Chapter Three

'Peak oil' concerns about future oil supply

3.1 Proponents of peak oil views argue that official estimates of future oil production are overly-optimistic, and that supply will be constrained by a shortage of resources soon enough to be a concern.

3.2 Peak oil commentators include a number of prominent oil industry experts including oil industry veterans Colin Campbell and Jean Laherrere; Kenneth Deffeyes (formerly of Shell Oil and Princeton University); Ali Samsam Bakhtiari (formerly of Iranian National Oil Company); Matthew Simmons (leading energy industry financier and a former energy adviser to US Vice-President Dick Cheney), and Chris Skrebowski (editor, *Petroleum Review*).[1] Peak oil views are expressed by the Association for the Study of Peak Oil and Gas (ASPO) among other groups.

Peak oil views and responses in summary

3.3 Peak oil commentators commonly predict a peak of conventional oil production somewhere between now and 2030. They fear that declining production after the peak will cause serious hardship if mitigating action is not started soon enough. In summary, their arguments are:

- Official estimates of world reserves, future reserve growth and future discoveries are over-optimistic. In particular:
  - Reported reserves in the Middle East are untrustworthy. We should not be confident that the Middle East will be able to increase production to the extent required by International Energy Agency (IEA) projections to satisfy predicted demand.
  - The US Geological Survey's (USGS) 2000 report (which is the key source for optimistic estimates of the ultimately recoverable resource) is flawed in various ways.
- Discovery of oil peaked in the 1960s and has generally declined since then. This trend should be expected to continue.
- World production should be expected to peak when about half the ultimately recoverable resource has been produced. Production in many major oil-producing countries is already declining.

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1 Bureau of Transport and Regional Economics, *Is the world running out of oil - a review of the debate*, working paper 61, 2005, p. 4.

- There are very large resources of non-conventional oil (such as Canadian tar sands and Venezuelan heavy oil).[2] However the difficulty, cost and environmental problems of exploiting them means it is unlikely that they can be brought on stream in time or in enough quantity to make up for the predicted decline of conventional oil.

3.4 ASPO suggests that the total past and future production of conventional oil will be about 1,900 billion barrels. This is much less than the USGS mean estimate of at least 3,345 billion barrels.[3]

3.5 Other commentators who reject peak oil concerns commonly argue that pessimistic views of future oil supply do not allow for the likely increase in oil exploration and technological advances in oil recovery that would be spurred by rising prices. They also argue that as conventional oil is depleted market forces will bring nonconventional oil and alternative fuels on stream to fill the breach when the price is right. For example, ABARE's long term projections of oil demand assume an oil price of $US40 per barrel, on the grounds that oil prices will be held to that level by competition from substitutes, such as oil from coal, which become viable at about that price.[4]

3.6 'Peak oil' arguments are enlarged below with responses from their critics interleaved. Committee comments are partly in place and partly at the end of the chapter.

Is 'ultimately recoverable resource' a useful concept?

3.7 The core logic of the most common peak oil argument is shown in the following table. The reasoning is:

- the ultimately recoverable resource (total production past and future) is X;
- past production is Y;
- annual production is increasing at rate Z (this allows future production during the growth period to be estimated);

2 Estimated recoverable reserves are 315 billion barrels of tar sands in Canada and 270 billion barrels of heavy oil in Venezuela. ABARE, *Australian Commodities*, June 2006, p. 305. This may be compared with current proved reserves of conventional oil of 1,200 billion barrels.

3 Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006], p. 4. 'At least 3,345 barrels': see chapter 2, footnote 43.

4 ABARE, *Australian Commodities,* June 2006, p. 303ff. Dr J. Penm (ABARE), *Committee Hansard,* 18 August 2006, p. 59.

- the rate of production will peak when about half the ultimately recoverable resource has been produced.[5] [6]

3.8 Knowing X,Y and Z, the peak year can easily be calculated. But the result depends crucially on the estimate of the ultimately recoverable resource (URR): the total amount that will ever be produced. This is very uncertain. For example, taking expected demand growth as 1.5 per cent per year (which is close to official predictions), different estimates of the URR give peak years as follows:

Figure 3.1 – Simplified peak oil calculation

Assumptions: • Past production is 1,000 billion barrels. • Present production is 30 billion barrels per year. • Pre-peak production grows at 1.5% per year.[1] • Peak production occurs when half of total production (URR) has been produced.
Billion barrels.

A. total production (URR)	B. future production (A-1,000)	C. total production before peak (A/2)	C. future production before peak: C-1,000	at 1.5% annual growth, peak is -	annual production at peak	annual production at peak: million barrels per day
2,000[2]	1,000	1,000	0	now	30	82
3,000[3]	2,000	1,500	500	in 15 yrs	37	101
4,000[4]	3,000	2,000	1,000	in 28 yrs	45	123
5,000[5]	4,000	2,500	1,500	in 38 yrs	52	142

1. The growth rate would be expected to fall to zero as the peak is approached, causing a gradual transition rather than a sudden peak. This would make a lower, earlier peak than shown.[7] How gradual the transition would be is a matter of debate.
2. 'Early peakers', eg ASPO Australia, *Submission 135C*, (approximately).
3. For example, USGS 2000 mean estimate (approximately).
4. For example, ExxonMobil, *Tomorrow's Energy*, 2006, p. 5: including non-conventional.
5. For example, International Energy Agency, *Resources to Reserves*, 2005, p. 17: including nonconventional, shale oil, enhanced oil recovery.

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5 For example, Campbell C.J. & Laherrere J.H, 'The End of Cheap Oil', *Scientific American*, March 1998, p 78. Estimates by ASPO use detailed country-specific data and assumptions (eg, extrapolating the production trend of countries already in decline) to calculate country peaks, and sum these to estimate a global peak. Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006].

6 Another line of argument is that oil discovery peaked in the 1960s, and production may be expected to mirror discovery after a time lag. For example Laherrere J., *Forecasting Production From Discovery,* May 2005, at http://www.mnforsustain.org/oil_forecasting_production_using_discovery_laherrere505.htm

7 US Energy Information Administration, *Long Term World Oil Supply (A Resource Base/ Production Path Analysis)*, July 2000, slide 18, at http://www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2000/long_term_supply/index.htm

3.9 Some critics of peak oil views argue that the very concept of 'ultimately recoverable resource' (URR) is not useful. Firstly, it is argued that the URR cannot be usefully estimated as it will change in future (for example, as technological advances make more oil economically recoverable). Past estimates have always been too pessimistic:

> The primary flaw in Hubbert-type models is a reliance on URR as a static number rather than a dynamic variable, changing with technology, knowledge, infrastructure and other factors, but primarily growing.[8]

3.10 Secondly, critics argue that the size of the resource is not of interest in any case, because market forces will ensure that there is no need to recover it all: as depletion increases prices and technological progress facilitates alternatives, other fuels will take over:

> The world will never run out of oil. For reasons of economics if not politics, humanity will quit using oil long before nature exhausts its supply.[9]

3.11 Examples of this are said to be coal replacing wood in 17th century England (driven by the increasing scarcity of wood), and kerosene replacing whale oil in 19th century America (made possible by the discovery of petroleum).[10]

Comment

3.12 The view that the ultimately recoverable resource of oil is irrelevant seems to be mostly based on an optimistic view of future technological progress.[11] However there is no guarantee that the advances of the past will be repeated indefinitely in future. For example, the discovery of petroleum at the time that whale oil was becoming scarce was fortuitous. There is no guarantee that the same thing will happen again at a needed time - and today the stakes are much higher.

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8 Lynch M.C., *The New Pessimism about Petroleum Resources: Debunking the Hubbert Model (and Hubbert Modellers),* n.d.. Similarly: 'Estimates of declining reserves and production are incurably wrong because they treat as a quantity what is actually a dynamic process driven by growing knowledge…Because the concept of a fixed limit is wrong, the predicted famine always fails.' Adelman M.A. & Lynch M.C., 'Fixed View of Resource Limits Creates Undue Pessimism', *Oil and Gas Journal*, vol. 95 no. 14, 7 April 1997, p. 56.

9 *Oil and Gas Journal,* vol. 101 no. 32, 18 August 2003, editorial. Similarly: 'The total mineral in the earth is an irrelevant non-binding constraint. If expected finding-development costs exceed the expected net revenues, investment dries up and the industry disappears. Whatever is left in the ground is unknown, probably unknowable, but surely unimportant: a geological fact of no economic interest.' Adelman M.A., 'Mineral depletion with special reference to petroleum, *The Review of Economics and Statistics*, vol. 72 no. 1, February 1990, p. 1.

10 McCabe P.J., 'Energy Resources - Cornucopia or Empty Barrel', *AAPG Bulletin*, vol. 82 no. 11, November 1998, p. 2122.

11 'Oil is, after all, a finite resource. The larger message in OGJ's series is that human ingenuity is not.' *Oil and Gas Journal,* vol. 101 no. 32, 18 August 2003, editorial.

3.13 A key feature of conventional oil is its very high Energy Return on Energy Invested (EROI). Alternative fuels now in prospect (such as nonconventional oil or oil from coal) are less advantageous in this regard. Moving to other fuels will have an economic cost that should be anticipated, even allowing that it will not be necessary to use the last conventional oil.

3.14 Estimating the ultimately recoverable resource of conventional oil is of interest because it gives an indication of when supply might peak and how soon those costs might start to bite. Given the fundamental importance of this to the future world economy, even an uncertain estimate is better than none.

3.15 Note also that statements like 'humanity will quit using oil long before nature exhausts its supply' accept that oil production will reach a peak and decline. This now seems to be accepted in the industry and official peak agencies such as the IEA (as shown, for example, by the scenarios described from paragraph 3.79 below).[12] In that case the key difference of opinion is not whether there will be a peak of oil production, but whether the decline of oil will be driven by resource scarcity with harmful effects (as peak oil commentators fear), or whether it will be driven by market forces developing alternative fuels in a timely way to offset the depletion of oil, presumably with benign effects (as 'economic optimists' seem to expect).

