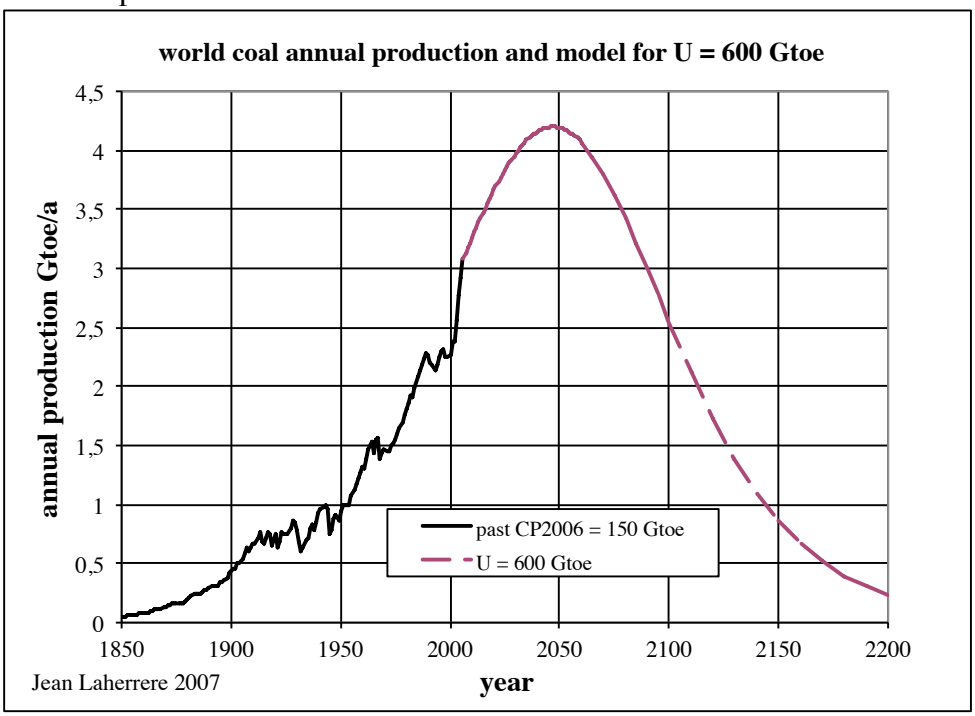
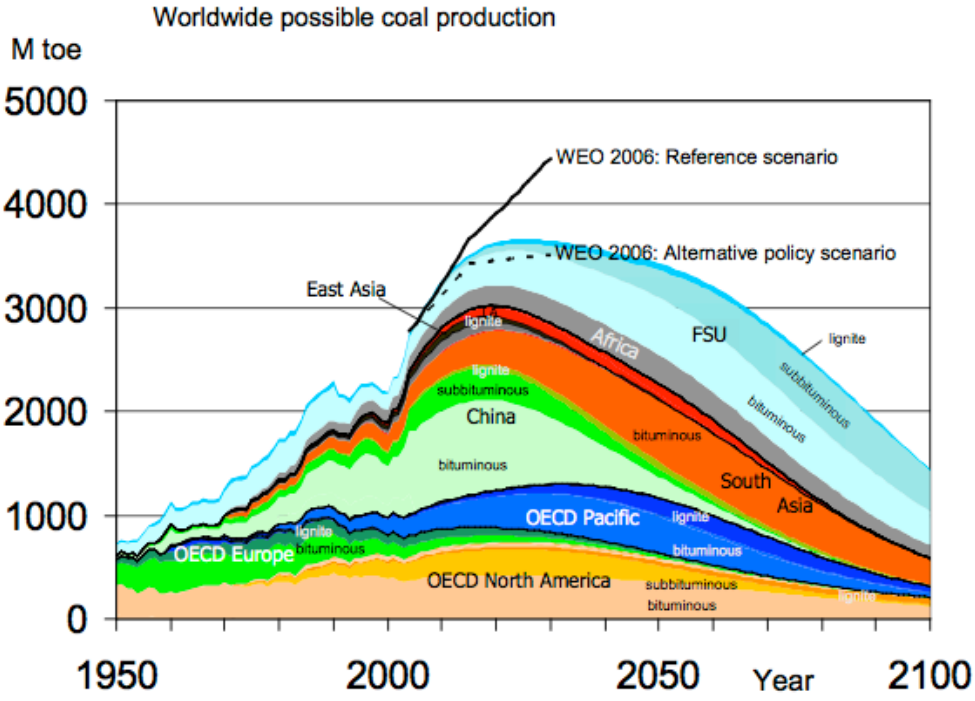
Jean Laherrere 12 October 2012

Update on coal

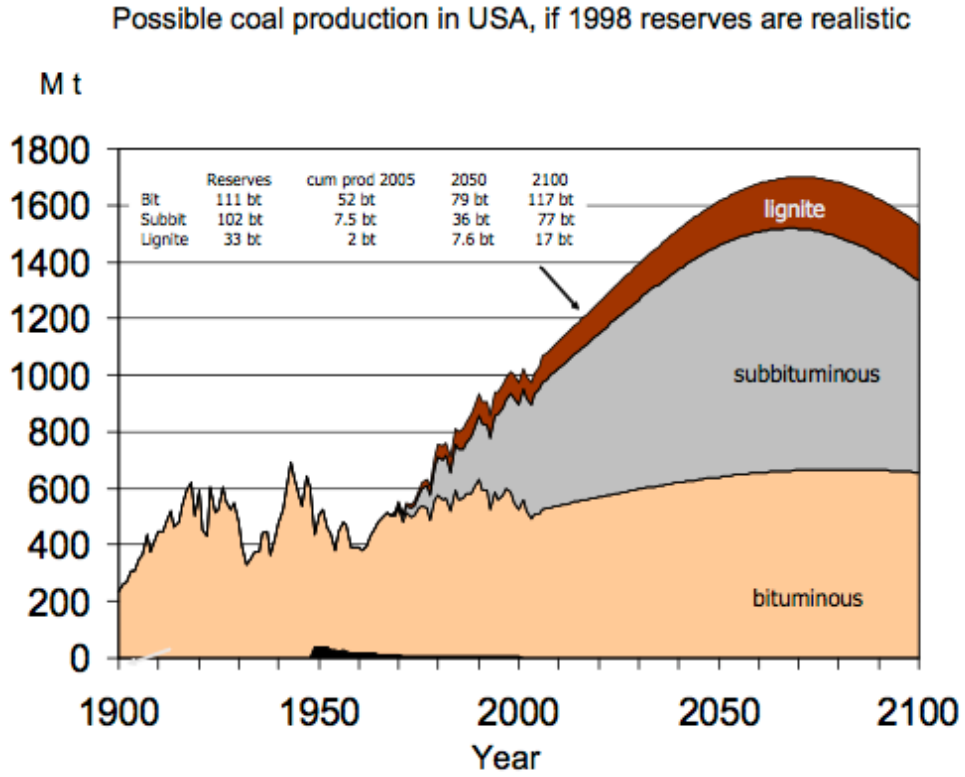
In 2007 the world coal production was modeled with an ultimate of 600 Gtoe and the peak was forecasted around 2050 at 4.2 Gtoe.
Figure 1: world coal production and model for an ultimate of 600 Gtoe in 2007



At the same time, Energy Watch Group (Zittel LBST) 2007 "Coal: resources and future production" was modeling the world coal production with a peak around 2030 at 3.6 Gtoe, well below the IEA/WEO 2006 forecast which was at 4.5 Gtoe.
Figure 2: world coal production by the Energy Watch Group in 2007



