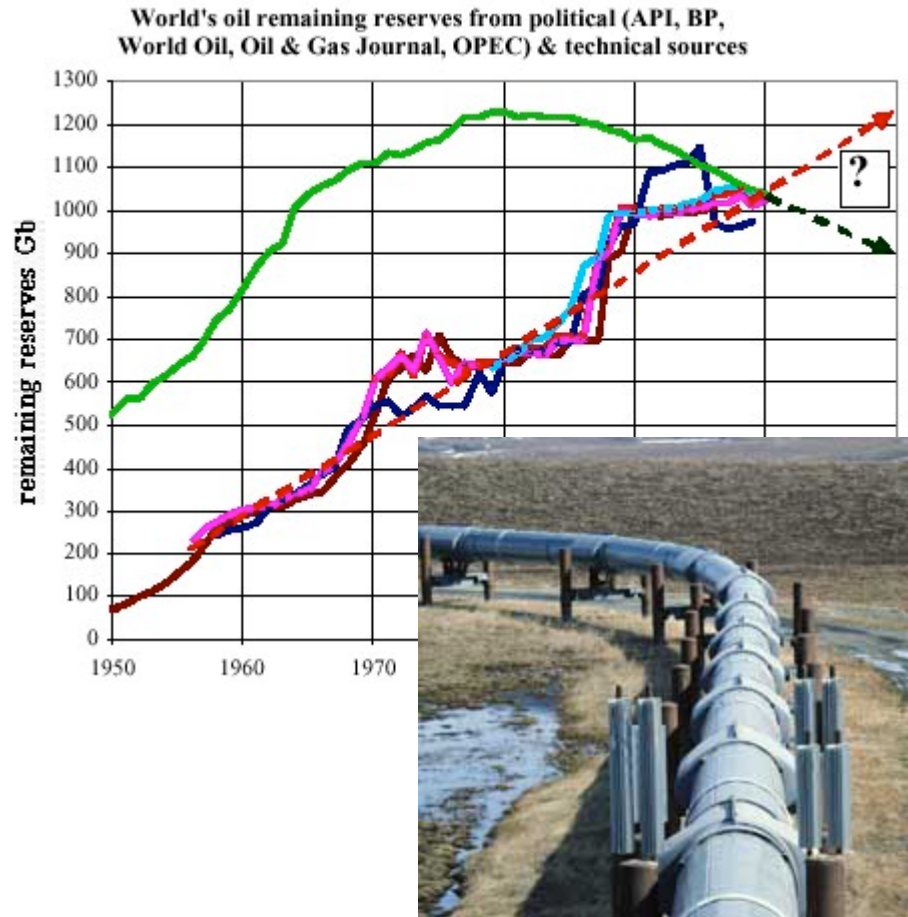



# World's Fragile Oil Flows from Declining Reserve Base

## Global Oil Reserves and Annual Oil Flows

March 2008



 Chris Skrebowski: “the world needs oil flows”

Prepared by: Matt Mushalik (MIEAust, CPEng)

[mushalik@tpg.com.au](mailto:mushalik@tpg.com.au)

## Summary:

300 Gb of a total of 1,200 Gb conventional oil reserves reported by the BP Statistical Review have been re-classified to less useful "resources" by former Aramco chief Sadad al Hussein, greatly reducing remaining reserves to around 900 Gb of various reserve categories (proven, probable and possible) which are hard to verify reliably. More strictly defined technical reserves (as opposed to political reserves), proven and probable, have peaked in 1980 and declined to only 800 Gb. What's worse, **almost half of the current global oil production (45%) comes from a very narrow reserve base of just 190 Gb** or around 1/5th of the remaining reserves. **It is depleting rapidly at a rate of around 7 % pa., with annual production declining consistently since 2002.**

The bulk of conventional oil reserves, 80% in fact, much of which is practically outside the control of Western countries, produce a little over half the global annual flows but at much lower annual production rates of between 1.3 % (Venezuela), 2.2 % (OPEC Middle East) and 3.5 % (Former Soviet Union), suggesting that these countries either do not want or, worse still, are not able to increase production because even the reduced, remaining reserves may still be too high, contain a lot of the probable category difficult to prove up or are of lower quality (heavy, sour oil). **If current trends continue, disproportionate depletion rates, structural imbalances and reserve uncertainties will inevitably lead to disruptions of oil supplies in the next decade.**

In this situation, and in the absence of sufficient alternative fuels which could replace oil<sup>1</sup>, it violates all rules of prudent governance to plan and build more oil dependent infrastructure like airport extensions, freeways, road tunnels, car-dependent shopping centres and sub-divisions etc. without performing a **proper fuel availability study** for the life span of these projects, including a **critical path analysis of future clean energy supplies** and **feasible** technological developments. It will be better for the financial sector and the economy in general to invest in energy efficient electric rail and limit expenditure for roads to proper maintenance of existing roads and the removal of accident black spots. Bike and bus lanes would also be a good investment.