3.16 In *either* case, estimating the time of the peak is arguably a matter of interest for prudent public policy. Official predictions which deal only with the growth period are not telling the full story.[13]

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12 For example: 'How rapidly will production decline after the peak?... For conventional oil, important horizons of finiteness are indeed coming into view.' *Oil and Gas Journal*, 18 August 2003, editorial. 'Of course, oil production must peak one day.' IEA, *World Energy Outlook 2005,* p. 140. The US Energy Information Administration has estimated dates for the peak of conventional oil for various scenarios, broadly following the 'Hubbert curve' methodology. A similar exercise by the IEA estimated a peak of conventional oil production between 2013 and 2037 depending on assumptions. See paragraph 3.79.

13 Calling the URR 'a dynamic variable' (Lynch) depends on defining URR as 'the amount of oil which *is thought recoverable* given existing technology and economics….' (emphasis added. See paragraph 2.9). In this scheme the URR is *nothing more than* a number, calculated today by a certain methodology, which may be different when calculated tomorrow by the same methodology (given updated data).

The more common definition of URR seems to be 'the amount of oil *which will ever be recovered'* (BP). Peak oil arguments concerning the 'Hubbert curve' must define the URR in this way. This URR is a definite number which does not change over time. However it cannot be known exactly until production has ended, and there is great uncertainty in estimating it before then.

Much of the 'economic optimist' critique of peak oil concerns probably comes down to a view that estimates of the URR (in the second sense) are so uncertain that they are not useful for planning purposes.

Estimating the ultimately recoverable resource: issues

3.17 Peak oil commentators commonly estimate a URR of conventional oil considerably lower than official agencies such as the US Geological Survey. For example, ASPO suggests a URR of about 1,900 billion barrels. This is much less than the mean estimate of at least 3,345 billion barrels in the US Geological Survey's *World Petroleum Assessment 2000* (USGS 2000).[14]

3.18 The main points which cause peak oil commentators to make lower estimates are their views that:

- estimates of reserves in the Middle East are uncertain and probably overstated;
- USGS 2000 estimates of future reserve growth and future new field oil discoveries are overstated because of unsound methodology.

Arguments about reserve estimates

3.19 Peak oil commentators argue that reported reserves figures are unreliable as they are 'clouded by ambiguous definitions and lax reporting practices.'[15] In particular, they argue that reserves figures for the Middle East are untrustworthy, since:

- state owned oil companies do not release field by field figures to allow independent auditing;
- in many Middle East countries reported reserves were increased enormously for political reasons, absent any significant discoveries, during the ‘quota wars’ of the 1980s; and
- in some countries reported reserves have been unchanged for years, implying that new discoveries and reserve growth exactly match production, which is implausible.[16]

3.20 The inference is that reported reserves in the Middle East are implausibly high. ASPO suggests that as much as 300 billion barrels may be in question.[17] This is important because 62 per cent of worldwide reported proved oil reserves - 742 billion barrels - are in the Middle East. 22 per cent - 264 billion barrels - are in Saudi Arabia

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14 Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006], p. 4. US Geological Survey, *World Petroleum Assessment 2000.* '*At least* 3,345 billion barrels': see chapter 2, footnote 43.

15 K.Aleklett & C.J.Campbell, *The Peak and Decline of World Oil and Gas Production*, n.d. [2003], p. 1.

16 K.Aleklett & C.J.Campbell, *The Peak and Decline of World Oil and Gas Production*, n.d. [2003], p. 6.

17 Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006], p. 3.

alone.[18] The world's reliance on Middle Eastern oil is expected to increase as production in other areas declines.

3.21 Concerning the consistency and reliability of reserves reporting generally, USGS 2000 noted that 'criteria for the estimation of remaining reserves differ widely from country to country.' The IEA notes that 'there is no internationally agreed benchmark or legal standard on how much proof is needed to demonstrate the existence of a discovery [or] about the assumptions to be used to determine whether discovered oil can be produced economically.' Further, 'a lack of independent auditing makes it impossible to verify the data, even on reported proved reserves in many countries.' The IEA is working with relevant organisations to improve the definition and classification of energy reserves and resources. The United Nations Economic Commission for Europe has developed a United Nations Framework Classification for Energy and Mineral Resources.[19]

3.22 Concerning Middle East reserves, comments by the IEA support peak oil concerns up to a point. According to the IEA, 'there are doubts about the reliability of official MENA [Middle East and North Africa] reserves estimates, which have not been audited by independent auditors…'. On the matter of reserve revisions, the IEA agrees that sharp increases in reported Middle East reserves in the 1980s and 90s 'had little to do with the actual discovery of new reserves':

> MENA proven oil reserves increased sharply in the 1980s and, after a period during which they hardly increased, rose further around the turn of the century…. As a result, world oil reserves increased by more than 40%.
>
> This dramatic and sudden revision in MENA reserves has been much debated. It reflected partly the shift in ownership of reserves away from international oil companies, some of which were obliged to report reserves under strict US Securities and Exchange Commission rules. The revision was also prompted by discussions among OPEC countries over setting production quotas based, at least partly, on reserves. What is clear is that the revisions in official data had little to do with the actual discovery of new reserves….[20]

3.23 On the other hand, the IEA argues that:

- 'a substantial rise in oil prices would lead to higher reserves estimates, as more oil reserves become economically viable…';

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18 *BP Statistical Review of World Energy 2006*, p. 6.

19 US Geological Survey, *World Petroleum Assessment 2000,* p. RG-2. IEA, *World Energy Outlook 2004,* p. 87. *World Energy Outlook 2005,* p. 128.
For UNECE work see http://www.unece.org/ie/se/reserves.html
A resume of the project is in *UNECE Weekly*, no.76, 12-16 July 2004, at http://www.unece.org/highlights/unece_weekly/weekly_2004/UNECE_weekly_2004-76.pdf

20 International Energy Agency, *World Energy Outlook 2005*, pp 123-126.

- the region has been 'far from fully explored', since current high reserves to production ratios mean there has been little motive for exploration - as a result 'there is tremendous potential for adding to proven reserves';
- because recovery factors are generally lower in the Middle East than in the rest of the world, 'there is a large potential for improving these [recovery] factors by introducing more advanced technology and modern production practices'.[21]

3.24 Saudi Arabian authorities argue that they are 'very confident' of their reserves figures - including 'another 100 billion barrels [beyond currently proved reserves] that we feel very confident will be recovered with current technologies and upcoming technologies'.[22]

Arguments about future reserve growth

3.25 'Reserve growth' is the commonly seen increase in the estimated reserves of already discovered oilfields over time. Three main factors contribute to this:

- Operators generally only report reserves that are known with high probability. As knowledge of the field improves with development more accurate estimates become available.
- As an oilfield is developed, drilling tends to extend its initial boundaries.
- A reserve is defined as that part of an accumulation of oil which is *commercially viable* to produce with today's prices and technology. As technological improvements make recovery cheaper at the margin or increase the recovery factor, the reserve increases.[23]

3.26 In the US lower 48 states from 1966 to 1979, over half of the reserve growth was attributed to improved recovery rates (as opposed to better delineation of field boundaries).[24]

3.27 USGS 2000 estimated future world reserve growth by analogy with the history of reserve growth in the USA. This procedure was admittedly not ideal: it would have been better to use a history of *world* reserve growth, but the data needed was not available. USGS 2000 discussed reasons why the analogy of US reserve growth could under- or over-estimate world reserve growth:

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21 International Energy Agency, *World Energy Outlook 2005,* pp 128-131.

22 Dr Nansen G. Saleri, 'Future of Global Oil Supply: Saudi Arabia', conference presentation 24 February 2004, Saudi-US Relations Information Service, at www.saudi-us-relations.org/energy/saudi-energy-saleri.html

23 ABARE, *Australian Commodities*, vol. 13 no. 3, September 2006, pp 502-3.

24 Porter E.D., *Are We Running Out of Oil?* American Petroleum Institute Policy Analysis and Strategic Planning Department, discussion paper 81, December 1995, p. 37.

- world oil and gas fields might in effect be 'younger' than US fields of similar calendar age, because of longer delays from discovery to full development (younger fields tend to have more reserve growth);
- future world reserve growth might benefit from better technology than that which created the historical record of US reserve growth;
- a world oil shortage might accelerate activities designed to generate reserve growth;
- criteria for reporting reserves might be less restrictive in the world as a whole than in the USA;
- reported reserves might be deliberately overstated in some countries; and
- large fields around the world might have more development than US fields before the release of initial field-size estimates.

3.28 The first three points would cause the USGS 2000 methodology to under-estimate future reserve growth; the last three points would cause an over-estimate. The report commented that 'the balance that will ultimately emerge from these and other influences upon world reserve growth relative to US reserve growth is unclear.' The estimate of future world reserve growth 'carries much uncertainty', but it was considered to be more useful than making no estimate at all.[25]

3.29 Since part of recent US reserve growth has been caused by technological improvements, estimating future world reserve growth by analogy appears to incorporate an assumption that improved recovery because of technological improvements will continue at a similar rate.

3.30 In the result, potential reserve growth outside the USA from 1995-2025 was predicted to be almost as important as potential future discoveries (mean estimate 612 billion barrels of reserve growth versus 649 billion barrels of new discoveries: see Chapter 2, Figure 2.4).

3.31 'Peak oil' commentators argue that estimating future world reserve growth by analogy with past US reserve growth is unsound, since US reserve growth has been enlarged by factors which do not apply world wide or will not apply as much in future:

- historically, US reserve reporting has been driven by US prudential standards which encourage conservative bookings in the first instance and larger later additions;
- company balance sheets benefited from gradual booking of reserves; and
- in the US, initial field development tended to use primary oil recovery only, with enhanced oil recovery applied late in field life.

