Jean Laherrere 11 August 2012

Comments on L. Maugeri : **Oil : the next revolution- the unprecedented upsurge of oil production capacity and what it means for the world**
Harvard Kennedy School Belfer Center for Science and International Affairs June 2012
This study is done under the Geopolitics of Energy Project funded by BP

Leonardo Maugeri is an economist who works for ENI since 1994, but he is currently on a sabbatical leave and a senior Fellow at Harvard University.
He wrote in October 2009 an article in Scientific American:
"*Squeezing More Oil From the Ground*." *Amid warnings of a possible "peak oil," advanced technologies offer ways to extract every last possible drop"* which is now found with another title "Another Century of Oil? Getting More from Current Reserves" at
http://www.scientificamerican.com/article.cfm?id=squeezing-more-oil&page=5
I wrote some comments on the oil drum « Comments on Squeezing more oil from the ground by L. Maugeri Scientific American October 2009»
http://www.peakoil.net/publications/comments-on-squeezing-more-oil-from-the-ground,
http://aspofrance.viabloga.com/files/JL_Maugeri2009.pdf
http://europe.theoildrum.com/node/5865#more

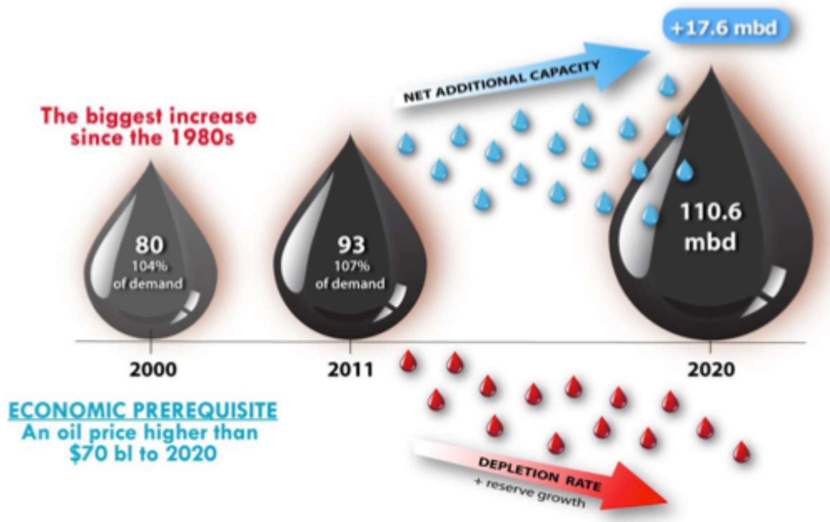
I again disagree with L. Maugeri's stand that oil production capacity is surging, because production capacity data is completely unreliable, being guesses and not real measures. Only oil production data should be forecasted. His forecast on non conventional oil is also flawed.
L. Maugeri has a poor understanding on accuracy of oil data. His statements are political and not scientific. His paper does not deserve to be on Harvard University site in a Center for science.

My detailed comments are:

-page 1
Based on original, bottom-up, field-by-field analysis of most oil exploration and development projects in the world, this paper suggests that an unrestricted, additional production (the level of production targeted by each single project, according to its schedule, unadjusted for risk) of more than 49 million barrels per day of oil (crude oil and natural gas liquids, or NGLs) is targeted for 2020, the equivalent of more than half the current world production capacity of 93 mbd.
In his list of abbreviations, "million barrels per day" is reported Mbd, why to use mbd in the text?
In fact it should be Mb/d. ENI must follow the SI (International System of units), which is the rule in every country outside the US non federal, Liberia and Myanmar.
In SI, million is mega or M, m is metre or milli, d is day (dies) or deci, so mbd is millibarrel multiplied by days!
The field by field study is mainly from Iraq contracts, which is unlikely to be realized because political constraints.

the net additional production capacity by 2020 could be 17.6 mbd, yielding a world oil production capacity of 110.6 mbd by that date – as shown in Figure 1.

Figure 1: World oil production capacity to 2020
(Crude oil and NGLs, excluding biofuels)



The oil production capacity is a very badly defined value and the data for OPEC spare capacity from EIA and IEA differs widely, as shown by Rembrandt Koppelaar in these two graphs from 2003 to 2009 (http://europe.theoildrum.com/node/5787).
EIA reports very little UAE spare capacity in 2003 when IEA reports more than 2 Mb/d.
Figure 1: OPEC spare capacity by EIA & IEA from Koppelaar 2003-2009

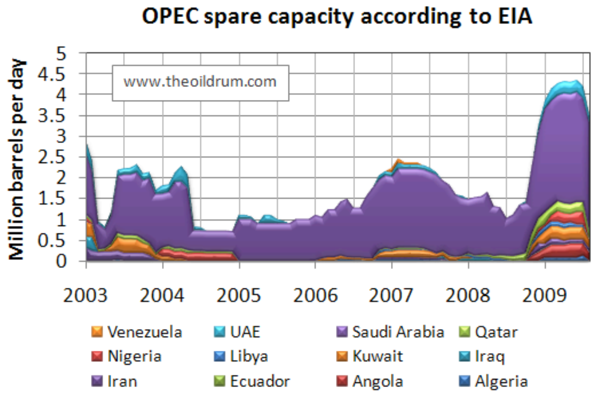


Figure 1 - OPEC spare capacity according to the Energy Information Administration from January 2003 to August 2009

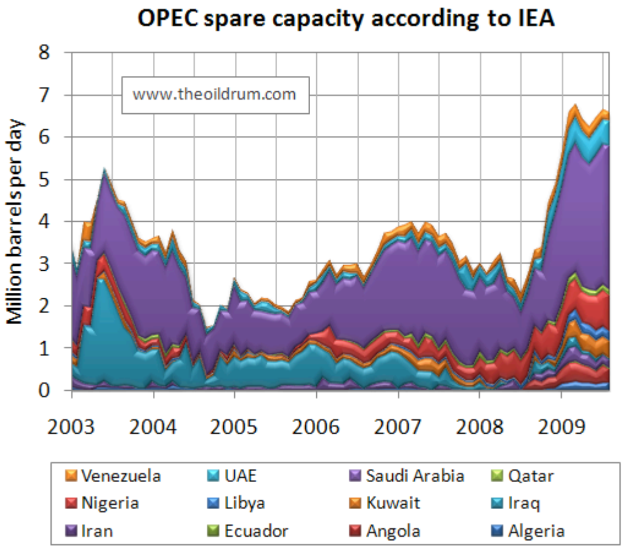
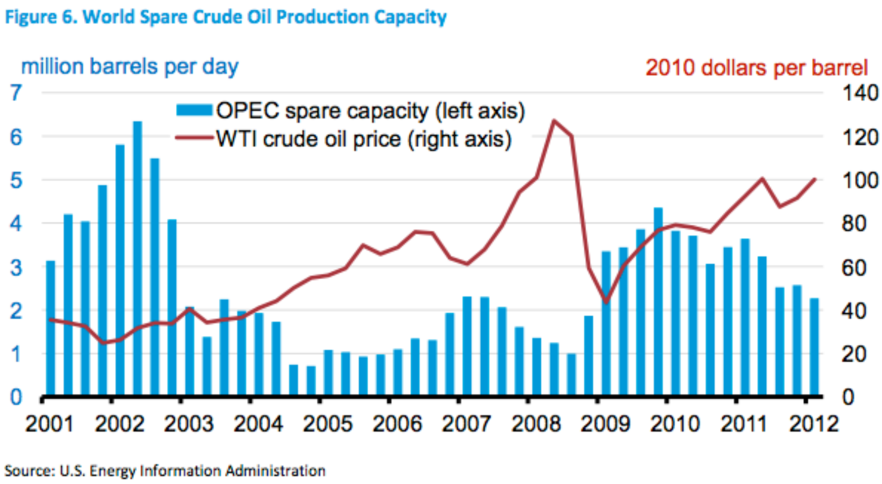


Figure 2 - OPEC Spare Capacity from January 2003 to August 2009 according to the International Energy Agency

OPEC spare capacity is reported by EIA http://www.eia.gov/analysis/requests/ndaa/pdf/ndaa.pdf in this graph showing the inverse correlation with WTI real oil price (in 2010$/b) and if OPEC capacity is shown, the title is for world spare oil production capacity! EIA assumes that the non-OPEC production has no spare capacity.

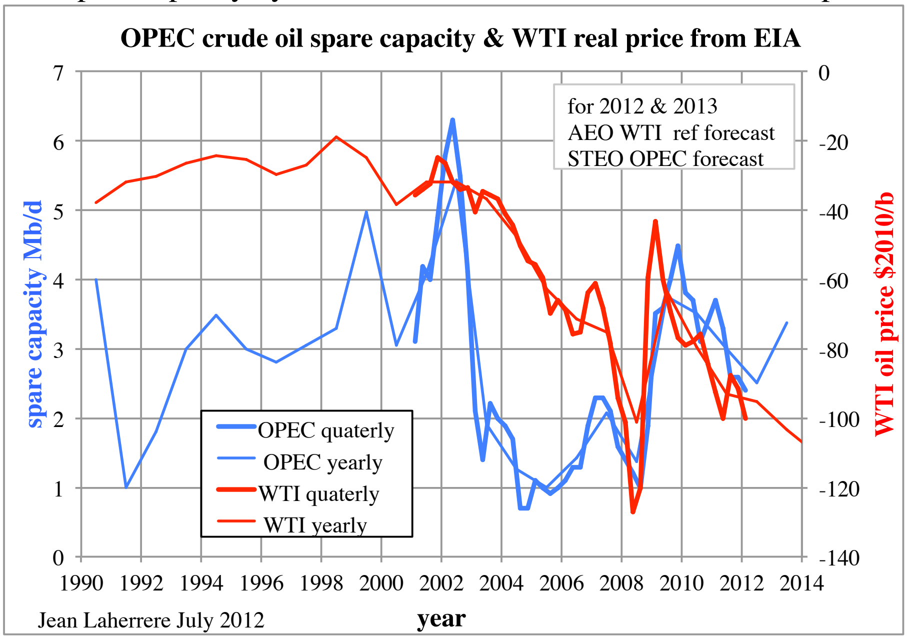
Figure 2: OPEC spare capacity by EIA 2001-2012 and WTI crude oil price



EIA provides data since 1990 and a better presentation can be plotted for WTI shown as negative value. The relationship between OPEC spare capacity and WTI may seem good by period, but it is not very reliable. It is obvious that the "*unprecedented upsurge of oil production capacity*" claimed by Maugeri is the OPEC increase in 2009 (from 1 to 5 Mb/d) correlating well with the decrease in WTI from 120 $/b to 50 $/b. The meaning is clear for 2009: low oil price is connected to high oil spare capacity. But, like egg and chicken, which starts first? Spare capacity being a guess, it is difficult to time exactly the increase, depending on the brains of the author!

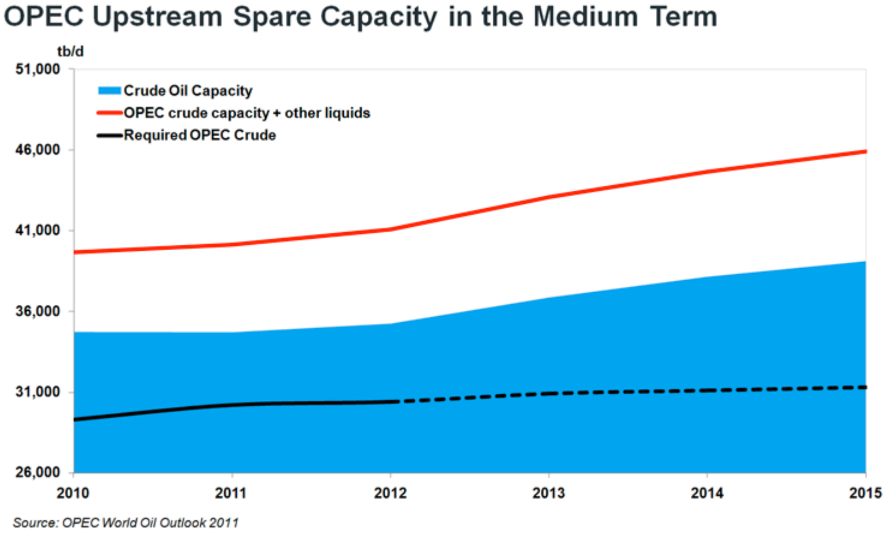
OPEC annual spare capacity from EIA was 3.05 Mb/d in 2000 and 2.99 Mb/d in 2011: it means the same on a long period. For the period 1990-2012 the EIA average is about 3 Mb/d with up to 6 and down to 1: usually a surge follow a fall! For long term forecast, extrapolation from the past has to be done on long term and not on short term!

Figure 3: OPEC spare capacity by EIA/AEO & STEO 1990-2013 and WTI price in negative scale



OPEC in its monthly oil market report does not mention OPEC spare capacity and in its annual report there is only this sentence "*OPEC crude oil spare capacity is also expected to remain at*

comfortable levels", but no value! In the last OPEC Annual Statistical bulletin 2010-2011 edition "spare capacity is only mentioned in a note page 10 quoting 2005 OPEC Conference.
It is only in OPEC World Oil Outlook that a graph on spare capacity is given since 2009 http://www.opec.org/opec_web/en/data_graphs/646.htm, stating for WOO2011 that OPEC spare capacity was around 4 Mb/d in 2011 (against 2 Mb/d for EIA) and should be 8 Mb/d in medium term.
Figure 4: OPEC spare capacity by OPEC WOO 2011



To estimate the spare capacity, it is necessary to know exactly what is the production?
It appears that OPEC does not agree on what is their production. This graph uses **secondary sources** data, but it should be quite different using **direct communication** data!
There are discrepancies on capacity and on production between OPEC presentations: Ch.Khelil "Oil production capacity" Sept 2006 OPEC seminar
http://www.opec.org/opec_web/static_files_project/media/downloads/press_room/Chakib_Khelil.pdf
and Dr Nimat B. Abu Al-Soof "Upstream Oil Industry Analyst OPEC " May 2007
http://www.opec.org/opec_web/static_files_project/media/downloads/publications/OPEC%20Spare%20Capacity.pdf.
For 2003 Khelil reports OPEC capacity at 29 Mb/d when al-Soof at 31 Mb/d
The inaccuracy on OPEC capacity is more than 2 Mb/d
Figure 5: OPEC spare capacity by Khelil 2007

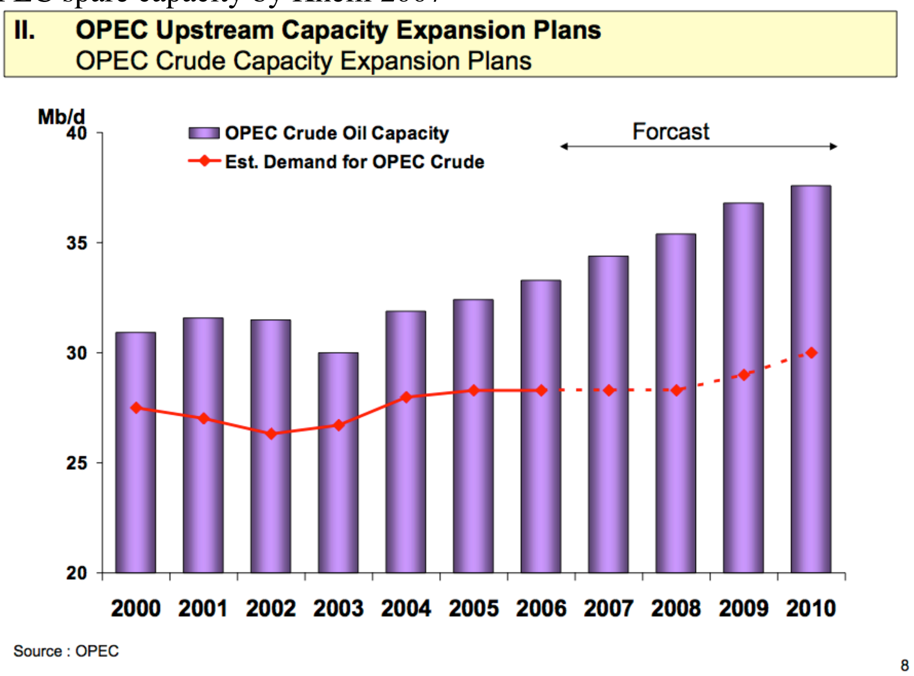
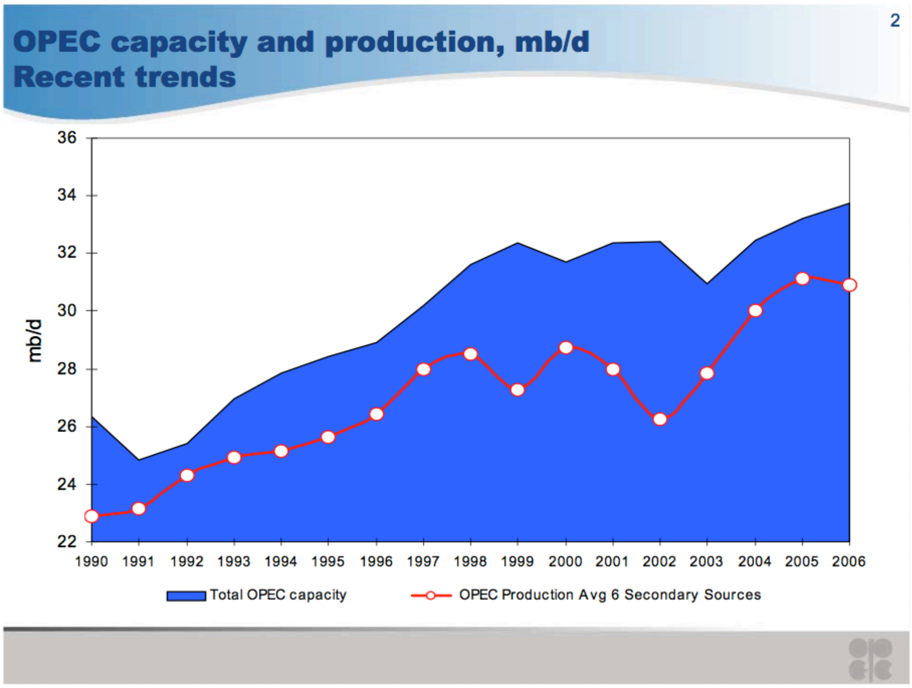


