EXECUTIVE SUMMARY / KEY FINDINGS

CRUDE OIL – THE SUPPLY OUTLOOK

Scope

The main purpose of this paper is to project the future availability of crude oil up to 2030. Since crude oil is the most important energy carrier at a global scale and since all kinds of transport rely heavily on oil, the future availability of crude oil is of paramount interest. At present, widely diverging projections exist in parallel which would require completely different actions by politics, business and individuals.
The scope of these projections is similar to that of the World Energy Outlook by the International Energy Agency (IEA). However, no assumptions or projections regarding the oil price are made.

In this paper a scenario for the possible global oil supply is derived by aggregating projections for ten world regions. In order to facilitate a comparison, the definition of the world regions follow the definition used by the International Energy Agency (IEA):

- **OECD North America**, including Canada, Mexico and the USA.
- **OECD Europe**, including Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Slovak Republic, Spain, Sweden, Switzerland, Turkey and the UK.
- **OECD Pacific**, including
  – OECD Oceania with Australia and New Zealand,
  – OECD Asia with Japan and Korea.
- **Transition Economies**, including Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Estonia, Yugoslavia, Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Romania, Russia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Cyprus and Malta.
- **China**, including China and Hong Kong.
- **East Asia**, including Afghanistan, Bhutan, Brunei, Chinese Taipei, Fiji, Polynesia, Indonesia, Kiribati, The Democratic Republic of Korea, Malaysia, Maldives, Myanmar, New Caledonia, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Island, Thailand, Vietnam and Vanuatu.
- **South Asia**, including Bangladesh, India, Nepal, Pakistan and Sri Lanka.

- **Latin America**, including Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominic. Republic, Ecuador, El Salvador, French Guyana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Kitts-Nevis-Antigua, Saint Lucia, St. Vincent Grenadines and Suriname, Trinidad and Tobago, Uruguay and Venezuela.
- **Middle East**, including Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates, Yemen, and the neutral zone between Saudi Arabia and Iraq.
- **Africa,** including Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, the Central African Republic, Chad, Congo, the Democratic Republic of Congo, Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, the United Republic of Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.

However, the scenario results presented in this paper are very different to the scenarios presented by the IEA in their periodic editions of the World Energy Outlook (WEO) where continuing growth of oil supply and as a consequence a continuation of business as usual for decades to come is deemed possible.

Methodology

The analysis in this paper does not primarily rely on reserve data which are difficult to assess and to verify and in the past frequently have turned out to be unreliable. The history of discoveries is a better indicator though the individual data are of varying quality. Rather the analysis is based primarily on production data which can be observed more easily and are also more reliable. Historical discovery and production patterns allow to project future discoveries and – where peak production has already been reached – future production patterns.

The analysis is based on an industry database for past production data and partly also for reserve data for certain regions. As reserve data vary widely and as there is no audited reference, the authors have in some cases made their own reserve estimates based on various sources and own assessments. Generally, future production in regions which are already in decline can be predicted fairly accurately relying solely on past production data.

The projections are based also on the observation of industry behaviour and on “soft” indicators (for instance, the recent turn about in the communication by the IEA and a remarkable quote by King Abdullah of Saudi Arabia).