Organisations who choose to ignore this advice and still want to continue with business as usual should get a **bank guarantee from OPEC** on the status of their reserves and production capacities. Governments could take up the proposal from American Investment Banker Matthew Simmons who demands for years now that a thorough 3rd party audit of all Middle East OPEC oil fields be conducted.<sup>2</sup>

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<sup>1</sup> See chapter 6 in my submission to DOTARS

The End of Freeways – the tipping points of peak oil and global warming, April 2007

[http://www.dotars.gov.au/roads/F3toM7Review/pdf/SUBMISSION\\_47-Mr\\_Matt\\_Mushalik.pdf](http://www.dotars.gov.au/roads/F3toM7Review/pdf/SUBMISSION_47-Mr_Matt_Mushalik.pdf)

<sup>2</sup> Twilight in the Desert, Matthew Simmons

<http://www.simmonsco-intl.com/files/Twilight%20in%20the%20Desert%20Presentation.pdf>

**Details:**

According to BP statistics, booked oil reserves seem to have grown over the last decades. But it is shown here that this impression is quite misleading. "Proved reserves and oil sands" stand at 1,372 Gb according to the BP Statistical Review (from June 2007)<sup>3</sup> which include 164 Gb from Canadian tar sands. That makes approximately 1200 Gb for conventional oil. But last year in October, in an Oil & Money conference in London<sup>4</sup> ex Aramco Executive Vice President Sadad Al Hussein presented a paper which showed that reserves are only 900 Gb<sup>5</sup>. Having worked in an OPEC country, he should know, although he did not specify which countries had overstated their reserves. This is to be interpreted as a warning. More may yet to come.

**"Reserves" are inflated with >300 B bbls of "resources"**

	Depleted	Statistical reliability	Production Outlook	Technical basis
Actual Reserves : 0.9 Trillion	Proven > 90%	Proven oil In Place – high confidence Developed – clear recovery factor Undeveloped – good, recov. est.	Growth thru actual reservoir mgmt. & performance	Improved Oil recovery thru existing technology
	Probable > 50%	Probable oil in place – confident Developed - prelim. recovery factor Undeveloped – est. fair recovery	Growth thru delineation, testing & development	Clear opportunity with existing technology
Contingent Resources: 1.1 Trillion	Potential > 5%	Potential oil in place – low confiden. Drilled – v. low recovery factor Undrilled – recovery likely poor	Growth thru pricing, delineation or IOR/EOR technology	indicative claim & potential opportunity
	Resource: Uneconomic volume & commerciality	Likely presence but undelineated Oil or GIP	Profitability or Technology currently inadequate	Available access but lacks good reservoir and fluids data
Prospective & Speculative Resources: 2.0 Trillion	Oil, Gas, Shales, EHC & to be discovered resources (speculative outlook)	Technically present but physically inaccessible hydrocarbons	Future resolution thru exploration & relevant technology	General geological, seismic and/or physical indications
		Conceptually Possible Hydrocarbons, incl. EHCs		

<http://www.energyintel.com/om/speakersNew.asp?Year=2007&filename=SadadIbrahimAlHusseini.pdf>

So what's happening to oil reserves? Well, the difference of 300 Gb are much less certain, less useful, harder-to-get and much more expensive "resources", not reported "proven" reserves. That's not good news. A lot of the resources can never be recovered in practice. Refer to the example of Kuwait presented further down. Even of the remaining 900 Gb we cannot be sure

<sup>3</sup> Statistical Review of World Energy 2007

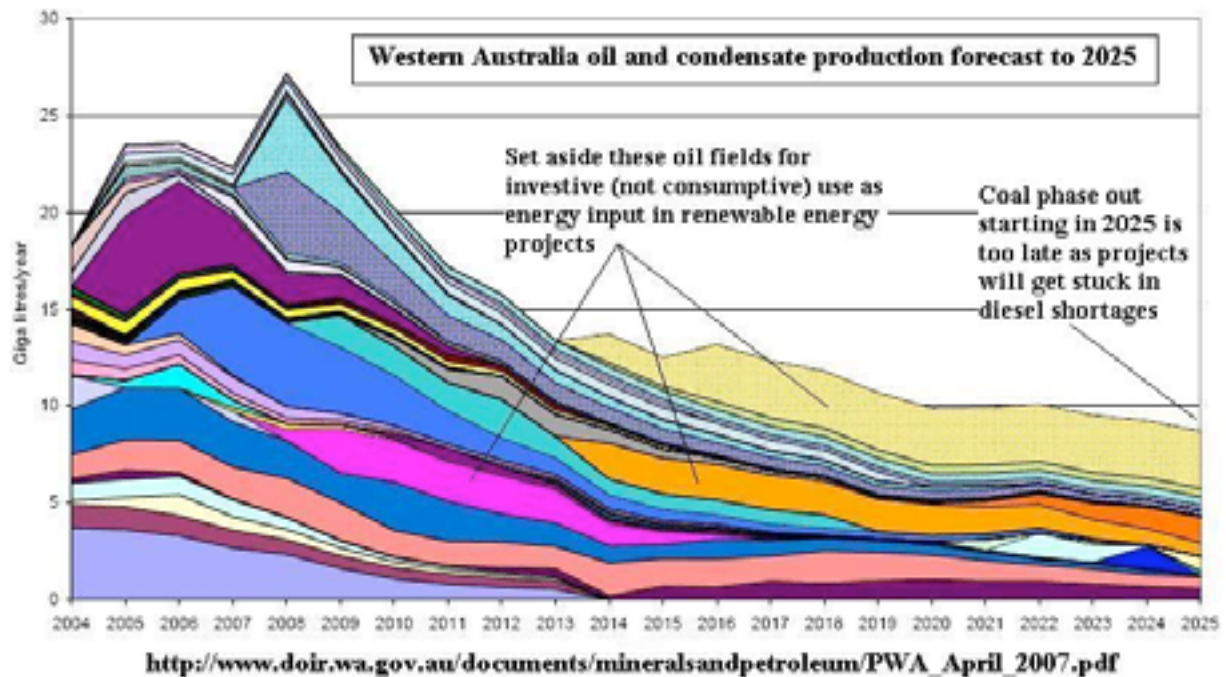
<http://www.bp.com/productlanding.do?categoryId=6848&contentId=7033471>