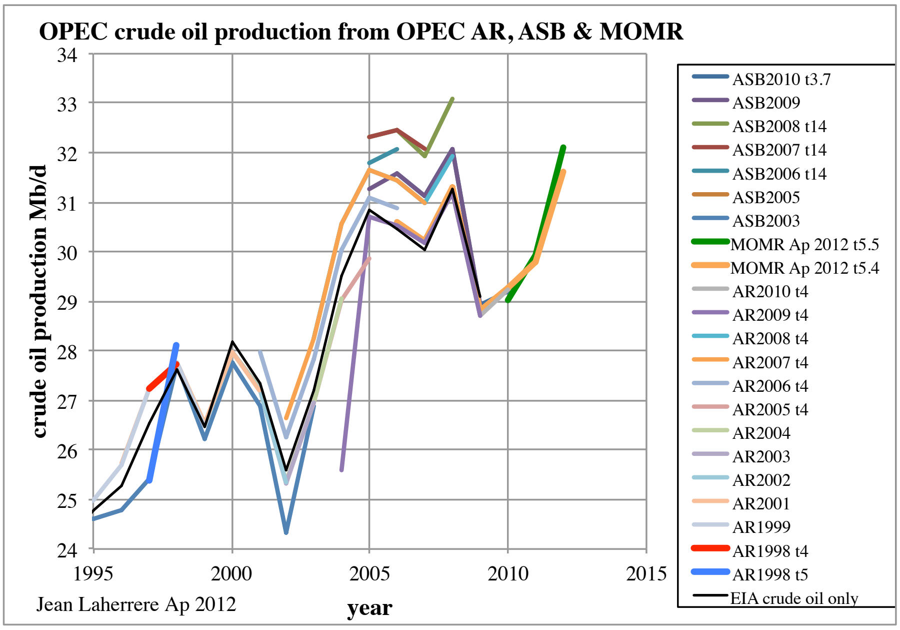
Figure 6: OPEC spare capacity by al-Soof 2006



In fact the reliability of OPEC oil production is very poor (because they cheat on quotas, they cheat on production data or on definition).
OPEC reports mainly its production from **secondary sources**, meaning that the value reported by its members (called **direct communication**) is less reliable.
The difference between secondary sources and direct communication vary (from -7 % for 1997 to 4 % in July 2012), in particular for Venezuela (from -25 % in 1997 to 19 % in July 2012).
Direct data is more often higher than secondary sources, but not always because of the quotas.
Table: crude oil production sources: AR 1998 & MOMR Ap 2012

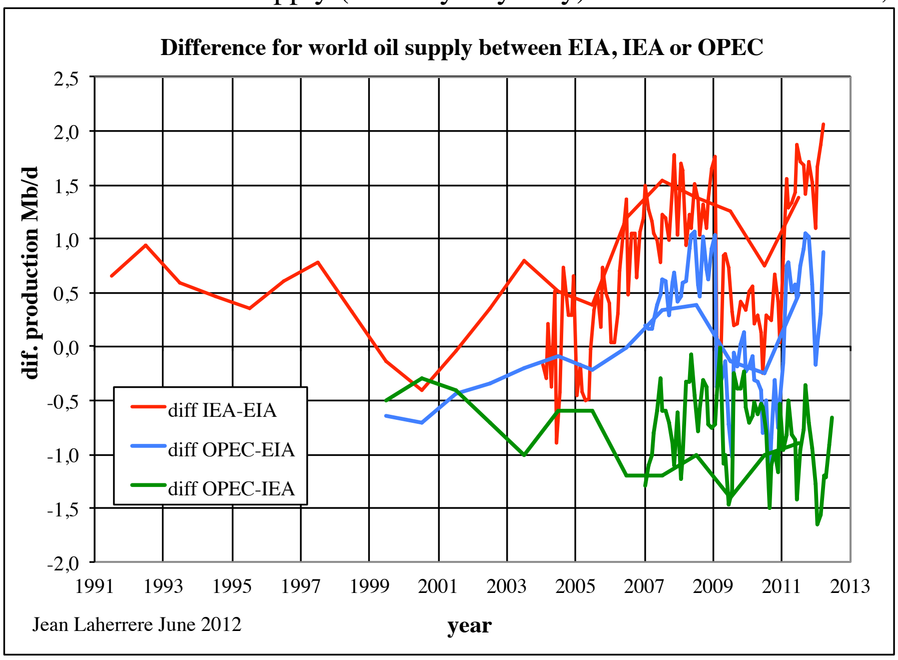
Mb/d	**secondary sources**	**direct communication** by member countries	difference %
OPEC			
1997	27.228	25.384	-7
1998	27.726	28.100	1
2010	29.254	29.020	-1
2011	29.776	29.942	1
Feb 2012	31.176	32.107	3
July 2012	31.619	32.964	4
Venezuela			
1997	3.228	2.411	-25
1998	3.137	3.409	9
2010	2.338	2.779	19
2011	2.380	2.795	17
Feb 2012	2.379	2.785	17
July 2012	2.370	2.831	19

The data for OPEC crude oil production also vary with time from different OPEC Annual Reports & Annual Statistical Bulletins
For the year 2005, OPEC data varies from 29.9 Mb/d (AR 2005) to 32.3 Mb/d (ASB 2007 & 2008), when EIA value is 30.8 Mb/d
For 2006 to 2008 between the values from AR2009 and ASB 2009 there is about 1 Mb/d.
OPEC data is compared to EIA crude oil only production up to 2009 (EIA ceased to publish such data in January 2011 because budgets cuts).
Figure 7: OPEC crude oil production from AR & ASB OPEC reports compared to EIA crude oil only (1980-2009)

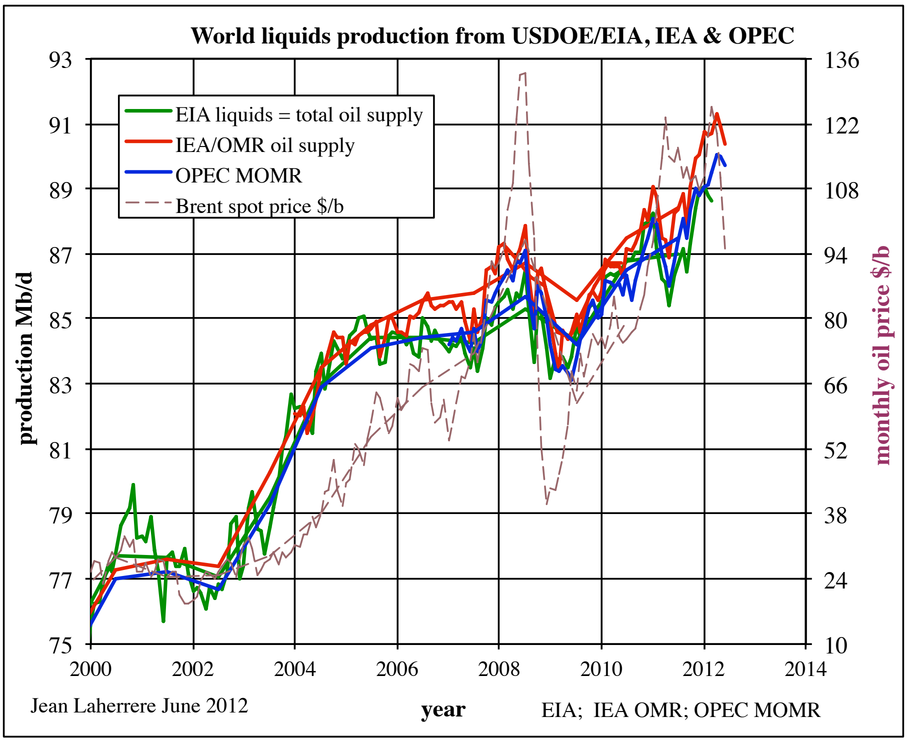


It appears that the accuracy of OPEC oil production is about 2 Mb/d!

World oil production capacity is badly known and its use should be avoided being completely unreliable. Only CERA is forecasting production capacity when reliable agencies forecast only oil production.
Already the world oil supply data differs widely from source (EIA, IEA, OPEC), mainly due to different definitions. For the period 1991-2012 the discrepancy could be plus or minus 2 Mb/d and the most striking is the sharp change at the beginning of the year due to change in definition.
The monthly data does not agree with the annual data, showing the uncertainty of the data, varying with time and authors!
Figure 8: difference for world oil supply (monthly & yearly) between USDOE/EIA, IEA & OPEC



EIA data is late to be reported without too much revision. EIA has warned that they may stop reporting international data because budget cuts!
Figure 9: world liquids production from USDOE/EIA, IEA & OPEC with Brent oil price



Using oil production capacity is adding more uncertainty, but it is a trick to claim in future that the forecast was right by manipulating the data.
In fact past world crude oil + NGL production data from EIA gives from 2000 to 2011 an increase of 7.7 Mb/d against 13 Mb/d for production capacity in Maugery's figure 1.
As OPEC spare capacity from EIA was about the same and Non-OPEC production is at or close full capacity (EIA Newell 23 Feb 2011), this 13 Mb/d looks wrong!
There is no increase in US crude oil /NGL production from 2000 to 2011.

EIA Mb/d	2000	2011	increase 2000-2011
world			
-crude oil (& condensate)	68.522	74.030	
-NGPL	6.376	8.571	
-crude oil & NGL	74.898	82.601	7.7
US			
-crude oil	5.881	5.659	
-NGPL	1.911	2.183	
-crude oil & NGL	7.792	7.832	0

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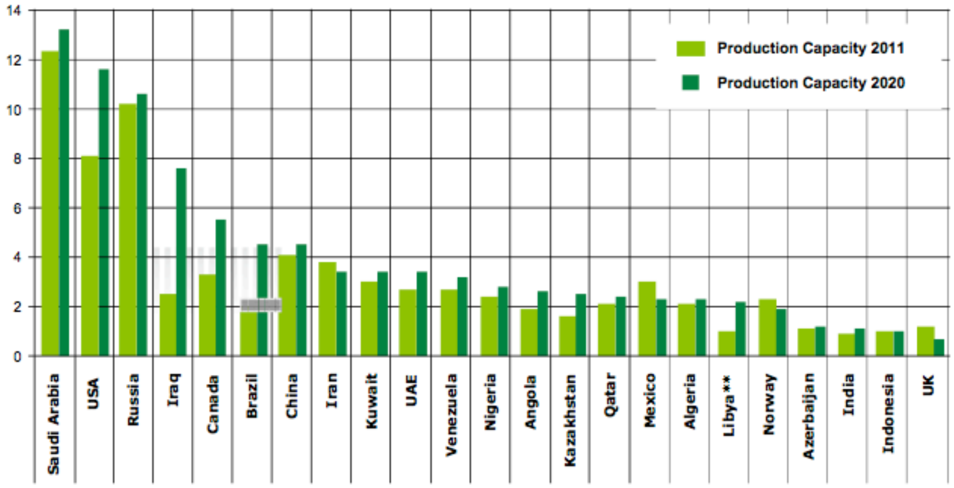
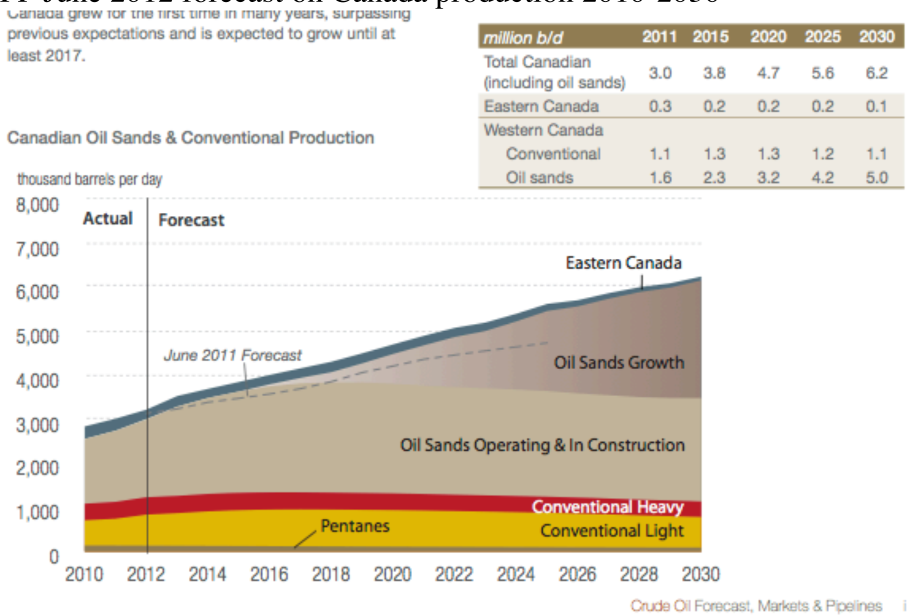
Figure 2: Country-by-country evolution of oil production capacity to 2020
(First 23 countries)



Let's compare Maugeri's increase from 2011 to 2020 to official production forecasts in Mb/d

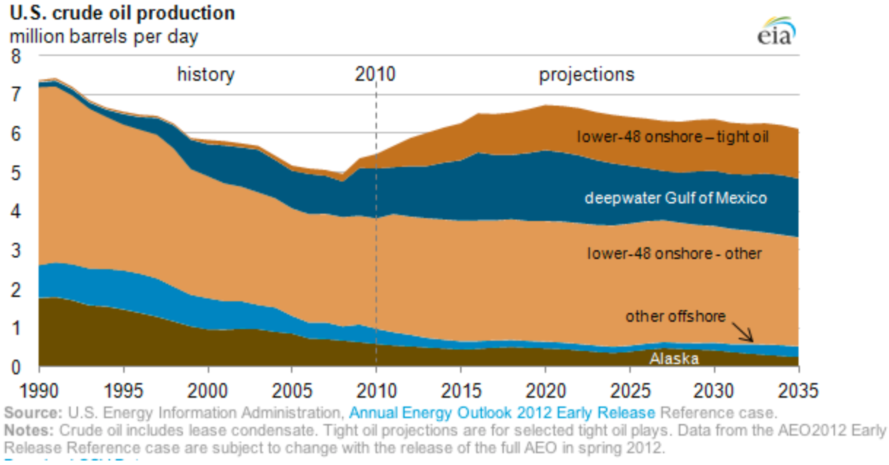
Canada	Maugeri	CAPP June 2012 oil prod	Maugeri/CAPP
2011	3.2	3	1.07
2020	5.6	4.7	1.19
increase	2.4	1.7	1.41

Figure 10: CAPP June 2012 forecast on Canada production 2010-2030



USA	Maugeri	EIA/AEO2012 production			Maugeri/EIA
		crude	NGL	crude+NGL	
2011	8	5.68	2.16	7.34	1.09
2020	11.6	6.73	2.79	9.52	1.21
increase	3.6			2.2	1.64

Figure 11: EIA AEO 2012 forecast on US crude oil production 1990-2035



Again Maugeri could claim that he is right because his forecast is on capacity, which is guessed, when every reliable forecast is on production!

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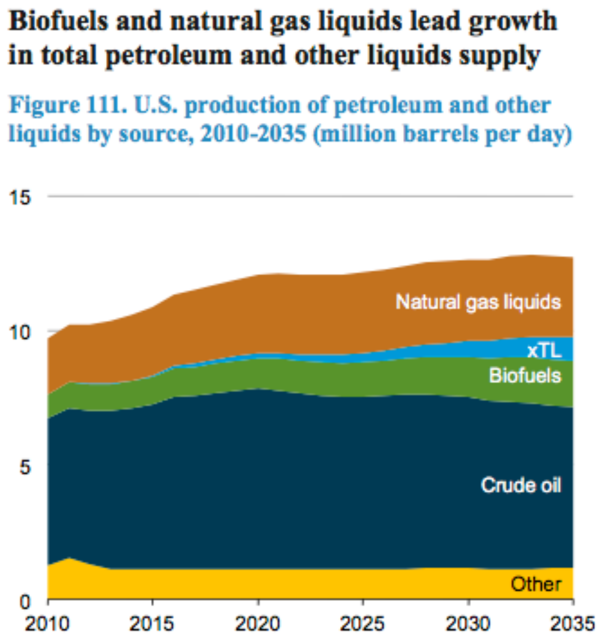
Thus, the U.S. could produce 11.6 mbd of crude oil and NGLs by 2020, making the country the second largest oil producer in the world after Saudi Arabia. Adding biofuels to this figure, the overall U.S. liquid capacity could exceed 13 mbd, representing about 65 percent of its current consumption.
In Maugeri's figure 2 for the US production capacity for 2020 was 11.6 Mb/d, but in page 4 it is indicated as production.
Maugeri forecasts US liquids capacity for 2020 at 13 Mb/d adding biofuels, but quid refinery gain which for the US was 1 Mb/d in 2010, being a not negligible part of the US liquids production (refinery gain could come from imported oil but it uses domestic natural gas for making lighter products, being a kind of GTL).
AEO 2012 table A11 forecasts in Mb/d

domestic production	2010	2020	2035
crude oil	5.47	6.70	5.99
NGL	2.07	2.91	3.01
refinery processing gain	1.07	0.94	0.85
ethanol	0.85	1.04	1.65
biodiesel	0.01	0.12	0.13
CTL	0	0	0.28
total	9.34	11.62	11.06

AEO 2012 graph include "other" which is mainly refinery gain.
Figure 12: EIA AEO 2012 forecast on US liquids production 1990-2035



Maugeri's forecast of US 13 Mb/d seems significantly higher than EIA last forecast!

† In the first quarter 2012, average world oil production consistently reached or surpassed 91 mbd

Oil supply First quarter 2012 in Mb/d

EIA	88.8
IEA	90.7
OPEC	89.2

91 Mb/d was not reached!

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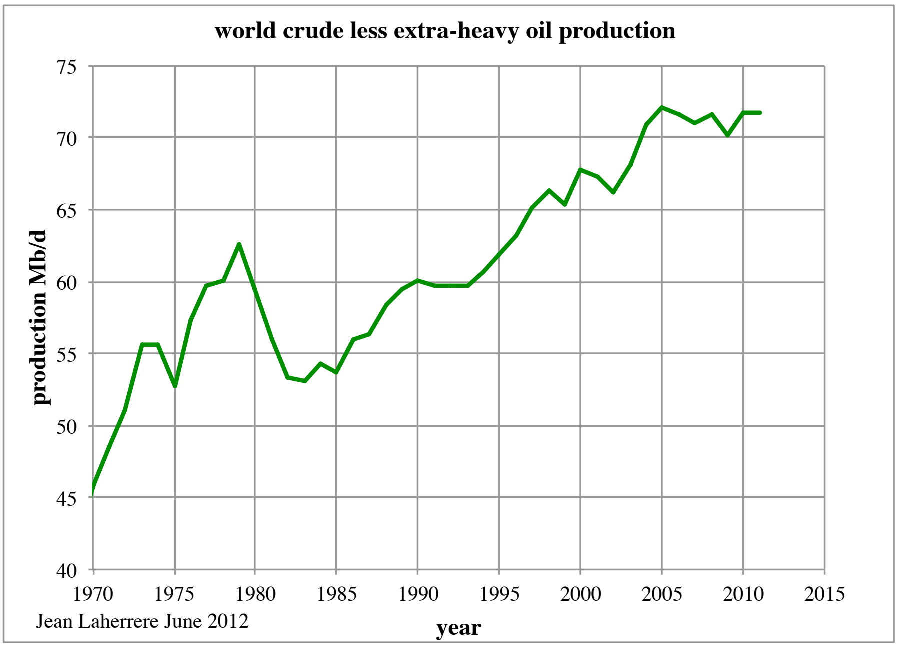
In the aggregate, conventional oil production is also growing throughout the world at an unexpected rate, although some areas of the world (Canada, the United States, the North Sea) are witnessing an apparently irreversible decline of the conventional production.
Technology may turn today's expensive oil into tomorrow's cheap oil.

