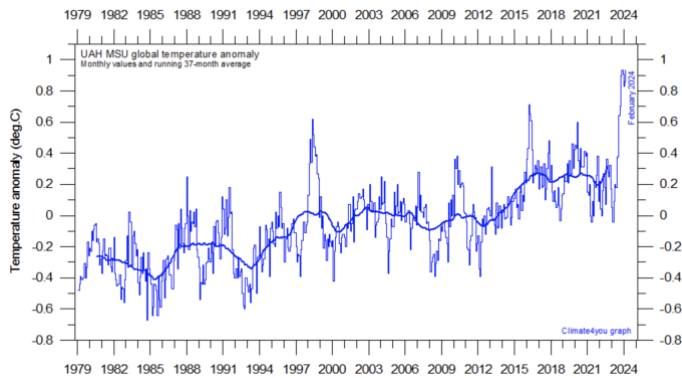


Figure 1—Global mean sea level (GMSL) trend in mm per year from 1900 to 2015; based on data from tide gauges and satellites. From Dangendorf et al. (2019)³⁸.

Detail temperature & sea level since 1980
 temperature satellite UAH



sea level

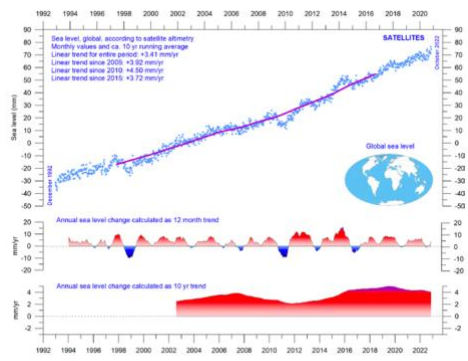


Figure 35: Global sea level change since December 1992

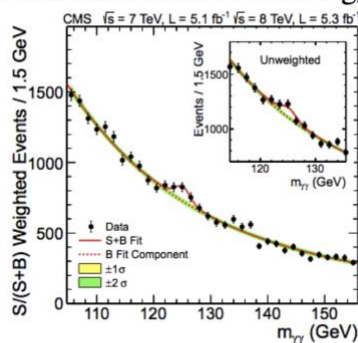
-Higgs boson and science

In 2005 I was invited to make a presentation at the CERN near Geneva «Peak oil and other peaks» www.hubbertpeak.com/laherrere/CERN200510.pdf and I visited the LHC (Large Hadron Collider) and its detector CMS where the Higgs boson was detected in 2012.

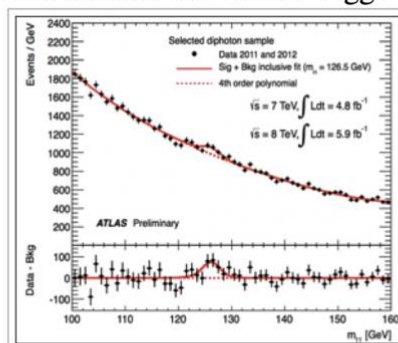
Higgs boson in quantum mechanics explained how the particles got mass in the mid-sixties. In my 2019 paper «Le pic pétrolier ? implication économique, climatique et démographique » Sciences Po forum <https://aspofrance.files.wordpress.com/2019/03/sciencespo-19mars2019pres.pdf> I show these graphs where the boson is found as a bump in a display of number of events versus energy.

In 2012 a small bump in CMS detector is found at 125 GeV (130 times more massive than a proton) but almost none for the detector Atlas. In 2015 a bump is found at 750 GeV at Atlas and called particle X, but described later in 2016 as artefact.

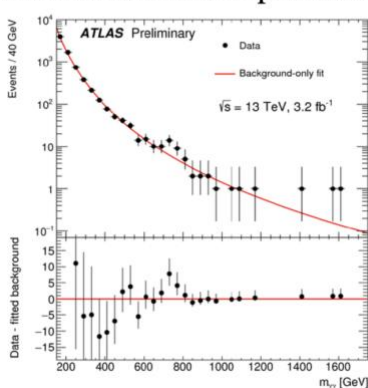
Détecteur CMS = boson Higgs = bosse



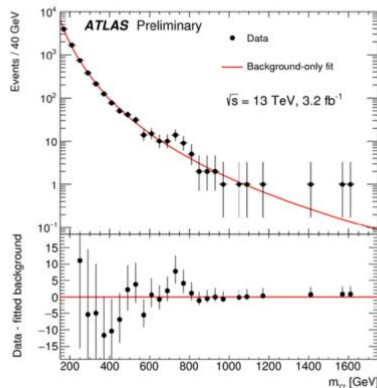
Détecteur Atlas = boson Higgs = bosse similaire



En 2015 découverte particule X à 750 GeV



En 2016 = X = artefact



What I find the most uncertain is the degree of certainty reported

When the New Scientist reported about the putative confirmation of the Higgs boson, they wrote: ‘Five-sigma corresponds to a p-value, or probability, of 3×10^{-7} , or about 1 in 3.5 million. There’s a 5-in-10 million chance that the Higgs is a fluke.’

Read <https://dirnagl.com/2014/07/28/higgs-boson-and-the-certainty-of-knowledge/>

The 2012 Higgs boson discovery is far for being a certitude and furthermore I am unable to find 12 years later what this discovery has achieved in reality!

It is a fact that particles have a mass! The problem is the neutrino.

Few people know that their bodies are crossed by 100 trillion neutrinos every second!

The problem is that scientists are unable to find the way the Universe works.

Quantum mechanics does not agree with general relativity!

Is an electron a particle or a wave?

Nobody has seen the “3 quarks” inside the nucleus: they see only what goes out when shooting across: quark is not a fact but a theory!

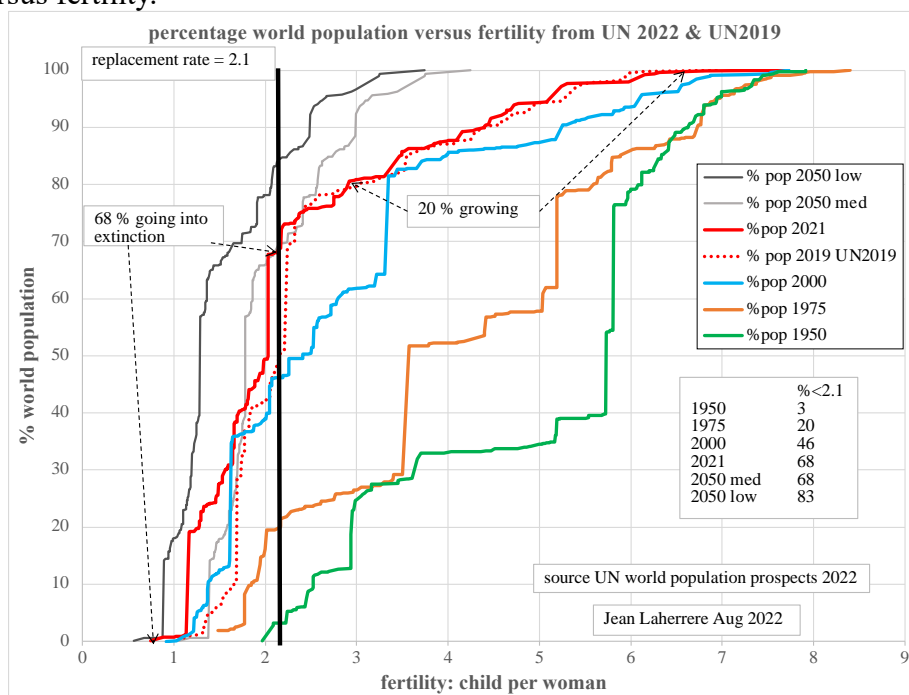
In astronomy Universe is presented with Dark Matter and Dark Energy being 95 % of the mass, but without knowing what it is and where it is: a perfect mess! But if Newton law is slightly changed (Mond theory) dark matter and dark energy are not needed anymore!