China was forecasted peaking in the 2010s and close to exhaustion in 2070.
The US coal production was forecasted peaking in 2080.
Figure 3: US coal production by the Energy Watch Group in 2007



EWG study was based on BP 2006/WEC 2004 estimates about 500 Gt for hard coal and about the same for lignite & subbituminous coal, for a total of about 1000 Gt or 500 Gtoe, meaning an ultimate of 650 Gtoe.
Figure 4: history of hard coal reserves by EWG 2007

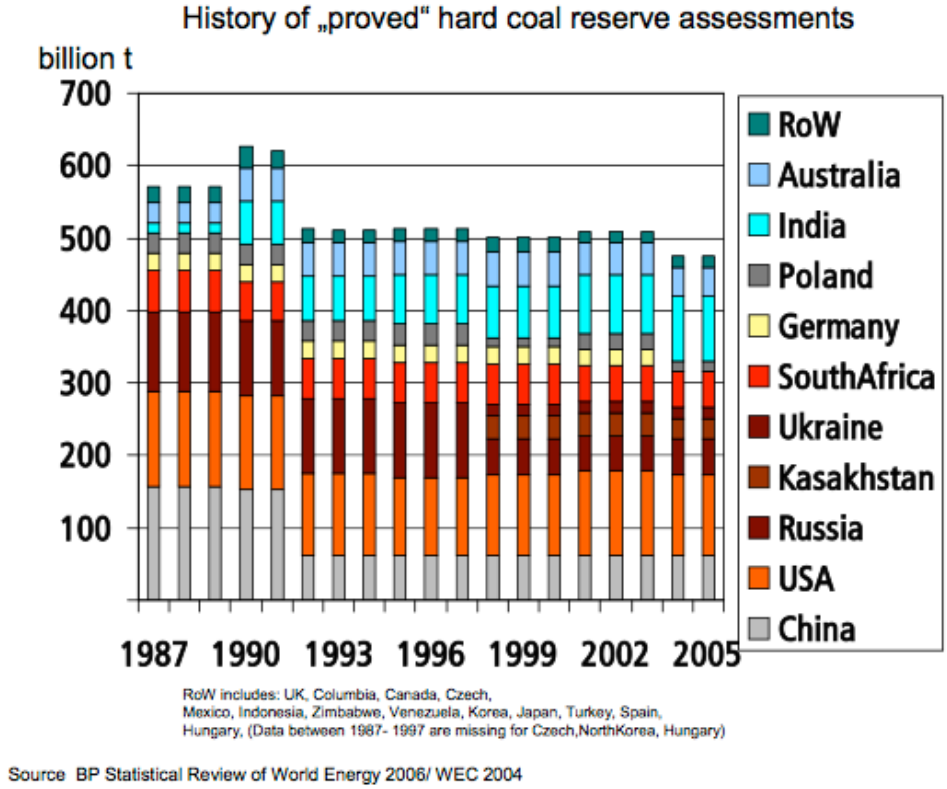
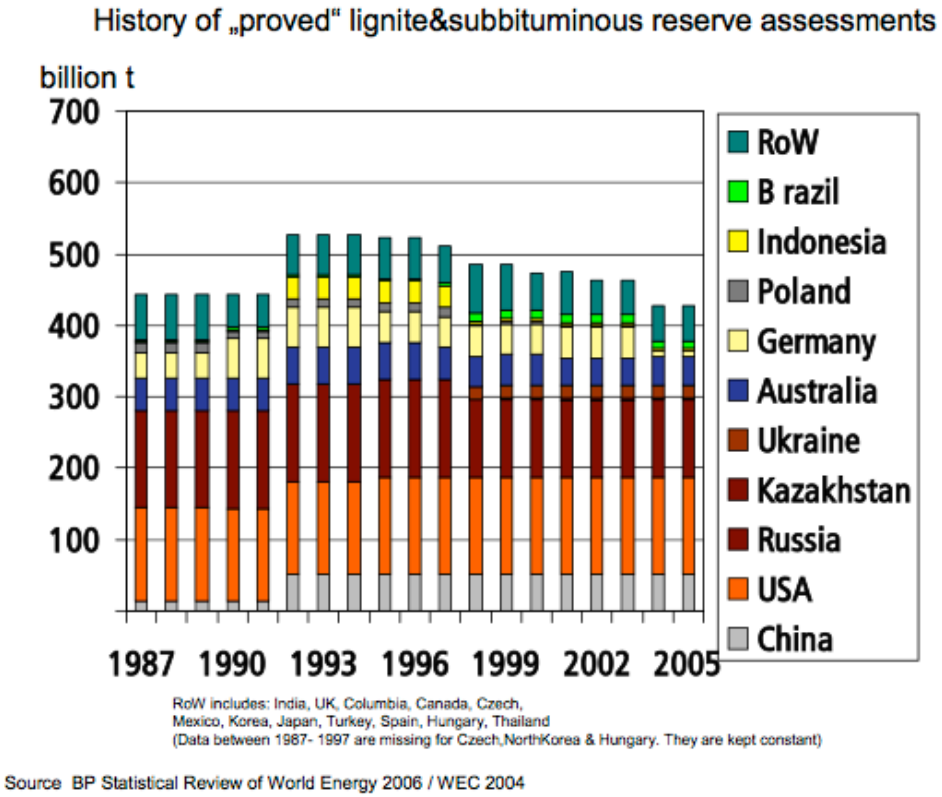
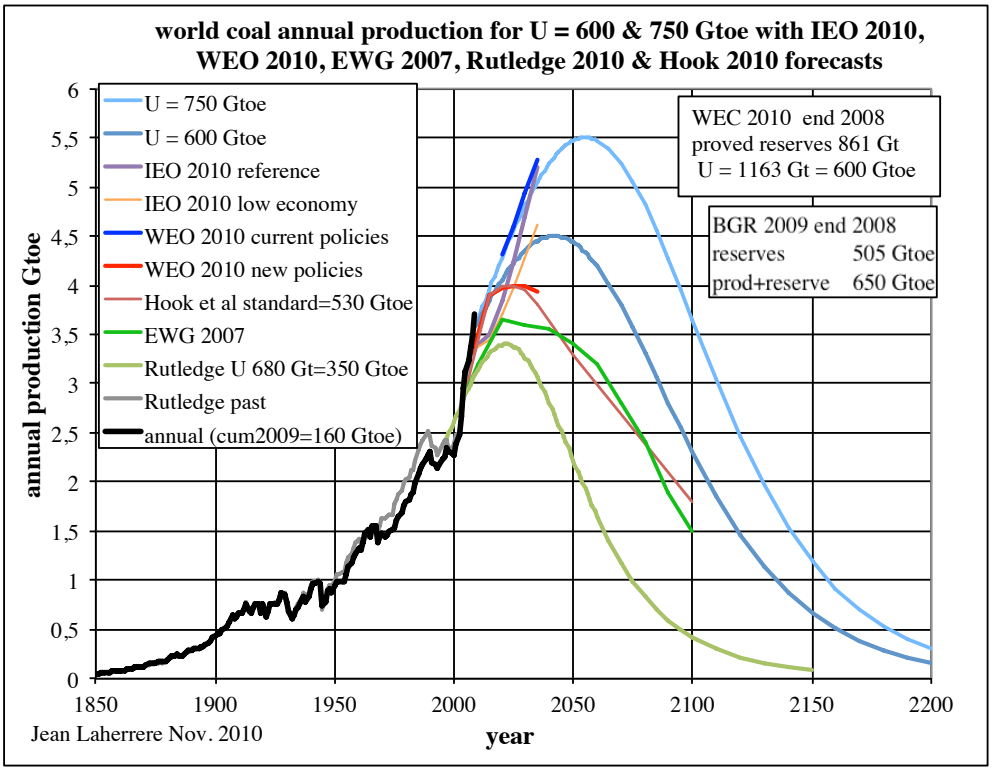