There is no consensus on the definition of conventional oil, for some it is the easy flowing oil, for others it is the oil from continuous-type accumulations. Maugeri states page 14 EIA definition of conventional by "*produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore*". But EIA does not provide the production data of so-called conventional oil and, neither Maugeri, except claiming an unexpected present growth for the world.

Extra-heavy oil (Athabasca & Orinoco) are obviously not conventional and the world crude less extra-heavy oil production from EIA (being more than the EIA definition) displays an increase from 1982 to 2005, but **since 2005 it is plateauing at 72 Mb/d, contrary to Maugeri's claim**.

Figure 13: world crude less extra-heavy oil production 1970-2011



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The unexpected and rapid increase of oil production from the forerunner of ***shale/tight oil*** *(the Bakken Shale formation in North Dakota) is astonishing: production has grown from a few barrels in 2006 to more than 530,000 barrels in December 2011. This development seems consistent with the best study ever conducted on the geological features and potential productivity of Bakken (Price, 1999), which estimated the maximum Original Oil in Place of the whole formation at more than* ***500 billion barrels, with a probable recovery rate of about 50 percent.***

production North Dakota from Bakken
2006 = 2.3 Mb for the year, production December 2011 = 14.6 Mb for the month
December 2006 = 10 kb/d December 2011= 510 kb/d
L. Maugeri, who is called to be a world oil expert, should know the difference between b and b/d.
He should have checked with page 47 where he writes, again confusing bd, b/d and b
Thanks to the Bakken Shale, oil production in North Dakota skyrocketed from around 110,000 bd in 2006 (of which 7,600 boe/d in the Bakken Shale) to nearly 264,000 boe/d in 2010 and more than 530,000 barrels in December 2011.
But the Bakken formation which is produced is not the shaly part, but the sandy limestone (or dolomite for Elm Coulee) in the middle: calling Bakken a shale play is wrong. It is a structural/stratigraphic play depending of the quality of the reservoir and it is called now light tight oil.

and page 48
In April 2008, a report by the North Dakota Department of Mineral Resources (NDDMR) estimated that the North Dakota portion of the Bakken contained up to 167 billion barrels, and that approximately 2.1 billion barrels of that oil (the estimated ultimate recovery), less than 2 percent, could be recovered using 2008 technology. In any case, the report also recognized that technological evolution could dramatically increase the recovery factor.34

Maugeri quotes on page 8 the Bakken oil in place as being 500 Gb (a maximum) **with a recovery of 50%.** But why to chose an obsolete (1999) and controversial paper when many more recent estimates exist from USGS and in particular from North Dakota Department of Mineral Resources and to mention them only page 48.

In the book written by Leigh C. Price (1999/2000) USGS geochemist “Origins and characteristics of the basin-centered continuous-reservoir unconventional oil-resource base of the Bakken Source System, Williston Basin http://www.scribd.com/doc/73214146/5/The-Bakken-Source-System
In section 10.0, we present preliminary mass-balance calculations regarding the amount of oil generated by the Bakken shales in the Bakken HC kitchen of the Williston Basin (North Dakota and Montana). Our calculations suggest that 413 billion barrels of oil have been generated, with a potential upside of 503 billion barrels and a minimum of 271 billion barrels. These numbers are larger than three previously-published estimates of 92, 132, and 150 billion barrels”
The assumption of a recovery of 50% is well above the recovery in a conventional field and seems unrealistic.
Price 1999’s paper is described as controversial in ND DMR 2006 Bakken Formation Reserve Estimates Julie LeFever and Lynn Helms
https://www.dmr.nd.gov/ndgs/bakken/newpostings/07272006_BakkenReserveEstimates.pdf
<<*Nature of the Controversy*
The methods used by Price to determine the amount of hydrocarbons generated by the Bakken and the idea that the oil has not migrated out of the Bakken are under dispute.
Price (unpublished) used a more complete database and estimated that the Bakken was capable of generating between 271 and 503 BBbls of oil with an average of 413 BBbls. New estimates of the amount of hydrocarbons generated by the Bakken were presented by Meissner and Banks (2000) and by Flannery and Kraus (2006). The first of these papers tested a newly developed computer model with existing Bakken data to estimate generated oil of 32 BBbls. The second paper used a more sophisticated computer program with extensive data input supplied by the ND Geological Survey and Oil and Gas Division. Early numbers generated from this information placed the value at 200 BBbls later revised to 300 BBbls when the paper was presented in 2006.
How much of the generated oil is recoverable remains to be determined. Estimates of 50%, 18%, and 3 to 10% have been published.
How much of the oil that has been generated is technically recoverable is still to be determined. Price places the value as high as 50% recoverable reserves. A primary recovery factor of 18% was recently presented by Headington Oil Company for their Richland County, Montana wells. Values presented in ND Industrial Commission Oil and Gas Hearings have ranged from 3 to 10%. The Bakken play in the North Dakota side of the basin is still in the learning curve. North Dakota wells are still undergoing adjustments and modifications to the drilling and completion practices used for this formation. It is apparent that technology and the price of oil will dictate what is potentially recoverable from this formation.<<

It is found today on http://en.wikipedia.org/wiki/Bakken_formation: **<<History of Bakken oil resource estimates**
<<A landmark paper by Dow and a companion paper by Williams (1974) recognized the Bakken formation as a major source for the oil produced in the Williston Basin. These papers suggested that the Bakken was capable of generating 10 billion barrels (1.6×109 m3) of oil (BBbls). Webster (1982, 1984) as part of a Master’s thesis at the University of North Dakota further sampled and analyzed the Bakken and calculated the hydrocarbon potential to be about 92 BBbls. These data were updated by Schmoker and Hester (1983) who estimated that the Bakken might contain a resource of 132 BBbls of oil in North Dakota and Montana. A research paper by USGS geochemist Leigh Price in 1999 estimated the total amount of oil contained in the Bakken shale ranged from 271 billion to 503 billion barrels (8.00×1010 m3), with a mean of 413 billion barrels (6.57×1010 m3).[14] While others before him had begun to realize that the oil generated by the Bakken shales had remained within the Bakken, it was Price, who had spent much of his career studying the Bakken, who particularly stressed this point. If he was right, the large amounts of oil remaining in this formation would make it a prime oil exploration target. However, Price died in 2000 before his research could be peer-reviewed and published. Nevertheless, the drilling and production successes in much of the Bakken beginning with the Elm Coulee Oil Field discovery in 2000 have proven

correct his claim that the oil generated by the Bakken shale was still there. New estimates of the amount of hydrocarbons generated by the Bakken were presented by Meissner and Banks (2000) and by Flannery and Kraus (2006). The first of these papers tested a newly developed computer model with existing Bakken data to estimate generated oil of 32 BBbls. The second paper used a more sophisticated computer program with extensive data input supplied by the ND Geological Survey and Oil and Gas Division. Early numbers generated from this information placed the value at 200 BBbls later revised to 300 BBbls when the paper was presented in 2006.".[15] In April 2008, a report issued by the state of North Dakota Department of Mineral Resources estimated that the North Dakota portion of the Bakken contained 167 billion barrels (2.66×1010 m3) of oil.[6]
While these numbers would appear to indicate a very large oil resource, the percentage of this oil which might be extracted using current technology is another matter. Estimates of the Bakken's technically recoverable oil have ranged from as low as 1% — because the Bakken shale has generally low porosity and low permeability, making the oil difficult to extract — to Leigh Price's estimate of 50% recoverable.[16] Reports issued by both the USGS and the state of North Dakota in April 2008 seem to indicate the lower range of recoverable estimates are more realistic with current technology.
The flurry of drilling activity in the Bakken, coupled with the wide range of estimates of in-place and recoverable oil, led North Dakota senator Byron Dorgan to ask the USGS to conduct a study of the Bakken's potentially recoverable oil. In April 2008 the USGS released this report, which estimated the amount of technically recoverable, undiscovered oil in the Bakken formation at 3.0 to 4.3 billion barrels (680,000,000 m3), with a mean of 3.65 billion.[5] Later that month, the state of North Dakota's report [6] estimated that of the 167 billion barrels (2.66×1010 m3) of oil in-place in the North Dakota portion of the Bakken, 2.1 billion barrels (330,000,000 m3) were technically recoverable with current technology.
In 2011, a senior manager at Continental Resources Inc. (CRI) declared that the "Bakken play in the Williston basin could become the world's largest discovery in the last 30-40 years", as ultimate recovery from the overall play is now estimated at 24 billion bbls. This considerable increase has been made possible by the combined use of horizontal drilling, fracking, and a large number of wells drilled. While these technologies have been consistently in use since the 1980s, Bakken is the place where they are being most heavily used: 150 active rigs in the play and a rate of 1,800 added wells per year. CRI developed a technology allowing its rigs to move a few hundred yards on hydraulic "feet", increasing the rate of well completion.<<

To add confusion USGS 2012-1118: "Variability of Distributions of Well-Scale Estimated Ultimate Recovery for Continuous (Unconventional) Oil and Gas Resources in the United States" http://pubs.usgs.gov/of/2012/1118/ reports EUR (estimated ultimate recovery) in Mb when it should be in Gb. Shale oil is not called tight oil, but continuous oil.
They speak about continuous-oil but it is obviously discrete fields.
Figure 14: USGS 2012-1118 table 4: estimated ultimate recovery in Mb

Table 4. Input data for estimated ultimate recovery distributions for United States continuous-oil assessment units, values in millions of barrels of oil. [AU, assessment unit; and EUR, estimated ultimate recovery]

AU number	AU name	Province	Year assessed	Minimum EUR	Median EUR	Maximum EUR	Mean EUR
50310164	Eastern Expulsion Threshold	Williston Basin	2008	0.002	0.12	5	0.241
50310163	Nesson-Little Knife Structural	Williston Basin	2008	0.002	0.09	4	0.185
50210361	Cane Creek Shale Oil	Paradox Basin	2011	0.002	0.08	3	0.154
50310165	Northwest Expulsion Threshold	Williston Basin	2008	0.002	0.065	4	0.151
50310161	Elm Coulee-Billings Nose	Williston Basin	2008	0.002	0.08	2	0.135
50270561	Marias River Shale Continuous Oil	Montana Thrust Belt	2002	0.001	0.08	1.6	0.126
50370361	Niobrara Continuous Oil	Southwestern Wyoming	2002	0.001	0.08	1.6	0.126
50300361	Niobrara Continuous Oil	Hanna, Laramie, Shirley Basins	2005	0.001	0.04	1.6	0.079
50310162	Central Basin-Poplar Dome	Williston Basin	2008	0.002	0.025	2	0.064
50210363	Gothic, Chimney Rock, Hovenweep Shale Oil	Paradox Basin	2011	0.002	0.03	1.5	0.064
50580162	Woodford Shale Oil	Anadarko Basin	2010	0.003	0.03	1.5	0.064
50200561	Deep Uinta Overpressured Continuous Oil	Uinta-Piceance	2000	0.003	0.045	0.45	0.059
50440165	Spraberry Continuous Oil	Permian Basin	2007	0.001	0.045	0.4	0.057
50490170	Eagle Ford Shale Oil	Gulf Coast Mesozoic	2010	0.002	0.03	1	0.055
50490168	Austin Pearsall-Giddings Area Oil	Gulf Coast Mesozoic	2010	0.002	0.04	0.5	0.055
50330361	Niobrara Continuous Oil	Powder River Basin	2002	0.002	0.028	0.5	0.042
50330261	Mowry Continuous Oil	Powder River Basin	2002	0.002	0.025	0.35	0.035
50340262	Mowry Fractured Shale Continuous Oil	Big Horn Basin	2008	0.002	0.025	0.35	0.035
50390261	Fractured Niobrara Limestone (Silo Field Area)	Denver Basin	2001	0.002	0.022	0.4	0.033
50390661	Niobrara-Codell (Wattenberg Area)	Denver Basin	2001	0.003	0.008	0.1	0.011

The mean EUR for continuous-oil assessment units Williston Basin are:
-Eastern expulsion threshold 0.241 Mb or 241 Mb?
-Nesson-Little Knife structural 0.185 Mb or 185 Mb?
-Northwest expulsion threshold 0.151 Mb or 151 Mb?
-Elm-Coulee-Billings Nose 0.135 Mb or 135 Mb?
-Central Basin-Poplar Dome 0.064 Mb or 64 Mb?

The older report U.S. Geological Survey Williston Basin Province Assessment Team, 2011, "Assessment of undiscovered oil and gas resources of the Williston Basin Province of North Dakota, Montana, and South Dakota, 2010": U.S. Geological Survey Digital Data Series 69–W, 7 chaps displays a map indicating the main structural features
Figure 14: USGS 2011 DGS 69-W: map of Williston basin features

2 Executive Summary—Assessment of Undiscovered Oil and Gas Resources, Williston Basin Province

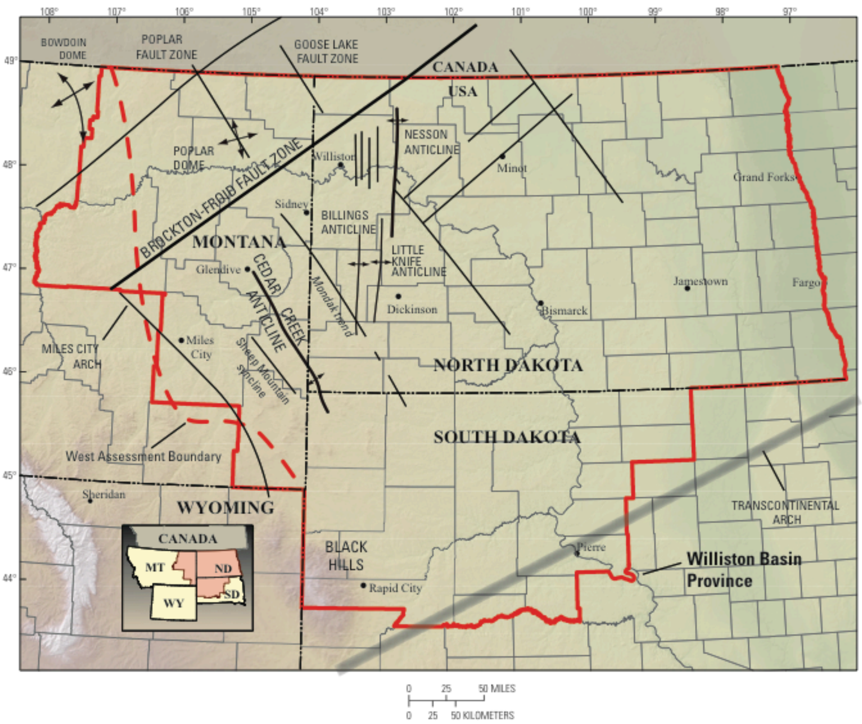


Figure 1. Location and physiographic features of the Williston Basin Province. Black lines not labeled are major lineaments or faults. Solid red line is province boundary; dashed red line represents the western boundary for assessment units. Lineaments and structure locations are from Gerhard and others (1982) and Anna (1986).

This report estimates the undiscovered for the main assessments units being structural (nose, dome) under the item of continuous oil & gas resources.

Figure 15: USGS 2011 DGS 69-W: undiscovered resources in Mb & Gcf

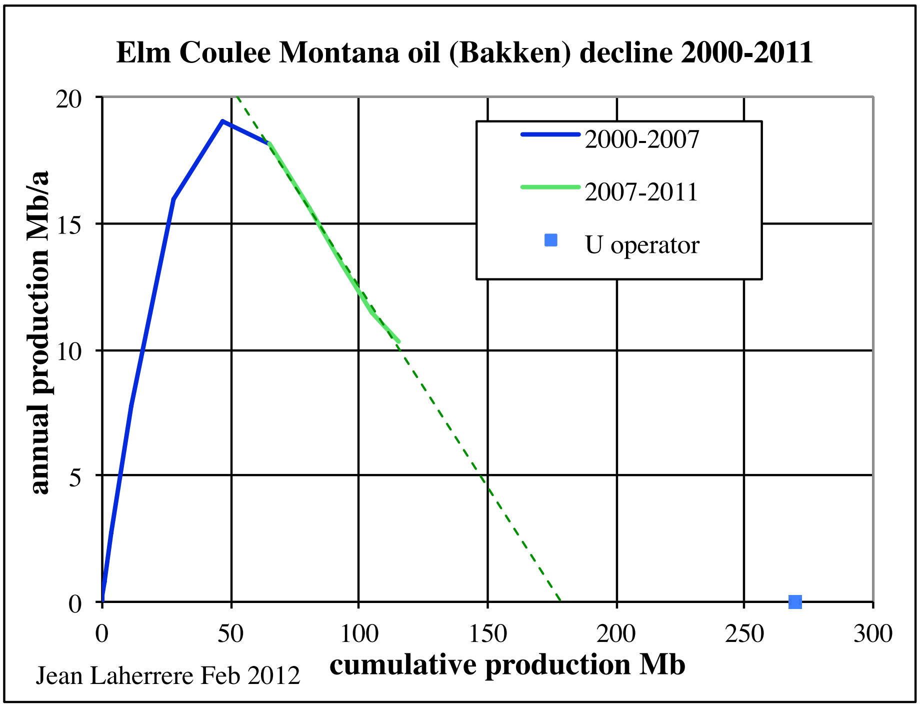
Table 1. Williston Basin Province assessment results.