Peter Higgs has passed away in April 2024 at the age of 94.

-world fertility & extinction

In my 2022 paper: “In 2021, 68% of the world is going into extinction”

<https://aspoFrance.org/2022/09/18/in-2021-68-of-the-world-is-going-into-extinction/> I display the graph of percentage of the world versus fertility.

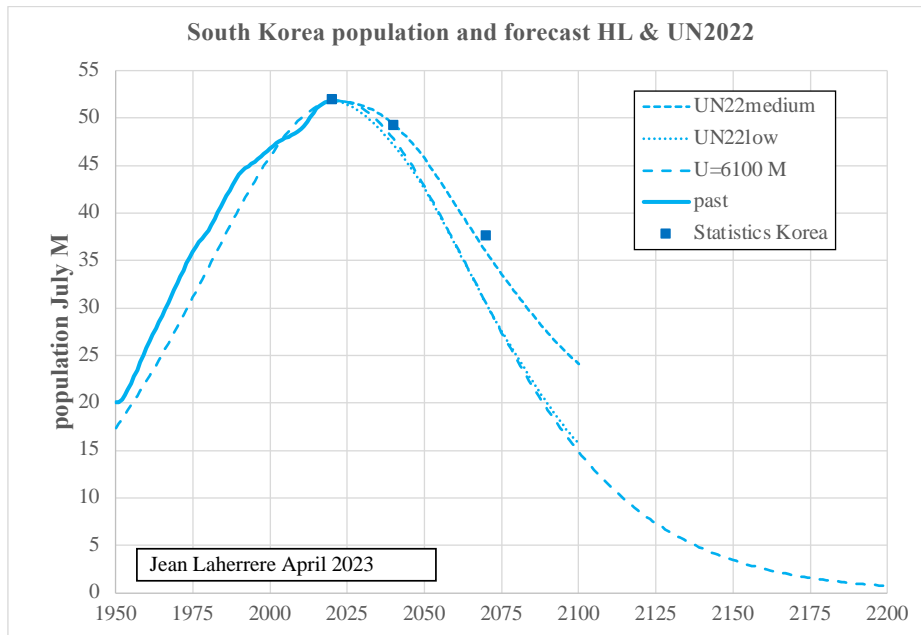


In 1950 only 3% of the world population was below the fertility rate of replacement being 2.1 child per woman. But in 1975 the percentage was 25 %, in 2000 46% and in 2021 68%: the change is drastic meaning that soon most of the world will go towards extinction except the African countries below Sahel, which will move all around to fill the empty places. It is called the Great Replacement!

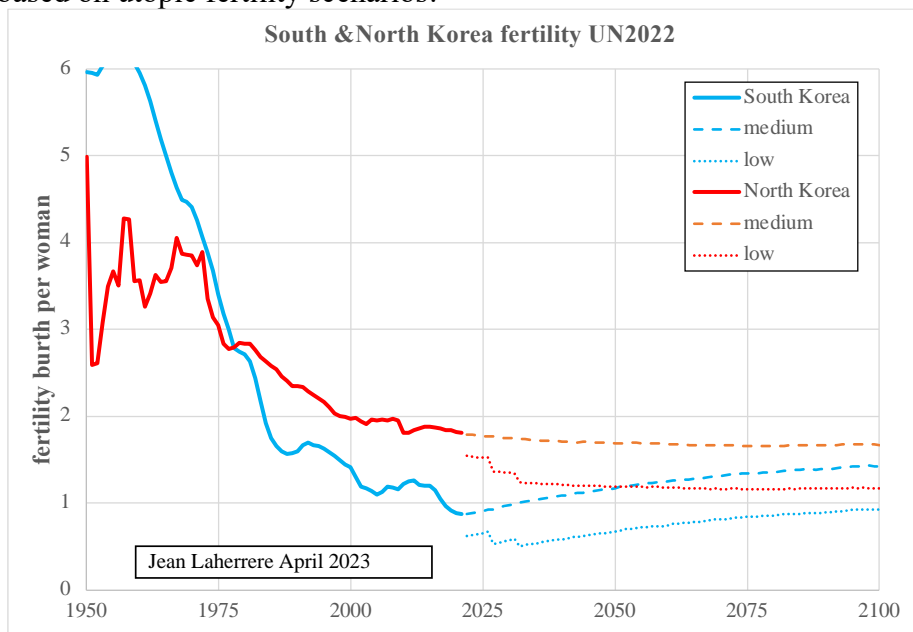
In the past I was worried by the future lack of resources, but today it is by the lack of fertility.

South Korea fertility is 0,72 children per woman in 2023 (Statistics Korea), 0.78 in 2022.

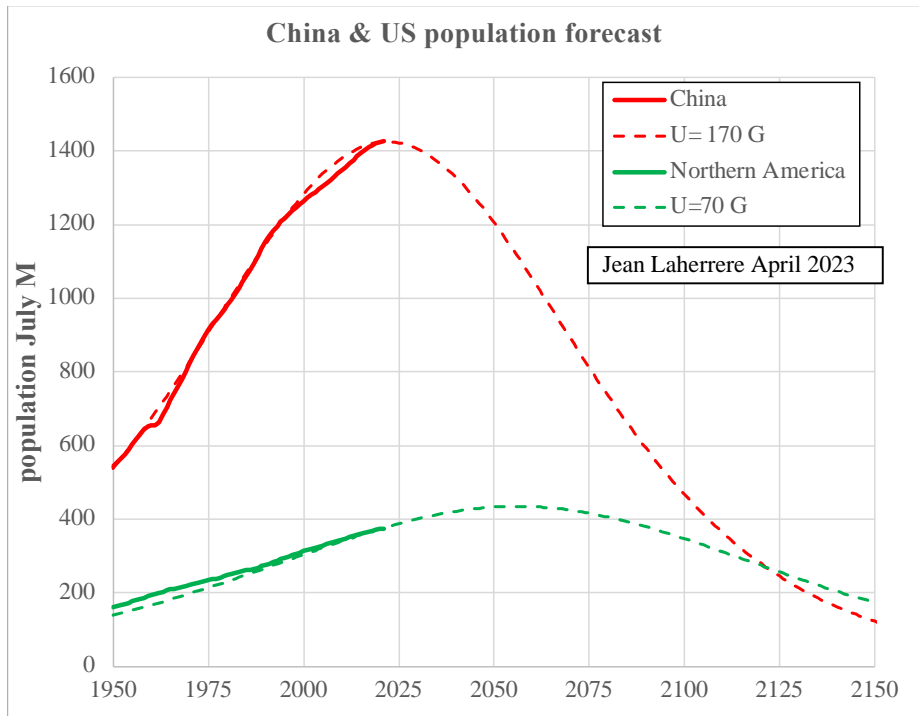
South Korea population is presently peaking at 52 M, but could be only 15 M in 2100:



South Korea fertility is much less than North Korea: UN2022 medium forecast for a future increase is based on utopic fertility scenarios!