<sup>4</sup> The Global Energy Industry's Premier Conference <http://www.energyintel.com/om/>

<sup>5</sup> Oil reserves inflated by 300bn barrels; <http://www.energybulletin.net/36458.html>  
<http://www.energyintel.com/om/speakersNew.asp?Year=2007&filename=SadadIbrahimAlHusseini.pdf> Please note that this slide show contains a graph showing a production plateau in the next decade which is impossible if reserves are only 900 Gb. Irish oil geologist Colin Campbell estimates declining oil production using the same reserve figure.

how much of this is proven (P1, 90% probability), proven and probable (P2, 50% probability) or proven, probable and possible (P3, 10 % probability) reserves. For the proper definitions of reserves refer to a paper prepared by the Society of Petroleum Engineers<sup>6</sup>. The problem is similar to those Shell reserves which had to be re-classified<sup>7</sup>. There was a lot of media attention then. But amazingly, the media did not take notice of this much larger amount of 300 Gb. However, the problem is real. In fact, it is one of the reasons why oil is peaking now. So what will that mean for our oil production?<sup>8</sup>

Let's have a closer look. Each oil reservoir produces a certain amount of oil each year. Australia, for example, has a reserve of 4.2 Gb<sup>9</sup> and produces 544 kb/d, equal to around 4.7% pa. This rate is called the depletion rate. It differs from country to country, depending on the production history of oil fields, whether they are on-shore or off-shore, and which technologies have been and are being used to extract the oil. This is the production profile from WA:



<sup>6</sup> Petroleum Reserves & Resources Definitions by the Society of Petroleum Engineers  
[http://www.spe.org/spe-site/spe/spe/industry/reserves/Petroleum\\_Reserves\\_Definitions\\_1997.pdf](http://www.spe.org/spe-site/spe/spe/industry/reserves/Petroleum_Reserves_Definitions_1997.pdf)

<sup>7</sup> Ex-Shell Executive Says He Questioned Reserves  
<http://query.nytimes.com/gst/fullpage.html?res=9907E0D9163BF937A25757C0A9629C8B63>

<sup>8</sup> Interview ABC's Nightline with President Bush

Bush: **"If they don't have a lot of additional oil to put on the market, it is hard to ask somebody to do something they may not be able to do."**

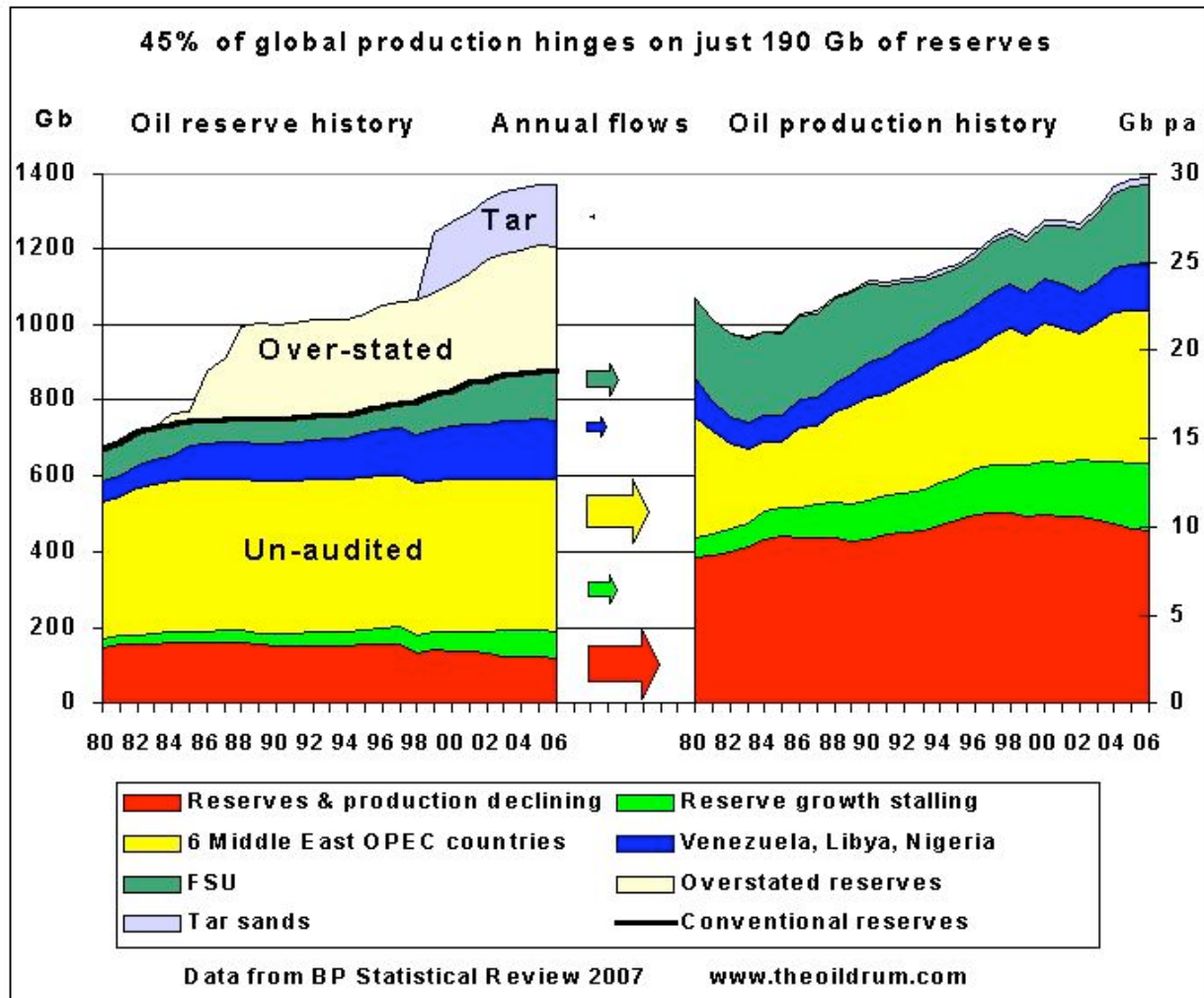
<http://abcnews.go.com/Video/playerIndex?id=4140859>