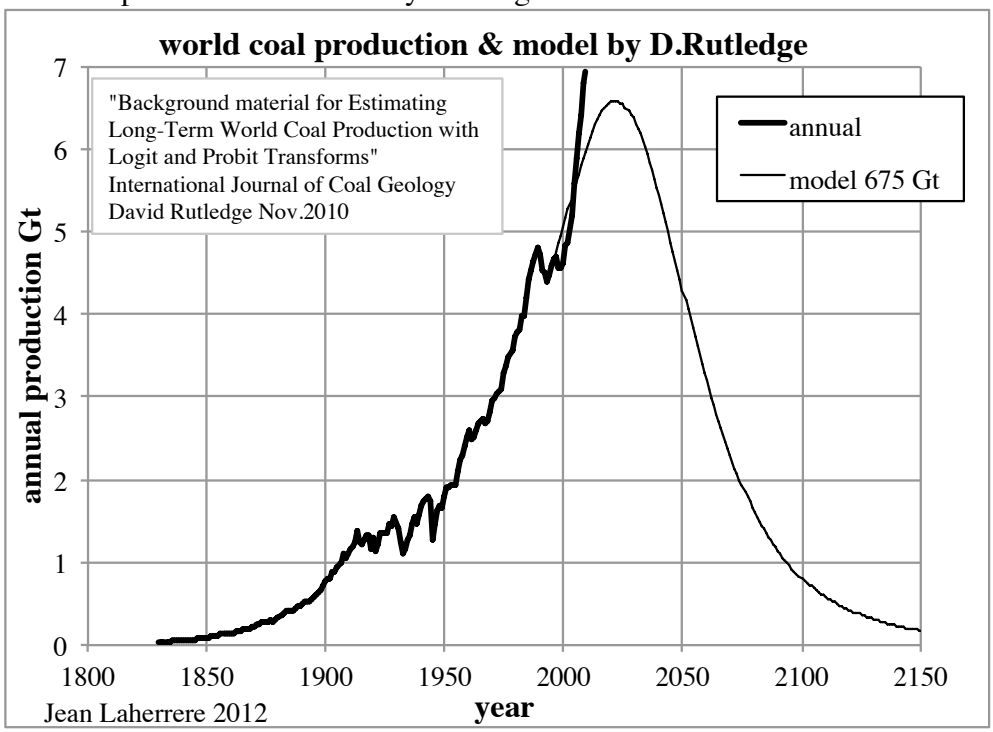
Figure 5: history of lignite & subbituminous reserves by EWG 2007



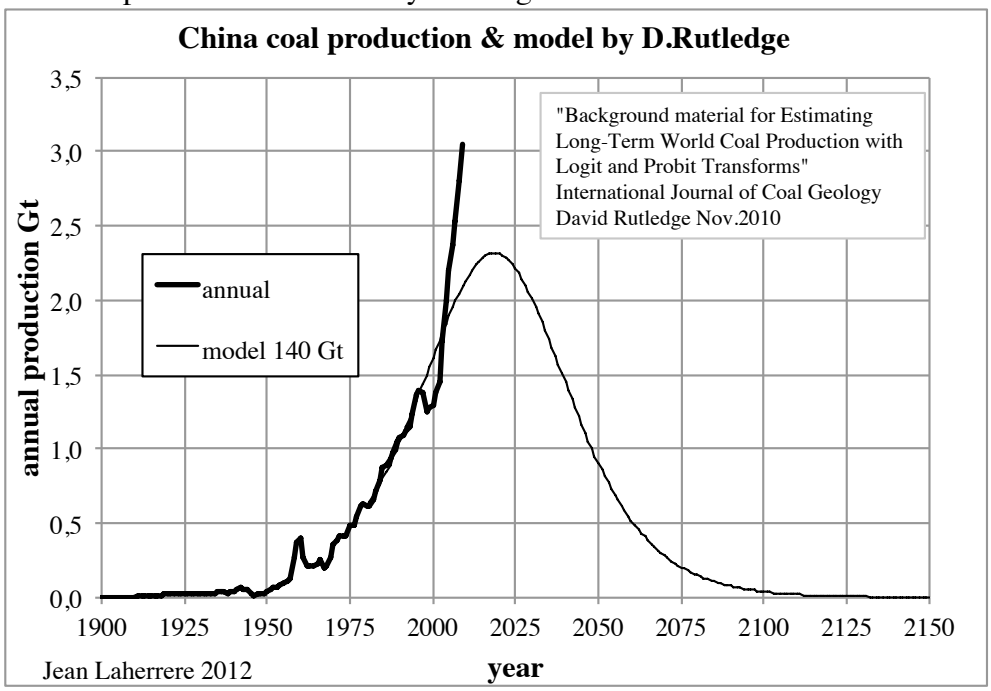
In 2010 my modeling was increased with an ultimate of 750 Gtoe to take care of the strong increase of production since 2000 mainly due to China. The peak was then still in 2050 but at 5.5 Gtoe. The cumulative production was 156 Gtoe and the remaining reserves estimated at 505 Gtoe by BGR, 405 Gtoe by WEC (copied by BP).
The EWG (Energy Watch Group) was far below. The Uppsala group (Hook et al) modeling was based on an ultimate of 530 Gtoe
Figure 6: world coal production for U= 600 & 750 Gtoe with IEO 2011, WEO 2010, EWG 2007, Rutledge 2010 & Hook 2010 forecasts



In 2010 David Rutledge (Caltech) published a report giving all the data on excel on Internet: "Background material for Estimating Long-Term World Coal Production with Logit and Probit Transforms" International Journal of Coal Geology Nov.2010
His model was for an ultimate of 675 Gt or about 350 Gtoe.
Figure 7: world coal production & model by Rutledge 2010