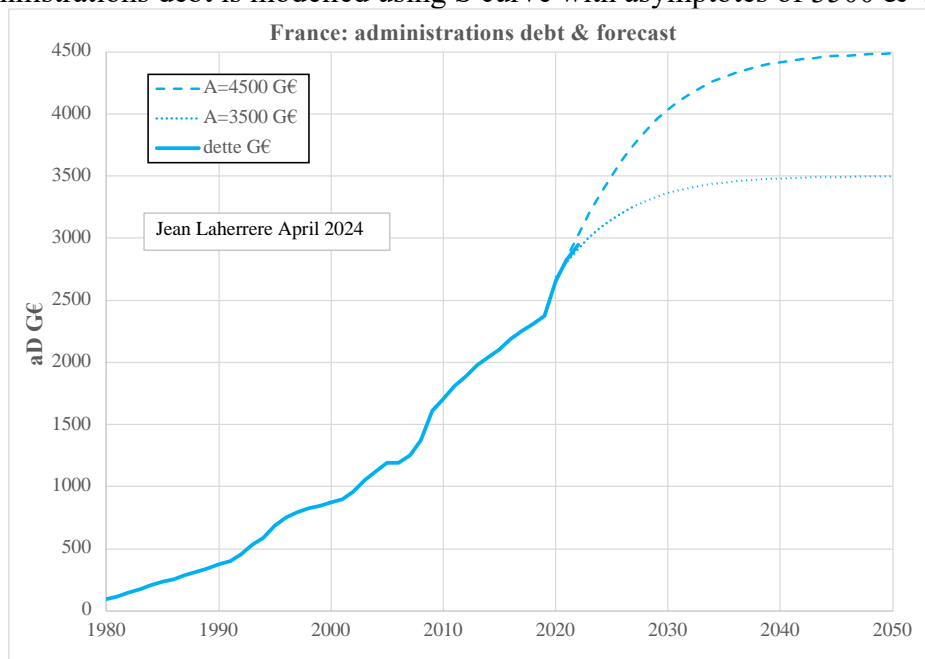


In 2120 China could have the same population as US.
 Xi Jinping dream of China being ahead of US in 2049 looks very difficult to reach.
 In addition, Xi policy of putting the Communist Party in control of everything perturbs China dynamism when removing successful Jack Ma! Real Estate collapse with Evergrande is a good example of some Chinese tycoons .poor policy

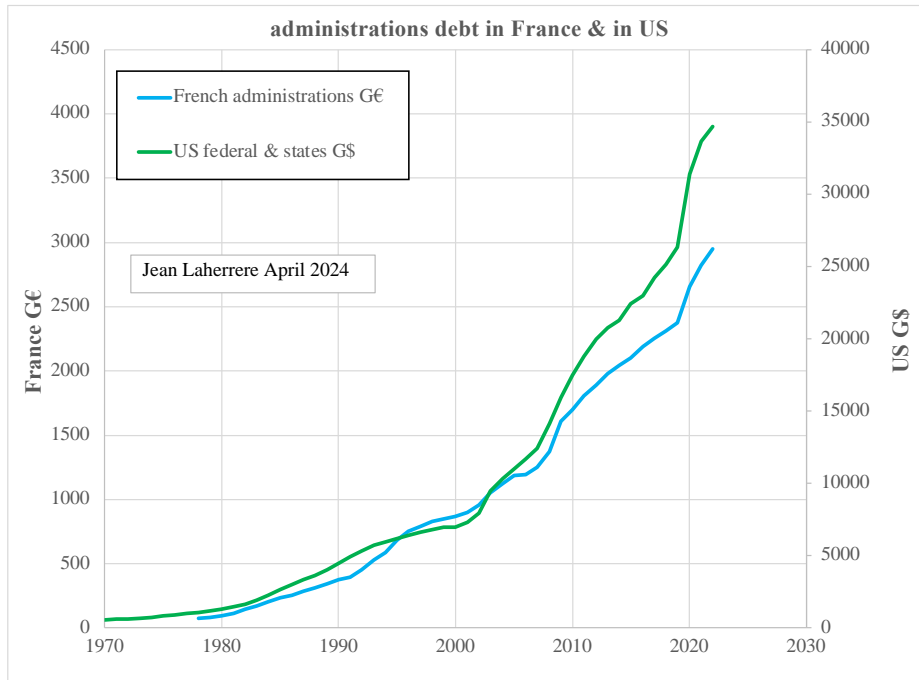


-France & US administrations debt

French administrations debt is modelled using S curve with asymptotes of 3500 & 4500 G€

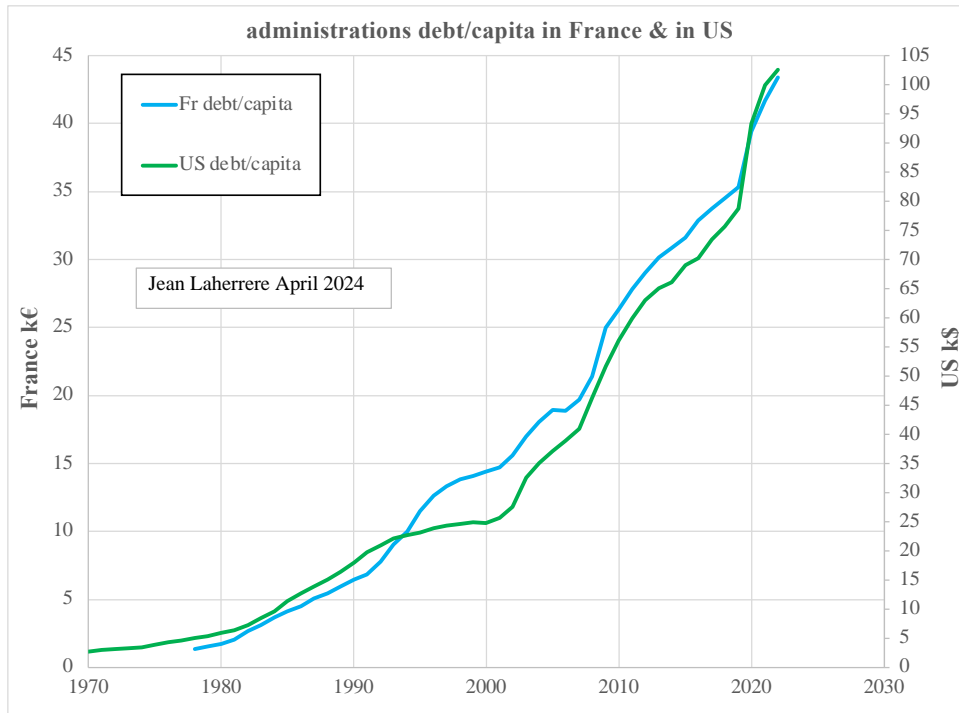


France debt was compared with US debt: their trends were similar from 1970 to 2009, but beyond US is getting worse