[MMBO, million barrels of oil; BCFG, billion cubic feet of gas; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. For gas accumulations, all liquids are included as NGL (natural gas liquids). F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. TPS, total petroleum system; AU, assessment unit. Gray shading indicates not applicable]

	Total Petroleum System and Assessment Unit	Field Type	Total Undiscovered Resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Continuous Oil and Gas Resources	**Bakken–Lodgepole TPS**													
	Elm Coulee–Billings Nose AU	Oil	374	410	450	410	118	198	332	208	8	16	29	17
	Central Basin–Poplar Dome AU	Oil	394	482	589	485	134	233	403	246	10	18	35	20
	Nesson–Little Knife Structural AU	Oil	818	908	1,007	909	260	438	738	461	19	34	64	37
	Eastern Expulsion Threshold AU	Oil	864	971	1,091	973	278	469	791	493	20	37	68	39
	Northwest Expulsion Threshold AU	Oil	613	851	1,182	868	224	411	754	440	16	32	64	35
	Coalbed Gas TPS													
	Fort Union Coalbed Gas AU	Gas					368	791	1,701	882	0	0	0	0
	Total Continuous Resources					3,645				2,730				148

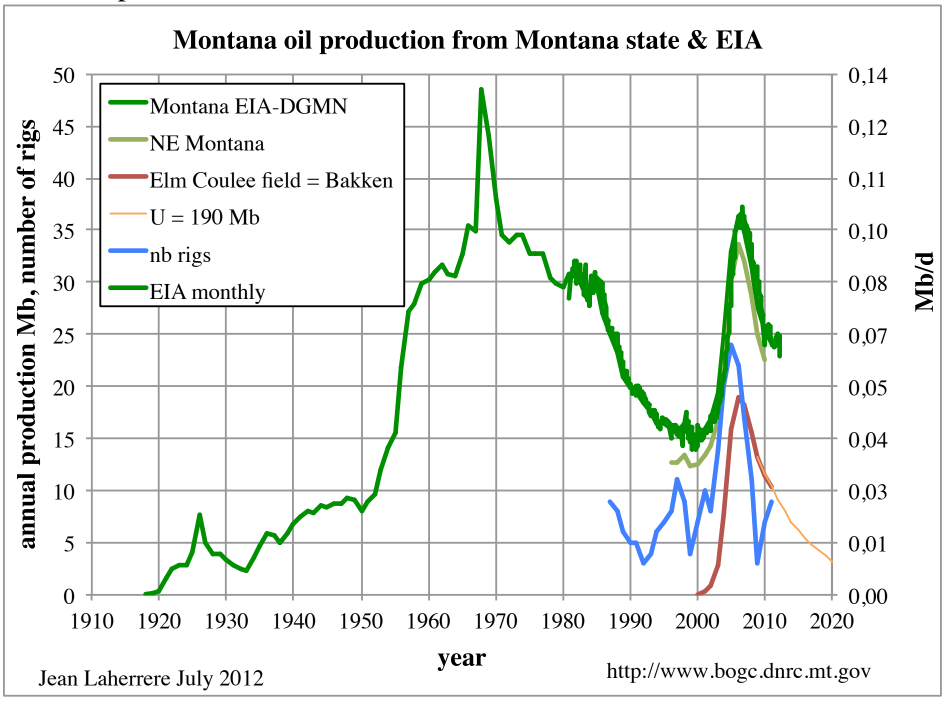
It is surprising to see that the undiscovered mean for Elm Coulee - Billings nose is assessed at 410 Mb, when in the estimated ultimate recovery EUR is reported by USGS 2012-1118 at 135 Mb. It seems that the ultimate is not for the area but for the present discovered fields (in fact Elm Coulee). But the plot of the oil decline for Elm Coulee (in Montana) shows a decline 2007-2011 of 12%/a, leading toward 190 Mb (and not 135 Mb) and the operator reports 270 Mb.

Figure 16: Elm Coulee (Montana & Bakken) oil decline 2000-2011



Montana oil production displays an interesting sharp peak in 1968 at 130 000 b/d and a second peak also sharp in 2006 at 100 000 b/d

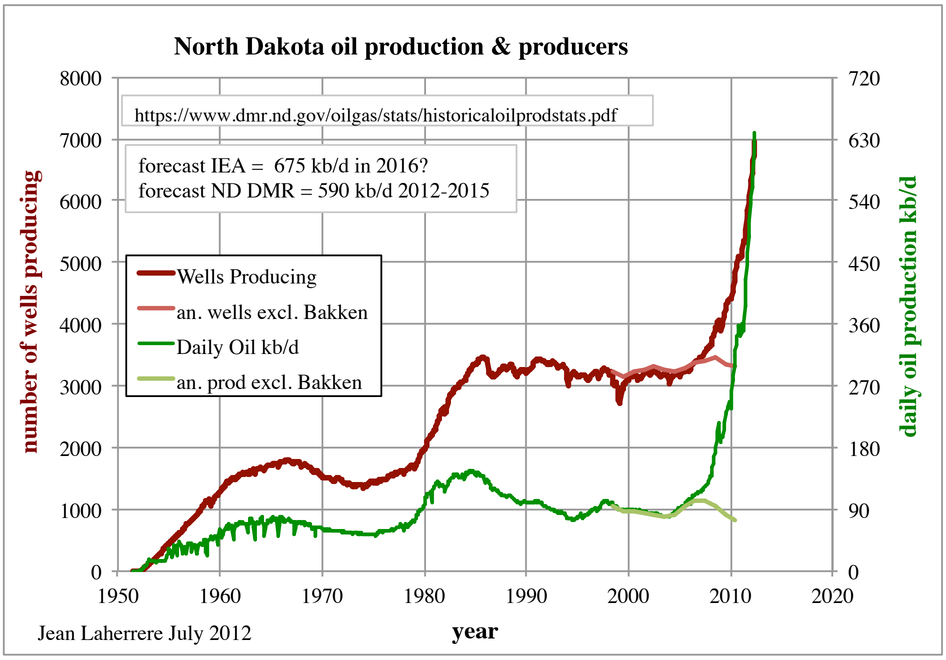
Figure 17: Montana oil production from Montana State & EIA



It is likely that North Dakota will follow the same pattern of sharp increase and sharp decrease, like Montana.

But it is hard to guess the level of the peak, which depends upon the number of wells drilled: it could be this year or next, but I doubt that they can keep adding producers wells with such rate, doubling the number since 2005, contrary of what it is said: it is not a continuous-type accumulation, but sweet spots fields. The best way to see that it is to look at the EIA video on Bakken drilling activity from 1985 to 2010 http://www.eia.gov/todayinenergy/detail.cfm?id=3750#

Figure 18: North Dakota oil production & producers



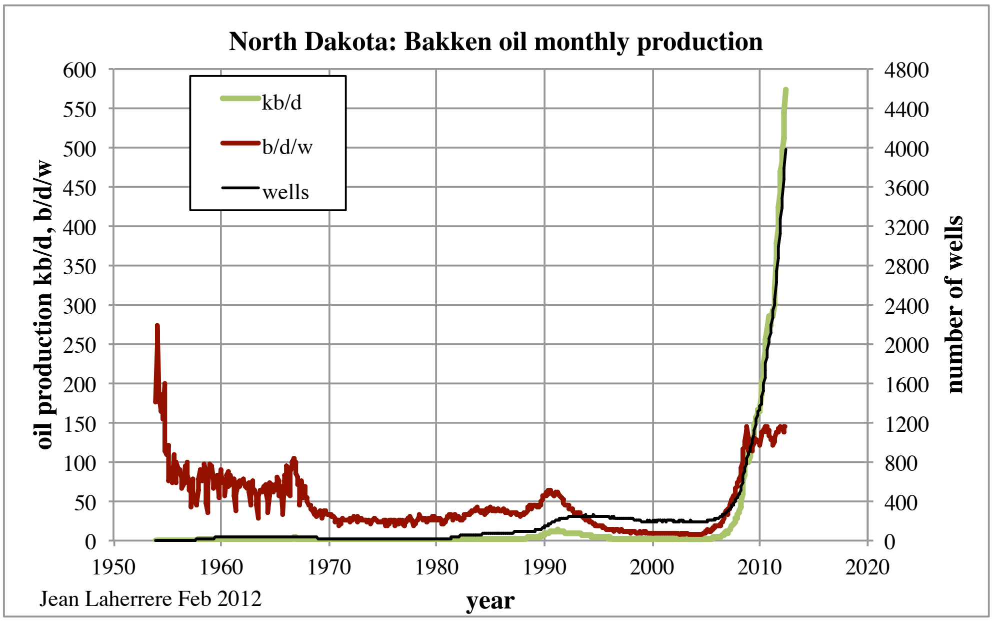
IEA medium-term oil & gas markets 2011
http://www.iea.org/publications/freepublications/publication/MTOGM2011_Unsecured.pdf
forecasts the Bakken production (called light tight oil) with 472 kb/d in 2012 (when it is already at 575 kb/d just for North Dakota alone in May 2012) and at 752 kb/d in 2016.
Figure 19: US light oil production 2010-2016 for IEA medium-term oil & gas markets 2011

The most frequently-mentioned source of growth in light tight oil is the **Bakken formation**, which straddles the North Dakota/Montana border and extends into Manitoba and Saskatchewan in Canada. North Dakota has seen oil production rise from an average 85 kb/d in 1994-2004 to 220 kb/d in 2009 and 310 kb/d in 2010. The reserves base there is substantial. A US Geological Survey in 2008 estimated that Bakken held 4 billion bbls of recoverable oil, while in 2010, the North Dakota Geological Survey estimated an additional 2 billion bbls in the nearby Three Forks formation (incorporated with Bakken in our estimates). US independent producer Continental, the largest holder of acreage in the Bakken, meanwhile estimates that the formation holds as much as 24 billion bbls of (recoverable) oil equivalent, which would make it one of the largest concentrations of hydrocarbon liquids to be tapped in the US. Our projections see Bakken light tight oil output roughly tripling to 750 kb/d by 2016, with around 90% stemming from North Dakota.

US Light Tight Oil Production
(thousand barrels per day)

	2010	2011	2012	2013	2014	2015	2016
Bakken	268	363	472	566	651	716	752
Barnett	15	23	29	35	42	46	51
Eagle Ford	21	40	65	98	138	193	260
Monterey	7	8	10	20	30	40	50
Niobrara	61	85	114	143	179	215	247
TOTAL	**372**	**519**	**691**	**863**	**1040**	**1210**	**1359**

The present Bakken oil production increase is so sharp that it was not forecasted properly and likely it could not be sustainable. The production per well stays around 140 b/d/w; but it will fall as soon as the drilling will slow down. The number of Bakken wells went from 200 in 2005 to 4000 today.
Figure 20: North Dakota: Bakken oil monthly production & number of wells



North Dakota Department of Mineral Resources described in 2008 the Bakken with a recovery of 1.4% of oil in place (149 Gb)
2008 DMR Bakken assessment (North Dakota Department of Mineral Resources)
STATE OF NORTH DAKOTA BAKKEN FORMATION RESOURCE STUDY PROJECT By M. Bohrer, S. Fried, L. Helms, B. Hicks, B. Juenker, D. McCusker F. Anderson, J. LeFever, E. Murphy, S. Nordeng April 2008
<<The original oil in place in the Bakken Formation within the thermally mature portion of the State of North Dakota is estimated to be 149.2 billion barrels. The estimates are presented by County and separated into the total Bakken Formation, upper Bakken shale member, middle Bakken member, and lower Bakken shale member to make them more useful for resource evaluation and planning (Tables 1-4) and (Figures 3-6).
The Bakken Formation EUR using current drilling and completion practices within the thermally mature portion of the state of North Dakota has also been estimated. The estimated ultimate recovery is approximately 1.4% of original oil in place, which is equal to 2.1 billion barrels.<<
The structural features are shown for the Bakken/Three Forks production. The Three Forks formation is just a reservoir below the Bakken lower shale. It is the Bakken middle formation, which produces because it is not shale but a sandy limestone and the Three Forks formation is

Figure 21: Williston Basin Bakken features from ND DMR 2008

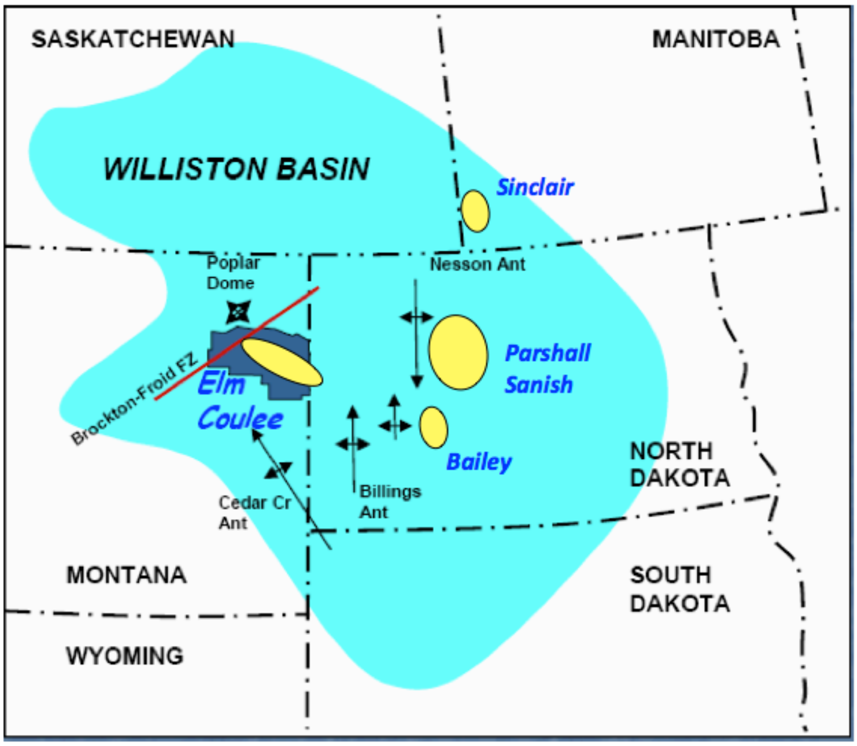


Figure 3 – Williston Basin with major structural features and modern Bakken / Three Forks production areas.

The Bakken oil in place is 149 Gb with 2.1 Gb recoverable.

Figure 22: North Dakota Bakken oil in place & reserves from ND DMR 2008

Table 1
Bakken Formation Oil In Place and Recoverable Reserves (barrels)
April 7, 2008

	Mean Values				
County	OOIP per County	OOIP per 640	EUR per County	EUR per 640	Rec Factor
McKenzie	32,438,937,580	11,698,740	382,654,320	138,000	1.18
Mountrail	27,242,795,837	14,043,773	424,826,873	219,000	1.56
Williams	26,263,485,095	12,235,090	474,392,108	221,000	1.81
Dunn	18,059,716,691	9,392,995	294,169,921	153,000	1.63
Divide	16,836,857,774	13,380,393	123,315,660	98,000	0.73
Burke	14,891,719,317	16,715,777	187,975,278	211,000	1.26
Ward	4,540,670,907	7,903,591			
McLean	3,253,719,118	10,742,320			
Billings	3,141,271,156	4,636,325	115,858,434	171,000	3.69
Stark	2,349,351,546	2,856,068	86,371,150	105,000	3.68
Golden Valley	66,147,411	1,209,544			
Grant	62,508,094	509,248			
Slope	10,586,089	238,919			
Total	149,157,766,614		2,089,563,745		

DMR 2010 “Three Forks assessment” shows that the geographic distribution of the Three Forks oil is very unequal, with few sweet spots.

Figure 22: North Dakota Three Forks oil in place in acre-foot oil from ND DMR 2010

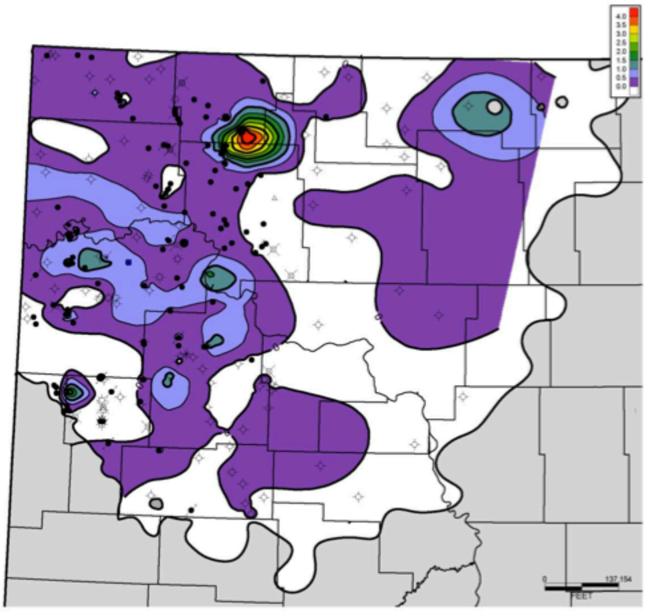


Figure 4) Total original oil in place (OOIP) for the Three Formation contoured as acre-feet oil. Only those intervals containing at least 50% oil-filled porosity contribute to the net pay that is contoured as acre-feet oil. The well locations illustrated correspond to the wells used in this study.

The total EUR is 2.1 Gb for Bakken and 1.9 Gb for the Three Forks, with a total of 3.9 Gb.
Figure 23: North Dakota oil in place & EUR for Bakken & Three forks from DMR 2010

Most Likely						
	Bakken		Three Forks		Total	
County	OOIP per County	EUR per County	OOIP per County	EUR per County	OOIP per County	EUR per County
Billings	3,141,271,156	115,858,434	1,717,909,400	154,611,846	4,859,180,556	270,470,280
Bottineau			1,642,257,140	147,803,143	1,642,257,140	147,803,143
Burke	14,891,719,317	187,975,278	2,084,609,970	187,614,897	16,976,329,287	375,590,175
Divide	16,836,857,774	123,315,660	855,513,980	76,996,258	17,692,371,754	200,311,919
Dunn	18,059,716,691	294,169,921	2,008,459,540	180,761,359	20,068,176,231	474,931,279
Golden Valley	66,147,411		25,519,700	2,296,773	91,667,111	2,296,773
Grant	62,508,094				62,508,094	
McHenry			539,104,280	48,519,385	539,104,280	48,519,385
McKenzie	32,438,937,580	382,654,320	3,941,684,770	354,751,629	36,380,622,350	737,405,950
McLean	3,253,719,118		351,841,190	31,665,707	3,605,560,308	31,665,707
Mercer			118,427,220	10,658,450	118,427,220	10,658,450
Morton			84,144,950	84,144,950	84,144,950	84,144,950
Mountrail	27,242,795,837	424,826,873	1,676,048,980	150,844,408	28,918,844,817	575,671,281
Oliver			9,002,880	810,259	9,002,880	810,259
Renville			183,377,880	16,504,009	183,377,880	16,504,009
Slope	10,586,089				10,586,089	
Stark	2,349,351,546	86,371,150	1,604,239,450	144,381,551	3,953,590,996	230,752,701
Ward	4,540,670,907		446,420,030	40,177,803	4,987,090,937	40,177,803
Williams	26,263,485,095	474,392,108	2,666,823,630	240,014,127	28,930,308,725	714,406,235
Total	**149,157,766,614**	**2,089,563,745**	**19,955,384,990**	**1,872,556,554**	**169,113,151,604**	**3,962,120,299**

Maugeri is quoting unrealistic and obsolete assessment of Bakken reserves, by reporting first 500 Gb of oil in place with a recovery factor of 50% (or 250 Gb of reserves), neglecting the recent studies, in particular by the agency knowing the most, being the North Dakota Department of Mineral Resources.