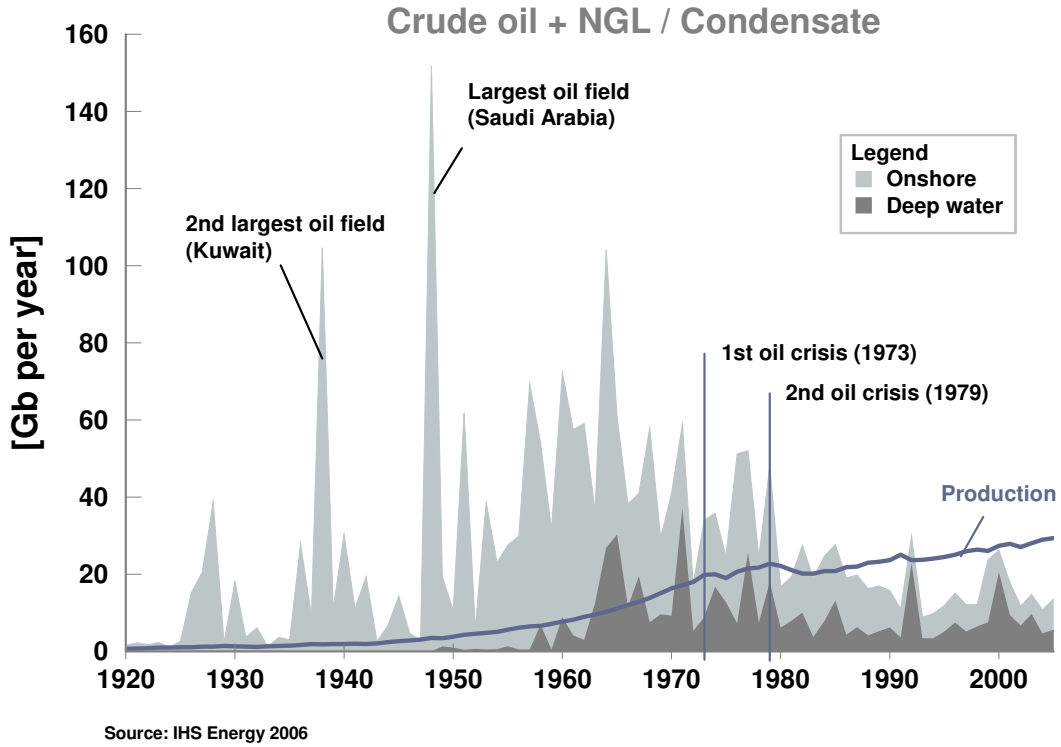
Understanding the future of oil

Only oil that has been found before can be produced. Therefore, the peak of discoveries which took place a long time ago in the 1960s, will some day have to be followed by a peak of production. After peak oil, the global availability of oil will decline year after year. There are strong indications that world oil production is near peak.

The growing discrepancy between oil discoveries and production is shown in Figure 1.

In the period 1960 to 1970 the average size of new discoveries was 527 Mb per New Field Wildcat. This size has declined to 20 Mb per New Field Wildcat over the period 2000 to 2005.

Figure 1: History of oil discoveries (proved + probable) and production



Source: IHS Energy 2006

Remaining world oil reserves are estimated to amount to 1,255 Gb according to the industry database [IHS 2006]. There are good reasons to modify these figures for some regions and key countries, leading to a corresponding EWG estimate of 854 Gb. These modifications are explained in the chapters describing the detailed scenarios. The resulting reserve figures are given in in the following Figure 2 and in Table 1 (there described as EWG estimates and shown together with the IHS data). The greatest difference are the reserve numbers for the Middle East. According to

IHS, the Middle East possesses 677 Gb of oil reserves, whereas the EWG estimate is 362 Gb.

Figure 2: World oil reserves (EWG assessment)

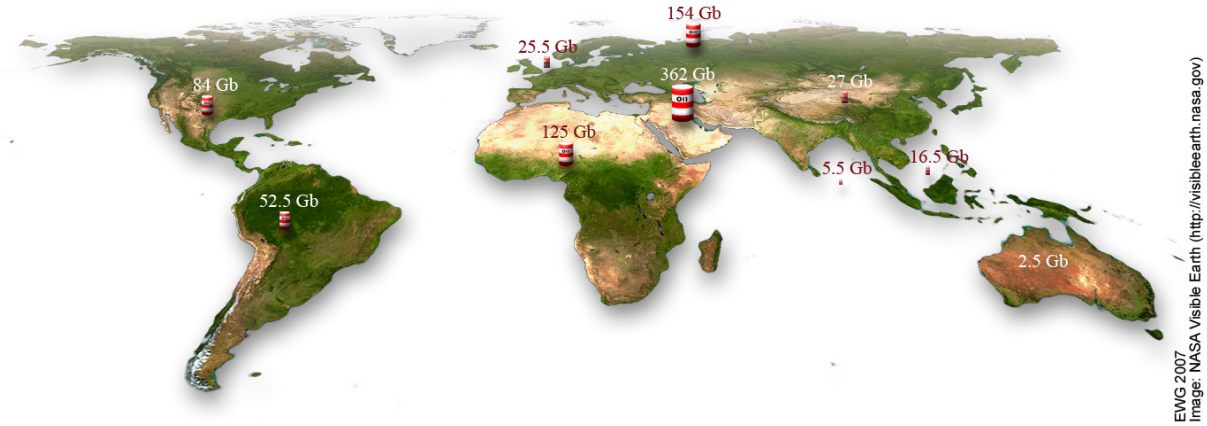
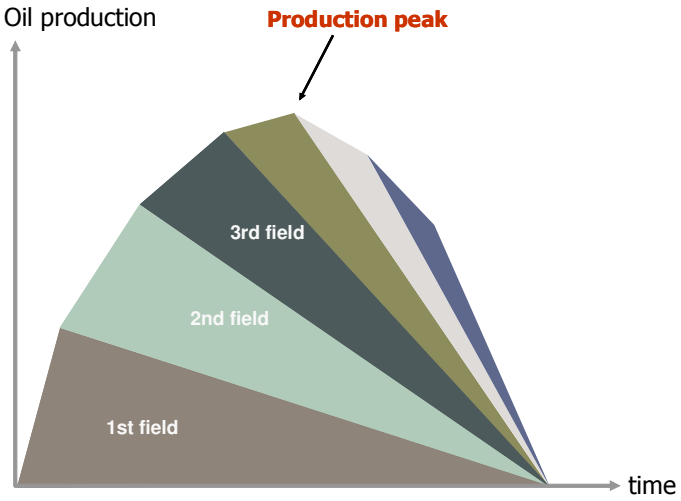