<sup>9</sup> From BP Statistical Review. This figure seems to be Economic Demonstrated Resources for C&C and LPG according to the McKelvey classification (988 + 1,894 + 1,343) = 4.23 Gb  
<http://www.ga.gov.au/servlet/BigObjFileManager?bigobjid=GA8550>

The proven and probable P2 reserves including NGLs are 2.084 Gb as of 1/2005. For consistency reasons this paper uses the BP data. But this is another example how different reserve and resource data are being mixed up in the statistical review.

UK produces at 15.4 % of its reserve pa, but Nigeria only at 2.5 % pa. There are huge differences. Also, in some countries the reserves are declining over time, in other countries reserves are growing. This is called reserve history.

The following graph shows this history, together with oil production in 2006. All data are from the BP Statistical Review.



- Canadian tar sands: limiting factor is hydrogen from natural gas to form liquid hydrocarbon chains
- Reserves and production declining after a common peak in the end 90s: US, Canada, China, Mexico, Norway, UK ...
- Reserve growth stalling: Algeria, Angola, Brazil, India, Ecuador, Egypt, Vietnam ...
- 3 Middle East OPEC countries: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates

The size of the arrows represents the volume of the oil flow. The tag “un-audited” may apply to other oil suppliers as well.

The main highlights on this graph are:

(a) The recently added Canadian tar sand reserves produce only 1 Mb/d, negligible in comparison to the total global oil production. Prof. Aleklett from ASPO found in a special study that their dependence on natural gas as a source of hydrogen is unsustainable<sup>10</sup>. Climatologist James Hansen warns that emissions from unconventional fuels must be constrained in order to avoid dangerous climate change<sup>11</sup>. The EIA estimated that - leaving aside all environmental concerns - the maximum syncrude production possible by 2030 (in more than twenty years) could be just 3.6 mb/d. The hype about these tar sands lead to reports in the media about Canada becoming another Saudi Arabia. That is wishful thinking. BP shows responsibility by reporting tar sand reserves separate from conventional oil.

(b) OPEC's overstated reserves from the so-called quota wars, which have to be re-classified as resources, are shown to produce no oil. In a very simplified procedure, the yellow shaded area on the graph has been calculated as the difference between BP's reserves and a rounded 400 Gb, the approximate reserves in 1983/84, before the spurious reserve additions (see Colin Campbell's description below). In view of the uncertainties, it would be purely academic to be more accurate than this.

ASPO newsletter March 2007. Irish oil geologist Colin Campbell writes:

"Prices fell as production from other areas, including the North Sea, rose during the 1980s, and the OPEC countries found themselves facing low revenues and competing with each other for production quota which was based largely on reported reserves. Kuwait had been consistently reporting reserves as originally determined by Gulf and BP, but in 1985 announced a massive increase from 64 to 90 Gb (billion barrels), although nothing particular had happened in the oil fields. Having already produced 22 Gb, this was close to the sum of past production and remaining reserves.

2 years later it added further 2 Gb, which exhausted the patience of its neighbours, causing Abu Dhabi to match Kuwait, reporting the same 92 Gb (up from 31 Gb), for Iran to go one better at 93 Gb (up from 49 Gb) and Iraq to cap both with a rounded 100 Gb (up from 47 Gb). Saudi Arabia could not match Kuwait because it was already reporting more, but 2 years later announced a massive increase from 170 Gb to 258 Gb, probably following Kuwait's example of reporting the total found, not the remaining reserves. Abu Dhabi continues to report the same 92 Gb, despite 11 Gb of subsequent production, and the reports of the other countries are barely changed. Accordingly, little credence can be placed on these reserve estimates, with as much as 300 Gb being in doubt."