25 US Geological Survey, *World Petroleum Assessment 2000*, p. RG-10ff.

3.32 It is argued by contrast that today, worldwide:

- most reserves do not meet US prudential standards (that is, they are estimated more liberally in the first place, giving less potential for later increases);
- companies no longer have the luxury of spreading reserves bookings over time; and
- enhanced oil recovery is now applied extensively and early in field development; thus not so much should be expected by way of later reserve growth from this source.[26]

3.33 Further, it is argued that the USGS 2000 approach 'failed to understand that reserve growth is mainly confined to large fields with several phases of development, and will not be matched in the smaller fields of the future.'[27]

3.34 These points would be expected to make future worldwide reserve growth less than past US reserve growth. USGS 2000 acknowledges some of them, as noted above.[28]

3.35 In 2005 some USGS 2000 authors compared reserve growth from 1996 to 2003 against the UGGS 2000 estimates. They found that in these years - 27 per cent of the USGS 2000 forecast period - 28 per cent of the expected reserve growth of conventional oil had materialised. Thus reserve growth pro-rata has been as expected.[29]

3.36 This is not necessarily a complete vindication of USGS 2000 on this point, because reserve growth is related to new discoveries, and new discoveries have been tracking well below expectations, as discussed below (paragraphs 3.38-3.49).

Arguments about future new field oil discoveries

3.37 The rate of discovery of oil should be expected to rise to a peak, then fall, as explained in the IEA's 2005 report *Resources to Reserves*:

> In the initial stage of exploration for a resource such as oil, the success rate for discoveries is small because geologists do not know where it is best to explore. But as more oil is found, we learn more about places where it is likely to be found, and the success rate increases. However, because the amount of oil in the ground is finite, there eventually comes a time when

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26 ASPO Australia, *Submission 135C*, pp 6-7.

27 K. Aleklett & C.J. Campbell, *The Peak and Decline of World Oil and Gas Production*, n.d., p. 9.

28 US Geological Survey, *World Petroleum Assessment 2000,* pp RG-12-13.

29 Klett T.R. & others, 'An evaluation of the US Geological Survey *World Petroleum Assessment 2000*', *AAPG Bulletin*, vol. 59 no. 8, August 2005, p. 1033ff. Canadian tar sands - the greatest single addition to reserves in the last decade - were excluded from this assessment.

> most of it has been found, and it becomes more and more difficult to find additional reservoirs: the exploration success rate decreases again.[30]

3.38 It appears that the world has passed the peak rate of oil discovery. According to the IEA's *World Energy Outlook 2004* new field oil discoveries have declined sharply since the 1960s. In the last decade discoveries have replaced only half the oil produced.[31] The average size of discoveries per wildcat (new field exploration) well - about 10 million barrels - is barely half that of the period 1965-79.[32]

3.39 According to Mr Longwell (former executive vice-president of ExxonMobil), 'It's getting harder and harder to find oil and gas…'

> Industry has made significant new discoveries in the last few years. But they are increasingly being made at greater depths on land, in deeper water at sea, and at more substantial distances from consuming markets.[33]

3.40 ASPO argues that the declining trend in discovery should be expected to continue:

> World discovery has evidently been in decline since 1964, despite a worldwide search always aimed at the biggest and best prospects; despite all the many advances in technology and geological knowledge; and despite a favourable economic regime whereby most of the cost of exploration was offset against taxable income. It means that there is no good reason to expect the downward trend to change direction.[34]

3.41 The following figure, based on information from Exxonmobil, shows the declining trend in discovery. Expected future discovery appears to be an extrapolation of the trend, added by ASPO (who supplied the graphic). This suggests future

30 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 38.

31 Oil reserves have continued to increase, but this includes reserve growth, as discussed above.

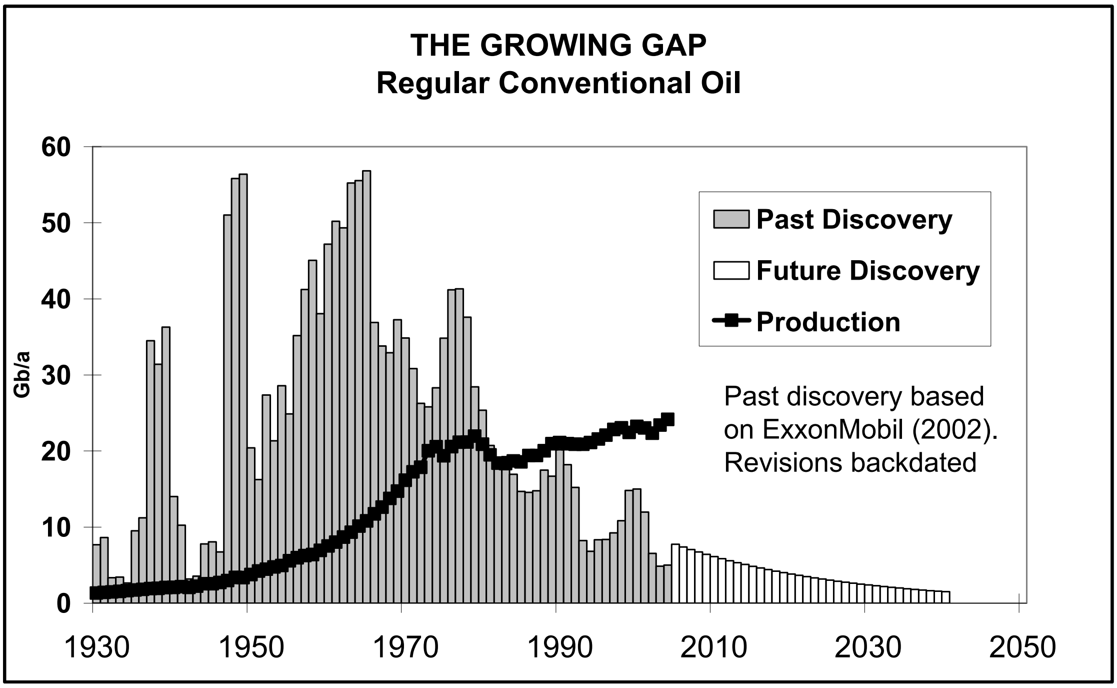
32 International Energy Agency, *World Energy Outlook 2006*, p. 90.

33 Longwell H. (ExxonMobil), 'The Future of the Oil and Gas Industry: past approaches, new challenges', *World Energy* vol. 5 no. 3, 2002, p. 103. Similarly, F. Harper (BP exploration consultant): 'Whilst some corners of the planet still remain to be explored, sufficient exploration has been carried out globally to indicate there won't be another discovery on the scale of the fields in the Middle East…[technology] will do something to defer the peak, but it's not a magic bullet.' remarks at an ASPO workshop, May 2004, at http://www.gasandoil.com/goc/features/fex42409.htm

34 ASPO Ireland, *Submission 10,* p. 3.

discovery of conventional oil (which in this figure does not include natural gas liquids) of something less than 10 billion barrels per year.[35]

Figure 3.2 – Discovery versus production of conventional oil
source: ASPO Ireland, Submission 10
'ExxonMobil (2002)' refers to Longwell H., 'The Future of the Oil and Gas Industry: past approaches, new challenges', *World Energy* vol. 5 no. 3, 2002, p. 100ff.



3.42 It may seem that the recent record of increasing reserves contradicts this picture. However reported reserve additions include reserve growth as discussed above. ASPO argues that when discussing the trend in discovery, reserve additions by reserve growth should be backdated to the original discovery of the field. ASPO argues that the discovery trend is relevant not only because of its implications for the ultimately recoverable resource, but also because 'oil has to be found before it can be

35 ASPO Ireland, *Submission 10,* p. 3. Longwell H. (ExxonMobil), 'The Future of the Oil and Gas Industry: past approaches, new challenges', *World Energy* vol. 5 no. 3, 2002, p. 100ff. A similar picture emerges in Francis Harper (exploration consultant, BP), *Ultimate Hydrocarbon Resources in the 21st Century.* AAPG conference 'Oil and Gas in the 21st Century', September 1999, UK. Quoted in Illum K., *Oil Based Technology and Economy - prospects for the future*, Danish Board of Technology and Society of Danish Engineers, 2004, p. 62.

produced, which means that production in any country, region, and eventually the World as a whole, has to mirror discovery after a time-lapse.'[36]

3.43 Political and market factors can disrupt the predicted discovery curve. According to the IEA the fall in discovery is largely the result of reduced exploration activity in the regions with the biggest reserves.[37] The declining average size of new field discoveries is said to be caused by the fact that the industry has had difficulty getting access to prospective acreage; and also by the virtual cessation of exploration in the Middle East, where discoveries have been largest. The IEA thinks that the Middle East/North Africa has some of the greatest potential for finding new fields, and expects there will be a rebound in exploration in the Middle East as the decline of existing fields speeds up and the number of undeveloped fields drops.[38]

3.44 The long term discovery trend may be compared with USGS 2000 estimates and the recent record of discovery.

3.45 USGS 2000 estimated potential new field discoveries outside the USA in the forecast period 1995-2025.[39] The results are described as quantities 'that have the potential to be added to reserves'. It is not particularly clear what assumptions this involves (if any) about future technological improvements. A 2005 review by some USGS 2000 authors says that USGS 2000 was 'an estimate of that part of the geologic resource endowment that could be considered accessible *using existing technology* in the foreseeable future.' (emphasis added).[40]

3.46 USGS 2000 estimated potential conventional oil discovery (excluding natural gas liquids) over 30 years as 649 billion barrels, or about 22 billion barrels per year on average (see Chapter 2, Figure 2.4). This implies a drastic turnaround of the 40 year declining trend in the rate of discovery.

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36 ASPO Ireland, *Submission 10*, p. 3. This assumes that reserves, once found, will be produced in a timely way: see IEA, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 39. This seems a reasonable assumption: 'There is a ready market for additional oil flows. The days of large oil companies having substantial reserves banks are largely over. This means that any substantial finds will become development projects in a very limited time, unless actively inhibited by politics or access.' *Petroleum Review,* January 2004, editorial.

37 This would be explained as rational market behaviour: there is no point spending money prematurely on exploration to add to reserves which are already ample.

38 International Energy Agency, *World Energy Outlook 2004,* pp 97-8. *World Energy Outlook 2006*, pp 89-90.

39 This was done by a bottom-up expert assessment in which geologists made judgments about the likely number and size of undiscovered fields in 246 assessment units. US Geological Survey, *World Petroleum Assessment 2000,* p. AR -1ff.