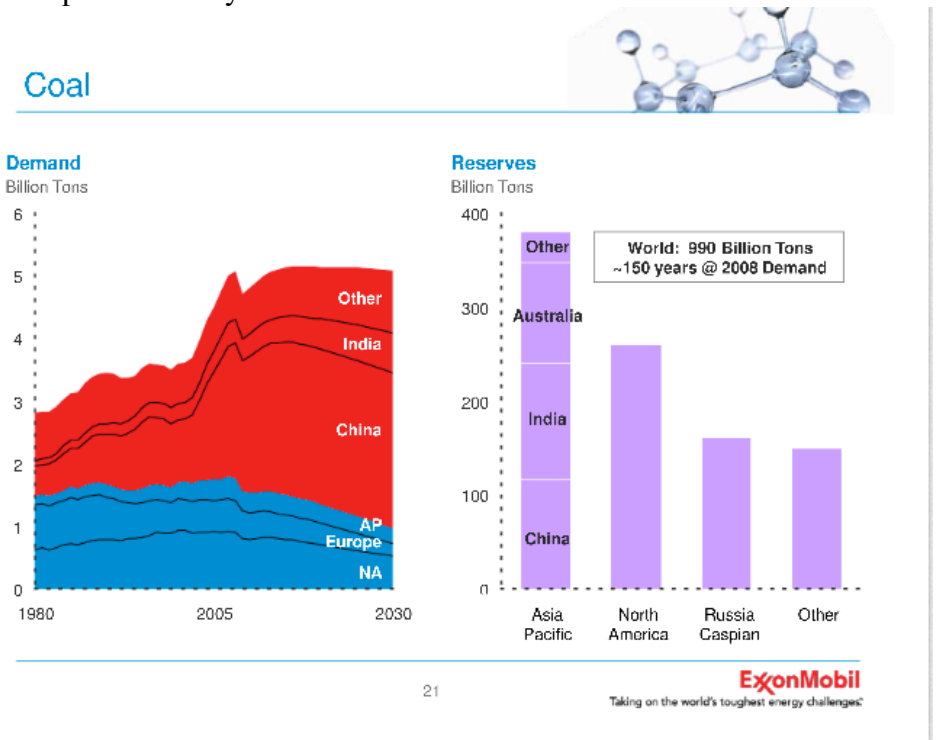


Rutledge models China with an ultimate of 140 Gt (about 70 Gtoe)
Figure 8: China coal production & model by Rutledge 2010



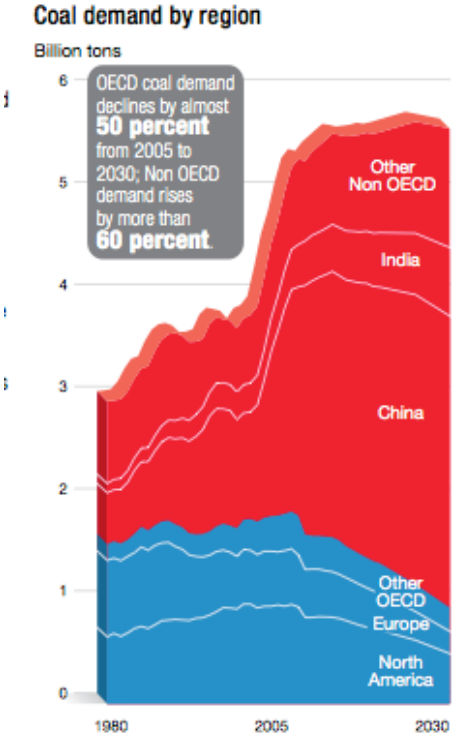
The forecast of Exxon-Mobil in their "Outlook for energy" has varied with time for the last three years.
Exxon-Mobil "The Outlook for Energy a view to 2030" US EIA and John Hopkins University 2010 Energy Conference Tom Eizember Corporate Strategic Planning 6 April 2010 was forecasting a flat coal demand at 5 Gt from 2010 to 2030. Their reserves estimate was at 990 Gt.

Figure 9: world coal production by Exxon-Mobil 2010



In 2011, Exxon-Mobil forecast was flat from 2010 to 2030, but at a higher level of 5.5 Gt

Figure 10: world coal production by Exxon-Mobil 2011



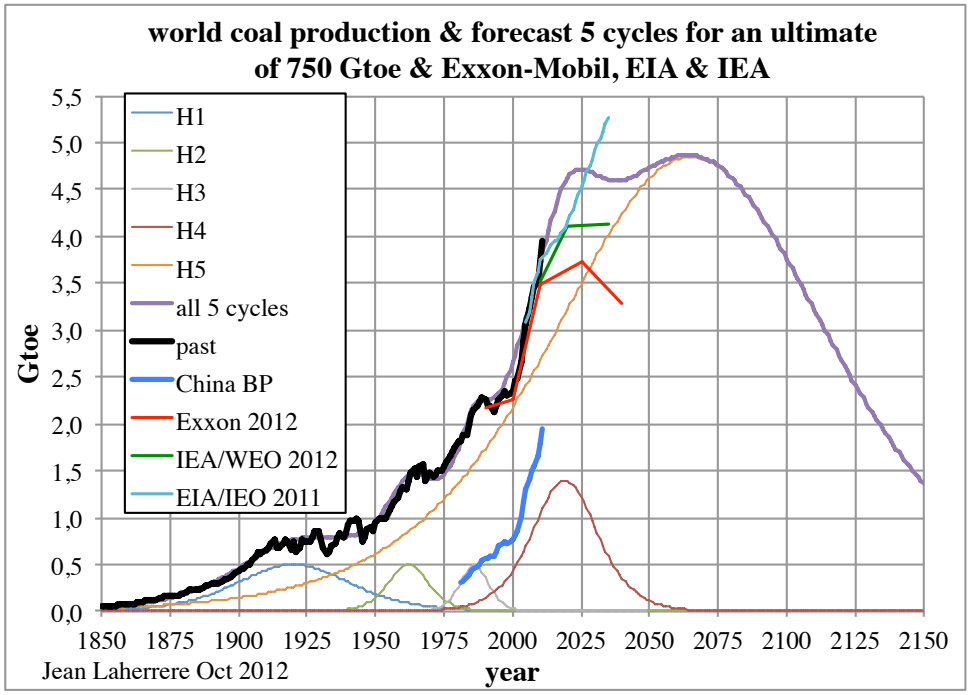
In 2012 Exxon-Mobil in the outlook to 2040 forecasts coal demand in 2040 being less than in 2010 with a peak in 2025 at 3,7 Gtoe, compared to my model at 4.6 Gtoe

The EIA/IEO 2012 is not yet published but the 2011 edition forecasts for 2035 a production of 5.3 Gtoe, higher than my plateau at 4.6 Gtoe.

My new update in 2012 on coal production is based on an ultimate of 750 Gtoe, modeled with 5 cycles and compared to Exxon-Mobil 2012, IEA/WEO 2012 and EIA/IEO 2011.

Exxon-Mobil and IEA are already too low compared to 2011 value, only EIA seems in line with my forecast.

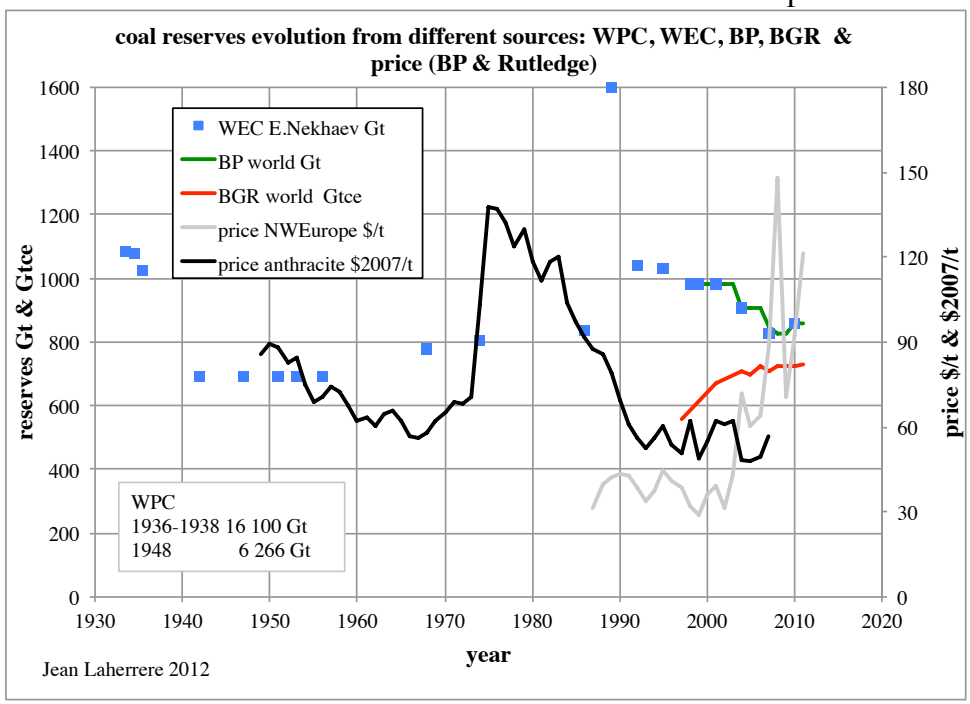
Figure 11: world coal production modeled with 5 cycles for an ultimate of 750 Gtoe with forecasts from Exxon-Mobil, IEA & EIA