But the graph of debt per capita displays a different story as the change in population is different: France is above from 1995 to 2019

US for the covid increased debt more than in France: it was also” whatever it costs



But today the debt/capita is the same as it was in 1980, but with a correlation where 45 € = 105 \$ or 1 € = 2.3 \$ it is far to the present value where 1 € = 1.08 \$

US debt per capita is double than in France!

It is far from what I thought!

Graphs are helpful!

-France & US parabolic fractal income distributions

In my old papers I display the good parabolic fractal of nature events as earthquakes, oil reserves and incomes

-Laherrère J.H. 1996 "Distributions de type fractal parabolique dans la Nature"-Comptes Rendus de l'Académie des Sciences- T.322 -Série Ila n°7-4 Avril p535-541

<http://www.oilcrisis.com/laherrere/fractal.htm>

-Laherrère J.H., D.Sornette 1998 " Stretched exponential distributions in nature and economy: fat tails" with characteristic scales" European Physical Journal B 2, April II, p525-539 :

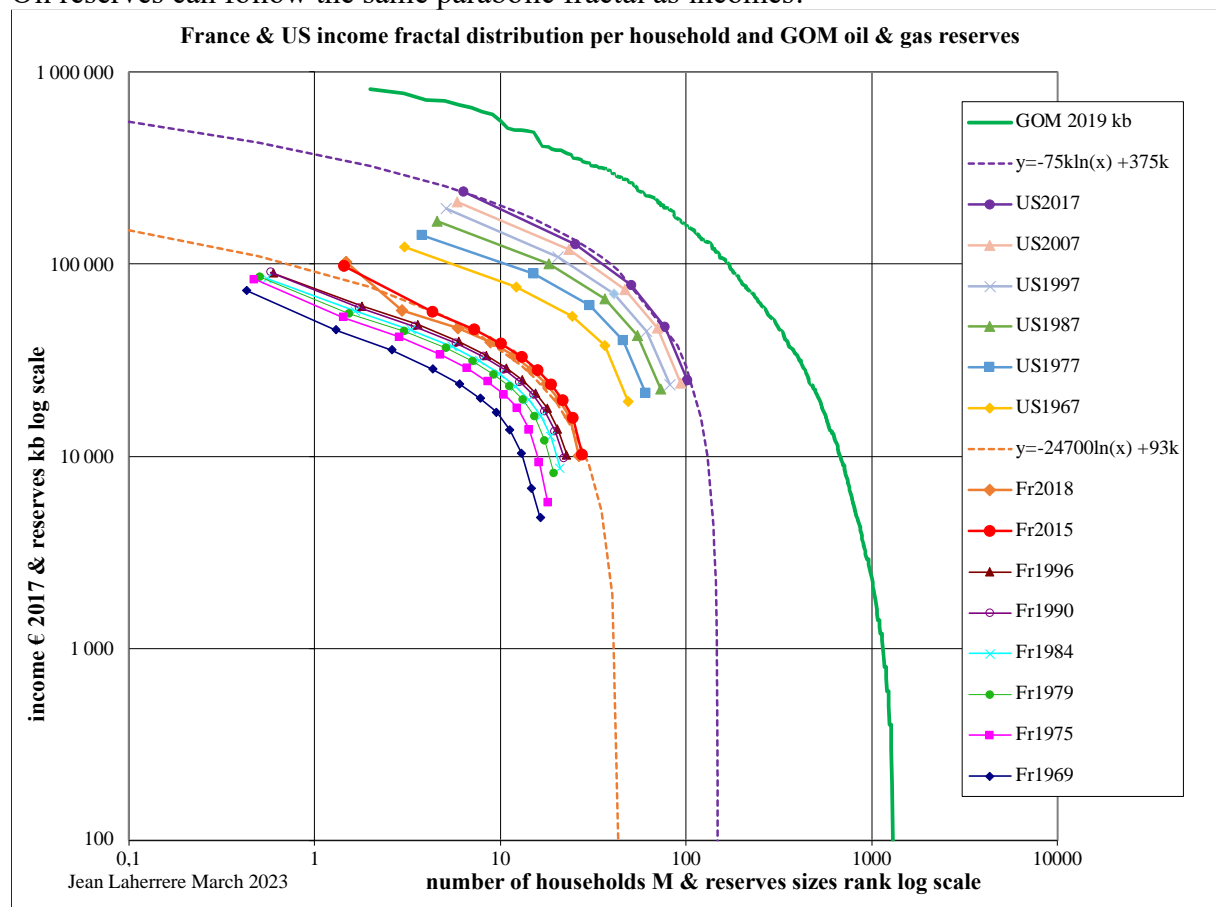
<http://xxx.lanl.gov/abs/cond-mat/9801293> or <http://www.edpsciences.com/articles/epjb/pdf/1998/08/b8019.pdf>

France and US incomes display parallel fractal distribution which moves parallel with time (in fact with population)

The richest US incomes are higher than in France because US has a higher population = 5 times.

It is amazing to find that the Gulf of Mexico oil fields reserves is also parallel to US incomes.