40 Klett T.R. & others, 'An Evaluation of the US Geological Survey World Petroleum Assessment 2000', *AAPG Bulletin*, vol. 89 no. 8, August 2005, p. 1034.

3.47 Conventional oil discoveries outside the USA from 1996 to 2003 (not including natural gas liquids) have been 69 billion barrels, or about 8.6 billion barrels per year on average - about 40 per cent of the suggested rate, and much closer to the ASPO prediction. According to ASPO 'this is doubly damning because the larger fields are found first.'[41]

3.48 Some also argue that the exploration behaviour of the oil majors suggests that they think USGS 2000 'discoverable' estimates are over-optimistic. For example:

> Dr Jeffrey Johnson from ExxonMobil [at an ASPO conference in May 2004] declined to answer a question of why his company was not vigorously drilling for oil in the United States, given that the USGS predicts that more than 80 billion barrels are there to be found before year 2025.[42]

3.49 USGS 2000 authors stress that USGS 2000 was an estimate of amounts *with potential* to be added to reserves, not an attempt to predict amounts that would actually be found - as that would depend also on market conditions. They argue that the result could be explained as follows:

- Most of the undiscovered resources are in 'environmentally, economically or politically difficult locations'. In contrast, previously discovered fields 'have consistently presented a stable, known opportunity for oil and gas investment.'
- In most of the period 1996-2003 the price of oil has been relatively low. Rates of exploratory drilling have been very low. It appears that in this period explorers have preferred developing existing fields with a view to reserve growth, in preference to exploring for new fields, as a 'low cost, minimal risk strategy.'[43]

Comment

3.50 On the face of it the shortfall of oil discovery since 1996, compared with that implied by USGS 2000, supports the ASPO position. However it is hard to say how much of the difference is validly explained by reasons suggested above. Certainly

41 Klett T.R. & others, 'An Evaluation of the US Geological Survey World Petroleum Assessment 2000', *AAPG Bulletin*, vol. 89 no. 8, August 2005, p. 1038. K. Aleklett & C.J. Campbell, *The Peak and Decline of World Oil and Gas Production*, n.d., p. 9.

42 Aleklett K., *International Energy Agency Accepts Peak Oil*, n.d., at www.peakoil.net/uhdsg/weo2004/theuppsalacode.html

43 Klett T.R. & others, 'An Evaluation of the US Geological Survey World Petroleum Assessment 2000', *AAPG Bulletin*, vol. 89 no. 8, August 2005, p. 1039.

exploration effort will be influenced by the price of oil.[44] On the other hand, it appears that in the long term there has been little correlation between the oil price and oil discovery. According to Mr Longwell of ExxonMobil, 'most of our discoveries were made in a much lower price environment than today [2002], and cycles of discovery show little correlation with price over the long term…'

> Discovered volumes, over a long period of time, have not been closely related to price fluctuations.[45]

3.51 ASPO argues that 'oil companies work in advantageous tax regimes… exploration is not therefore much affected by economic constraints…'

> Prime prospects are viable under most economic conditions, but high-risk speculative prospects are drilled at times of high oil price with tax dollars.'[46]

3.52 This seems to support the view that the long term trend decline in discovery should be expected to continue - the argument being that the trend primarily reflects the fact that most of the world has been well explored, and the best prospects tend to be found first. However the committee notes the IEA's view that this might be changed by more exploration in the Middle East, which is said to be still very prospective but relatively little explored.

3.53 The suggestion by USGS 2000 authors that explorers have preferred developing existing fields to new field exploration in recent years implies that reserve growth and new field discovery are negatively correlated: one will relatively decrease if exploration investment flows preferentially to the other.

3.54 In that case one might expect that if discoveries have been lower than expected, reserve growth would have been higher. This has not been the case: discoveries have been below expectation, but reserve growth has not been above it.

3.55 It should also be noted that about half the officially expected future conventional oil discovery outside OPEC Middle East is arctic and deepwater.[47] There is probably more uncertainty about achieving the suggested discovery rate in these areas, than in other areas.

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44 According to the IEA, over the last 15 years the elasticity of exploration and production expenditures to the crude oil price has averaged 0.5 - in other words, a 10% increase in the price has led to a 5% increase in exploration and production expenditure, 'boosting new discoveries.' *World Energy Outlook 2004,* p. 90. ABARE reports that 'capital investment and exploration activity have been rising over the past few years in response to higher oil prices.' *Australian Commodities*, vol. 13 no. 3, September 2006, p. 500.

45 Longwell H. (ExxonMobil), 'The Future of the Oil and Gas Industry: past approaches, new challenges', *World Energy* vol. 5 no. 3, 2002, p. 102.

46 ASPO, *Presentation on Oil Depletion, Part 1*, n.d., at http://www.oildepletion.org/roger/ASPO_info/ASPO_tutorial/tutorial_pdf-files/ASPO-1_notes.pdf

47 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 65.

The role of technological progress in increasing reserves

3.56 Optimistic views of future oil supply tend to assume continued technological progress. This includes advances that make it easier to discover oil, or to produce it in more difficult locations, or those that increase the recovery factor - that is, make it possible to produce more of the oil originally in place in a field.

3.57 For example, ExxonMobil argues that 'continued technology advances will be needed to increase supplies… these advances evolve over time and are expected to continue…'[48] The USGS 2000 calculation of future reserve growth, by using the analogy of past US reserve growth, seems to assume that technological improvements which have enlarged reserves in the past will continue at the same rate.[49]

3.58 On the other hand, a recent IEA report notes the risks of relying on future technological improvements:

> Most projections assume various levels of sustained improvement in technologies… Projections are based heavily on extrapolating past industry trends. There are three reasons, however, why such assumptions may need to be re-examined.
>
> • As the industry moves on to more and more "difficult" oil and gas deposits, the pace of technological progress will need to accelerate significantly if past production trends are to be maintained.
>
> • Although technological advances appear to be continuous when averaged over time, such advances actually come in discrete steps as successive new techniques are deployed. There is no guarantee that the required key technologies will actually emerge in time to make new supplies available in the way that the models project.
>
> • Technological progress also needs investment; and long lead times are often involved.

3.59 The report notes that upstream research and development expenditure declined during the period of low oil prices in the 1990s, and comments that 'this could be a worrying sign that technological progress might be slower over coming years than in the past.'[50]

3.60 The prospect of significantly increasing the recovery factor is often held out as a way of increasing the ultimately recoverable resource. The recovery factor - the

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48 ExxonMobil, *Tomorrow's Energy*, 2004, p. 6.

49 'This process [the USGS 2000 methodology] clearly assumes some enhanced oil recovery (EOR), since enhanced oil recovery may already be assumed in the figures for proven reserves, also because the reserve growth curve, calibrated on United States data, contains the amount of EOR historically performed in that country.' International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 63.

50 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, pp 19 and 33-34.

proportion of the oil originally in place in a field that can be recovered - varies enormously depending on the geological conditions. On average it is about 35 per cent. A small percentage increase could lead to a large increase in reserves. According to the IEA:

> Some fields are now reaching 50% recovery rates. Norway, for example, has been particularly active in bringing up the recovery levels…. Increasing the worldwide average recovery rate to 45% in existing fields would usher in "new" oil reserves larger than those of Saudi Arabia.[51]

3.61 Others argue that the prospect of greatly increasing reserves through enhanced recovery techniques in future is over-rated, on the grounds that most modern fields are developed efficiently from the start:

> Of course it is possible to go back to an old field developed long ago with poor technology and extract a little more oil from it by a range of well known methods, such as steam injection. But this is a phenomenon of the dying days of old onshore fields of the United States, Soviet Union and Venezuela. Most modern fields are developed efficiently from the beginning.[52]
>
> The annual growth in average oil recovery is a small fraction of 1 per cent. A 10 per cent gain is certainly achievable but it may take a lot of time or a significant increase in technological capability to realize the prize.'[53]

Comment

3.62 How much faith to place in future technological progress is one of the key uncertainties of managing the risks of the oil future. There is no guarantee that the advances of the past will continue at the same rate indefinitely. As technology improves, it is possible that there will come a time of declining marginal returns to investment in yet further improvement.

Estimates of the ultimately recoverable resource

3.63 Estimates of the ultimately recoverable oil resource (URR) vary widely. Part of the variation may depend on what categories are included, particularly in relation to nonconventional oil.

3.64 ASPO suggests a URR of 'regular conventional oil' of 1,900 billion barrels. This is based on detailed country by country data and assumptions (eg extrapolating

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51 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, pp 51-2.

52 Campbell C.J., *The Imminent Peak of World Oil Production*, presentation to a House of Commons All-Party Committee 7 July 1999.

53 F. Harper (BP exploration consultant), quoted in Quoted in Illum K., *Oil Based Technology and Economy - prospects for the future*, Danish Board of Technology and Society of Danish Engineers, 2004, p. 61.

the production trend of countries already in decline). It excludes deepwater and polar oil and natural gas liquids.[54]

3.65 USGS 2000 suggests a URR of at least 3,345 billion barrels of conventional oil (mean estimate: see Chapter 2, Figure 2.4). This includes natural gas liquids - for crude oil alone the figure is 3,021 billion barrels. This appears to be the basis of most official agency reporting.