Table 1: Oil reserves and annual oil production in different regions and key countries

Region	Remaining reserves		Production 2005		Consumption 2005 [Gb/yr]
	EWG [Gb]	IHS [Gb]	onshore [Gb/yr]	offshore [Gb/yr]	
OECD North America	84	67.6	3.20	1.71	9.13
Canada	17	15.3	0.89	0.12	0.82
USA	41	31.9	1.93	0.59	7.59
Mexico	26	20.4	0.36	1.00	0.72
OECD Europe	25.5	23.5	0.1	1.94	5.72
Norway	11	11.6	0	1.13	0.08
UK	8	7.8	0.01	0.70	0.65
OECD Pacific	2.5	5.1	0.025	0.18	3.18
Australia	2.4	4.8	0.02	0.17	0.31
Transition Economies	154	190.6	4.1	0.18	2.02
Russian Federation	105	128	3.4	0.13	1.00
Azerbaijan	9.2	14	0.01	0.15	0.04
Kazakhstan	33	39	0.47	0	0.08
China	27	25.5	1.1	0.22	2.55
South Asia	5.5	5.9	0.11	0.16	0.96
East Asia	16.5	24.1	0.3	0.65	1.75
Indonesia	6.8	8.6	0.27	0.11	0.43
Latin America	52.5	129	2.0	0.61	1.74
Brazil	13.2	24	0.075	0.55	0.75
Venezuela	21.9	89	1.17	0	0.20
Middle East	362	678.5	6.97	1.97	2.09
Kuwait	35	51	0.96	0	0.11
Iran	43.5	134	1.19	0.24	0.59
Iraq	41	99	0.67	0	
Saudi Arabia	181	286	2.85	0.86	0.69
UAE	39	57	0.46	0.45	0.14
Africa	125	104.9	2,03	1,53	1.01
Algeria	14	13.5	0.72	0	0.09
Angola	19	14.5	0.01	0.45	
Libya	33	27	0.61	0.02	
Nigeria	42	36	0.39	0.52	
World	**854**	**1,255**	**19.94**	**9.15**	**30.3**

In every oil province the big fields will be developed first and only afterwards the smaller ones. As soon as the first big fields of a region have passed their production peak, an increasing number of new and generally smaller fields have to be developed in order to compensate the decline of the production base. From there on, it becomes increasingly difficult to sustain the rate of the production growth. A race begins which can be described as follows: More and more large oil fields show declining production rates. The resulting gap has to be filled by bringing into production a larger number of smaller fields. However, these smaller fields reach their peak much faster and then contribute to the overall production decline. As a consequence, the region's production profile which results from the aggregation of the production profiles of the individual fields, becomes more and more “skewed”, the aggregate decline of the producing fields becomes steeper and steeper. This decline has to be compensated for by the ever faster connection of more and more ever smaller fields, see Figure 3.