[http://www.aspo-ireland.org/contentFiles/newsletterPDFs/newsletter75\\_200703.pdf](http://www.aspo-ireland.org/contentFiles/newsletterPDFs/newsletter75_200703.pdf)

(c) 3 countries, Libya, Nigeria and Venezuela, with around 160 Gb reserves deplete at a low 1.7% pa and contribute 9% of global production. Venezuela's low depletion rate results from reserves containing heavy oil

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<sup>10</sup> Canada's Oil Sands Resources and Its Future Impact on Global Oil Supply

<http://www.peakoil.net/uhdsg/OilSandCanada.pdf>

<sup>11</sup> Implications of "peak oil" for atmospheric CO2 and climate <http://arxiv.org/abs/0704.2782>

(d) 130 Gb from countries of the former Soviet Union deplete at 3.3% which is average, to contribute 15% of global oil flows

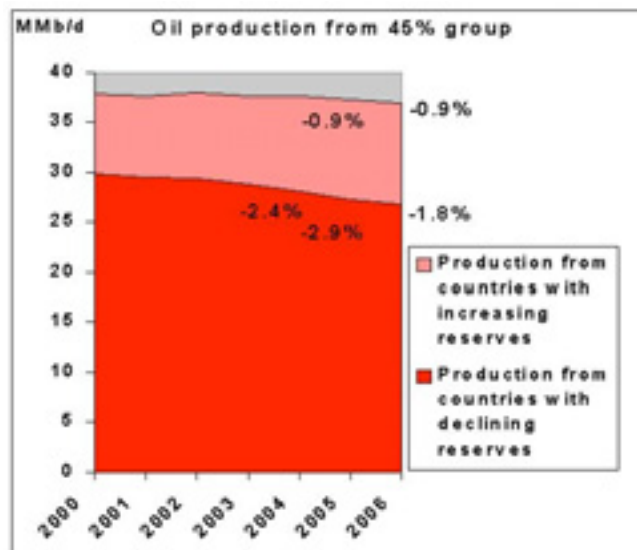
(e) 6 Middle East countries (Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates) produce only a very low 2.2% pa of their reserves of around 400 Gb. It represents 30% of the total global production. It is unclear whether, apart from the problem mentioned in (b), these reserves have been adjusted for production or into which reserve category they fall. The low production rates indicate that even the reduced, remaining reserves may be too high or contain more of the probable and possible categories difficult to prove up. Sour oil is also a problem.

(e) Around 120 Gb of reserves from countries like the US, Canada (conventional), China, Mexico, Norway, Oman, Indonesia, Malaysia, Australia, UK and others are in decline, despite reserve growth in fields, and deplete at a whopping rate of 8.2%, almost 4 times the OPEC rate.

(f) Another 70 Gb from Algeria, Brazil, Angola, Sudan, India, Ecuador and Vietnam have been growing but could just offset decline in the (e) group. Reserves deplete at 5.3 %


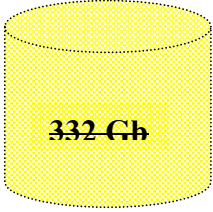



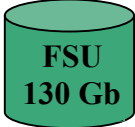
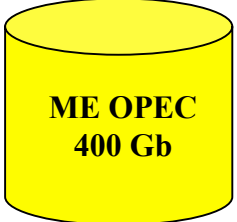

**The last 2 groups together, with only 190 Gb reserves, contribute almost half of the global production although their reserve share of the total is just around 20%.** These reserves have remained at the same level for 7 years now, that is reserve growth in some countries has just offset reserve depletion in other countries.

The annual oil production coming from these reserves has been falling for 4 years and the decline rate is now -0.9% pa.



**The combined depletion rate of 7.1 % pa means that these countries will exhaust their reserves very quickly and the global oil supply system will increasingly become dependent on a rather small number of countries sitting on 80% of the remaining reserves. Since their production rates in % of reserves are very low, the current level of global oil supplies cannot be maintained.**

This graph shows the imbalances in the oil supply system in more detail:

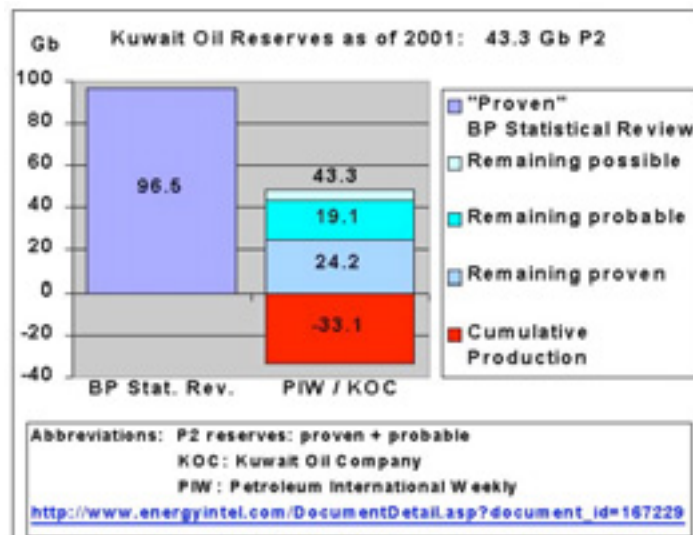
Which reserves produce how much oil?				
Size of reserves 2006 (to scale)	Annual flows (to scale)	Annual oil production rate 2006		
		in % of reserves	in MMb/d	in % of total
 <b>164 Gb</b>	↔	0.2 % pa	1 MMb/d	} <b>55%</b>
Overstated reserves:  <b>332 Gb</b>	Nil	Nil	Nil	
 Libya	↔	1.6 % pa	1.8 MMb/d	
 Nigeria	↔	2.5 % pa	2.6 MMb/d	
 <b>80 Gb</b>	↔	1.3 % pa	2.8 MMb/d	
Average depletion  <b>FSU 130 Gb</b>	→	3.5% pa	12.6 MMb/d	
Low annual flows:  <b>ME OPEC 400 Gb</b>	→	2.2% pa	24 MMb/d	
Rapidly depleting:  <b>190 Gb</b>	→	7.1% pa	36.9 MMb/d	} <b>45%</b>
Data from BP Statistical Review 2007		Total:	81.7 MMb/d	100%

As can be seen, there are huge reserves in the 1<sup>st</sup> column which produce little in the way of annual oil flows. The overstated reserves produce nothing right now, maybe decades later when all the other reserves have been exhausted.