3.66 Much higher figures are sometimes seen. These are speculative, and include nonconventional oil. For example ExxonMobil suggests a recoverable total of 4-5,000 billion barrels. The assumptions behind this are not stated.[55]

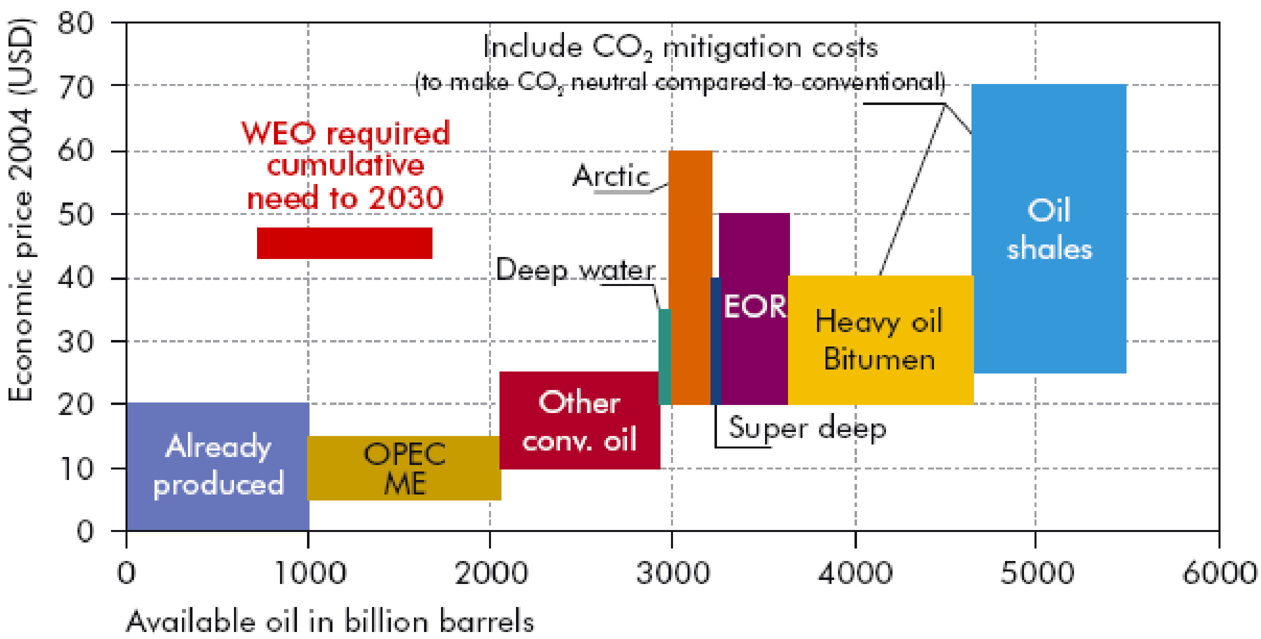
3.67 A 2005 IEA report suggested an ultimately recoverable total of up to 5,500 billion barrels, depending on the price of oil. In addition to conventional oil this includes estimates for deepwater and arctic oil, enhanced oil recovery, heavy oil and bitumen, and shale oil. It would require the oil price to reach $US70 per barrel in the long term to make all of the shale oil component viable:

54 Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006], p. 4.

55 ExxonMobil, *Tomorrow's Energy*, 2006, p. 5.

Figure 3.3 – Oil cost curve including technological progress: availability of oil resources as a function of economic price

source: IEA, *Resources to Reserves - Oil and Gas Technologies for the Energy Markets of the Future*, 2005, p. 17.



The x axis represents cumulative accessible oil. The y axis represents the price at which each type of resource becomes economical.

Source: IEA.

3.68 This figure appears to be based on the following textual comments estimating the nonconventional recoverable resource:

- undiscovered deepwater 120 billion barrels; undiscovered Arctic 200 billion; 'additional enhanced oil recovery potential' 300 billion;
- heavy oil and bitumen: 800 billion barrels based on 20 per cent recovery of 4,000 billion barrels of oil in place in Canada and Venezuela;[56] and
- oil from shale: 1,060 billion barrels based on estimated 2,600 billion barrels of hydrocarbons in place.[57]

56 ABARE in 2006 reported recoverable reserves of 315 billion barrels of tar sands in Canada and 270 billion barrels of heavy oil in Venezuela: *Australian Commodities*, June 2006, p. 305.

3.69 It is not clear what the degree of confidence is in these figures. It is not clear what justifies the suggested recovery factors for nonconventional oil.

3.70 It should be remembered that figures for the ultimately recoverable resource include oil produced to date: about 1,000 billion barrels.

Comment

3.71 It is unclear whether high end estimates of the ultimately recoverable resource are intended to be optimistic, mean or conservative estimates. It is unclear what they assume about future technological improvements.

3.72 In any case, it is noted below that large differences in the estimated URR make surprisingly little difference to the timing of peak oil. The exponential growth in demand is the dominating factor. See paragraph 3.83.

Relating the ultimately recoverable resource to peak: the Hubbert curve

3.73 Peak oil proponents commonly predict that world oil production will peak when about half the ultimately recoverable resource has been produced. This is based on the work of geologist M. K. Hubbert, who in 1956 correctly predicted that US lower 48 states oil production would peak around 1970. This combined his estimate of the ultimately recoverable resource with the assumption that total production would follow a roughly bell-shaped curve, with a long period of rising production followed by a long period of falling production (as explained at paragraph 2.15).[58]

3.74 If the rate of decline mirrors the rate of growth, the graph of annual production over time will be a symmetrical bell shape, and the year of highest production will be when half the ultimate production has occurred. The arithmetic involved is shown in the simplified peak oil calculation in Figure 3.1, (paragraph 3.8).

3.75 There is no inherent reason why the curve should be symmetrical: production growth depends on factors such the growth of the market for the product; while decline reflects other factors such as the increasing difficulty of producing the

57 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, pp 63, 65, 73, 75, and 82. Estimated resources in place: heavy oil and bitumen 6,000 billion barrels (of which Canada 2,500 billion, Venezuela 1,500 billion); oil shale 2,600 billion (of which USA 1,600 billion). Reason for discrepancies between the numbers and the graphic is unclear. The report also says 'super-deep reservoirs… could easily reach 300 billion barrels oil equivalent': p. 73. This does not appear to be included in the graphic. 'Additional enhanced oil recovery potential' of 300 billion barrels assumes a 'conservative recovery rate increase of 5 per cent of oil in place' above that implied by the USGS 2000 methodology: p. 63.

58 Hubbert gave two scenarios based on higher or lower estimates of remaining resources in 1955. Production history has been reasonably close to the high estimate. McCabe P.J., 'Energy Resources - Cornucopia or Empty Barrel', *AAPG Bulletin*, vol. 82 no. 11, November 1998, p. 2122.

depleting resource, or competition from substitutes. An earlier peak is associated with a slower decline after the peak. A later peak is associated with a sharper decline. [59]

3.76 Critics of the Hubbert approach argue that:

- the calculation depends on the size of the URR. If the estimate of URR is constantly changing, the calculation has no predictive value;
- there is no reason to assume that the decline profile will mirror the growth profile at world level. Many regions have not shown the suggested symmetrical profile. For example, Unites States post-peak decline has been slower than pre-peak growth; and[60]
- production histories of fossil fuels are driven more by demand than by the abundance of the resource. Post peak decline is driven by competition from substitutes, not by scarcity. For example: 'The decline in US supply after 1970 did not indicate that the US was "running out" of oil, but rather that the cost associated with much of remaining Lower 48 resources was no longer competitive with imports from lower cost sources worldwide. …the decline in US supply from 1970 represented not a signal of growing global resource scarcity, but rather a signal of growing global resource abundance.'[61]

Comment

3.77 The committee comments on the bullet points above:

- The uncertainty of estimating the ultimately recoverable resource is discussed above (paragraph 3.9). Given the importance of the issue, an uncertain estimate is better than none.
- It is true that there is no inherent reason why the peak should be at the half way point of production. However it appears that in fact it commonly is. One analysis found that of the over 50 oil-producing nations whose production has peaked, the peak occurred in the vast majority of cases when 40-60 per cent of URR had been extracted. It appears that within this range the exact figure is not very important: in another analysis, assuming that the peak production of nations occurred when 60 per cent (versus 50 per cent) of their extractable ultimate

59 International Energy Agency, *World Energy Outlook 2004*, p. 101.

60 Porter E.D., *Are We Running Out of Oil?* American Petroleum Institute Policy Analysis and Strategic Planning Department, discussion paper 81, December 1995, p. 17.

61 The implication is that Hubbert's reasoning concerning resource scarcity was completely wrong, but purely by chance market forces later created an outcome for the USA that looked the same as his prediction. McCabe P.J., 'Energy Resources - Cornucopia or Empty Barrel', *AAPG Bulletin*, vol. 82 no. 11, November 1998, p. 2110. Porter E.D., *Are We Running Out of Oil?* American Petroleum Institute Policy Analysis and Strategic Planning Department, discussion paper 81, December 1995, p. 19.

resource had been extracted added only 3-9 years to the timing of peak production.[62] According to the IEA 'oilfields will tend to enter a decline phase, other things being equal, when over 50 per cent of reserves have been produced'. [63]

- Production histories of fossil fuels may well have been driven more by changing demand than by the abundance of the resource. There is no guarantee that the same will apply to future demand for oil at the global scale.

Estimating the timing of peak oil

3.78 There are many estimates of the timing of peak oil. The more nonconventional oil is included, the later the peak will be; but at the same time, the more serious are the questions about what happens after the peak, since the nonconventional oil which has already been included is no longer available to buffer the decline.

3.79 The International Energy Agency in 2004, based on USGS 2000 figures for the ultimately recoverable resource, estimated a peak of conventional oil between 2013 and 2037 depending on assumptions. The 'reference scenario' assumes the USGS 2000 mean resource estimate (3,345 billion barrels: see Chapter 2, Figure 2.4). The 'low resource' and 'high resource' cases are a more cautious (90 per cent probable) figure and a more optimistic (10 per cent probable) figure. Demand is assumed to grow at slightly different rates in each case, on the assumption that prices change in response to different production levels.[64]

3.80 In the low resource case, production peaks in about 2015, and nonconventional oil meets just under a third of demand. In the high resource case conventional production peaks in 2033. In the reference case (mid-range resource estimate) the peak is around 2030. The scenarios do not claim that *total* oil production (as opposed to *conventional* oil production) would peak at those times. That would depend on whether non-conventional growth is greater than conventional decline after the conventional oil peak.