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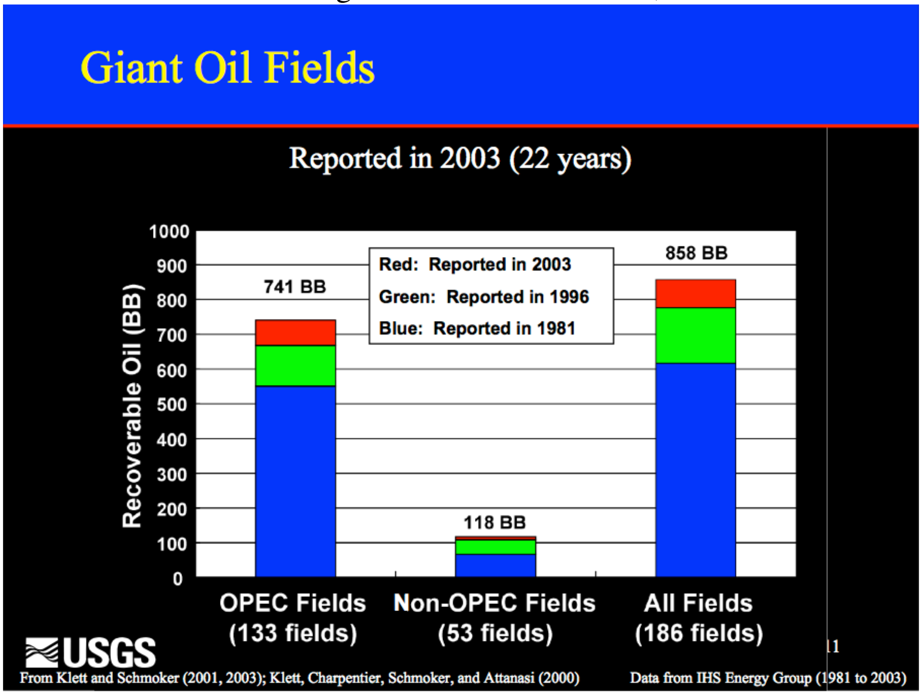
Reserve growth is a crucial element in the evolution of oil supply, and is often ignored or underestimated. Most analyses on oil reserves and supplies focus primarily on depletion rates of already producing oil basins, subtracting from reserves, and assuming a reduction of future production, without adequately factoring in their reserve growth. This underestimates the production of several oilfields, particularly the larger ones.
Two prominent geologists from the U.S. Geological Survey conducted a brilliant examination of "reserve growth" on a global scale. According to their extensive analysis, the estimated proven volume of oil in 186 well-known giant fields in the world (holding reserves higher than 0.5 billion barrels of oil, discovered prior to 1981) increased from 617 billion barrels to 777 billion barrels between 1981 and 1996. (Klett and Schmoker, 2003)
Because of "reserve growth," a country or a company may increase its oil reserves without tapping new areas if it can recover more oil from its known fields. One of the best examples of the ability to squeeze more oil from the ground comes from the Kern River Field in California.

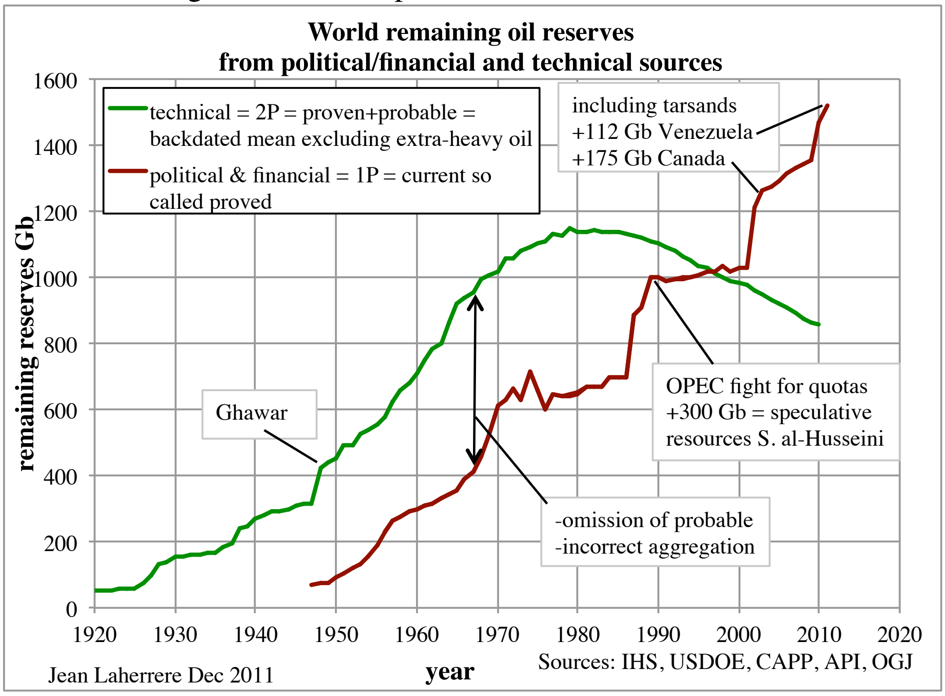
The USGS 2004 paper "Justification for proposing a study of large petroleum fields" T.R. Klett http://www.unece.org/fileadmin/DAM/energy/se/pdfs/adclass/Klett_LargeFields.pdf displays the growth for giant oil fields between 1981, 1996 and 2003. This growth is negligible for Non-OPEC in 2003.
Figure 24: USGS 2004: reserves change for 186 fields in 1981, 1996 & 2003



It is over 100 Gb from 1981 to 1996, but it is well known that during the period 1985-1989 because of the fight for quotas (based on reserves) between OPEC members (after the oil counter shock) the increase of 300 Gb for OPEC proved reserves represents in fact speculative resources as described in 2007 by the former VP Aramco Sadad al-Husseini. Scout reserves database are now obliged to report field estimates provided by NOCs since the NOCs are their customers, which was not the case in the past.

Reserve growth is confused by the reporting of remaining proved oil reserves. The only world official oil reserves are those reported by USDOE/EIA, IEA, OPEC and BP. Only EIA and BP provides a friendly updated database for proved reserves for every producing country since 1980. The remaining reserves are reported by OGJ in December from an enquiry on the remaining reserves at the following first of January before any technical study could be carried out. It is mainly a political statement and when the national agency does not answer (majority of cases), the last year value is kept. For last OGJ data at 01 Jan 2012 there are only 32 countries with change and 109 countries with no change, showing clearly that this data has nothing to do with reality!

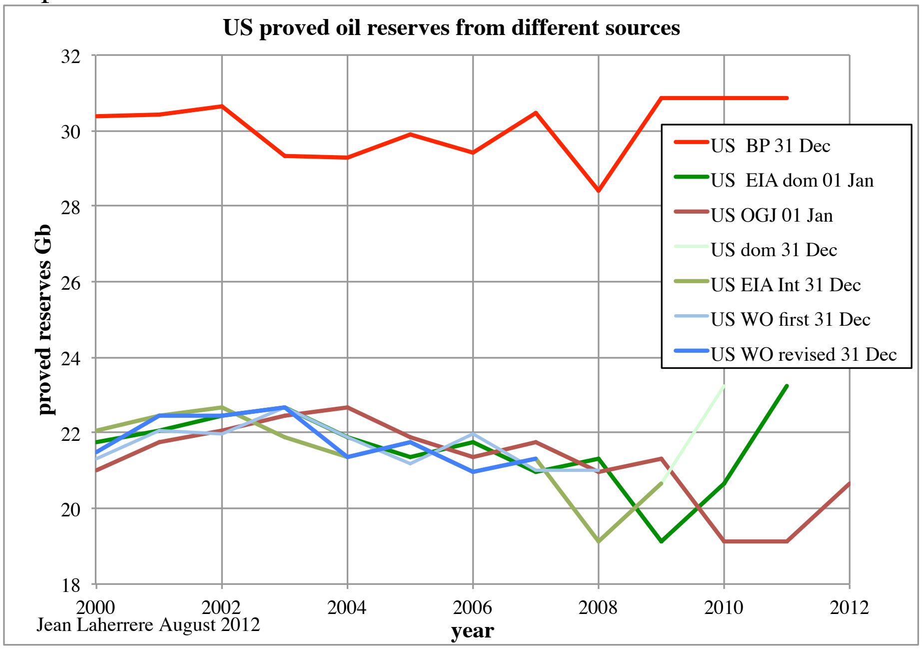
The source of confusion is that all IOCs are listed on the US stock market and they must follow the SEC (Security and Exchange Commission) rules, which up to 2010 was forbidding to report probable reserves. Only proved reserves with the ambiguous definition of reasonable certainty to exist could be reported, but reserves should be audited. OPEC countries report also proved reserves but without any audit, and the data is completely political.
The most amazing is that it is recognized (see SPE papers) that adding the field proved reserves of a country underestimate the proved reserves of the country. It is wrong to add proved reserves but, being the rule of the SEC, it is done by every one. Only mean field reserves can be added arithmetically to obtain the mean reserves of the country (or of the world). SEC rules were written to protect bankers and shareholders, not to satisfy science!
IOCs keep confidential their oil field reserves data and there are only few countries which oblige operators to report field estimates: UK, Norway and the US federal Gulf of Mexico (and some US States as California). Scout companies sell field reserves data and these reserves are 2P estimate because it is the data which is used to decide the development of their fields, based on the net present value computed on the mean reserves. IOCs 2P reserves satisfy science!
There is a huge difference between the political (OPEC)/financial (SEC) proved oil reserves (as reported by EIA) and the technical 2P as shown by this graph
Figure 25: world remaining reserves from political/financial and technical sources



The most amazing is to find that USDOE/EIA table of world crude oil proved reserves since 1980 on http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6 at end July 2012 does not advice what is the definition of the year, but the data for every country, except US, corresponds to OGJ data which is clearly on 01 January. But for the US the last value is 20.682 Gb for 2009, with NA (not available) for 2010, 2011 and 2012. But the comparison with the EIA domestic data EIA domestic end year http://www.eia.gov/dnav/pet/pet_crd_pres_dcu_NUS_a.htm indicates that 20.682 Gb corresponds to 2009, but it is on 31 December (as indicated on the htm version when the excel version is unclear). The domestic site also reports the value for 2010 being 23.267 Gb. It seems that the international EIA site ignore EIA domestic site and did not bother to check what the definition for the US is different from OGJ data. EIA reports exactly OGJ data for the world outside the US, except that OGJ reports the Neutral Zone (50/50 Kuwait and Saudi Arabia), when EIA reports Kuwait and Saudi Arabia including their share of the Neutral Zone.
In conclusion EIA world oil reserves reports on the year for the US at the end of the year and for the rest of the world for the beginning of the year: it is poor practice! The difference is small because

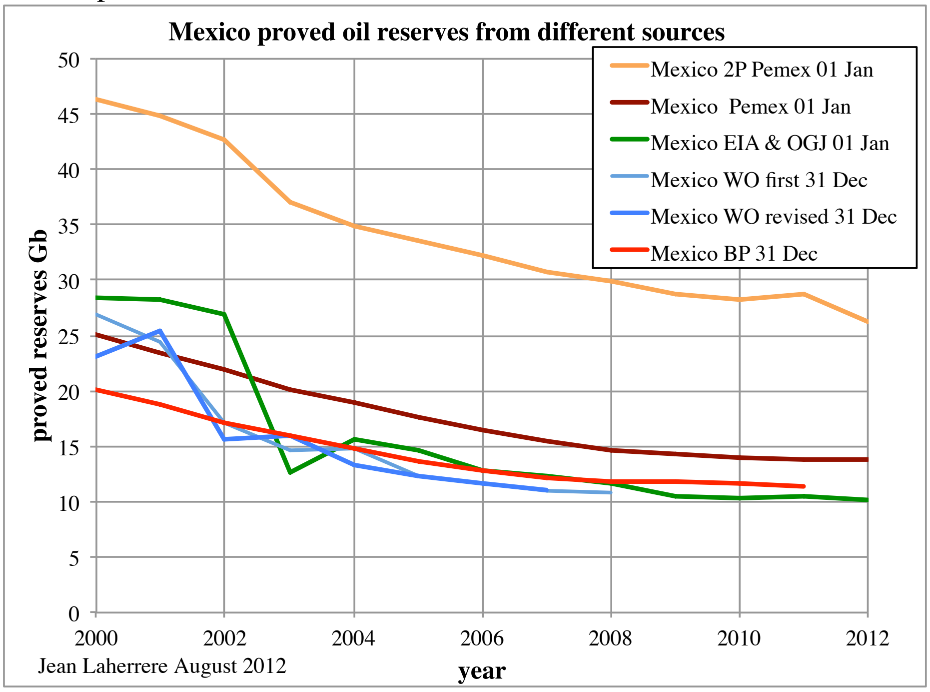
the small c variation of the US reserves in front of the uncertainty of the estimate, but the practice is flawed. The value for US proved oil reserves from different sources shows the chaotic reports for EIA for crude oil (domestic 01 January, when international at 31 December) and OGJ (which wrongly repeats the same value for 2000 and 2001) and the large difference with BP which reports crude oil and NGL at end year. WO reported also reserves at end year and revised reserves of the previous year, but WO stopped reporting world oil reserves in 2009.

Figure 26: US proved oil reserves from different sources



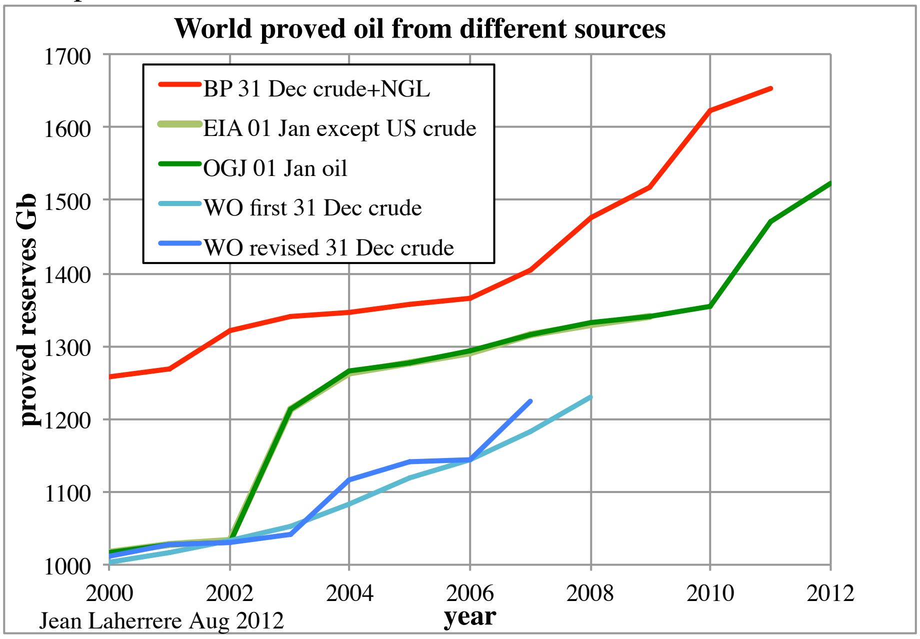
The comparison for Mexico oil reserves shows the difference between EIA/OGJ, WO, BP and Pemex, which also reported the 2P. Pemex 1P is smooth compared to the erratic EIA/OGJ. It is strange for EIA to trust more the obviously political and unreliable (reported too early to be technical and never revised) OGJ values than the official Pemex values.

Figure 27: Mexico proved oil reserves from different sources



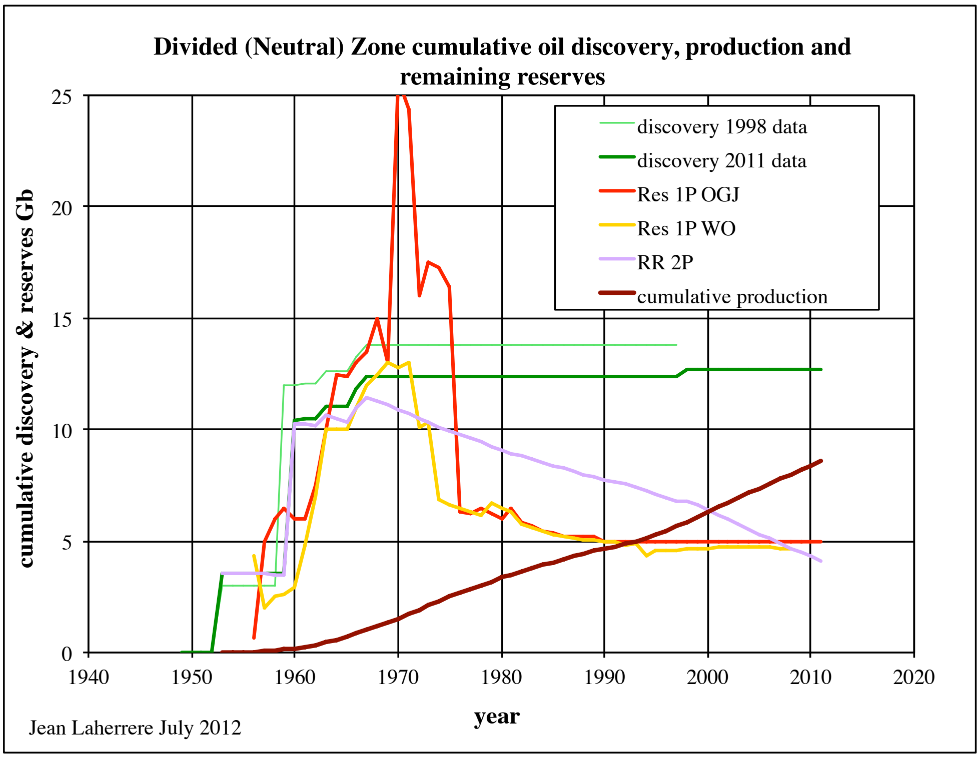
For the world proved oil reserves, the difference between EIA and OGJ because the different reporting for the US is very small, but it is huge with BP and WO because of including part of the extra-heavy oil which should be reported separately because the trapping is different and the production is different.