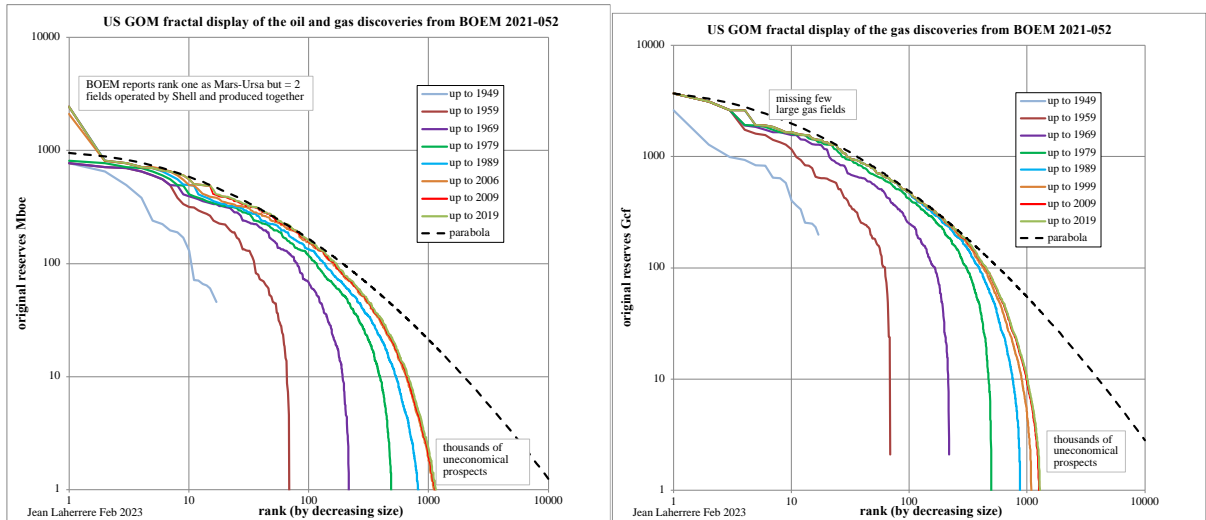
Oil reserves can follow the same parabolic fractal as incomes!



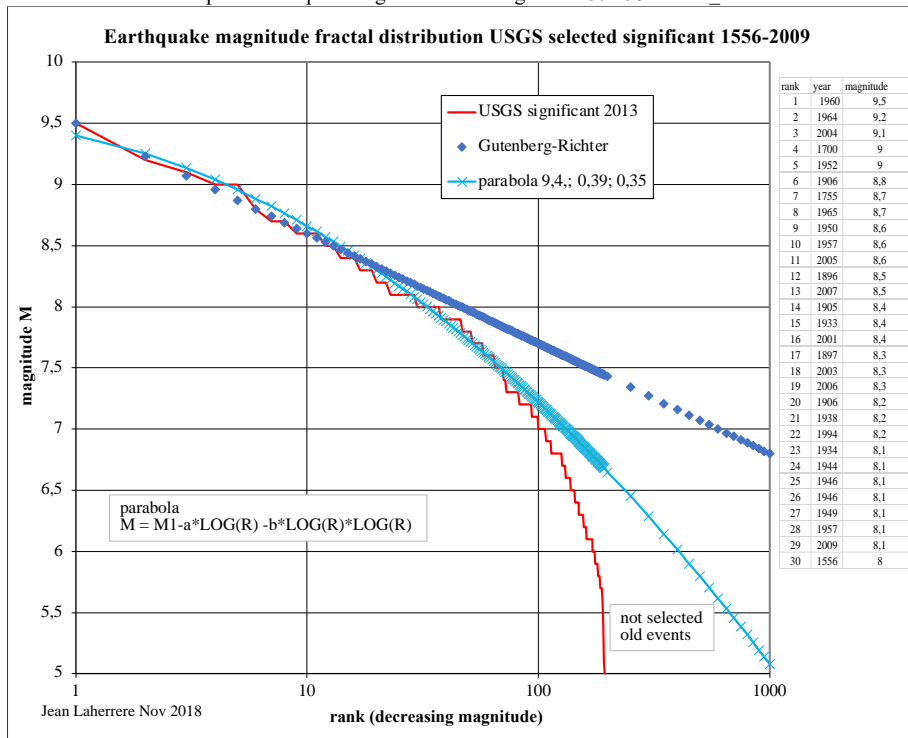
BOEM 2021-082 reports GOM reserves for 1325 fields at end 2019

Parabolic fractal display of oil & gas fields

display of gas fields only



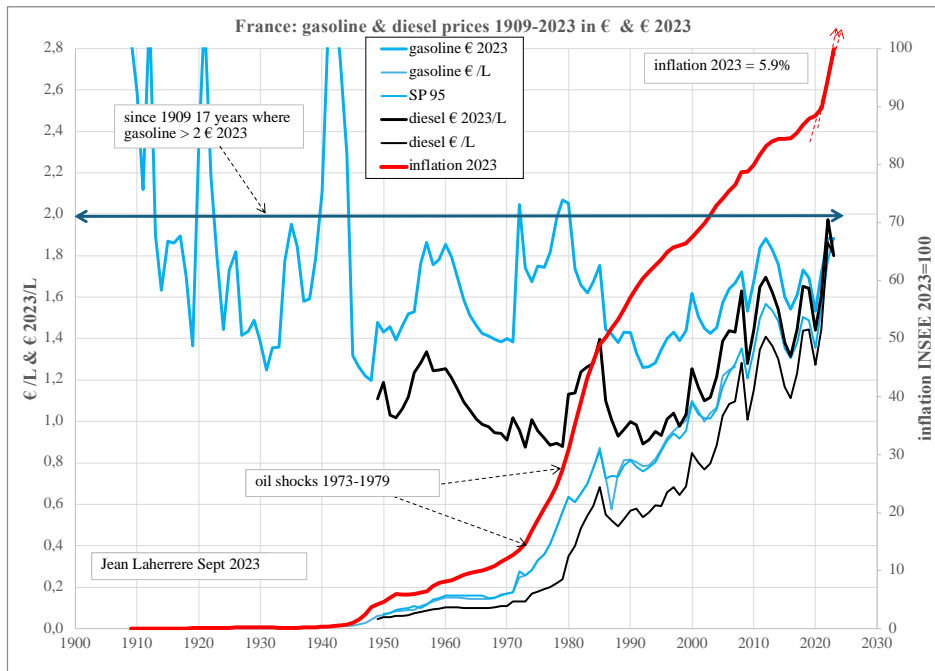
Earthquakes distribution displays also a parabolic fractal when the law (?) of Gutenberg-Richter is a linear fractal! https://en.wikipedia.org/wiki/Gutenberg%E2%80%93Richter_law



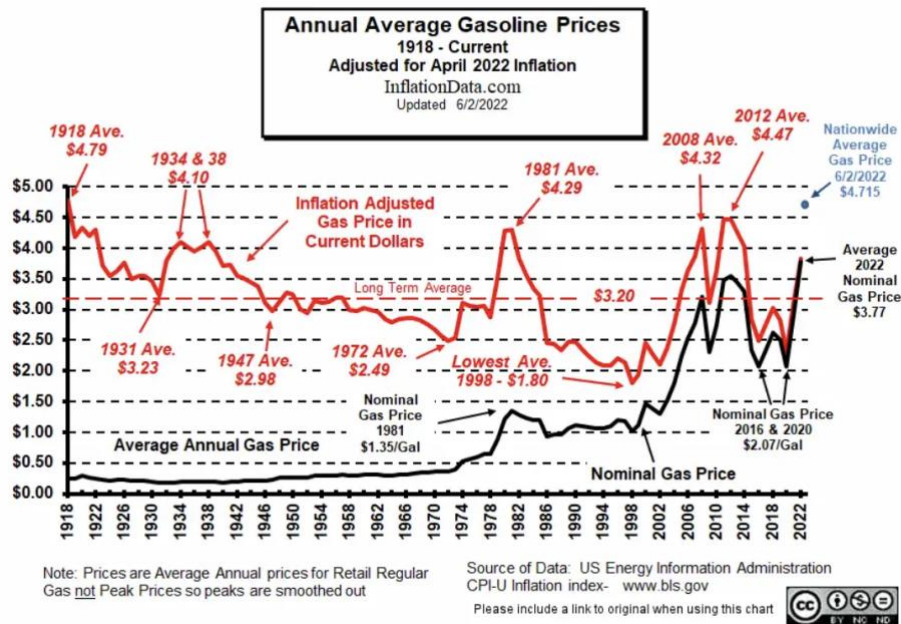
-France: diesel & gasoline constant prices