62 Duncan R., 'Three world oil forecasts predict peak oil production', *Oil and Gas Journal* vol. 101 no. 14, 2003, pp 18-21. Hallock J.L. & others, 'Forecasting the limits to the availability and diversity of global conventional oil supply', *Energy* 29 (2004), pp 1679 and 1685.

63 International Energy Agency, *Medium Term Oil Market Report*, July 2006, p. 23.

64 The source does not say what the modelled demand growth rates were.

Figure 3.4 – IEA peak oil scenarios billion barrels			
	low resource case	reference scenario	high resource case
remaining ultimately recoverable resource of conventional oil at 1/1/1996	1,700	2,626	3,200
peak period of conventional production	2013-2017	2028-2032	2033-2037
demand at peak of conventional oil (million barrels per day)	96	121	142
non-conventional oil production in 2030 (million barrels per day)	37	10	8
source: International Energy Agency, *World Energy Outlook 2004,* p. 102.			

3.81 However the situation differs greatly across regions. Some regions have already reached their production peak, and non-OPEC conventional oil production is expected to peak between 2010 and 2015. According to the IEA, 'the biggest increase is expected to occur in the Middle East. Consequently, the rate of expansion of installed production capacity in this region and the Middle East and North African (MENA) region as a whole will determine when global production peaks.'[65]

3.82 In a similar exercise, the US Energy Information Administration in 2000 estimated the peak of conventional oil for various scenarios resource limits and demand growth. The modelling assumed a decline path after the peak which maintains a reserves to production ratio of 10 to 1, based on US experience. Most of the scenarios lead to a peak between 2020 and 2050. For example, using the USGS 2000 mean estimate of the recoverable resource, and assuming 2 per cent annual growth in demand, leads to a peak in 2037:

Figure 3.5 – World conventional oil production scenarios Post-peak decline assumed to maintain a reserves to production ratio of 10 to 1.					
probability	ultimate recovery billion barrels	annual growth rate of production	estimated peak year	peak production billion barrels per year	peak production million barrels per day
95 per cent	2,248	1.0%	2033	34.8	95
	2,248	2.0%	2026	42.8	117
	2,248	3.0%	2021	48.5	133
mean (expected value)	3,003	1.0%	2050	41.2	113
	3,003	**2.0%**	**2037**	**53.2**	**146**
	3,003	3.0%	2030	63.3	173

65 International Energy Agency, *World Energy Outlook 2005,* p. 140.

5 per cent	3,896	1.0%	2067	48.8	134
	3,896	2.0%	2047	64.9	178
	3,896	3.0%	2037	77.8	213
Source: US Energy Information Administration, *Long Term World Oil Supply (A Resource Base/Production Path Analysis)*, 2000					

3.83 The authors comment that the outcome depends crucially on the assumed rate of demand growth, and by contrast is 'remarkably insensitive to the assumption of alternative resource base estimates…'

> For example, adding 900 billion barrels - more oil than had been produced at the time the estimates were made - to the mean USGS resource estimate in the 2 per cent growth case only delays the estimated production peak by 10 years.[66]

3.84 This study has been criticised for assuming that post-peak decline maintains a reserves to production (R/P) ratio of 10 to 1. This implies a decline which is very steep at first (between 6.7 per cent and 8.3 per cent per year depending on resource assumptions), and slows later (a steeper decline is associated with a later peak). By contrast, existing oilfields are said to be declining at an average rate of 4-6 per cent (see paragraph 3.92); so net decline post-peak will presumably be something less than that (since there will still be new developments offsetting part of the decline from existing fields). The IEA has noted that the assumptions used for decline rates in mature fields are the most uncertain part of any supply forecast.[67]

3.85 Critics argue that decline maintaining a reserves to production ratio of 10 to 1 is implausibly steep, and a more symmetrical profile is more usual.[68] Assuming 2 per cent growth and 2 per cent decline, in the USGS 2000 mean resource case, brings forward the peak from 2037 to 2016:

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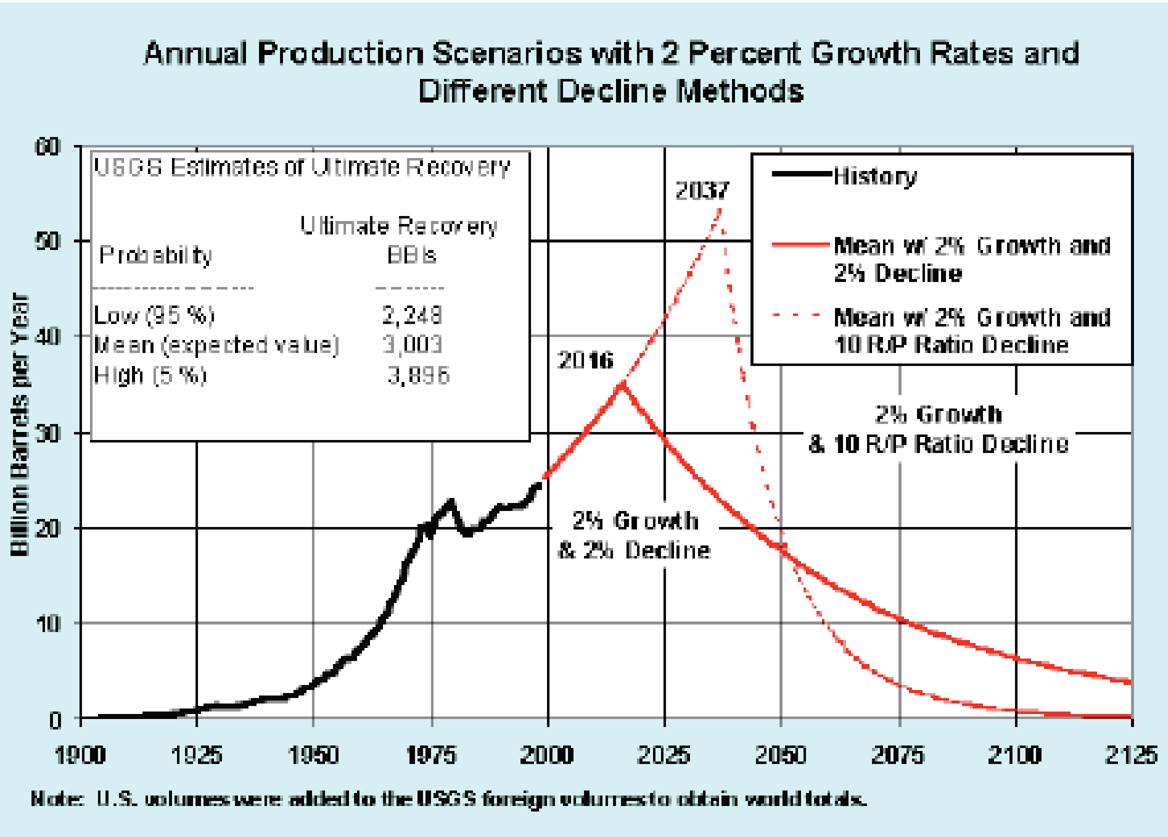
66 J.H.Wood, G.R.Long & D.F.Morehouse, *Long Term World Oil Supply Scenarios - the future is neither as bleak or as rosy as some assert*, US Energy Information Administration, 2004, pp 5-7.

67 International Energy Agency, *Medium Term Oil Market Report*, July 2006, p. 23.

68 R.L. Hirsch, R. Bezdek & R. Wendling, *Peaking of World Oil Production - impacts, mitigation and risk management,* 2005, p. 69. Hallock J.L. & others, 'Forecasting the limits to the availability and diversity of global conventional oil supply', *Energy* 29 (2004), p. 1683. Cavallo A., 'Predicting the peak in world oil production', *Natural Resources Research* vol. 11 no. 3, 2002, pp 187-195.

Figure 3.6 – EIA peak oil scenarios. Based on 2% annual demand growth and mean (expected) ultimate recovery of 3,003 billion barrels. Comparison of decline at 2 per cent per year (peak year 2016) and decline with reserves to production ratio 10 to 1 (peak year 2037)
Source: US Energy Information Administration, Long Term World Oil Supply (A Resource Base/Production Path Analysis), 2000



3.86 Many other commentators predict an earlier peak, apparently based on lower estimates of the ultimately recoverable resource. ASPO predicts a peak of conventional oil around 2010, with significant uncertainty on either side of that time.[69] Other opinions are gathered by Robert Hirsch, author of a 2005 report on peak oil for the US Department of Energy:

> **2005** - T. Boone Pickens (oil and gas investor)
> **2005** - K. Deffeyes (retired Princeton professor and Shell geologist)
> **at hand** - E.T. Westervelt et al (US Army Corps of Engineers)
> **now** - S. Bakhtiari (Iranian National Oil Company planner)
> **close or past** - R. Herrera (retired BP Geologist)
> **very soon** - H. Groppe (oil/gas expert and businessman)
> **by 2010** - S. Wrobel (investment fund manager)

69 ASPO Australia, *Submission 132*, p. 2.

around 2010 - R. Bentley (university energy analyst)
2010 - C. Campbell (retired oil company geologist)
2010+/- a year - C. Skrebowski (editor of Petroleum Review)
around 2012 - R.H.E.M Koppelaar (Dutch oil analyst)
a challenge around 2011 - L.M. Meling (Statoil oil company geologist)
within a decade - Volvo Trucks
within a decade - C. de Margerie (oil company executive)
2015 - S. al Husseini (retired executive vice-president of Saudi Aramco)
around 2015 - Merrill Lynch (brokerage/financial)
2015-2020 - J.R. West, PFC Energy
around 2020 or earlier - C.T. Maxwell, Weeden & Co., brokerage
within 15 years - Wood Mackenzie, energy consulting
around 2020 - Total, French oil company
mid to late 2020s - UBS (brokerage/financial
well after 2020 - CERA (energy consulting)
no sign of peaking - ExxonMobil (oil company)
impossible to predict - J. Browne (BP CEO)
deny peak oil theory - OPEC [70]

3.87 ASPO emphasises that 'these dates are of no particular significance. They are not high or isolated peaks, but simply the maximum values on a gentle curve…'

> Minor changes in the input or modelling could shift them by a few years, as could a collapse in demand from economic recession. That said, the overall pattern of growth being followed by decline is beyond doubt and immensely important.[71]

Comment

3.88 The timing of peak oil is debated. However the concept appears to be widely accepted, including by official agencies such as the IEA and the US Energy Information Administration, and some major oil companies.