Figure 28: world proved oil reserves from different sources



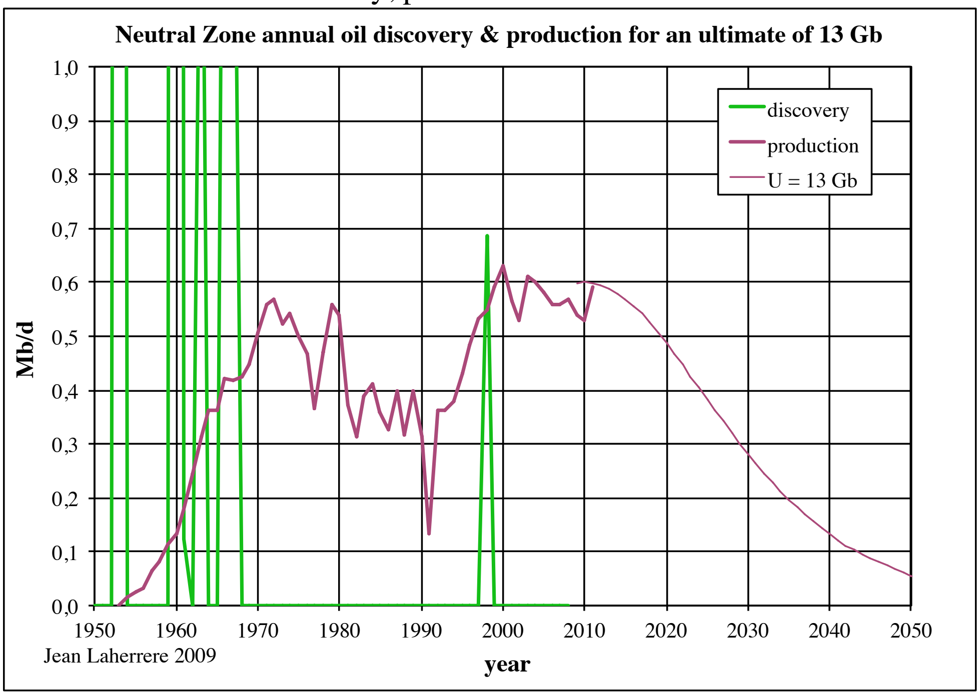
All OPEC reserves are unaudited. Only Kuwait values were audited at the request of the Parliament after a paper in 2006 by Petroleum Intelligence Weekly (PIW) reported that Kuwait's proven reserves were about half of what the government claimed. The result was kept confidential, but Kuwait did not change their reserves, likely changing the definition: the rumor was that the audit diminished the proven reserves, but the 2P (proven + probable) was close to the Kuwait value.
"Why Kuwait should keep its oil reserves secret" Published Date: July 11, 2007 By Jamie Etheridge http://www.kuwaittimes.net/read_news.php?newsid=MTQxNzYwMDMxNQ
In 1985, OPEC decided to tie proven reserves (the 90 percent category) to production quotas. Under its agreement with other OPEC producers, Kuwait has the right to produce nearly 2 million barrels per day. Its quota is based on Kuwait's official statement that it has 99 billion barrels of proven (remember the 90 percent) oil reserves.
In other words, Kuwait is allowed to produce 2.247 million barrels per day because it has nearly 100 billion barrels in proven reserves. In reality, Kuwait produces around 2.6 million bbl/d, according to the US Department of Energy and official OPEC statistics.

EIA recopy OGJ data, the only change is that EIA includes the Neutral Zone (50/50) within Kuwait and Saudi Arabia, when OGJ reports the Neutral (or Divided) Zone separately.
Neutral Zone proved reserves have been at 5 Gb since 1990 despite a significant production and no discovery since 1998!
The Neutral Zone cumulative 2P oil discovery is 12.7 Gb in 2011 data, but 13.8 Gb in 1998 data, showing a surprising negative reserve growth. We assume that the oil ultimate is 13 Gb. NZ is the only OPEC place which did not display a large reserve growth during the period 1985-1990, because its reserves are not involved in the political fight on quotas, where 300 Gb were added being only speculative resources (Sadad al-Husseini 2007), because the owners of NZ (Kuwait & Saudi Arabia) did increase their reserves at different time.
Figure 29: Divided (Neutral) Zone cumulative discovery, production and remaining reserves



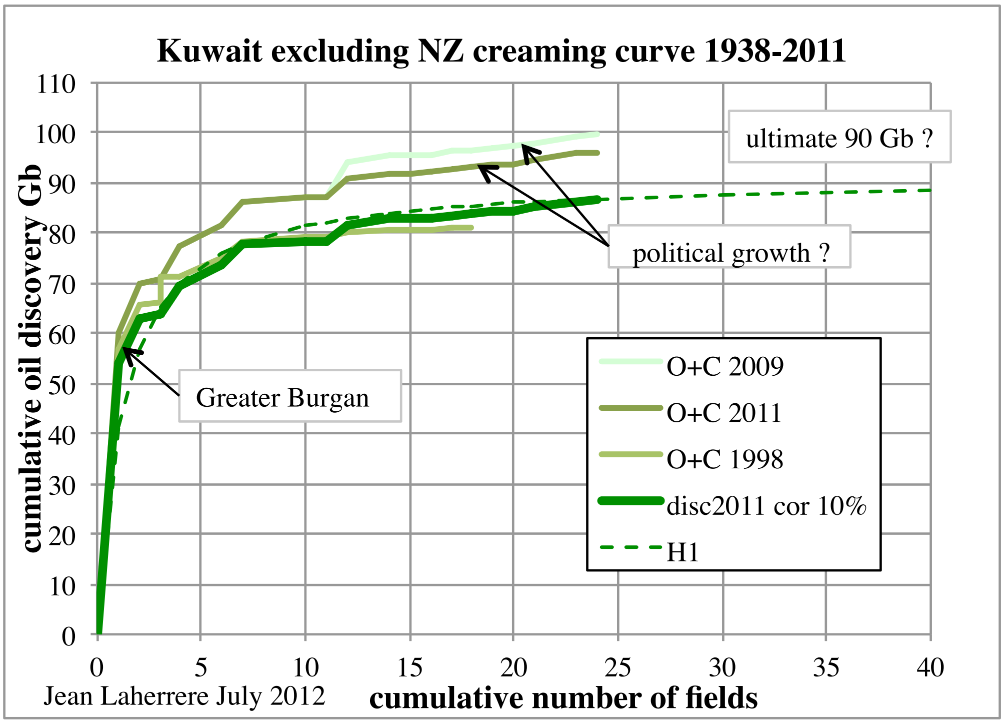
Neutral Zone production is modeled using an ultimate of 13 Gb being the asymptote of the cumulative discovery

Figure 30: Neutral Zone annual discovery, production for an ultimate of 13 Gb



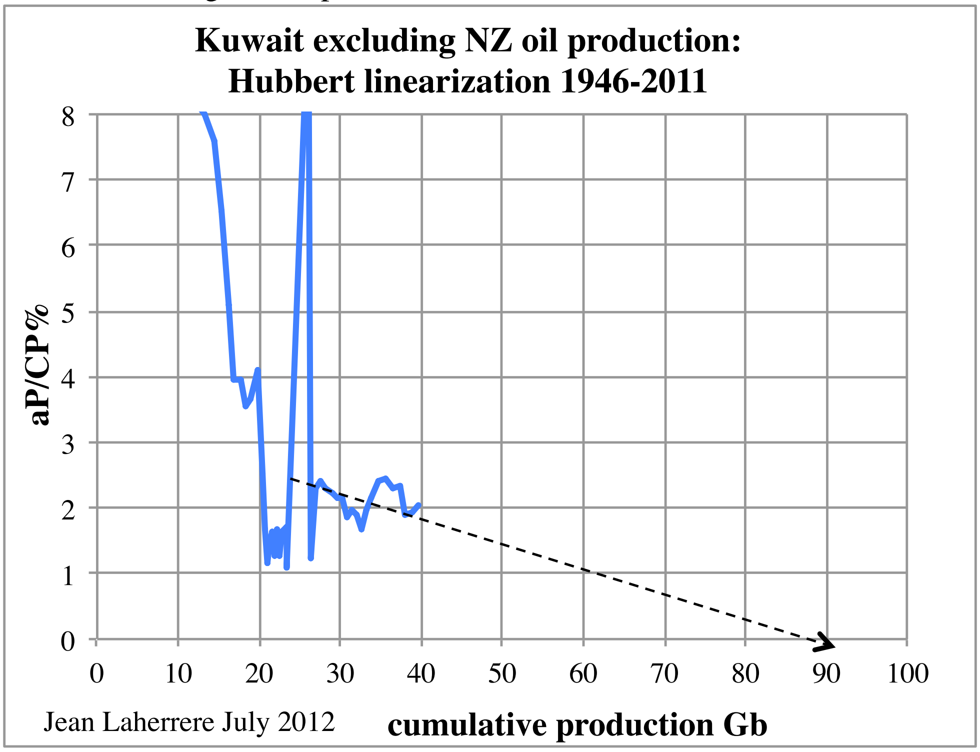
For Kuwait, the creaming curve of 1998, 2009 and 2011 data shows that the flattening is obvious since 1965 and there is no hope for deepwater discovery! Political growth seems to exist in 2009 and 2011 data and we believe that 2011 data should be corrected by 10 %, leading to an oil ultimate of 90 Gb.

Figure 31: Kuwait excluding NZ creaming curve 1938-2011



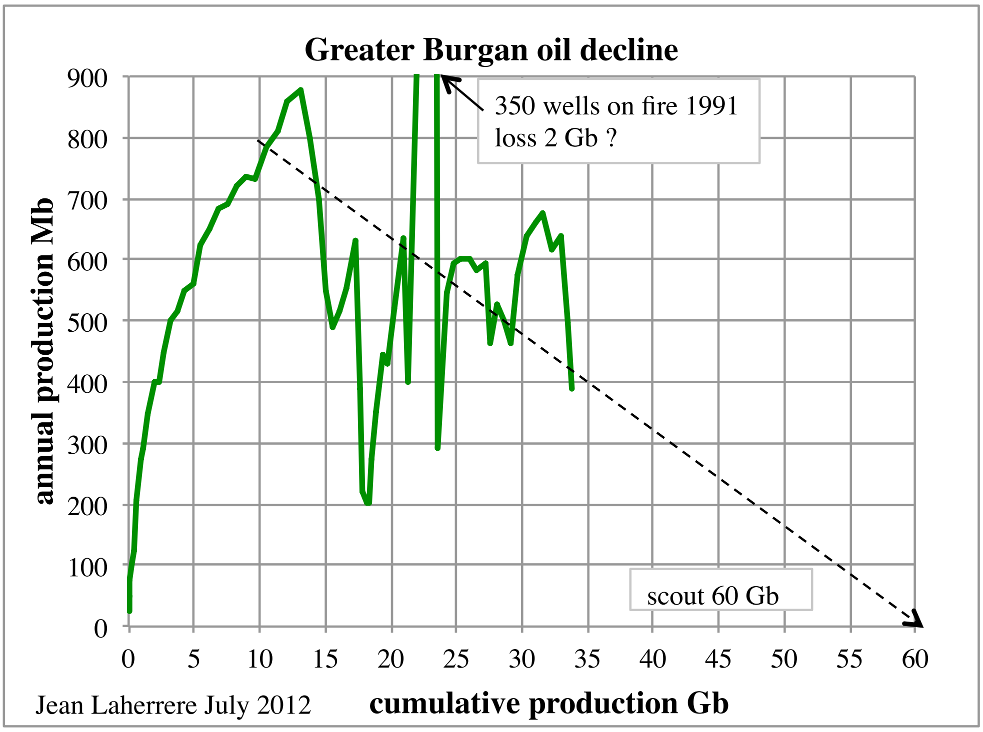
The Hubbert linearization of Kuwait oil production is hopeless to extrapolate the chaotic data because of quotas and wars.

Figure 32: Kuwait excluding NZ oil production: Hubbert linearization



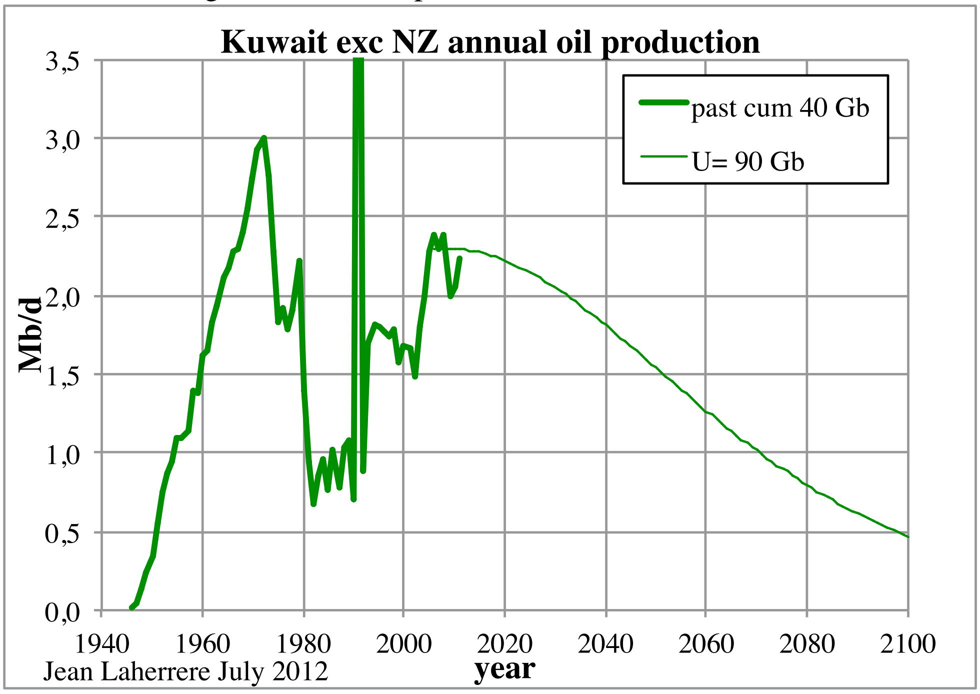
The main field (and the first found in 1938) is Greater Burgan, its annual production data is hard to find and chaotic because quotas and wars (in particular with 350 wells on fire in 1991). Its ultimate is reported to be 60 Gb but it is impossible to confirm with a reasonable accuracy with its present oil decline.

Figure 33: Greater Burgan oil decline



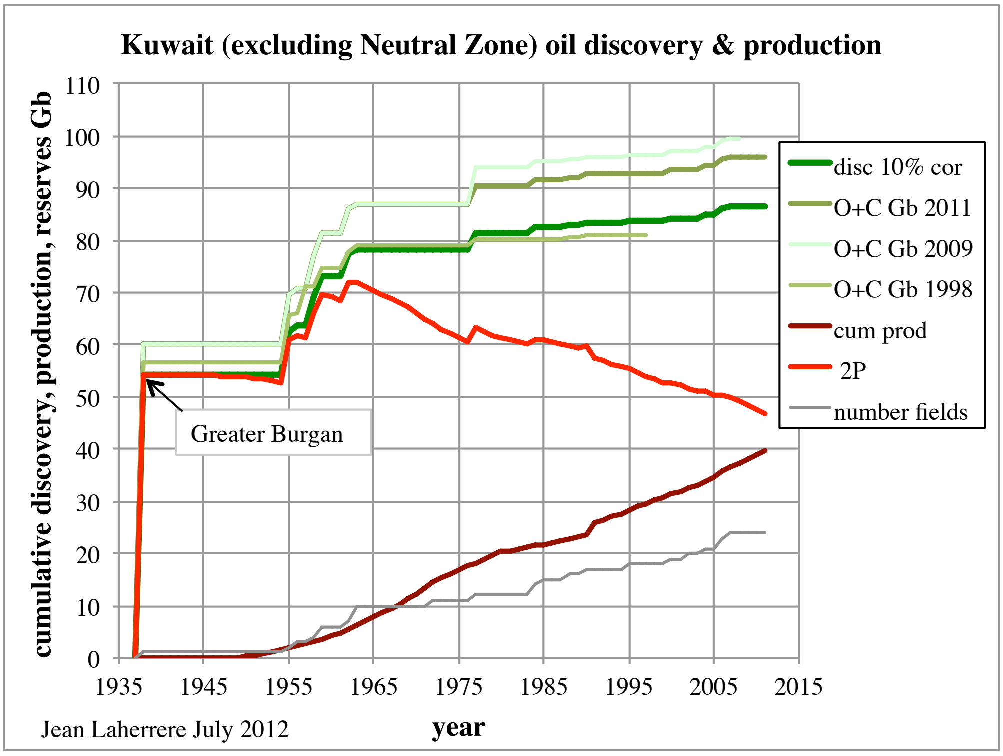
Assuming an oil ultimate of 90 Gb with a cumulative production at end 2011 of 40 Gb, the forecast of annual oil production shows that in 2100 Kuwait will still produce 0.5 Mb/d

Figure 34: Kuwait excluding NZ annual oil production & forecast for an ultimate of 90 Mb

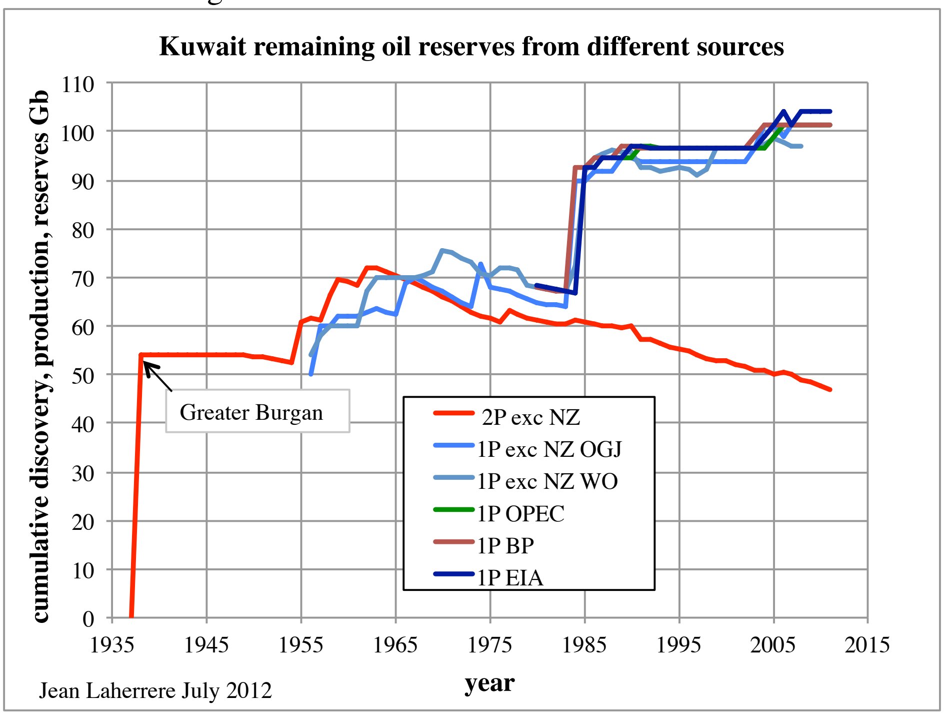


The cumulative oil discovery & production for Kuwait without the Neutral Zone displays the data from 1998, 2009 and 2011 editions (in green) for a total of 24 fields.