Diesel & gasoline prices are converted into €2023 using INSEE inflation

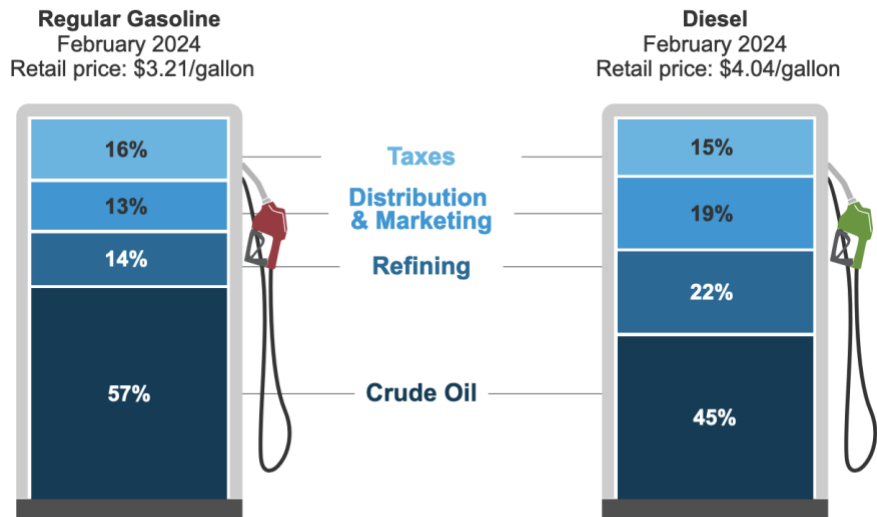
Since 1909 there are 17 years where gasoline price was over 2 €2023: French drivers have a different opinion because short memory!



In US gasoline price 1918-2019 in current price and constant \$2019: in 1918 gasoline was 4.8 \$2022 compared with 3.8 \$ in 2022:
 US gasoline real price has declined in a century!



In US in a gallon of fuel the percentage of refining & marketing is higher for diesel than for gasoline



eia Data source: U.S. Energy Information Administration, Gasoline and Diesel Fuel Update

-France: fiscal diesel loss

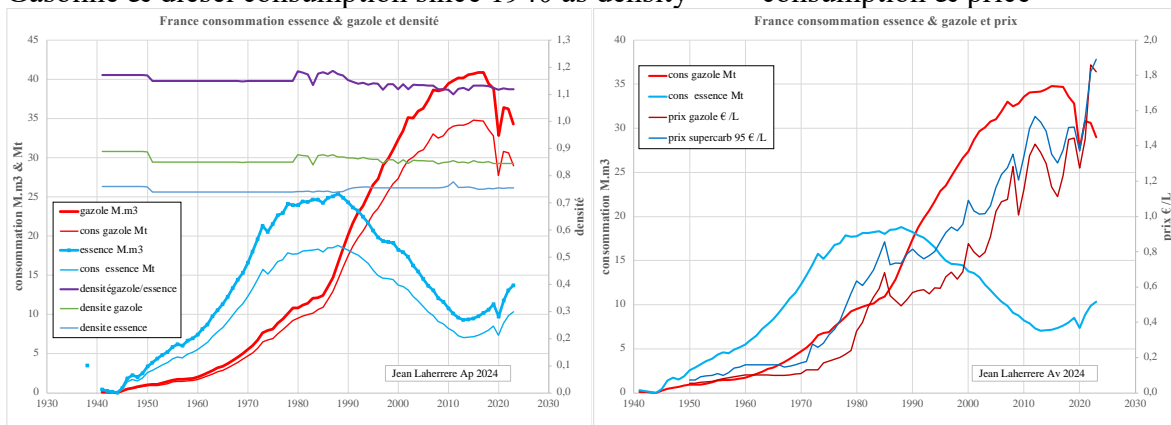
France was proud to be ahead within the world with diesel cars from Peugeot and Renault. From 1980 to 1995, France was the first European country in which diesel cars became more popular than petrol cars. In addition to offering improved performance, this preference was notably due to a much cheaper cost of use, in line with the taxation on both fuel types. After the 1973 oil shock, diesel cars became more appealing to individuals because of their lower fuel consumption. French manufacturers took this opportunity to invest in this technology.

Diesel is 12% heavier and then 12% more calorific than gasoline: diesel price should be 12% more than gasoline price, when it is sold in France much cheaper

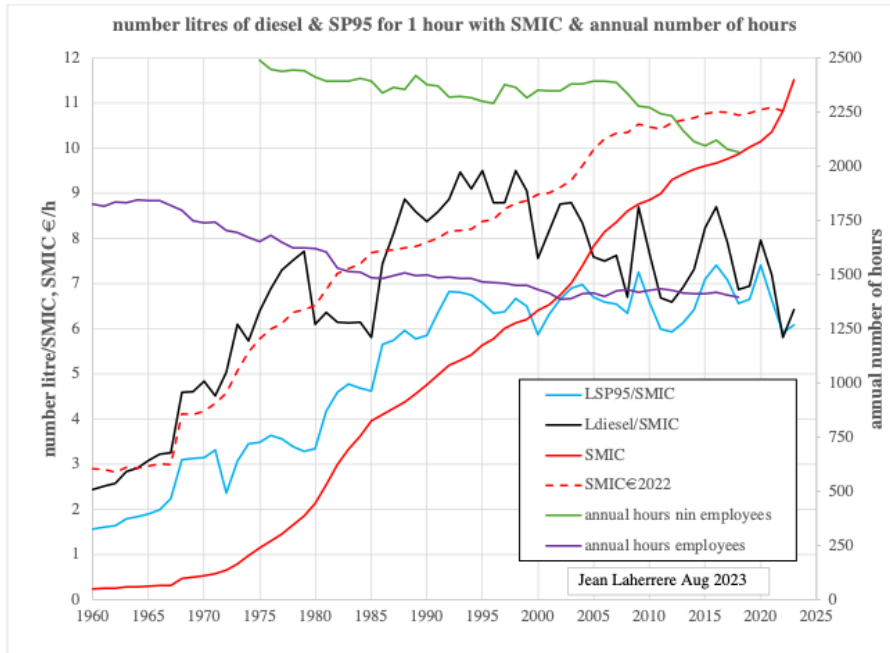
Diesel should be sold in equivalence with heat content as if was sold by weight and not by volume