3.89 The scenarios above by the IEA and US Energy Information Administration should be compared with the simplified peak oil calculation at Figure 3.1. Figure 3.1 is reasonably consistent with the official scenarios (after allowing that the Energy Information Administration scenarios at Figure 3.6 postpone the peak by assuming a steep decline). In Figure 3.1, even the most generous assumption of the ultimately recoverable resource - 5,000 billion barrels including nonconventional oil - still leads to a peak in 38 years - well within the maturity of today's children. The exponential growth of demand is the dominating force.

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70 Hirsch R., *Peaking of World Oil Production - an overview*, Atlantic Council workshop on Transatlantic Energy Issues*, 23 October 2006*, p. 11ff.

71 Campbell C.J., *The Availability of Non-conventional Oil and Gas*, n.d. [2006], p. 4.

3.90 Clearly, an optimistic view of **long term** oil supply cannot be sustained merely by saying, 'our estimate of the ultimately recoverable resource is bigger than yours'. It must rely on an optimistic view of the ability of market forces and technological progress to bring alternative fuels on stream in a timely way in sufficient quantity to serve the post-oil age.

Investment needed to maintain production

3.91 Reserves are stock; production is a flow. The rate of production is the matter of immediate concern: reserves are only of interest for what they imply about the future rate of production or future security of supply. New oil developments must make up for the declining production rate of existing fields before they can begin to satisfy any increase in demand. According to the IEA the assumptions used for decline rates in mature fields are the most uncertain part of any supply forecast.[72]

3.92 Various estimates exist of the average decline rate of existing oilfields.[73] ExxonMobil estimates 4-6 per cent per year. The IEA suggests that the global rate is 'closer to 5 per cent than 10 per cent'. Many countries are in overall decline. Decline rates are highest in mature OECD producing areas, and lowest in regions with the best production prospects, such as the Middle East.[74]

3.93 At current rates of depletion and demand growth, over two thirds of new production is needed to offset depletion, and this proportion is expected to increase.[75] According to the IEA, 'by 2030 most oil production worldwide will come from capacity that is yet to be built.'[76]

3.94 The upstream developments needed to offset decline and satisfy predicted demand growth will require very significant investment. Recent World Energy Outlooks have stressed with increasing urgency that there is no guarantee this will be forthcoming:

> Meeting the world's growing hunger for energy requires massive investment in energy-supply infrastructure… [In the reference scenario] Oil investment – three-quarters of which goes to the upstream – amounts to

72 International Energy Agency, *Medium Term Oil Market Report*, July 2006, p. 23.

73 Gas declines differently because of its different properties.

74 ExxonMobil, *The Lamp*, 2003 no. 1. International Energy Agency, *World Energy Outlook 2005*, p. 103. International Energy Agency, *Medium Term Oil Market Report*, July 2006, p. 23. ASPO Australia, *Submission 135*, p. 2. Chevron, quoting Worldwatch Institute, *Vital Signs,* 2005, p. 30: http://www.willyoujoinus.com/issues/alternatives/

75 International Energy Agency, *World Energy Outlook 2004*, p. 121. Rehaag K. (IEA), *Is the World Facing a Third Oil Shock?* Presentation to FVG & IBP workshop, Rio de Janeiro, 12 July 2004, p. 27.

76 International Energy Agency, *World Energy Outlook 2004,* p. 103. Similarly: 'By 2015, we will need to find, develop and produce a volume of new oil and gas that is equal to eight out of every 10 barrels being produced today.' ExxonMobil, *The Lamp*, 2003 no. 1.

> over $4 trillion in total over 2005-2030. Upstream investment needs are more sensitive to changes in decline rates at producing fields than to the rate of growth of demand for oil…
>
> There is no guarantee that all of the investment needed will be forthcoming… The ability and willingness of major oil and gas producers to step up investment in order to meet rising global demand are particularly uncertain.[77]

3.95 The level of investment affects the timing of peak oil:

> The rate of expansion of installed production capacity in [the Middle East] and the MENA [Middle East North Africa] region as a whole will determine when global production peaks… MENA production will most likely peak some time after global production. How soon after will depend on investment.[78]

3.96 IEA projections require a very high growth of production in Middle East countries to offset depletion in other areas. Middle East production is expected to nearly double to 2030 (see Chapter 2, Figure 2.3). Some 'peak oil' commentators doubt that this will be physically possible. For example, Matthew Simmons in *Twilight in the Desert* (2004) suggested that Saudi Arabian oil production is on the brink of decline. Critics of this view have made detailed responses arguing that in fact Saudi oilfields enjoy a 'gradual and well-managed depletion' and Saudi Arabia has good prospects for new discoveries. Saudi authorities claim that Saudi Arabia could produce up to 15 millions barrels per day to 2054 and beyond.[79]

3.97 For major oil projects there is a typical lead time of up to five years between decision and production. Chris Skrebowski, editor, *Petroleum Review,* has tabulated known major projects under development to predict supply expansion to 2010. His latest outlook for future supply (April 2006) is 'somewhat brighter than even six months ago… possibly as a result of high prices being sustained and triggering investment decisions.' It predicts gross new capacity from major projects (over 50,000 barrels per day peak flows) of over 3 million barrels per day per year from 2006 to 2010. This must offset depletion of existing fields and satisfy demand increases. Supply could fall short of expectations for several reasons, including increasing depletion:

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77 International Energy Agency, *World Energy Outlook 2006*, p. 40.

78 International Energy Agency, *World Energy Outlook 2005*, p. 140.

79 Simmons M.R., *Twilight in the Desert: the Coming Saudi Oil Shock and the World Economy*, c2005. Jarrell J., 'Another Day in the Desert: A Response to the Book "Twilight in the Desert"', *Geopolitics of Energy,* vol. 17 no. 10, October 2005. Saudi-US Relations Information Service newsletter, 25 August 2004. Saudi Arabian oil production is currently about 11 million barrels per day: BP Statistical Review of World Energy 2006, p.8

> Capacity erosion or depletion will increase as more countries reach the point where their production declines year on year… all the evidence shows that depletion tends to speed up rather than slow down.[80]

3.98 Skrebowski concludes that 'oil production has the potential to expand for the rest of the decade but shortly thereafter production is more likely to decrease than to increase.'[81] This is consistent with comments in the *World Energy Outlook 2006*: 'Increased capital spending on refining is expected to raise throughput capacity by almost 8 million barrels per day by 2010. Beyond the current decade, higher investment in real terms will be needed to maintain growth in upstream and downstream capacity.'[82]

The prospects of nonconventional oil

3.99 All scenarios for future oil production assume increasing nonconventional production to offset declining conventional oil. The main elements of this are usually defined as tar sands (mostly from Canada), heavy oil (mostly from Venezuela) and oil from shale. Some include as 'nonconventional oil' the output of gas to liquids (GTL) and coal to liquids (CTL) processes - these are considered in Chapter 6.

3.100 The nonconventional resource originally in place is very large - perhaps up to 7,000 billion barrels.[83] 80 per cent of this is in Canadian tars sands, Venezuelan heavy oil in Venezuela, and oil shale in the United States. However the proportion of it which is an economic reserve is relatively small, because of the difficulty of extracting it. IHS Energy estimated that there were 333 billion barrels of remaining recoverable bitumen reserves worldwide in 2003.[84] ABARE in 2006 reports recoverable reserves of 315 billion barrels of tar sands in Canada and 270 billion barrels of heavy oil in Venezuela. The shale oil resource is very large, but it requires a high oil price to be commercially viable.[85]

3.101 Production costs are typically much higher than for conventional oil. Energy intensive conversion processes are needed to make usable products, so their viability

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80 *Petroleum Review*, April 2006, editorial. It is unclear how important untabulated smaller projects are expected to be compared with the tabulated 'megaprojects'.

81 Skrebowski C., *Megaprojects analysis explained*, June 2006, at www.odac-info.org/bulletin/documents/megaprojects_explained.htm

82 International Energy Agency, *World Energy Outlook 2006*, p. 40.

83 International Energy Agency, *World Energy Outlook 2004*, p. 95. Another IEA report estimates the nonconventional resource as 2,500 billion barrels in Canada, 1,500 billion in Venezuela, and 2,600 billion in oil shale (of which 1,600 billion is in the USA): *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, pp 75 and 82. ABARE reports an estimate of shale oil resource in place of 2,900 billion barrels: *Australian Commodities*, June 2006, p. 305.

84 International Energy Agency, *World Energy Outlook 2004*, p. 95.

85 ABARE, *Australian Commodities*, June 2006, p. 305.

is very sensitive to input energy prices. This also means that on a 'well to wheels' basis the product has higher greenhouse gas emissions than conventional oil if the operation does not include carbon capture and storage.

3.102 A 2005 IEA report estimated the oil prices that would be needed to make various forms of nonconventional oil viable: It estimated up to $US40 per barrel for tar sands and heavy oil, and up to $US70 per barrel for shale oil: see Figure 3.3 above. ABARE reports an estimate of $US70-95 per barrel for an initial shale oil project, declining later.[86]

3.103 According to the *World Energy Outlook 2006,* production of oil from Canadian tar sands was 1 million barrels per day in 2005, and is projected to rise to 3 million barrels per day by 2015, and 5 million barrels per day by 2030. This is a significant increase on the previous projection 'in response to higher oil prices and to growing interest in developing such resources'. This assumes that no financial penalty for carbon dioxide emissions is introduced - as production is very carbon intensive, a charge could have a major impact on the prospects for new investment.[87]

3.104 Production of Venezuelan heavy oil is about 650,000 barrels per day and according to the 2004 *World Energy Outlook*, added capacity of 180,000 barrels per day by 2010 is planned.[88]

3.105 Peak oil commentators are concerned that exploitation of these nonconventional resources will be too difficult and costly to make much difference to the peak oil scenarios they predict:

> The Canadian operations are constrained by the mammoth nature of the task, the shrinking supplies of cheap gas to fuel the plants, water supply limits and the need to excavate ever greater thicknesses of overburden… it is important to remember that so far only the more favourable locations have been exploited.[89]

3.106 An IEA report notes the difficulty of supplying the gas and water needed for processing: 'In Canada more particularly this is expected to hamper heavy oil

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86 International Energy Agency, *World Energy Outlook 2006,* p. 98. International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 17. ABARE, *Australian Commodities*, June 2006, p. 305.