The ultimate of 750 Gtoe is based on the evolution of coal reserves from different sources

The remaining world coal remaining reserves vary from sources (WEC, BP recopying WEC, BGR) and time. The price is displayed and does not play any impact on reserves estimate.

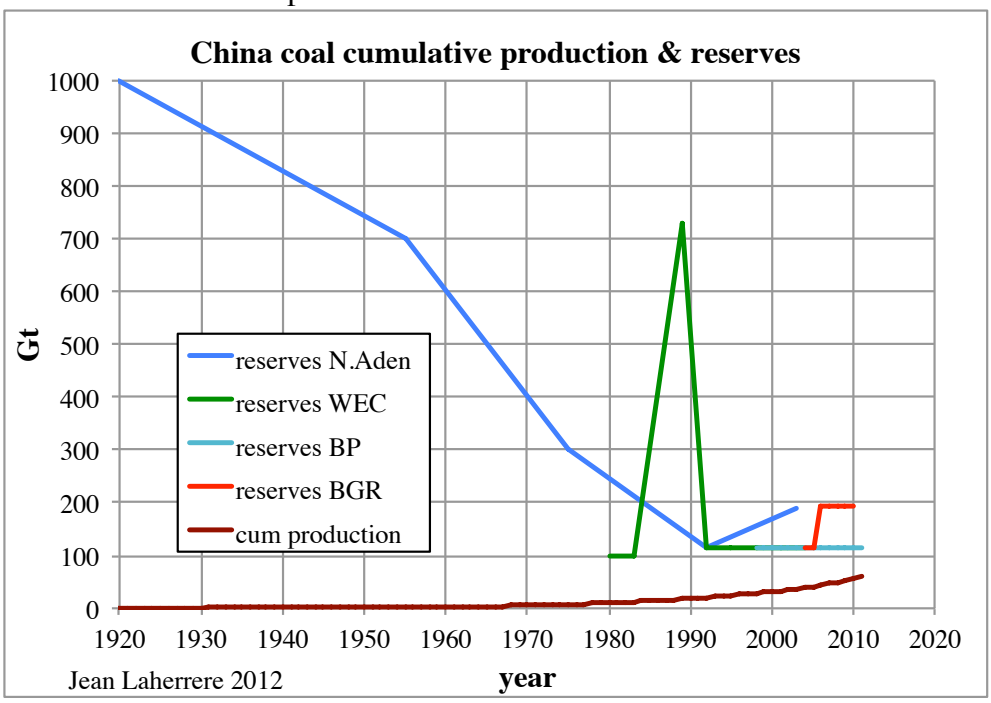
Figure 12: world coal reserves evolution from different sources and coal price



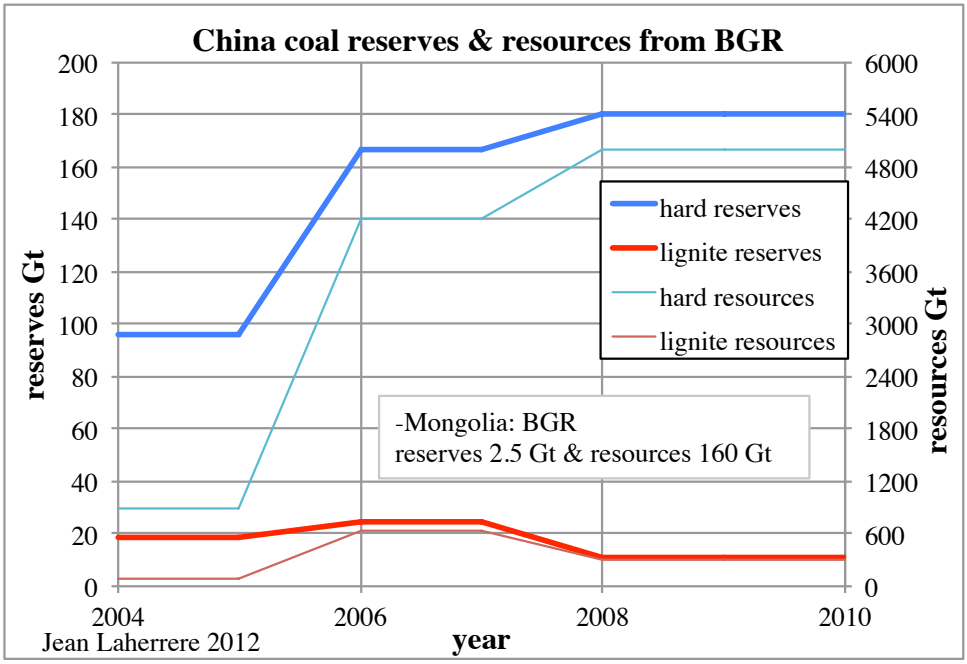
For BGR 2011 in Gt	hard coal	lignite
-reserves	728	276
-resources	17 204	4 154

The big problem is to distinguish between reserves, which are expected to be produce economically with the known technology and the resources, which are the volume without any constraints. Presently coal seams less than 50 cm, or deeper than 1500 m or offshore are not considered as reserves. It is why for the world the volume of resources is more than 20 times the volume of reserves. The constraints are mainly energetic: energy return over energy invested.
A big breakthrough could be "in situ gasification" (underground coal gasification = UCG), but many attempts in the last century (first patents in 1910) and in the new century were not successful. WEC 2007 estimated UGC potential at 600 Gt.