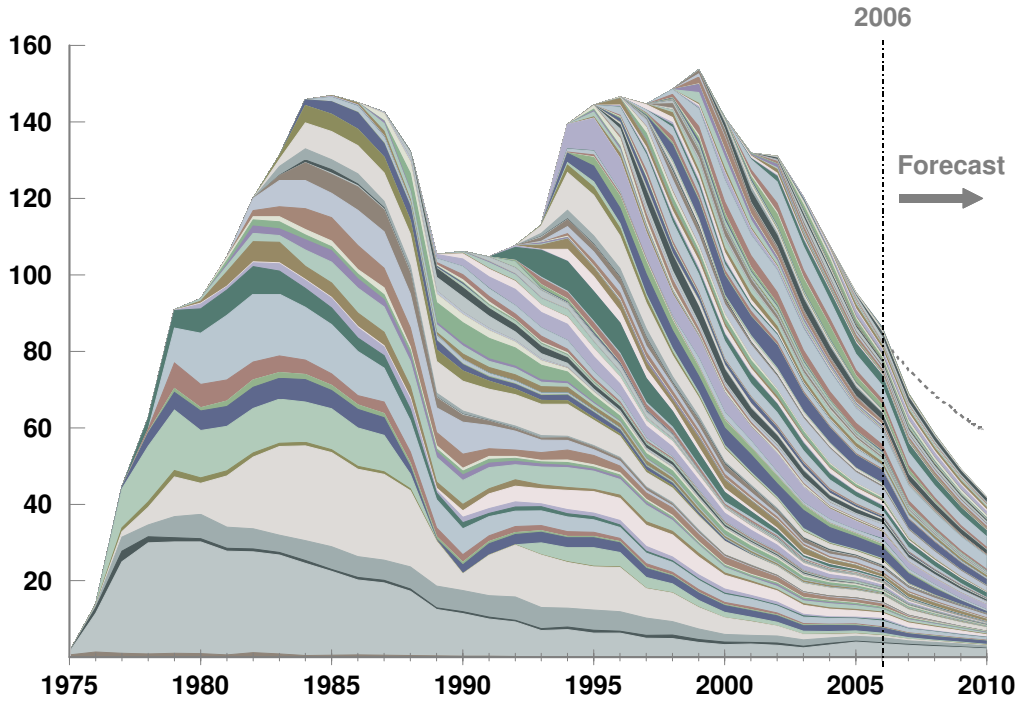
Figure 3: Typical production pattern for an oil region



So, the production pattern over time of an oil province can be characterised as follows: To increase the supply of oil will become more and more difficult, the growth rate will slow down and costs will increase until the point is reached where the industry is not anymore able to bring into production a sufficient number of new fields quick enough. At that point, production will stagnate temporarily and then eventually start to decline.

This pattern can be observed when looking at the oil production in the UK.

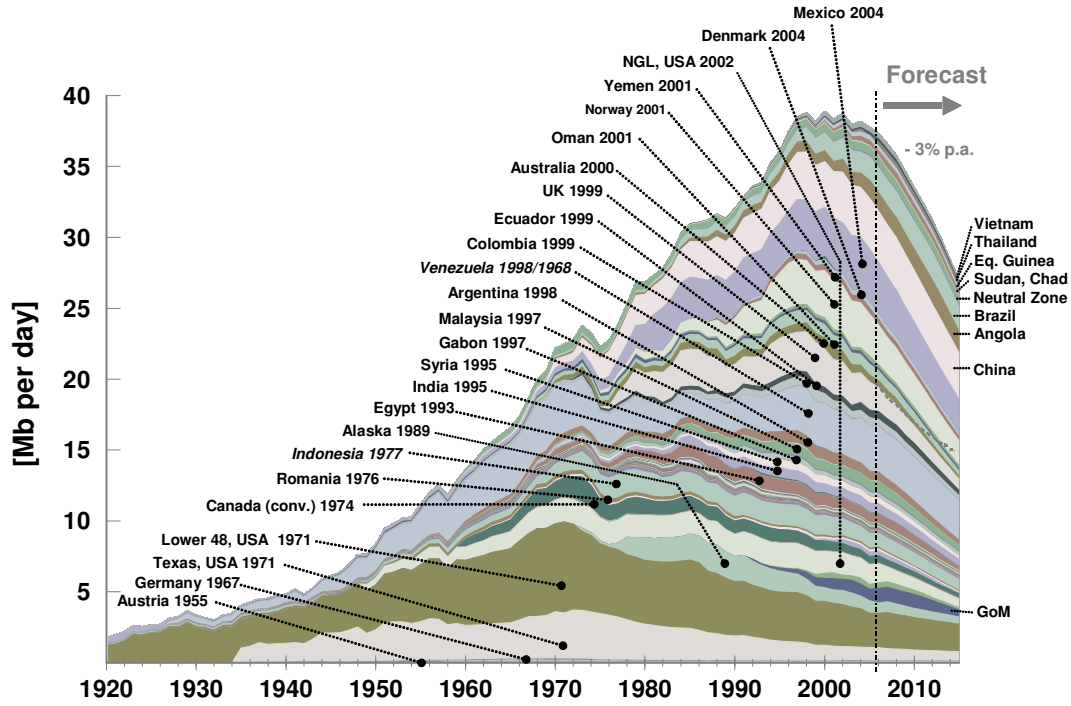
Figure 4: Oil production in the United Kingdom