Figure 35: Kuwait (excluding NZ) cumulative discovery, production and remaining reserves 2P



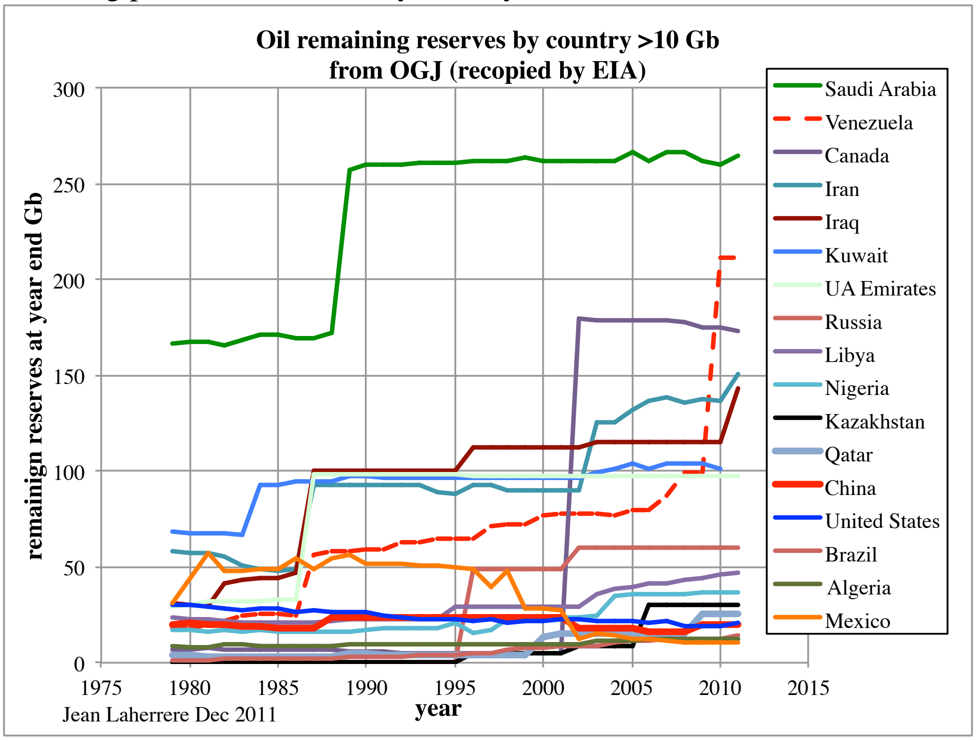
There is a significant increase from 1998 to 2009 data due to the fact that more and more scout field databases are obliged to report OPEC values in order to not upset national agencies. It is the same for BP which reports only national agencies reserves and not their own.
But in 2011 there is a surprising negative reserve growth, as it is shown for Neutral Zone.
The comparison of remaining reserves 1P (OGJ & WO) and the technical (correction of last data by 10%) 2P shows clearly that the increase in 1984 of 50% reserves increase by Kuwait due to the fight between OPEC members for quotas is political. Kuwait oil reserves from different source vary, including or not the Neutral Zone and being at 01 January or 31 December. Confusion is the rule in order to avoid comparison.
Figure 36: Kuwait remaining reserves from different sources



The loss of the 1991 fire (set by Saddam Hussein and burning 4-6 Mb/d) is estimated at 2 Gb, mainly in Burgan: see http://www.peakoil.net/Kuwait.html, but it is hardly noticed in the 2P values.

The display by country (over 10 Gb reserves) of proved oil reserves from OGJ shows clearly the drastic increases by step, when in reality reserves vary slowly, except when supergiants discovery. This data is strictly political and should be ignored! But it is the only data shown by the OPEC countries, constrained by their fight on quotas? It is only when OPEC quotas will disappear, that maybe truth will come?

Figure 37: remaining proved oil reserves by country >10 Gb from OGJ



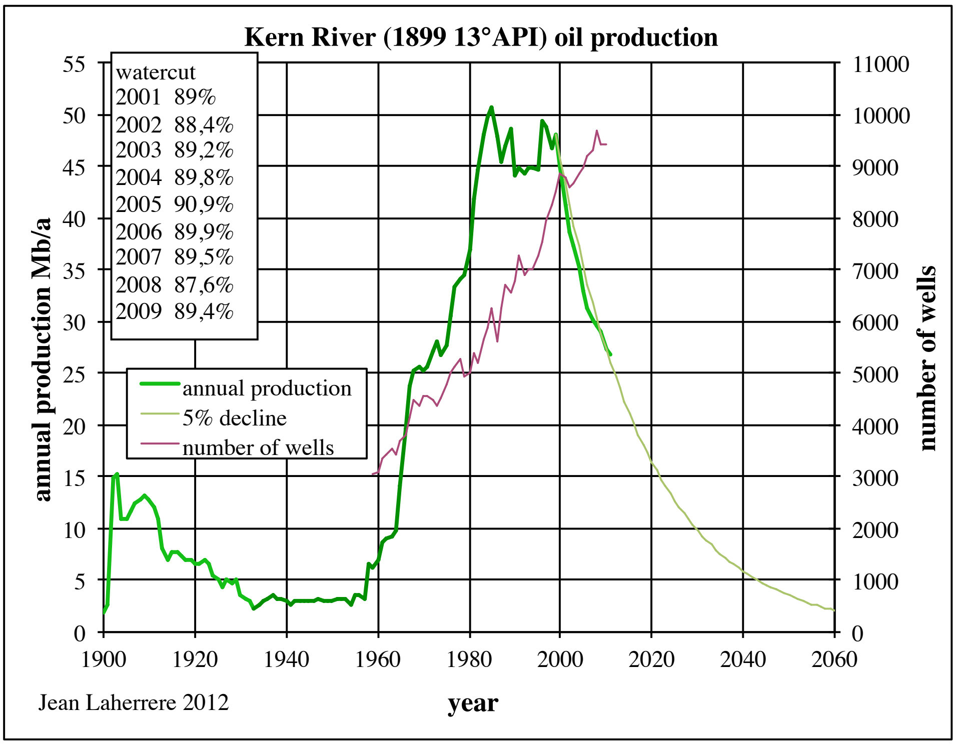
The reserve growth of OPEC claimed by Maugeri is very questionable because of political constraints and liars because of the fight between OPEC members on the quotas. The political increase of 300 Gb in OPEC reserves between 1984 to 1989 was described by ASPO as political, but due to technological progress by most analysts, when in 2007 the retired VP Aramco Sadad al-Husseini stated in London 2007 oil and Money conference that these 300 Gb were speculative resources, confirming ASPO claims! Scout databases (in particular IHS) are obliged to report OPEC field data when reported by OPEC members.

Maugeri's claim of reserve growth in the US taking as example Kern River is also comparing apple and orange. Kern River reserve growth is due to SEC rules, which represents very poor practice to represent the truth. Maugeri used already Kern River in his 2009 Scientific American paper and I criticized it: (http://aspofrance.viabloga.com/files/JL_Maugeri2009.pdf, http://europe.theoildrum.com/node/5865#more)

Kern River was discovered in 1899, being heavy oil (13% API), as Midway-Sunset discovered in the same basin in 1894. Its production needs steam injection (third recovery = unconventional) and started to increase in significant quantities in 1960 when the number of producing wells increased from 3000 to 9500 in 2010. The peak of production was from 1982 to 2000 (one century after discovery) and since 2000 the production declines by 5% despite a still rising number of wells. Its present watercut is around 90%.

The Californian department of conservation provides all the data since the start. There is here no data problem.

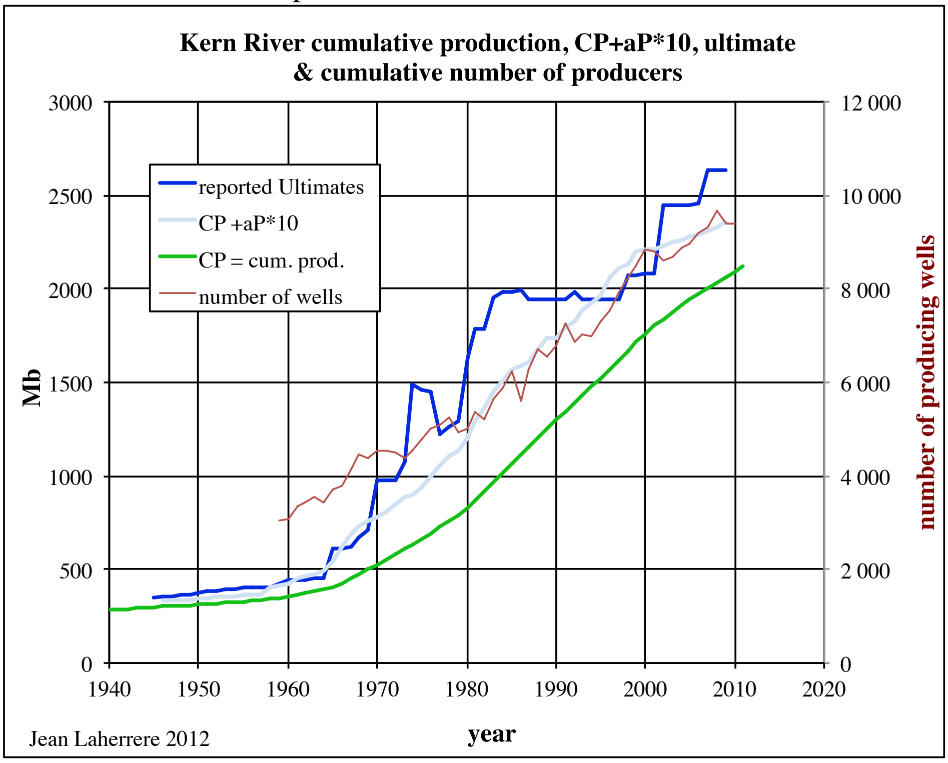
Figure 38: Kern River annual oil production 1900-2010



Following the SEC rules, only proved reserves around producing well are allowed (change since 2010) and known undeveloped part of the field cannot be reported as reserves. So reserves grow with the number of wells and this reserve growth is due to poor rules and practice. A rule of thumb often used in the US (even by the USGS) is to report as reserves ten times the present annual production.

The reported ultimates for Kern River from 1945 to 2009 can be compared with the number of producers, the cumulative production and the ultimate computed by adding the cumulative production with ten times the annual production. This plot (light blue) follows the trend of the reported ultimates (dark blue), but when it is larger than the reported ultimate, this value is increased.

Figure 39: Kern River cumulative production, number of wells & ultimate 1940-2011



USGS "Reserve Growth Assessment Fact Sheet-Assessment of Remaining Recoverable Oil in Selected Major Oil Fields of the San Joaquin Basin, California" April 2012
http://pubs.usgs.gov/fs/2012/3050/fs2012-3050.pdf
<<In the 1960s, introduction of thermal recovery technologies (application of steam technology) caused abrupt and substantial additions to reserves in fields that contain heavy oil (American Petroleum Institute (API) gravity less than 20 degrees). Similar additions to reserves have continued to the present. During the 1980s, reserve additions began to be made using hydraulic fracturing in Monterey Formation diatomites (sedimentary rock made up of the tiny silica skeletons of diatoms) on the west side of the basin. These additions have increased as production from diatomite replaces declining, but still substantial, production from overlying steam-flooded reservoirs. Since 1965, more than 8 billion barrels of recoverable oil have been added to reserves within existing fields.<<

Figure 40: USGS 2012: reserves, oil in place & recovery factor in San Joaquin basin

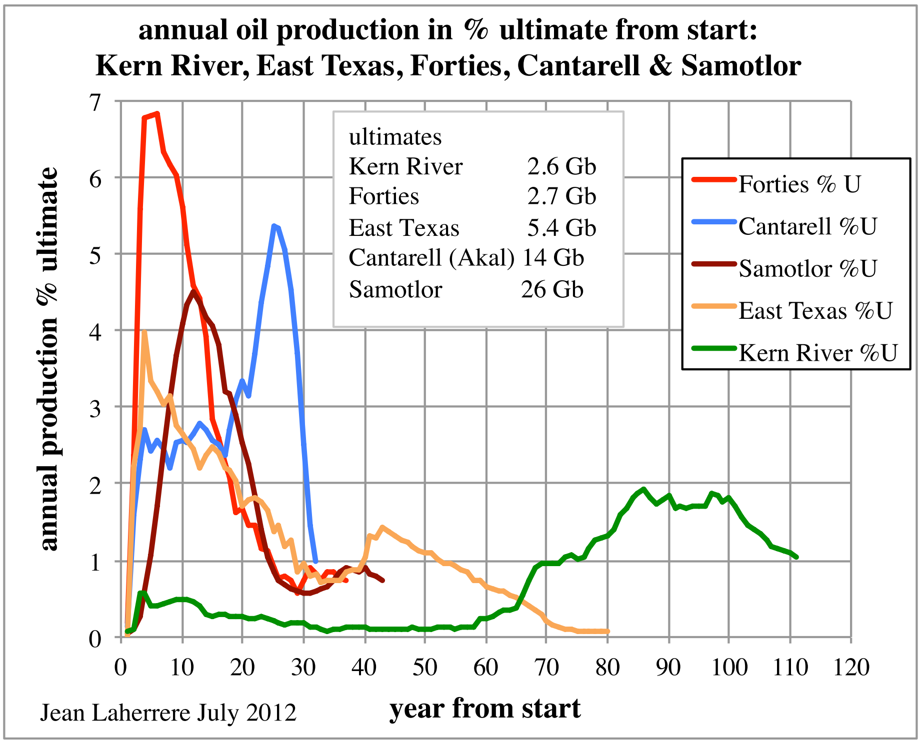
Key assessment data for oil fields individually assessed within the San Joaquin Basin, California.

[MMBO, million barrels of oil (BBO, billion barrels of oil; 1 BBO=1,000 MMBO); OOIP, original oil in place. Estimated recovery efficiency is potentially recoverable proportion of OOIP. Known recoverable oil is cumulative production plus reserves at the end of 2006, from California Division of Oil, Gas, and Geothermal Resources (2007)]

Field	Reservoir(s)	Known recoverable oil (MMBO)	Estimated OOIP (MMBO)			Estimated recovery efficiency (percent)		
			min	med	max	min	mode	max
Coalinga	Temblor reservoir	965	3,000	3,500	5,000	30	45	65
Cymric-Welport Area	Diatomite reservoir	163	425	600	1,000	25	40	55
	Pre-Monterey reservoirs	36	145	175	210	30	40	55
	Tulare reservoir	339	550	700	1,000	55	65	85
Elk Hills	Stevens/Monterey and older reservoirs	784	2,300	2,700	3,500	35	40	50
	Shallow Oil Zone	601	1,300	1,600	2,000	45	48	55
Kern River	All reservoirs	2,451	3,400	3,600	4,200	70	75	85
Lost Hills	Diatomite and older reservoirs	103	2,000	2,800	4,500	20	35	55
	Tulare-Etchegoin reservoir	374	655	700	1,500	45	55	65
McKittrick-Main Area	All reservoirs	203	525	800	1,700	40	50	60
Midway-Sunset	Diatomite reservoirs	21	300	1,500	3,000	10	20	40
	All reservoirs except diatomite	3,436	6,400	8,000	12,000	45	60	70
North Belridge	Diatomite reservoir	71	400	600	1,000	25	40	55
	Temblor and older sandstone reservoirs	70	300	350	500	25	30	40
	Tulare-Etchegoin reservoir	22	50	100	300	45	55	65
South Belridge	Diatomite reservoir	710	2,500	5,000	8,000	25	40	55
	Tulare reservoir	1,273	1,650	1,900	2,200	65	75	85

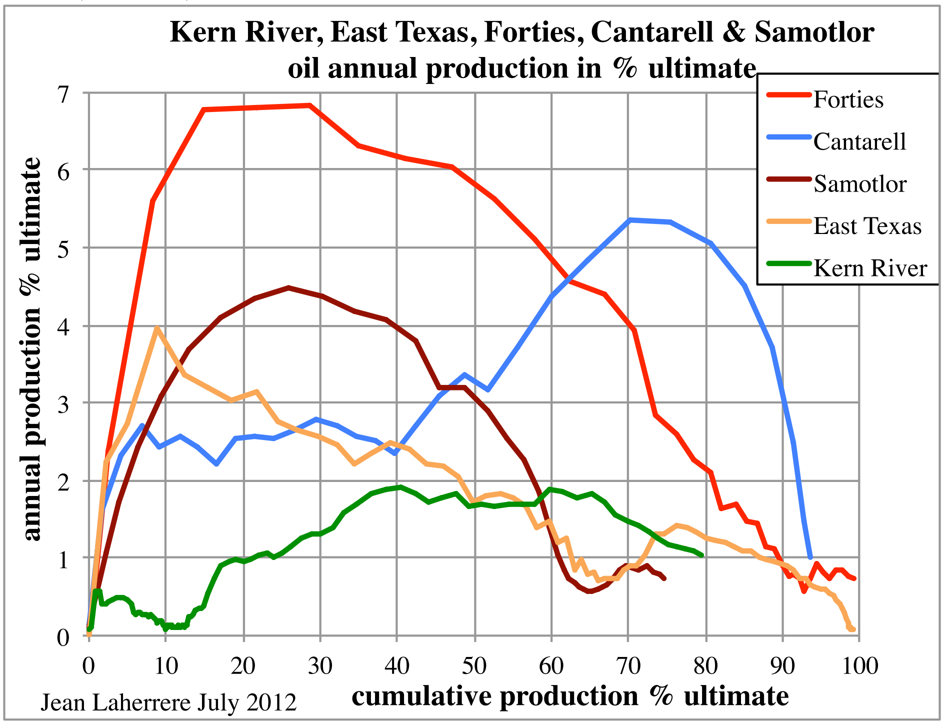
Kern River displays a different pattern when annual production plotted in percentage of its ultimate from production start compared to East Texas, Forties or Samotlor or even Cantarell (Akal-Nohoch field using an unconventional nitrogen injection). The ultimates are estimated to be 2.6 Gb for Kern River, 2.7 Gb for Forties, 5.4 Gb for East Texas, 14 Gb for Akal/Cantarell and 26 Gb for Samotlor. Kern River is a very poor reference for claiming reserve growth being an unconventional field with completely different behavior. Maugeri should have taken a conventional field as East Texas for reference, but he has preferred not because East Texas is a case of a large negative reserve growth with present estimate at 5.4 Gb (almost depleted) when from 1970 to 1990 OGJ ultimate was 6 Gb, being 10% higher than reality. It is the same negative growth for Brent oil reserves estimated by the Brown Book 2000 at 368 M.m3, when now the estimate (Brent is almost depleted) is 322 M.m3 or 13% less.