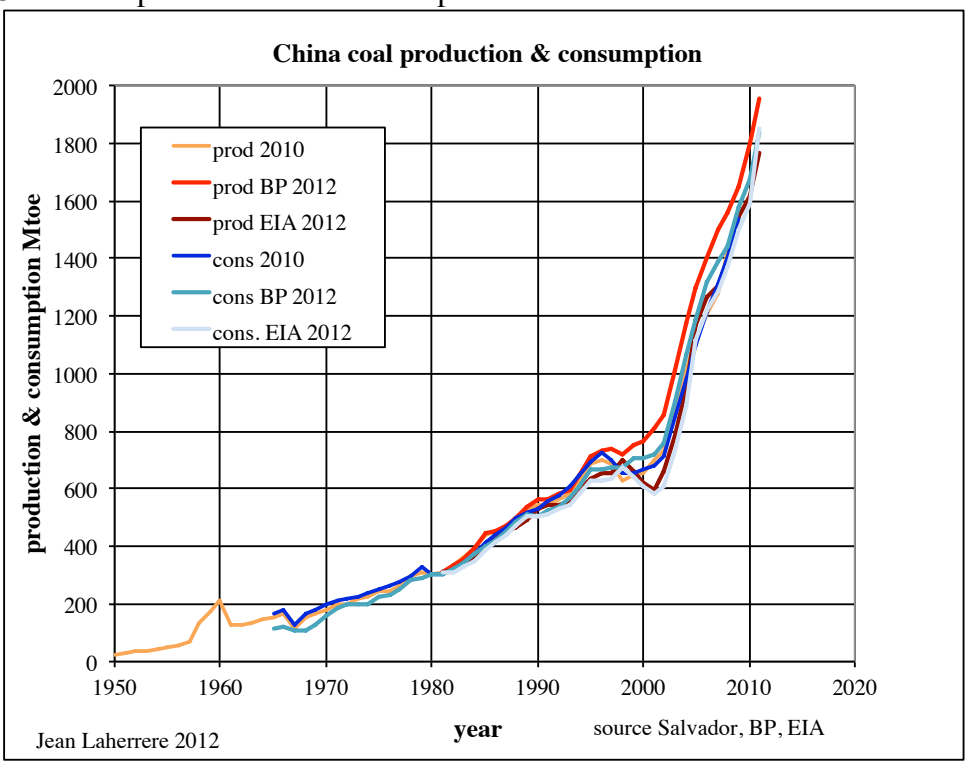
The spike on WEC estimates in 1989 is called the Chinese spike. It seems to be a mistake or a temporary change in definition?
Figure 13: China coal cumulative production and reserves evolution



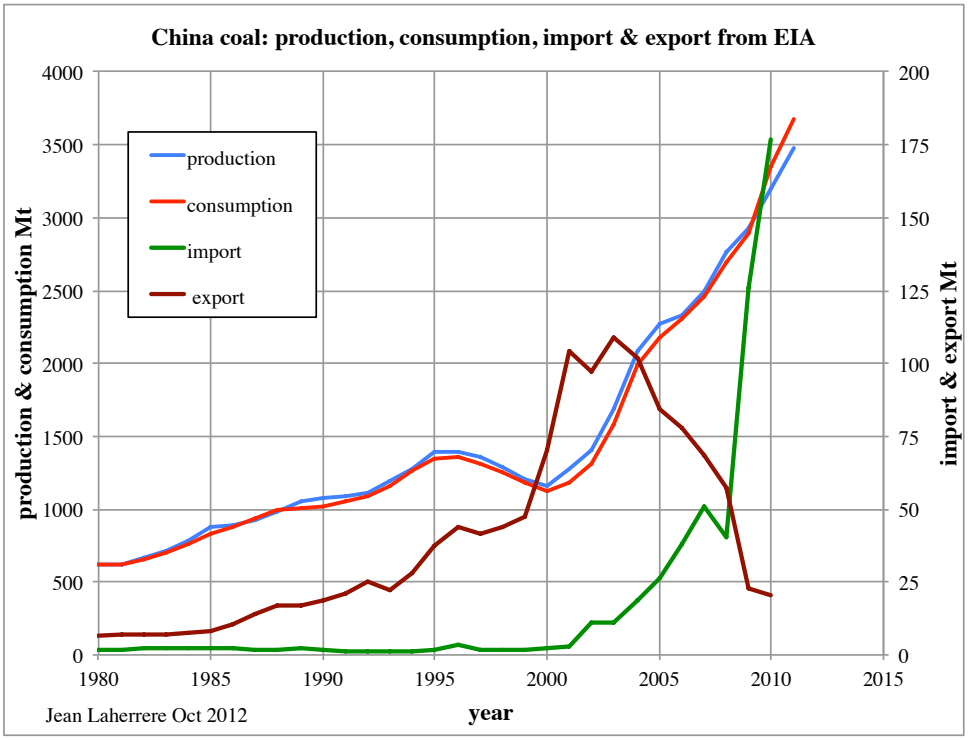
The BGR displayed an increase of China coal reserves and resources since 2004, broken down into hard coal and lignite (called before brown coal).
Figure 14: China coal reserves & resources from BGR



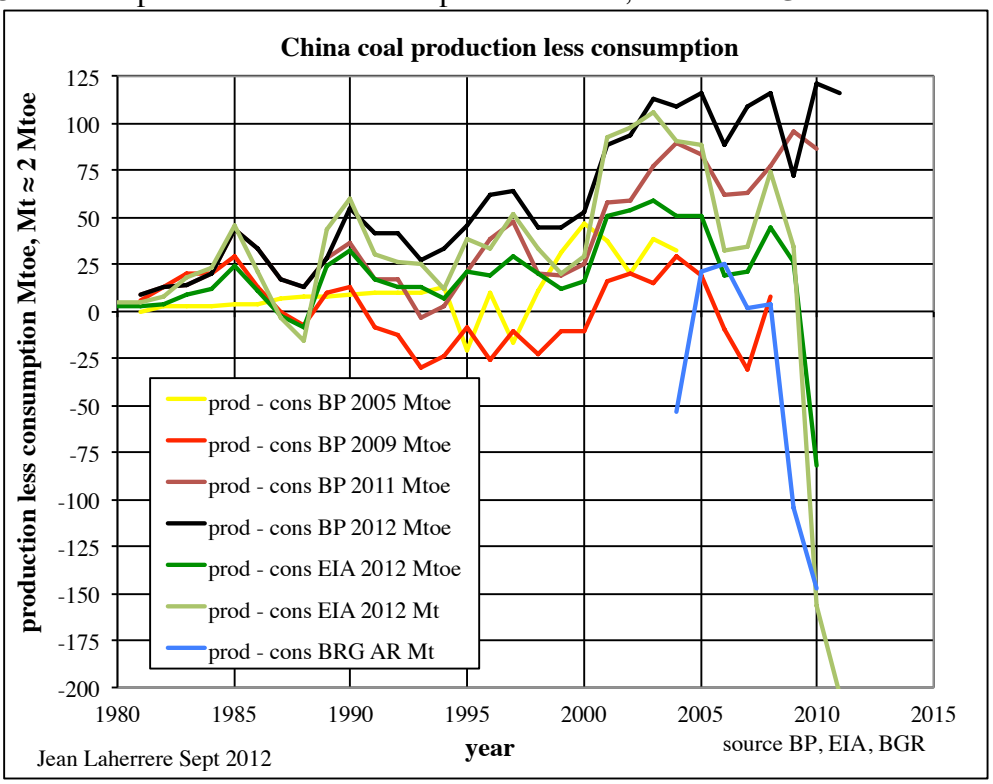
China is importing coal from Mongolia and BGR estimates Mongolia coal reserves at 2.5 Gt and resources at 160 Gt.
The data on China coal production and consumption varies with source, but after the trough of 1999 to control the wild local mines (where many death casualties) the increase since 2001 is spectacular close to 10%/a.
Figure 15: China coal production and consumption from different sources



But the most interesting is the evolution of imports and exports using EIA data. Export is declining since 2003 and import drastically increasing since 2008, because consumption diverges from production.
Most of data are in tonnes (Mt) but the heat content of coal varies and it is better to use tonne oil equivalent = toe.
Figure 16: China coal production, consumption, import & export from EIA