Source: DTI, May 2007; Forecast: LBST

Oil production in regions having passed their peak can be forecasted with some certainty for the next years. The following Figure 5 shows the production pattern of the countries outside OPEC (only Angola is included which has recently joined OPEC) and outside the former Soviet Union. Countries with a year behind their name are countries past peak, stating the year of peak production. On the top of the graph are the few countries in this group which have not reached peak yet. If it is assumed that the remaining regions with growth potential (especially Angola, Brazil and the Gulf of Mexico) will expand their production by the year 2010 (in accordance with the forecasts of the companies operating in these regions), total oil production of this group of countries, however, will continue to decline by about 3% per year, see Figure 5.

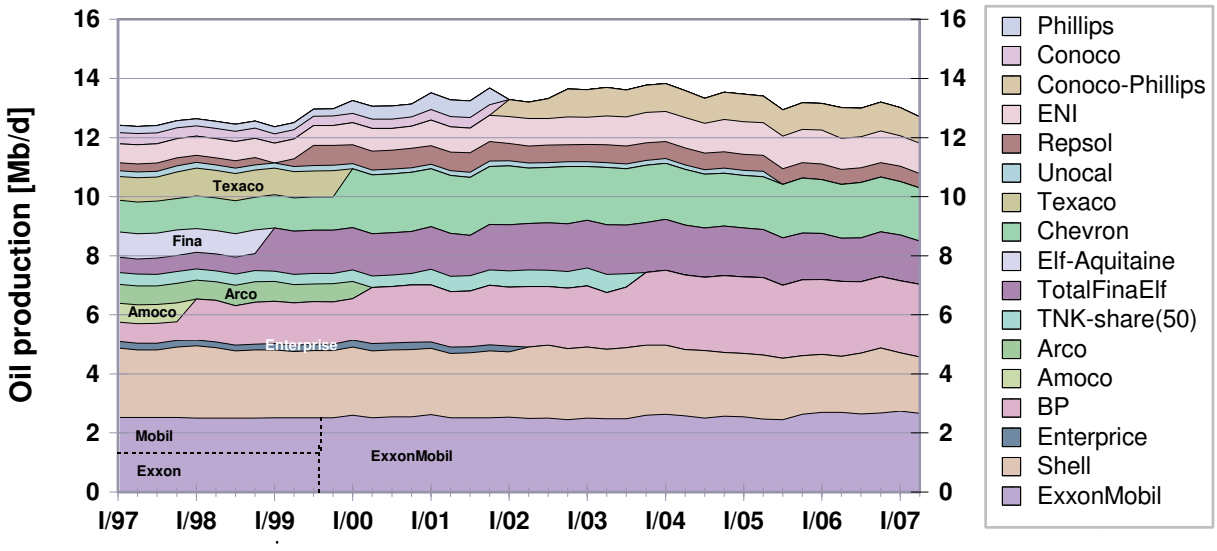
Figure 5: Oil producing countries past peak



Ludwig-Bölkow-Systemtechnik GmbH, 2007
Source: IHS 2006; PEMEX, petrobras ; NPD, DTI, ENS(Dk), NEB, RRC, US-EIA, January 2007
Forecast: LBST estimate, 25 January 2007

The difficulties of expanding oil production can also be demonstrated by looking at the performance of the big international oil companies. In aggregate, they were not able to increase their production in the last ten years, despite an unprecedented rise in oil prices.