Fiscal loss is due to diesel sold too cheap and not at gasoline price converted with diesel heat content, in order to qualify to France “liberty, equality and fraternity”

Gasoline & diesel consumption since 1940 as density consumption & price



Number of liters of gasoline and diesel with one hour of SMIC (salaire minimum interprofessionnel de croissance = minimum hourly salary) & annual number of hours

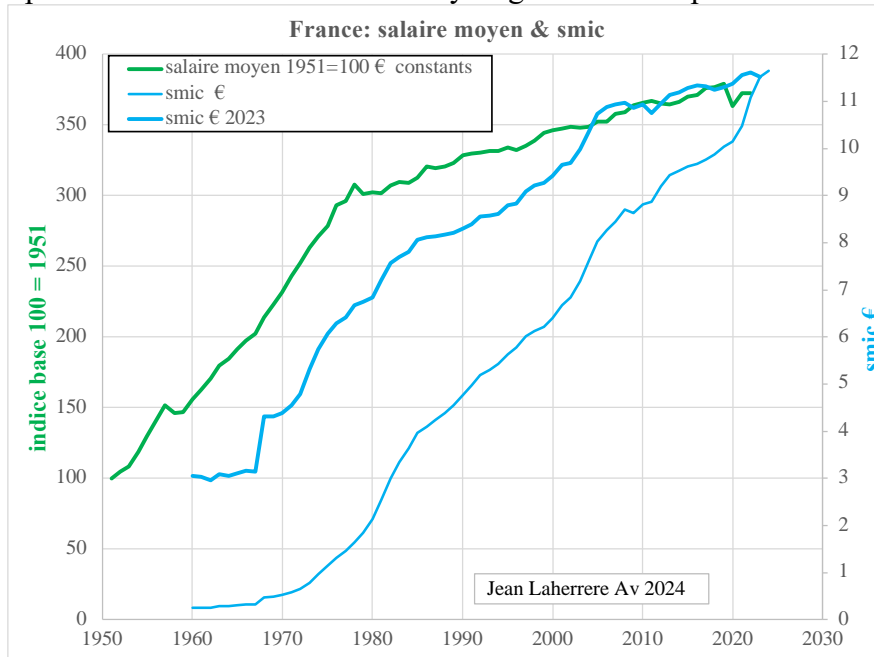


In 2023 one SMIC hour can buy 6.4 L of diesel when 9.5 L in 1995 but only 2.5 L in 1960 and 6 L in 1985

In 2023 one SMIC hour can buy 6 L of SP95 when between 6 & 7 L since 1990, but only 1.5 L in 1960

In 1960 employees work 1826 annual hours against 1396 h in 2018 24 % less!

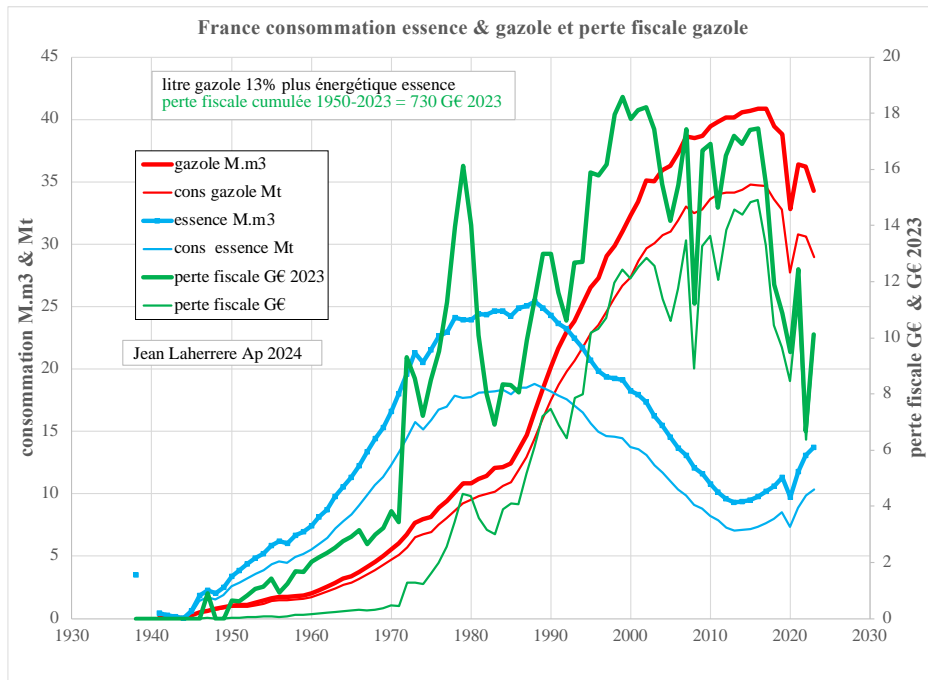
SMIC is compared with the French mean salary: it grows faster up to 2005 and since 2020!



Diesel by liter is heavier and more calorific than gasoline, but it is sold cheaper than gasoline because lower taxes

There is a diesel fiscal lost, compared with diesel being sold equal by calorific unit as gasoline

Diesel fiscal loss has peaked at 17 G€ in 2016. The cumulative diesel fiscal loss 1940-2023 is 730 G€2023 when France administrations debt is over 3000 G€



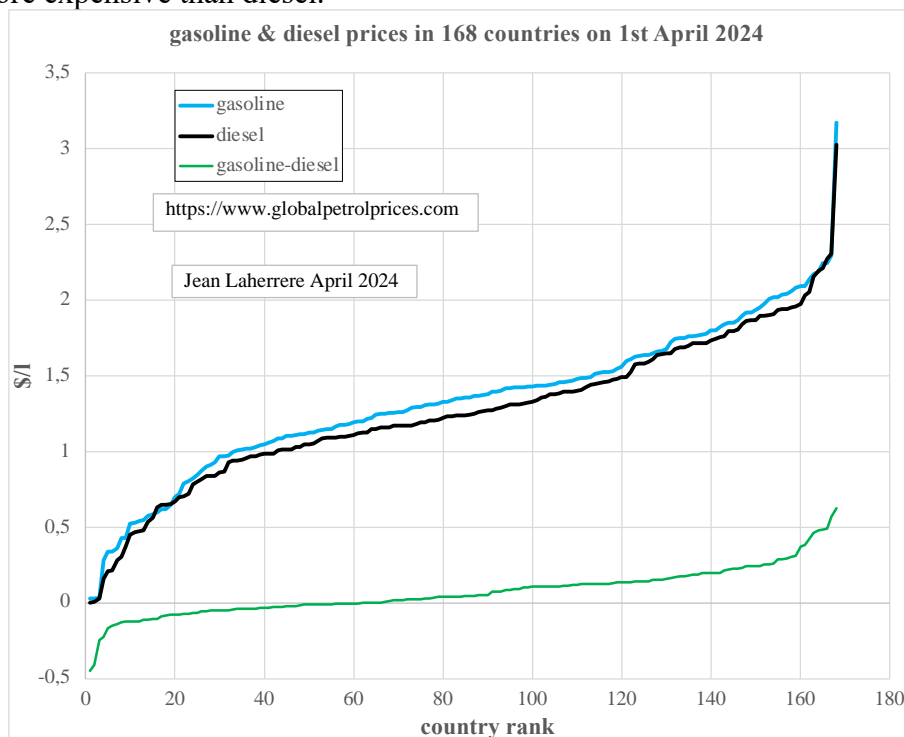
Selling diesel in line with gasoline heat content should have reduced France debt by 25%!