Figure 41: annual oil production in % ultimate for Kern River, East Texas, Forties, Cantarell & Samotlor



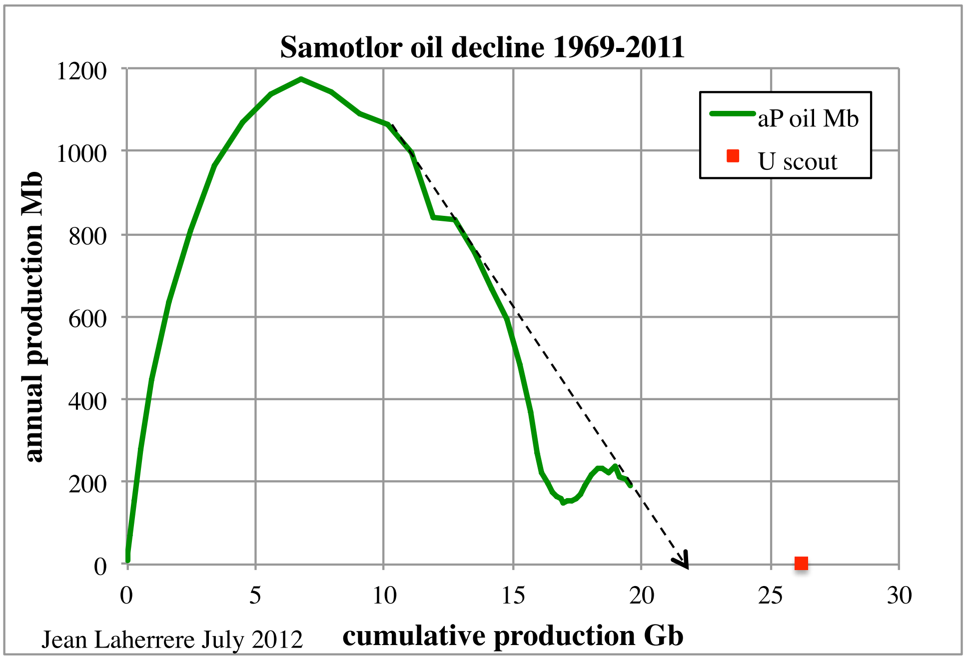
The plot of these five fields in annual production % ultimate versus cumulative production % ultimate shows clearly that Cantarell and Kern River are unconventional fields, compared to East Texas, Forties and Samotlor which displays similar behavior, but Forties being offshore is recovered faster with a 7% rate peak when less than 5% for onshore Samotlor and 4% for East Texas (using only primary recovery because secondary recovery with water injection started after 70% of the cumulative production was produced). Cantarell used nitrogen injection only after 50% cumulative production.

Figure 42: annual oil production in % ultimate versus cumulative production in % ultimate for Kern River, East Texas, Forties, Cantarell & Samotlor



Samotlor ultimate reported at 26 Gb is difficult to be confirmed by the oil decline, because of the collapse at the breakdown of the Soviet Union. A smaller ultimate is possible!

Figure 43:Samotlor annual oil decline 1969-2011



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From 2000 on, for example, crude oil depletion rates gauged by most forecasters have ranged between 6 and 10 percent: yet even the lower end of this range would involve the almost complete loss of the world's "old" production in 10 years (2000 crude production capacity = about 70 mbd)

Maugeri confuses depletion and decline. And his computation seems loose, according to this comment: "Tech Talk - New Energy Report from Harvard Makes Unsupportable Assumptions" Posted by Heading Out on July 1, 2012 - 5:12am http://www.theoildrum.com/node/9292#more

<<A 6% decline rate over 10 years would amount to 54% of the original amount, not "the almost complete loss...." Mistake or propaganda?<<

From the available annual oil production by field, it appears to me that the databases are too questionable, contradictory and incomplete to get a reliable estimate of world decline rate.

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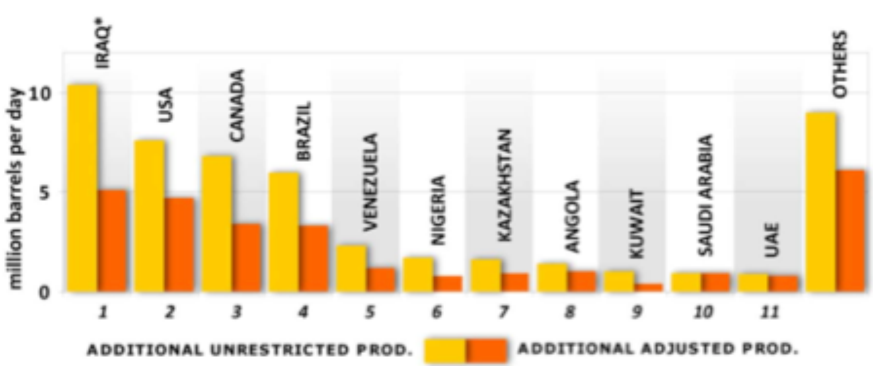
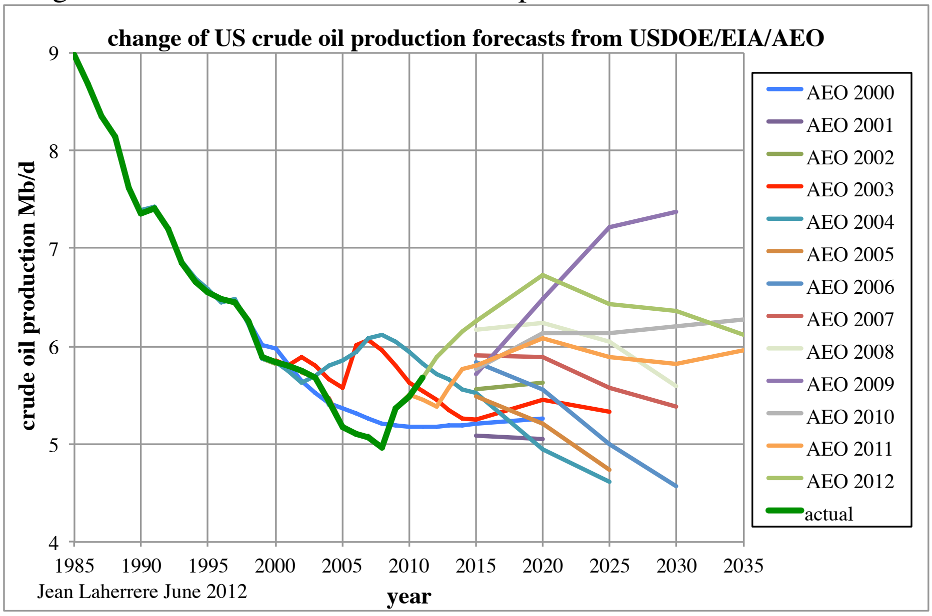
Figure 3: Worldwide potential additional liquids supply out to 2020 (crude oil and NGLs, excluding biofuels)

First 11 major countries in terms of incremental new supply (million barrels per day / mbd), not considering depletion and reserve growth.



The US the additional (from 2011 to 2010) adjusted production is given by Maugeri on his figure 3 as 4.7 Mb/d (additional adjusted production), but USDOE/EIA AEO 2012 forecasts only for crude oil production an increase 2011-2020 of about 1 Mb/d, 2020 being a secondary peak, as shown on this graph displaying AEO forecasts from AEO 2000 to AEO 2012. The display looks chaotic, showing clearly that forecast is unreliable!

Figure 44: change of EIA forecasts on US crude oil production from AEO2000 to AEO2012



This forecasted annual peak at 6.7 Mb/d for 2020 should be compared to the previous peak in 1970 which was close to 10 Mb/d

Figure 45: US crude oil monthly production from EIA

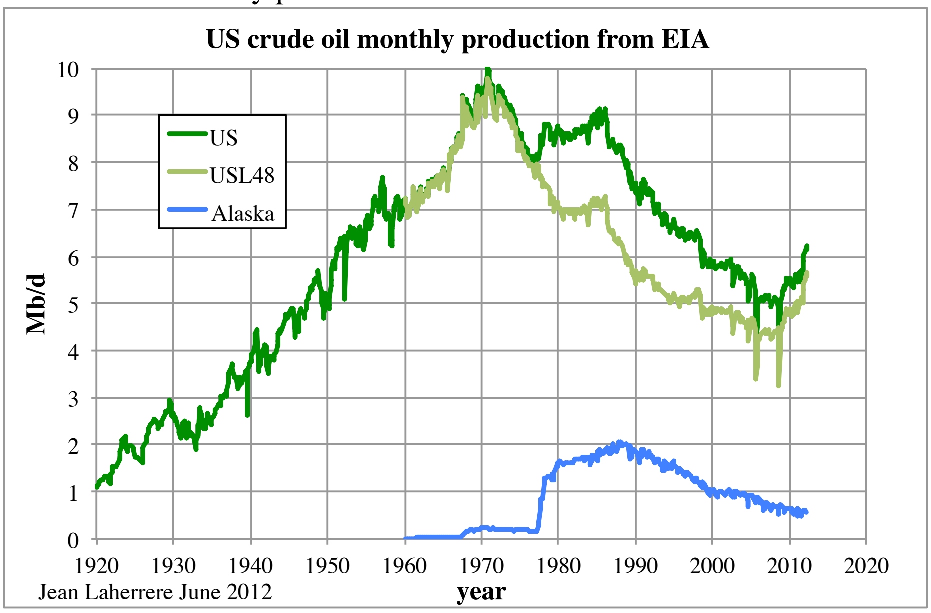


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Table 3: Additional production from U.S. shale/tight oil plays by 2020 (million barrels per day)

Shale play	Additional, unrestricted production	Additional adjusted production
Bakken/Three Forks	2.5	1.5
Eagle Ford	2.1	1.47
Permian	1	0.7
Utica	0.2	0.1
Niobrara/Codell	0.2	0.1
Others	0.6	0.3
Total	***6.6***	***4.17***

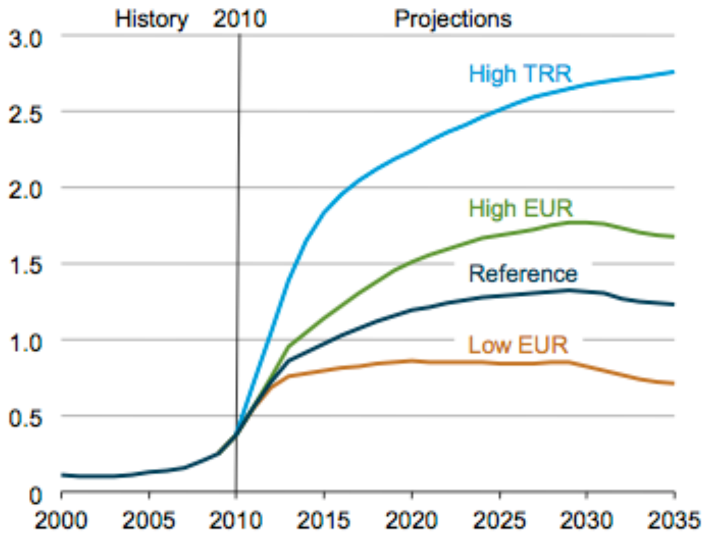
The term shale oil is now old fashion and replaced by tight oil! The word shale is now connected to hydraulic fracturation (called fracking in the medias) and has bad reputation. It is time to use a better term!

Maugeri forecasts an increase of tight oil production of 4.17 (admire the accuracy!) Mb/d from 2010 to 2020, when AEO 2012 (figure 55) forecasts an increase of 0.8 Mb/d in reference case and a maxi of 1.9 Mb/d, less than half of Maugeri's claim!

Like I always say, when more than two significant digits are given, it means that the second is surely wrong and likely the first one, because the author has a very poor understanding of the accuracy of the data!

Figure 46: AEO 2012 forecast on US tight oil production 2000-2035

Figure 55. U.S. production of tight oil in four cases, 2000-2035 (million barrels per day)



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The oil market is already adequately supplied with spare capacity of around 4 mbd

IEA Oil market report for July 2012 states: "OPEC's effective spare capacity in June was 2.35 mb/d", far from Maugeri's 4 Mb/d. But this 2.35 Mb/d is also wrong!

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The shale/tight oil boom in the United States is ***not a temporary bubble****, but the most important revolution in the oil sector in decades.*

Bakken production in Montana (see figure 17) looks a temporary bubble as it was for the peak in 1968.

The most important revolution in discovery was first the anticline model in surface geology, then the seismic common depth point and lately the deepwater.

In the aggregate, conventional oil production is also growing throughout the world, although some areas (the North Sea, face an apparently irreversible decline of the production capacity. In most traditional producing countries, old oilfields go through a production revival thanks to better techniques and knowledge, or advanced exploration and production technologies, so far used only in the U.S. and in the North Sea. Huge parts of the world are still relatively unexplored for ***conventional oil (for example, the Arctic Sea*** *or most of sub-Saharan Africa).*
The production of crude excluding extra-heavy oil which is more than conventional for most is plateauing since 2005 as seen in figure 13: it is wrong to claim that the world conventional oil production is growing.
It is difficult to say that Arctic sea is conventional oil!

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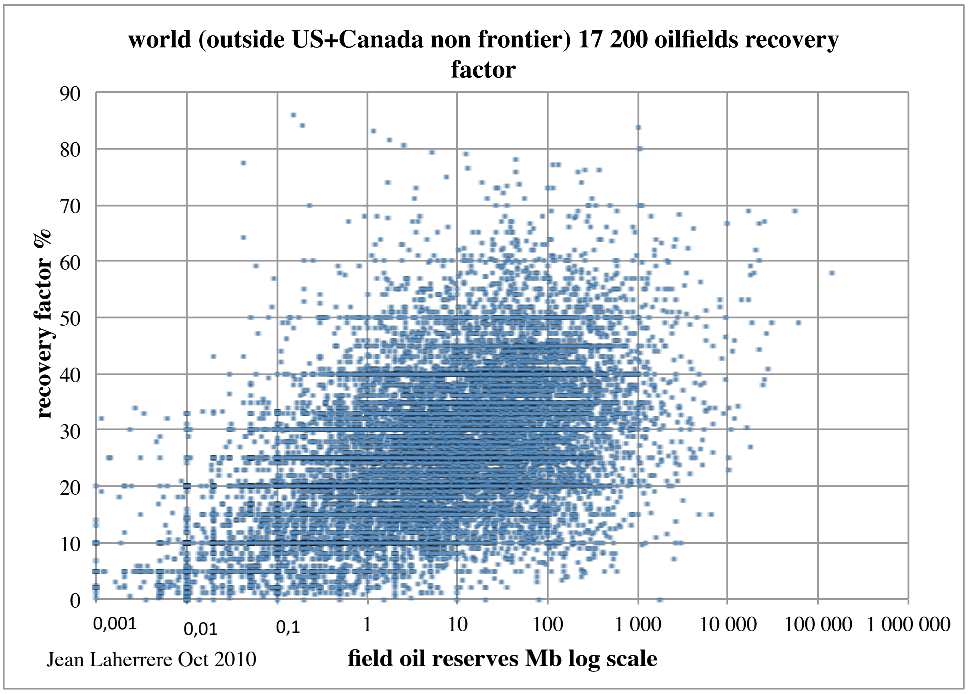
Usually, once a company (or country) determines the producible reserves of a field (after having assessed its ***proven reserves****, its initial rate of recoverability, and its costs) and begins to invest in its development, it is rarely wrong.*
Maugeri seems to ignore that the decision of developing a field is taken from the "”net present value" of the estimated entire production based on the mean reserves. Mean value (probability of about 45%) is far from proved value (probability assumed to be 90%). The proved reserves are only considered for not being too negative in the unlikely case that it occurs (there is a 10 % probability that the reserves could be lower), with a bad impact on the company assets.

Maugeri's presentation at CSIS http://csis.org/files/attachments/120626_EnergyMaugeri.pdf

-slide 2 :
-Limited Exploration Only 1/3 of world's sedimentary basins has been explored
This is a poor stand in front of claiming that technology has greatly improved. If only one third of the world 's sedimentary basins is explored, it is because geochemistry (which can quickly estimate how much the basin has generated oil or gas with few samples of the source-rocks) has recognized that there is little potential to explore in two thirds of the world sedimentary basins. Every sedimentary basin has been drilled (even Antarctica with JOIDES/OPD wells) or sampled. Antarctica (exploration is forbidden for a while) has a poor oil potential as far as I know.

-No current technology is capable to give an answer to the question "how much oil lies beneath?"
Maugeri seems unaware that geochemistry, using Rock-Eval equipment and source-rocks samples, can evaluate the amount of oil and gas generated by the source-rock.

-slide 3:
On average, less than 35% of already known oil is extracted today using business-as-usual technologies.
More expensive tech may dramatically increase oil recovery.
The range of the oil recovery factor is from 0.1% to 86% (East Texas) and the cloud is so large that an average has no meaning and varies form the way it is computed. The median value is 41% when from cumulative reserves or 25% when from cumulative number of fields
Figure 47: world (outside US & Canada onshore) 17 200 oilfields recovery factor



Business as usual is for economists but production engineers do not care for BAU because recovery factor depends mainly upon the geology of the reservoir. Technology cannot change the geology of the reservoir, but technology (in particular horizontal drilling) can help to produce faster, but no more (sometimes less) and many examples like Yibal the largest field in Oman, Rabi-Kounga the largest field in Gabon, like Cantarell (figures 41 & 42) with a sharp decline.

There are few papers which agree with Maugeri's oil revolution, like George Monbiot (who speaks about enough oil to fry us all!), but there are many papers which disagree:
-Richard Heinberg "peak denial" 2 July 2012
http://www.postcarbon.org/blog-post/985668-peak-denial
-Dave Summers " Tech Talk - New Energy Report from Harvard Makes Unsupportable Assumptions" 2 July 2012
http://www.theoildrum.com/node/9292
-Steve Sorrell "Commentary on Maugeri's decline rate assumptions" 6 July 2012
http://odac-info.org/sites/default/files/Maugeris-decline-rate-assumptions_commentary.pdf
-Sadad al Husseini "Commentary: Dr. Leonardo Maugeri's "Oil: The Next Revolution"" 14 July 2012
http://arabenergyclub.com/site/wp-content/uploads/2012/07/Commentary-from-Sadad-Hussaini-on-Maugeri's-paper.pdf
-Olivier Rech "« Nier l'imminence du pic pétrolier est une erreur tragique », dit l'ancien expert pétrolier de l'AIE" 9 juillet 2012, par Matthieu Auzanneau
http://petrole.blog.lemonde.fr/2012/07/09/nier-limminence-du-pic-petrolier-est-une-erreur-tragique-dit-lancien-expert-petrolier-de-laie/
« Denying the imminence of Peak Oil is a Tragic Error », says ex- IEA petroleum expert. 09 juillet 2012
http://petrole.blog.lemonde.fr/2012/07/09/denying-the-imminence-of-peak-oil-is-a-tragic-error-says-ex-iea-petroleum-expert/
-Chris Nelder "Is peak oil dead?" 24 July 2012
http://www.getreallist.com/is-peak-oil-dead-my-critique-of-the-maugeri-report-for-financial-times.html
-David Strahan "Oil glut forecaster Maugeri admit duff maths" 30 July 2012
http://www.davidstrahan.com/blog/?p=1570
-Ugo Bardi "Ugo Bardi: Strahan demolishes Maugeri" 30 July 2012
http://peakoil.com/production/ugo-bardi-strahan-demolishes-maugeri/
http://peakoil.com/generalideas/peak-oil-debunked-the-mechanisms-of-denial-at-work/