But the story looks completely different using BP data being production less consumption in Mtoe
The difference from 1980 was around zero for the data from BP 2009 (in red) but increasing up to 120 Mtoe in 2010 for BP 2012 (in black), when the data from EIA (in green) is - 75 Mtoe.
These drastic changes by BP are suspicious and indicate unreliable data.
In 2010 for BP China is a net exporter of 120 Mtoe when for EIA China is a net importer by 75 Mtoe: quite a difference. It seems looking at China & BGR data that BP is wrong.
Figure 17: China coal production less consumption from BP, EIA & BRG

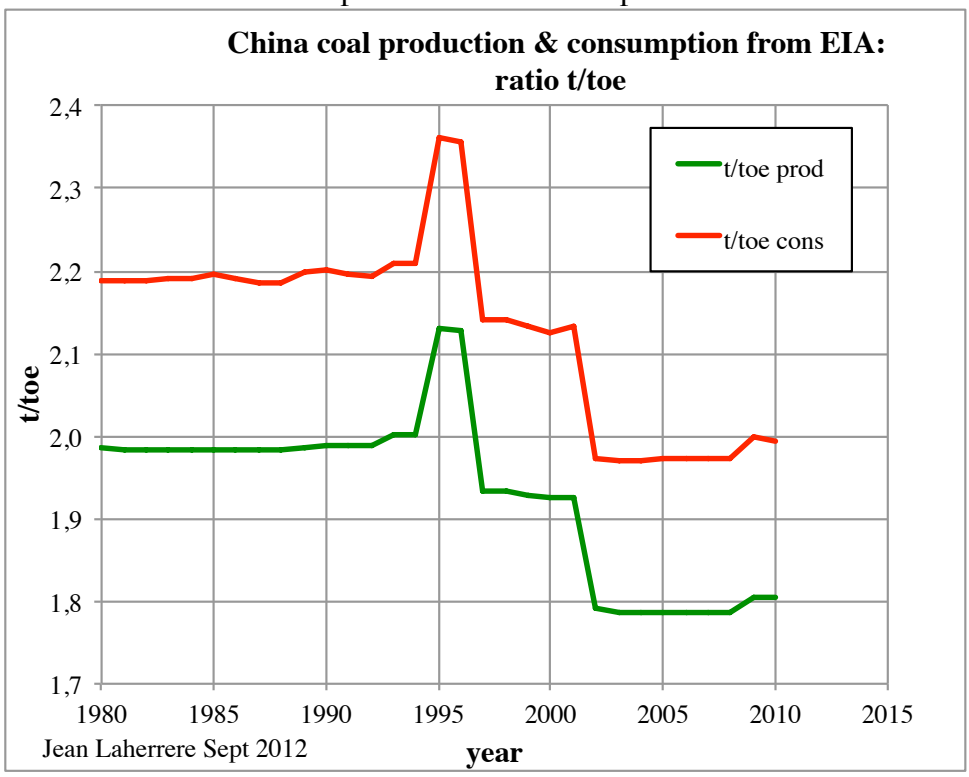


The comparison of EIA data for the difference production less consumption and export less import is interesting theses two values should be equal, they are not exactly

Figure 18: China coal production less consumption and export less import from EIA

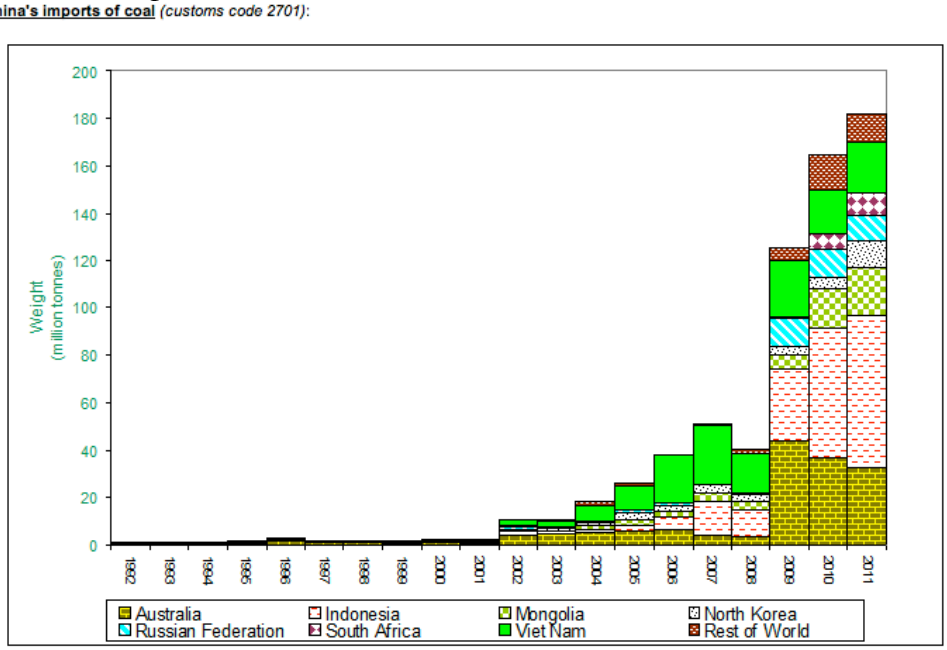
AS EIA reports the production and consumption data both in short ton (1 short ton = 0.907 t) and in toe, it is easy to plot the ratio t/toe which is about 2, but it varies with time and obviously it is not apply the same way for production and consumption, explaining the slight difference of the above graph, which confirms that China is presently a net importer of coal, despite BP data!
BP has to improve sharply their data, but EIA also but in a lesser manner.

Figure 19: China coal ratio t/toe from production & consumption from EIA



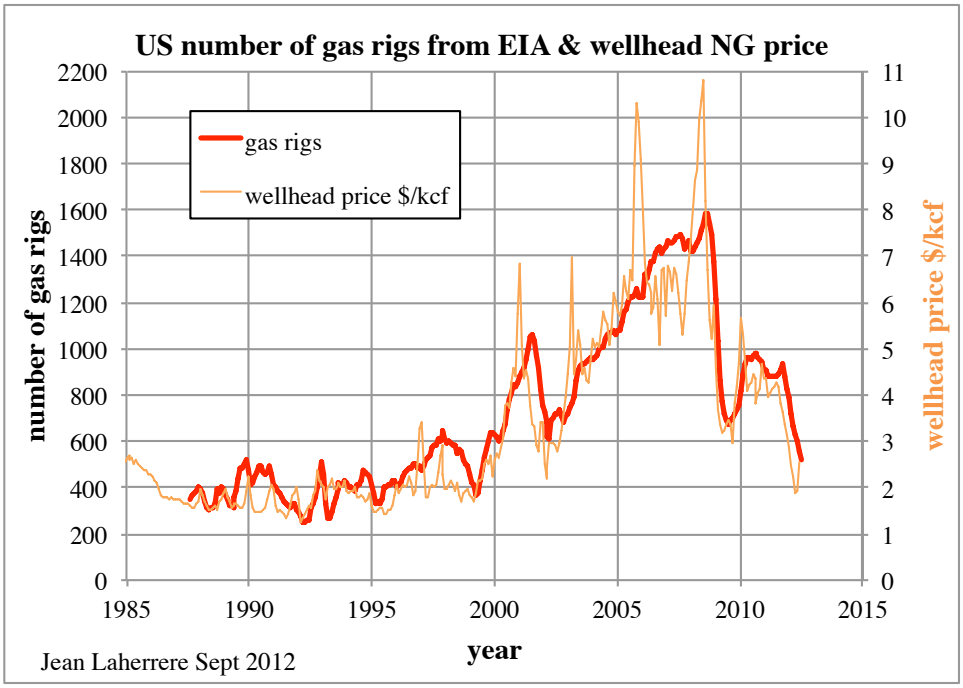
The graph from Chinese customs shows the sharp increase in 2009 of imports from Mongolia, Indonesia and Australia (and also South Africa and Russia)