On 1st April 2024 the range of gasoline and diesel prices is shown for 168 countries ranked by increasing price with a range for gasoline-diesel price of -0,45 \$/L (Nigeria) to 0,63 \$/L (Jordan)

Diesel is sold from 0,004 \$/L in Venezuela to 3,03 in Hong Kong

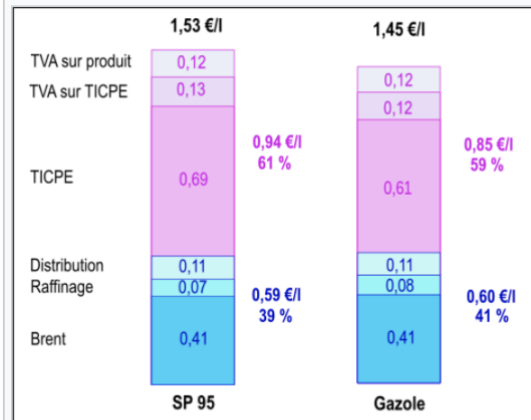
Gasoline is sold from 0,029 \$/L in Iran to 3,173 in Hong Kong

Only 60 countries sell gasoline cheaper than diesel and about 100 countries sell wrongly gasoline more expensive than diesel.

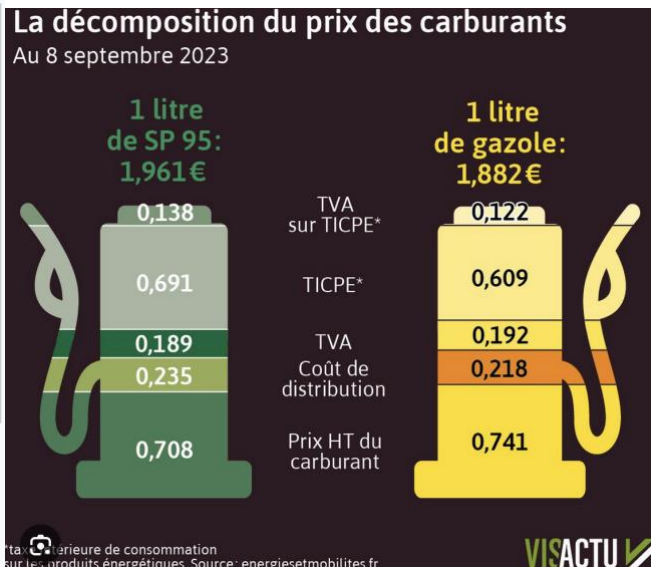


In France (Wikipedia) in 2018 gasoline SP95 was more expensive than diesel only because higher taxes: the cost of refinery is higher for diesel!

In France in 2023 the cost of crude and distribution was higher for diesel than gasoline (0.96 €/L against 0.94)

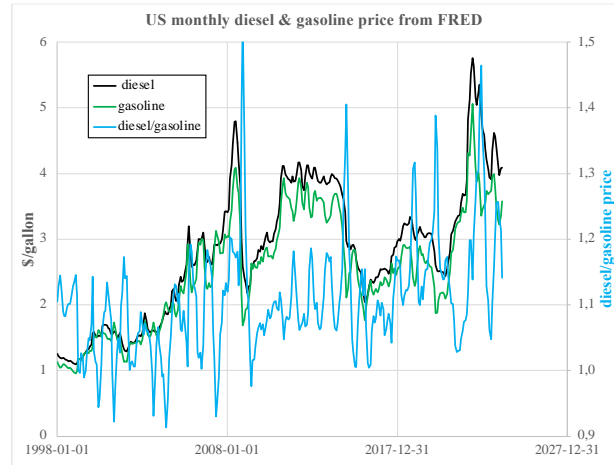
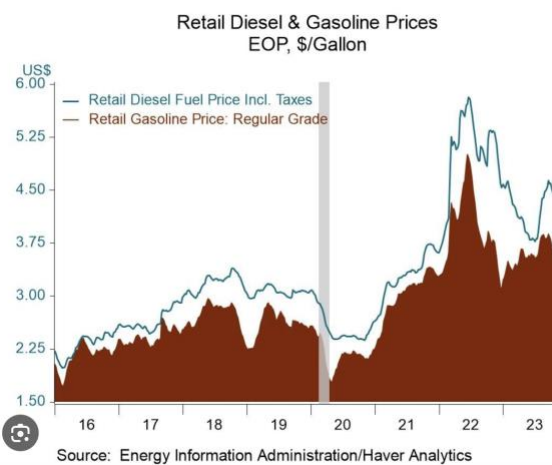


Comparaison de la structure de prix du gazole et du sans plomb 95 en France en mai 2018 (en bleu les coûts liés au produit, en rose les taxes).



Diesel is sold higher only because wrong taxes: diesel has 12% higher heat content than gasoline: it should be sold always more expensive than gasoline!

In US diesel price is higher more than gasoline price: in 2023 diesel was sold 4.21 \$/gallon against 3.52 for gasoline = it is 20 % more! more than its heat content, in contrary with France!



On the period Jan 1998-March 2024 diesel/gasoline price mean was 1,10 a little less than the ratio of heat content (1.14)

1 gallon of finished motor gasoline (containing about 10% fuel ethanol by volume) = 120 238 Btu. 1 gallon of diesel fuel or heating oil (with sulfur content less than 15 parts per million) = 137 381 Btu: the ratio diesel/gasoline heat content is 1.14:

US gasoline should be sold a little cheaper to respect the heat content!

In UK and Switzerland on 1st April 2024 diesel is sold over 2% more than gasoline: it is not enough to reach the calorific equivalence!

\$/L	gasoline	diesel	diesel/gasoline
United Kingdom	1.930	1.976	1.024
Switzerland	1.789	1.843	1.030

-conclusion

I do not like speech, I like graphs!

I do not remember text when I remember graphs

I hope that you like my graphs.

You may ask me questions to my mail address: jean.laherrere@wanadoo.fr

The list of my papers can be found at <https://aspoFrance.org/2024/01/05/bibliographie-de-jean-laherrere-janvier-2024/>