Figure 6: Oil production of the oil majors from 1997 to 2007

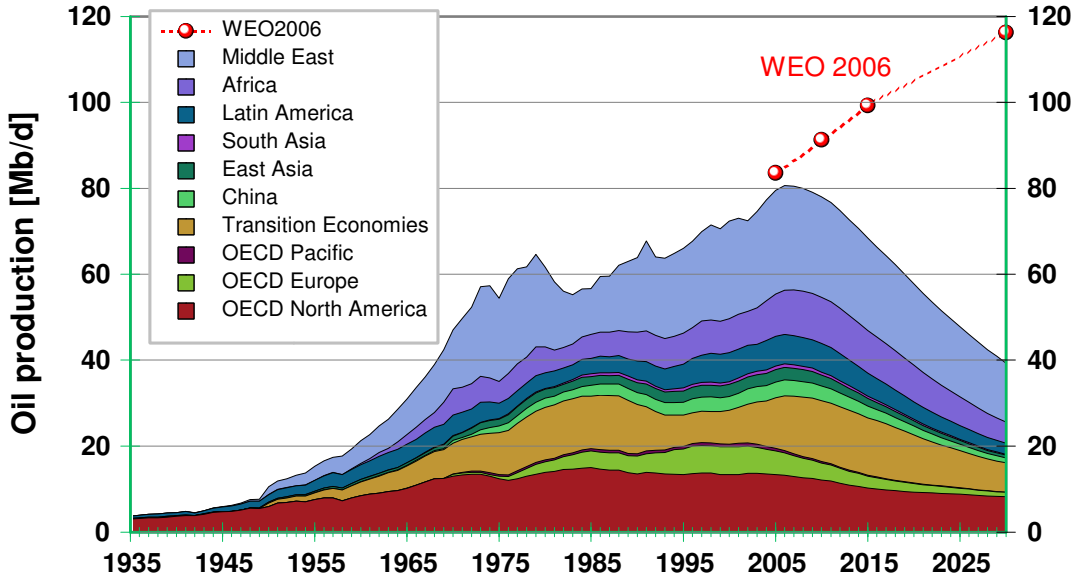


Key findings

- “Peak oil is now”.
  For quite some time, a hot debate is going on regarding peak oil. Institutions close to the energy industry, like CERA, are engaging in a campaign trying to “debunk” the “peak oil theory”. This paper is one of many by authors inside and outside ASPO (the Organisation for the Study of Peak Oil) showing that peak oil is anything but a “theory”, it is real and we are witnessing it already.
  According to the scenario projections, the peak of world oil production was in 2006.
  The timing of the peak in this study is by a few years earlier than seen by other authors (like e.g. Campbell, ASPO, and Skrebowski) who are also well aware of the imminent oil peak. One reason for the difference is a more pessimistic assessment of the potential of future additions to oil production, especially from offshore oil and from deep sea oil due to the observed delays in announced field developments. Another reason are earlier and greater declines projected for key producing regions, especially in the Middle East.
- The most important finding is the steep decline of the oil supply after peak.
  This result - together with the timing of the peak - is obviously in sharp contrast to the projections by the IEA. But the decline is also more pronounced compared with the more moderate projections by ASPO.
  Yet, this result conforms very well with the recent findings of Robelius in his doctoral thesis. This is all the more remarkable because a different methodology and different data sources have been used.

The global scenario for the future oil supply is shown in the following Figure 7.

Figure 7: Oil production world summary



The projections for the global oil supply are as follows:

- 2006: 81 Mb/d
- 2020: 58 Mb/d (IEA: 105[1] Mb/d)
- 2030: 39 Mb/d (IEA: 116[2] Mb/d)

The difference to the projections of the IEA could hardly be more dramatic.

- A regional analysis shows that, apart from Africa, all other regions show declining productions by 2020 compared to 2005.
  By 2030, all regions show significant declines compared to 2005.

Three examples for regional results[3] for key producing regions are given next.

[1] Since IEA gives data only for 2015 and 2030, those for 2020 are interpolated; these data include processing gains