Kuwait is a known example of how uncertain OPEC reserves are<sup>12</sup>. In January 2006, Petroleum International Weekly published details about a 2001 report from KOC (Kuwait Oil Company) in which it emerged that Kuwait's reserves are 50% lower than officially claimed. From the PIW article, reserves as of 2001 are as follows (reserve categories: P1 = proven; P2 = proven + probable; P3 = proven + probable + possible)

Summarized details from the PIW article as of 2001		
Initial oil in place	168.9 Gb	These are the "resources"
Original reserves	81.2 Gb	P3 = proven+probable+possible assumed recovery factor 48%
Cumulative production	33.1 Gb	
Remaining reserves	48.1 Gb	remaining P3 reserves
Out of which:	24.2 Gb	proven P1
	23.9 Gb	80% probable + 20% possible
Proven + probable	43.3 Gb	P2 reserves
Depletion level	43%	=33.1/(33.1+43.3)
Annual depletion rate	3.20%	= 2,148 kb/d of 24.2 Gb proven P1
Burgan field:	20 Gb	reserves
	1.7 Mb/d	Production plateau
Annual depletion rate	3.10%	

Please note that only about half of the initial oil in place can be extracted. Initial oil in place is the total amount of oil in the reservoir rock which could only be recovered by crushing the rock and pushing out the oil from every pore. In practice, even after applying techniques of enhanced oil recoveries like hydraulic fracturing, a lot of oil will remain in the rock simply because it is inaccessible. If it requires more energy to get at the rest of the oil than is contained in the remaining oil itself, any extraction will stop irrespective of oil price.



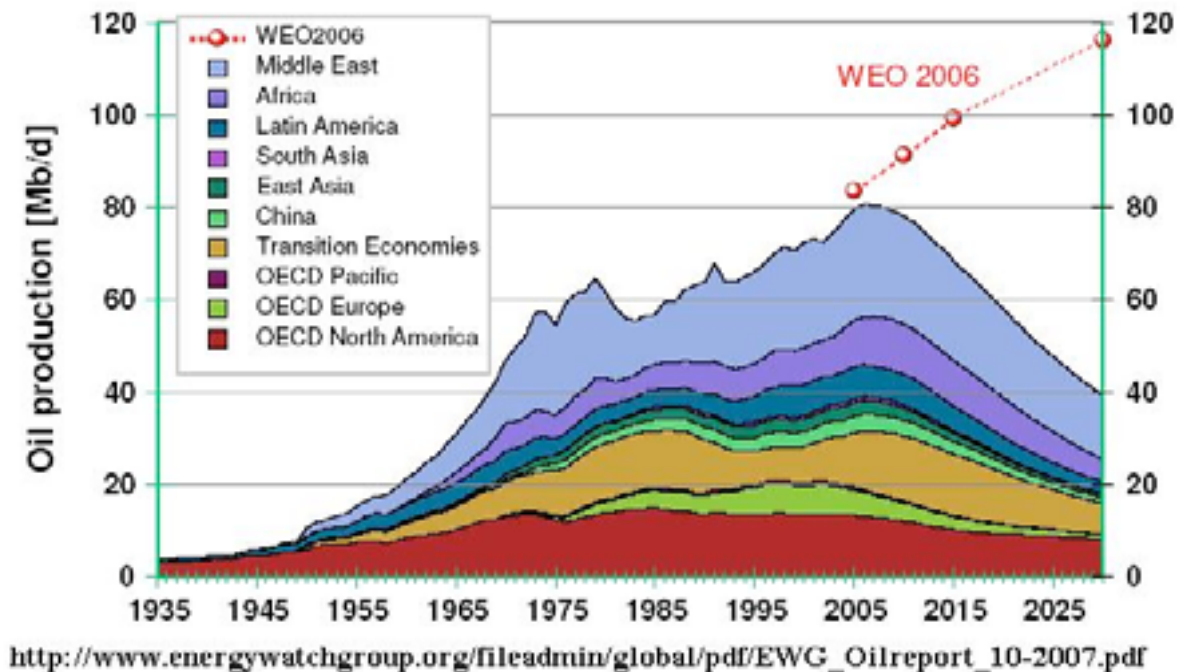
<sup>12</sup> Oil Reserves Accounting: The Case Of Kuwait  
[http://www.energyintel.com/DocumentDetail.asp?document\\_id=167229](http://www.energyintel.com/DocumentDetail.asp?document_id=167229)

This assessment is in stark contrast to 96.5 Gb "proved" reserves reported in the BP Statistical Review, which is even higher than the original P3 reserves. It also throws into doubt all USGS 2000 reserve growth calculations for Middle East OPEC countries, in which mean reserve estimates contain a so-called reserve growth element, computed by applying a factor of 0.44 to reserves plus past production<sup>13</sup>. This reserve growth was experienced in the US resulting from very conservatively reporting only proven, developed reserves (P1 developed) and then re-classifying P1 undeveloped and probable reserves into P1 developed reserves. The USGS 2000 team incorrectly applied the same procedure to the rest of the world. An earlier USGS study by C.D.Masters in 1994 and 1998 is now vindicated which stated:

"we assume that many other countries are, in fact, reporting, effectively, an Identified Reserve (Proved + Probable + Possible Reserves) or some major part thereof. In particular, this is considered to be true for all OPEC countries, the Former Soviet Union (FSU), China, and Mexico. The sum total of these major producers accounts for more than 90 per cent of world oil reserves; therefore, we have some confidence that the world value herein reported for Identified Reserves is a reasonable maximum value for known fields and greatly exceeds reserves developed for production."  
 From: Is USGS 2000 Assessment Reliable? <http://www.oilcrisis.com/laherrere/usgs2000/>

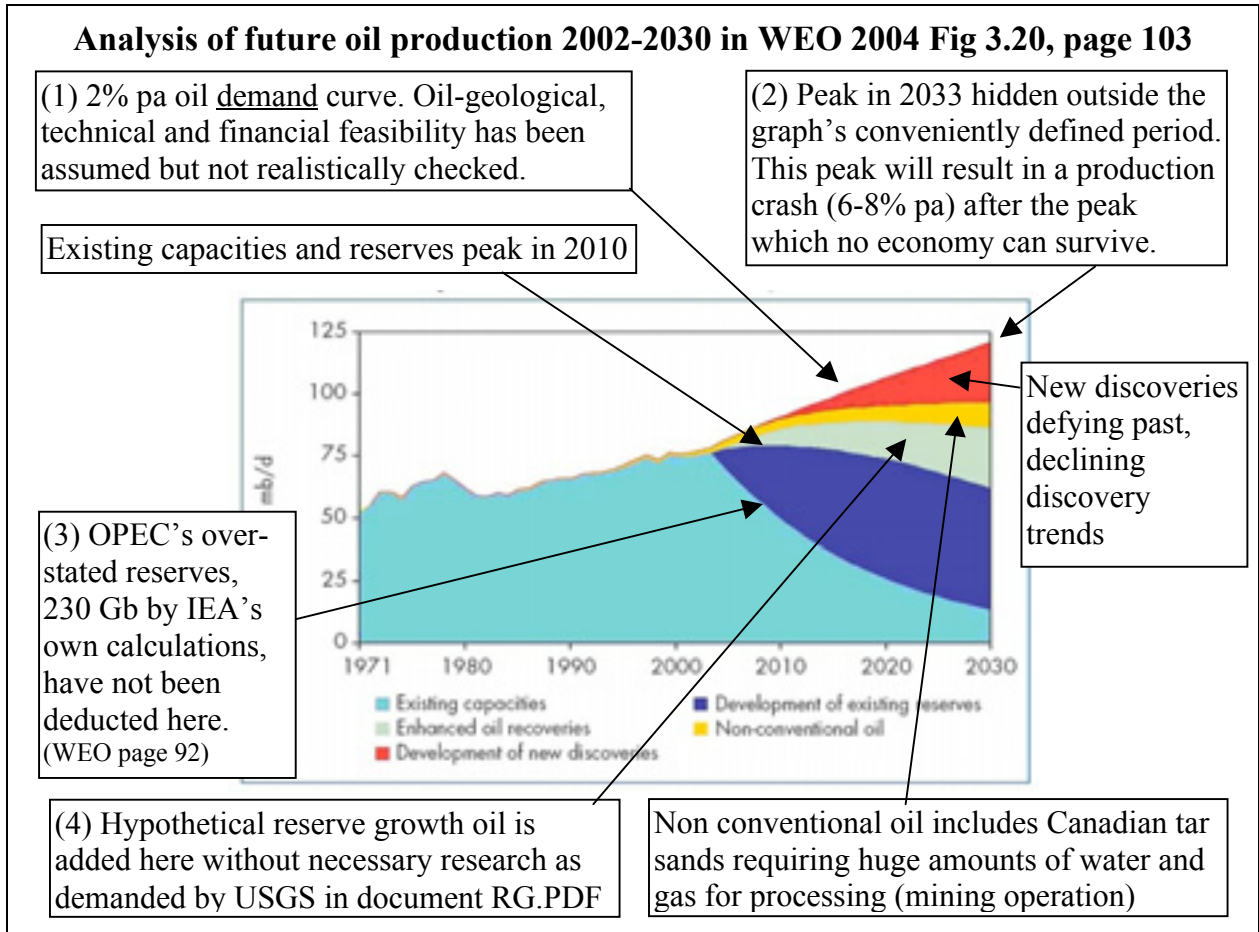
All projections based on the USGS 2000 study, like the IEA World Energy Outlooks, are therefore inflated, as shown in this graph of the Energy Watch Group:

Figure 7: Oil production world summary



<sup>13</sup> USGS Releases World Petroleum Assessment 2000: Global Reserve Growth Nearly Equals Undiscovered Resources <http://www.usgs.gov/newsroom/article.asp?ID=595>

More details on the reserve growth issue can be found in my submission 75 to the Productivity Commission on Energy Efficiency<sup>14</sup>. A critique on WEO 2004 projections is contained in my submission 69 to the Senate Inquiry on oil supplies<sup>15</sup>. This is an excerpt:



The International Energy Agency has become more cautious now with following statements:

Medium Term Oil Market Report 2007:

***"Despite four years of high oil prices, this report sees increasing market tightness beyond 2010, with OPEC's spare capacity declining to minimal levels by 2012"***

<http://online.wsj.com/public/resources/documents/iea20070707.pdf>

That is diplomatic language for oil shortages.