Figure 20: China coal imports from Chinese Customs



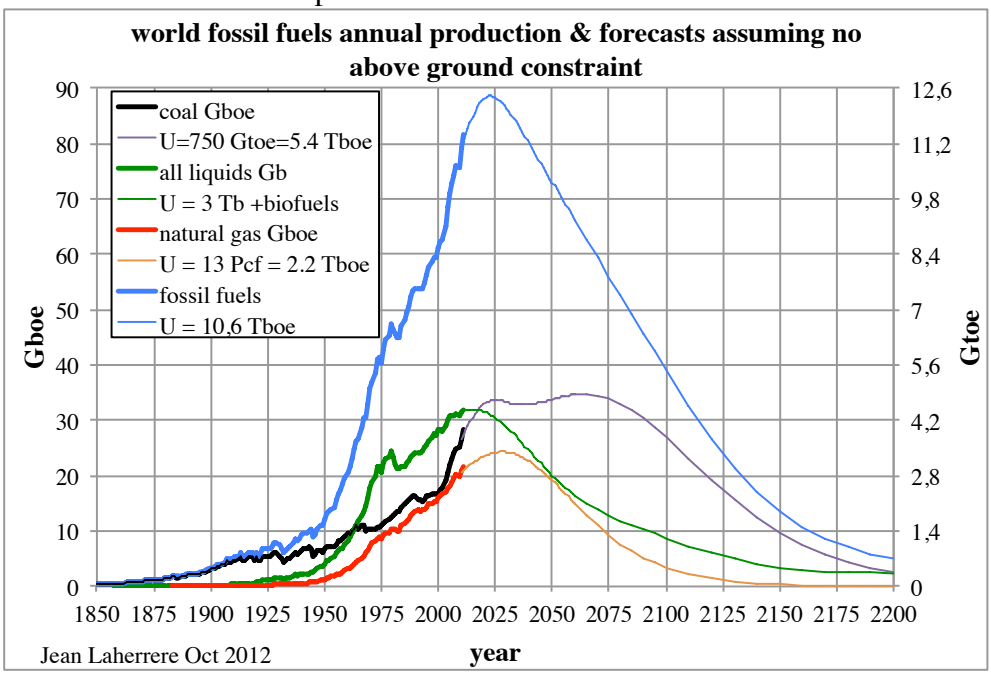
Mongolia is a growing coal producing country with a lot of potential.

The world coal production forecast has to be compared with oil and gas production.
The all liquids production is modeled with an ultimate of 3 Tb plus biofuels (maxi 6 Mb/d).
The natural gas production is modeled with an ultimate of 13 Pcf = 2.2 Tboe. The impact of the shale gas is in doubt, despite the IEA WEO 2011 "Are we entering a golden age of gas?" claiming a today's production for over 250 years, having a too short historical recent production (but first US natural gas production started in 1821 in Fredonia with shale gas production for lighting). There is not yet any commercial production of shale gas outside the US, where the owners of the land, having no right to royalties (in contrary with the US), will do anything to prevent any production, arguing with surface pollution and seismic activity (like recently in Dallas).
The WEO 2012 published "*Golden rules for a golden age of gas*", stating
"*Yet a bright future for unconventional gas is far from assured: numerous hurdles need to be overcome, not least the social and environmental concerns associated with its extraction*"
The collapse of the number of gas rigs in the US is due to a collapse of wellhead NG price, which is ridiculously low compared to wellhead oil price, because the lack of gaspipeline (40 % of the NG is burned in North Dakota) between new NG production and NG consumption. The lack of new gaspipeline could mean that the long term of the shale gas production is in doubt.
Figure 21: US number of gas rigs and wellhead price



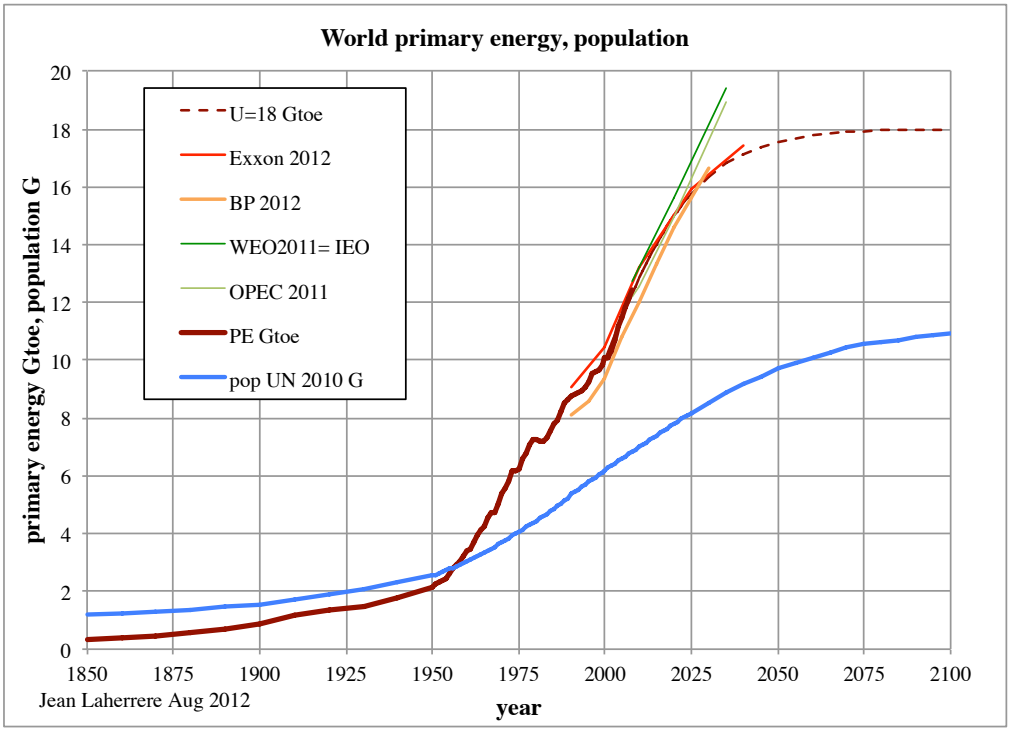
The new updated fossil fuels production and forecast on 1850-2200 displays in blue a very simple peak centered on 2025

Figure 22: world fossil fuels annual production & forecast1850-2200



Using UN 2010 population forecast, the fossil fuels production is displayed per capita and compared to the primary energy modeled with an ultimate of 18 Gtoe displayed with the forecasts by Exxon which is very close to our model, by BP and by EIA, IEA and OPEC which about equal.

Figure 22: world primary energy trending towards U = 18 Gtoe as forecasts by Exxon, BP, OPEC and IEA and population



Primary energy per capita is presently 13 boe: it could peak at 14 boe in 2025 and decline later at 12 boe in 2150. But the fossil fuels production per capita is presently 11 boe and will stay at this level up to 2025 then to decline sharply down to 1 boe in 2150. It means that in 2150 to keep our primary energy flat, 11 boe has to be provided by other energy than fossil fuels.

Figure 23: world fossil fuels production per capita compared to the primary energy per capita