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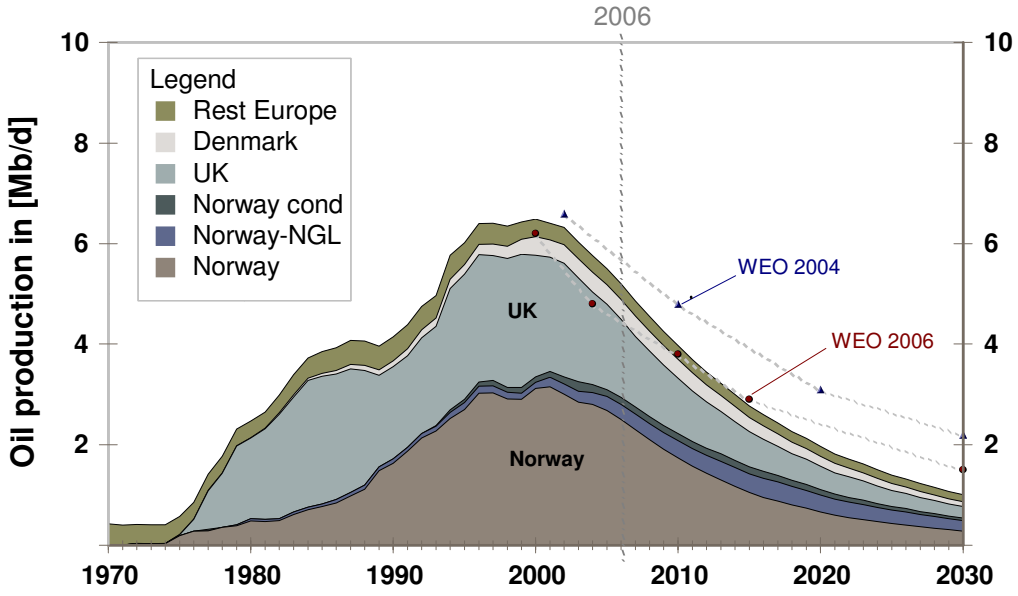
[3] Since IEA gives data only for 2015 and 2030, those for 2020 are interpolated

OECD Europe

Figure 8: Oil production in OECD Europe



The projections for the oil supply in OECD Europe are as follows:

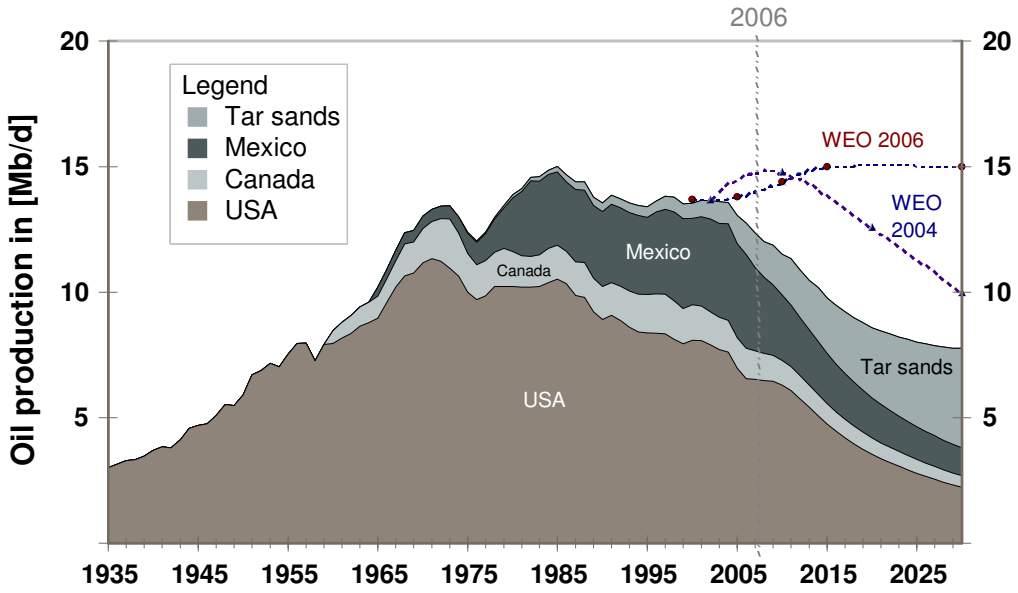
- 2006: 5.2 Mb/d
- 2020: 2 Mb/d (IEA: 3.3[4] Mb/d)
- 2030: 1 Mb/d (IEA: 2.6[5] Mb/d)

[4] For this comparison 2.3 Mb/d crude oil and 25% of OECD NGL are added

[5] For this comparion 1.5 Mb/d crude oil and 25% of OECD NGL are added

OECD North America

Figure 9: Oil production in OECD North America



The projections for the oil supply in OECD North America are as follows:

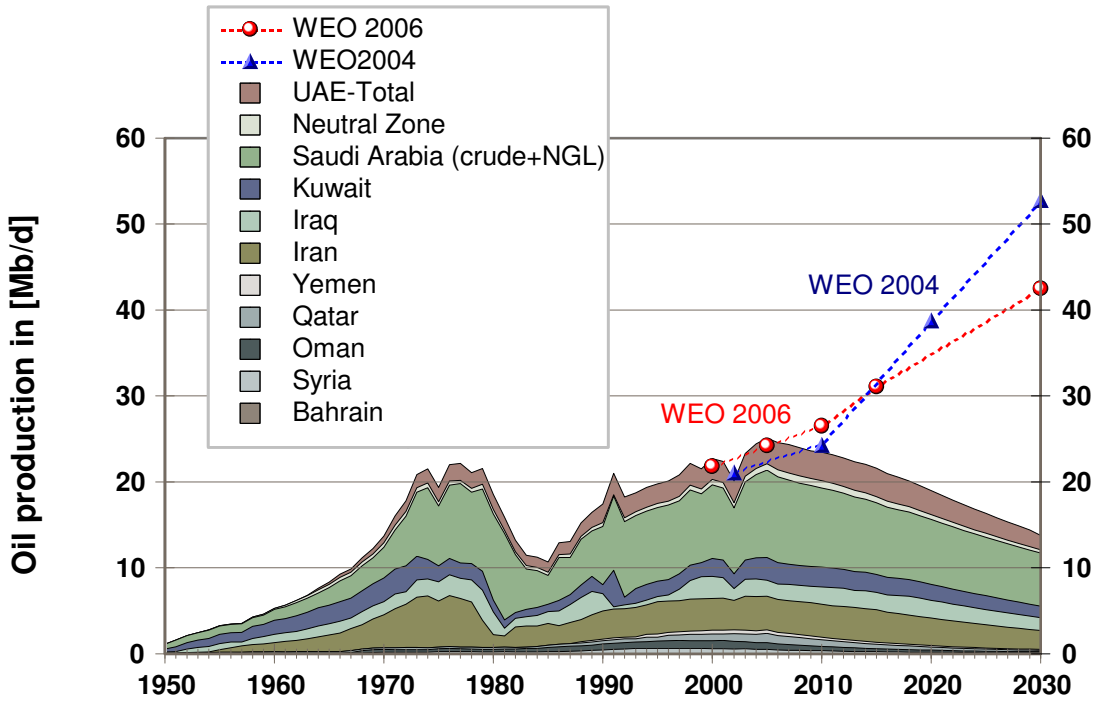
- 2006: 13.2 Mb/d
- 2020: 9.3 Mb/d (IEA: 15.9[6] Mb/d)
- 2030: 8.2 Mb/d (IEA: 15.9[7] Mb/d)

[6] For this comparison 8.6 Mb/d crude oil, Canadian tar sand and 75% of OECD NGL are added

[7] For this comparison 7.8 Mb/d crude oil, Canadian tar sand and 75% of OECD NGL are added

Middle East

Figure 10: Oil production in the Middle East



The projections for the oil supply in the Middle East are as follows:

- 2006: 24.3 Mb/d
- 2020: 19 Mb/d (IEA: 32.3[8] Mb/d)
- 2030: 13.8 Mb/d (IEA: 39.6[9] Mb/d)

This is the region where the assessment in this study deviates most from the projections by the IEA.

[8] 28.3 Mb/d crude oil and 4 Mb/d NGL

[9] 34.5 Mb/d crude oil and 5.1 Mb/d NGL

Conclusion

The major result from this analysis is that world oil production has peaked in 2006. Production will start to decline at a rate of several percent per year. By 2020, and even more by 2030, global oil supply will be dramatically lower. This will create a supply gap which can hardly be closed by growing contributions from other fossil, nuclear or alternative energy sources in this time frame.

The world is at the beginning of a structural change of its economic system. This change will be triggered by declining fossil fuel supplies and will influence almost all aspects of our daily life.

Climate change will also force humankind to change energy consumption patterns by reducing significantly the burning of fossil fuels. Global warming is a very serious problem. However, the focus of this paper is on the aspects of resource depletion as these are much less transparent to the public.

The now beginning transition period probably has its own rules which are valid only during this phase. Things might happen which we never experienced before and which we may never experience again once this transition period has ended. Our way of dealing with energy issues probably will have to change fundamentally.

The International Energy Agency, anyway until recently, denies that such a fundamental change of our energy supply is likely to happen in the near or medium term future. The message by the IEA, namely that business as usual will also be possible in future, sends a false signal to politicians, industry and consumers – not to forget the media.