IEA's chief economist Fatih Birol, after presenting the WEO 2007

***"...if we don't do anything very quickly, and in a bold manner, the wheels may fall off."*** <http://www.energybulletin.net/37000.html>

<sup>14</sup> Lessons from EIA Scenarios

Submission 75 to the Productivity Commission

<http://www.pc.gov.au/inquiry/energy/docs/submissions>

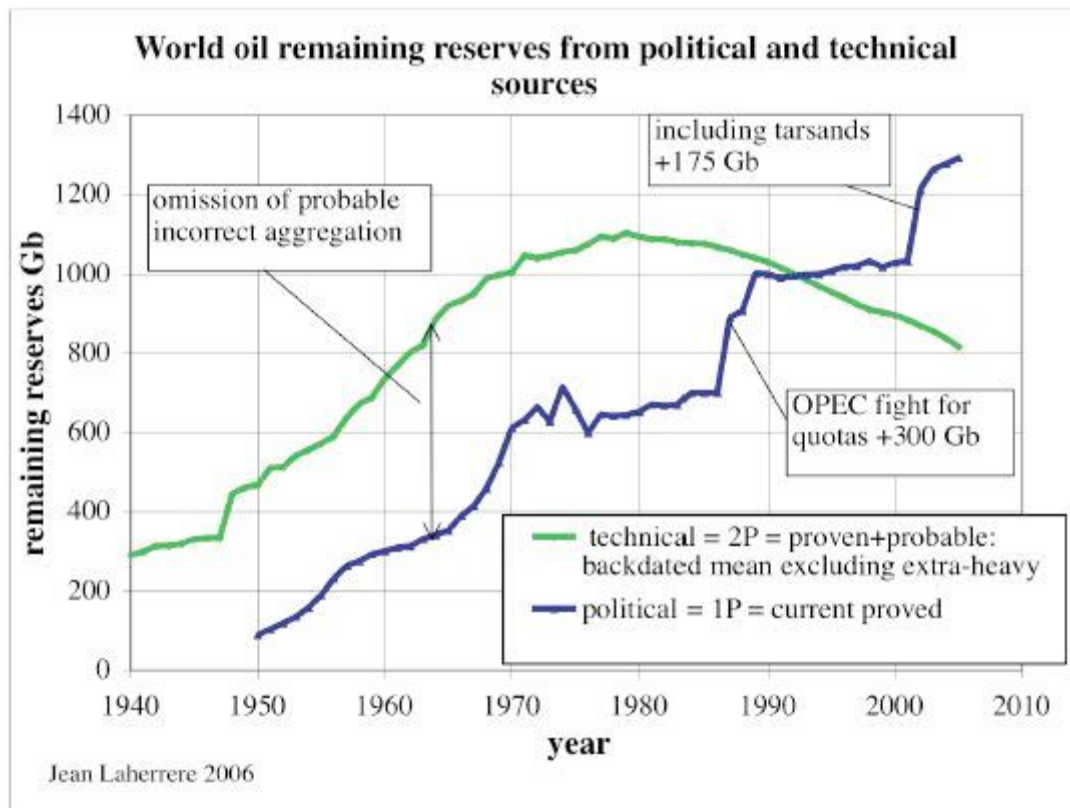
[http://www.pc.gov.au/\\_data/assets/pdf\\_file/0004/45643/sub075attachment1.pdf](http://www.pc.gov.au/_data/assets/pdf_file/0004/45643/sub075attachment1.pdf)

<sup>15</sup> Peak oil Ante Portas followed by global warming, Feb 2006

Submission 69 to the Senate Inquiry on oil supplies

[http://www.aph.gov.au/Senate/committee/rrat\\_ctte/oil\\_supply/submissions/sub69.pdf](http://www.aph.gov.au/Senate/committee/rrat_ctte/oil_supply/submissions/sub69.pdf)

ASPO oil expert Jean Laherrere calls the reserves in the BP statistics "political" and published a graph showing the difference between "political" and "technical" reserves<sup>16</sup> in which technical reserves peaked already in 1980 and have now fallen to 800 Gb, even lower than Hussein's 900 Gb.



<http://www.hubbertpeak.com/laherrere/Castilla200704.pdf>

**Conclusion: We are therefore in the paradox situation that - despite what appears to be at first glance sufficient, even growing reserves - we are facing an oil supply crunch in the not too distant future.**



Time is running out for urban rail solutions

<<< Perth motorists are still blissfully unaware that their State government has done the right thing by building a rail line on the median strip of 2 freeways. All stations along the line have park & ride facilities. So when petrol prices will explode and the first queues arrive at filling stations motorists will save time & money by using this new transport system.

<http://www.answers.com/topic/transperth-trains?cat=biz-fin>

Prepared by: Matt Mushalik (MIEAust, CPEng)

[mushalik@tpg.com.au](mailto:mushalik@tpg.com.au)

<sup>16</sup> Uncertainty of data and forecasts of fossil fuels by Jean Laherrere, ASPO, April 2007  
<http://www.hubbertpeak.com/laherrere/Castilla200704.pdf>