87 International Energy Agency, *World Energy Outlook 2006,* pp 98-9.

88 Esser R., *The Oil Industry Growth Challenge - expanding production capacity*, testimony to US House of Representatives Energy and Air Quality Subcommittee, 7 December 2005, p. 6. International Energy Agency, *World Energy Outlook 2004,* p. 115. There is no comparable discussion in *World Energy Outlook 2006* and it is unclear how Venezuelan heavy oil is accounted for in the 2006 supply projection tables (pp 92-3). It is noted that 'Most of the production of extra-heavy bituminous crude oil in Venezuela is now classified as conventional oil.' p. 97.

89 Aleklett K.& Campbell C.J., *The Peak and Decline of World Oil and Gas Production*, n.d., p. 14.

production as early as 2015.' [90] As well, it notes that processing consumes 20-25 per cent of the energy content of the product, with associated greenhouse emissions. Nuclear power is being discussed to provide the needed energy. Alternatively, carbon capture and storage in underground formations would be possible, but would cost about $US5-7 per barrel of product.

3.107 In general the IEA notes that 'producing such a massive amount of resources can only be done over long periods of time… simply mobilising the capital for exploitation of a significant fraction of the resources is likely to take several decades.'[91]

Implications for the price of oil

3.108 The effect of these scenarios on long term oil prices is of course much harder to predict, as it also depends on other factors such as economic growth, the trend in energy consumption per unit of economic output, and the development of alternative fuels.

3.109 ABARE sees 'a distinct possibility that world oil prices could remain relatively high for a number of years', but projects that prices will fall towards the end of the decade 'in response to higher global oil production and a substantial increase in oil stocks by that time.' In the short term, significant volatility in world oil prices is likely to continue as oil production capacity is expected to increase only gradually.[92]

3.110 ABARE's long term projections of demand for oil assume an oil price of $US40 per barrel, on the grounds that oil prices will be held to that level by competition from substitutes, such as oil from coal, which become viable at about that level.[93]

3.111 The *World Energy Outlook 2005* assumed a crude oil price easing from the current high to $US35 per barrel in 2010 as new crude oil production and refining capacity comes on stream; then increasing gradually to $US39 by 2030 (2004 dollars). It notes that 'the assumed slowly rising trend in real prices after 2010 reflects an expected increase in marginal production costs outside OPEC, an increase in the market share of a small number of major producing countries, and lower spare capacity.' Most of the new production capacity needed to satisfy the predicted demand is expected to come from OPEC countries, particularly in the Middle East. The slowly

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90 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 78.

91 International Energy Agency, *Resources to Reserves - Oil & Gas Technologies for the Energy Markets of the Future*, 2005, p. 81.

92 ABARE, *Australian Commodities,* June 2006, p. 303ff. *Australian Commodities,* September 2006, p. 501.

93 Dr J. Penm (ABARE), *Proof Committee Hansard,* 18 August 2006, p. 59.

rising price trend is not intended to mean a stable market: 'indeed, oil prices may become more volatile in future'.[94]

3.112 The *World Energy Outlook 2006* (released in November) revised these projections upwards 'in the expectation that crude oil and refined-products markets remain tight.' The crude oil price is assumed to average slightly over $US60 per barrel through 2007, easing to about $47 by 2012, then increasing gradually to $55 by 2030 (2005 dollars). The reasons given are the same. It is unclear why the same causes are now expected to have significantly more serious effects. The outlook notes that 'some commentators and investors predict further price rises, possibly to $100 per barrel.' It notes that 'new geopolitical tensions or, worse, a major supply disruption could drive prices even higher.' It repeats that prices are likely to remain volatile.[95]

3.113 These price projections reflect the authors' judgement of the prices that would be needed to stimulate sufficient investment in supply to meet projected demand.[96]

3.114 Demand for oil is relatively inelastic, largely because for its major use - transport - there are no easy substitutes. This means that a relatively small shortfall in supply can cause a large increase in price. This will increase the volatility of the price in response to small changes in supply when there is little spare capacity. The oil shocks of 1973-4 and 1979-80, in which prices trebled (1973-4) and doubled (1979-80) in a short period, were caused by supply shortfalls of 8 to 10 per cent.[97]

3.115 In a situation where demand is inelastic, a price rise transfers income from oil importing countries to oil exporting countries, and the net impact on world economic growth is negative.[98]

3.116 The IEA estimates that a permanent doubling of the crude oil price would be expected to cut demand by about 3 per cent in the same year and 15 per cent after more than ten years. This suggests that, other things being equal, a shortfall of supply of 3 per cent would be likely to cause the price to double in the short term.[99]

3.117 Most peak oil commentators refrain from predicting the future oil price, given the uncertainties involved. However 'early peakers' such as ASPO believe that prices much higher than the official agency projections are possible:

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94 International Energy Agency, *World Energy Outlook 2005*, pp 63-5.

95 International Energy Agency, *World Energy Outlook 2006*, pp 38-9 and 60-2.

96 International Energy Agency, *World Energy Outlook 2006*, p. 60.

97 Hirsch, R.L. Bezdek R.& Wendling R., *Peaking of World Oil Production - impacts, mitigation and risk management.*2005, p. 26. US Energy Information Administration, *Annual Oil Market Chronology*, at http://www.eia.doe.gov/emeu/cabs/AOMC/Overview.html

98 Hirsch, R.L. Bezdek R.& Wendling R, *Peaking of World Oil Production - impacts, mitigation and risk management.*2005, p. 28.

99 International Energy Agency, *World Energy Outlook 2006*, p. 286.

> When global peak oil occurs, oil shortages, many-fold price rises and possible international and national oil rationing are all plausible scenarios.[100]

3.118 A study by CIBC World Markets in 2005 considered the effects of growing theoretical demand to 95.7 million barrels per day in 2010, if supply was actually capped at 86.8 millions barrels per day. Using an elasticity of -0.15 (the IEA's long term figure) it found that the crude oil price would need to rise to $US101 per barrel to destroy enough demand to bring supply and demand into balance.[101]

3.119 In the longer term the oil price will depend on the price of substitutes. As noted, ABARE suggested that coal-to-liquids is viable at $US40 per barrel (see paragraph 3.110). The IEA suggests that heavy oil and bitumen are viable at $US40 per barrel, and oil from shale is viable at $US70 per barrel, even with the requirement to make them carbon neutral compared with conventional oil - see Figure 3.3.[102] The problems of mobilising the investment needed to create this supply are considered in Chapter 6.

3.120 It should be noted that peak oil proponents do not claim that peak oil is the cause of present high oil prices. If the oil price declines in the next few years, as ABARE suggests, this does not dispose of peak oil concerns. Peak oil is a different and much longer term concern.

New warnings in *World Energy Outlook 2006*

3.121 The International Energy Agency's *World Energy Outlook 2006* gives serious new warnings about the energy future. Its first words are:

> Current trends in energy consumption are neither secure nor sustainable – economically, environmentally or socially.[103]

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100 ASPO Australia, *Submission 132*, p. 2.

101 CIBC [Canadian Imperial Bank of Commerce] World Markets, *Not Just a Spike*, occasional paper 53, 13 April 2005. At http://research.cibcwm.com/economic_public/download/occ_53.pdf
The demand figure was based on 2.5% trend growth. Capping supply at 86.8 million barrels per day appears to be based on Chris Skrebowski's megaprojects information (see paragraph 3.97 above) although this is not acknowledged. The suggested demand is more than the IEA now predicts for 2010 (which is 91.3 million barrels per day in the reference (business as usual) scenario: *World Energy Outlook 2006*, p. 86); while an April 2006 update of the megaprojects information predicts more short term supply growth than earlier versions. These points would ameliorate the effect on the price.

102 The nonconventional oils consume significant energy in mining and conversion processes to make them usable. Thus their 'well to wheels' greenhouse impact per unit of end-use energy will be significantly greater than that of conventional oil, if production does not include carbon capture and storage.

103 International Energy Agency, *World Energy Outlook 2006,* p. 49.

3.122 A major focus of the report is the need for energy policy to be consistent with environmental goals - chiefly, the need to do more to reduce the fossil fuel carbon dioxide emissions which cause human-induced climate change:

> The current pattern of energy supply carries the threat of severe and irreversible environmental damage – including changes in global climate. … The need to curb the growth in fossil-energy demand, to increase geographic and fuel-supply diversity and to mitigate climate-destabilising emissions is more urgent than ever.[104]

3.123 Key points in the report are:

- rising demand for oil and gas, if unchecked, would accentuate vulnerability to a severe supply disruption and resulting price shock;
- the growing insensitivity of oil demand to price accentuates the possible impact on prices of a supply disruption. The concentration of oil production in a small group of countries with large reserves – notably Middle East OPEC members and Russia – will increase their market dominance and their ability to impose higher prices;
- there is no guarantee that the investment needed to meet demand will be forthcoming; and
- in the reference scenario (a 'business as usual' policy assuming no new policies during the projection period to 2030) fossil fuel demand and greenhouse gas emissions will follow 'their current unsustainable paths'. Energy related carbon dioxide emissions would increase by 55 per cent from 2004 to 2030.[105]

3.124 On the peak oil argument of whether the geological resource will be sufficient to meet demand, the report argues that 'although that is enough to meet all the oil consumed in the Reference Scenario through to 2030, *more oil would need to be found were conventional production not to peak before then*' (emphasis added). The report has already noted that there is no guarantee that the investment needed to do that will be made:

> Sufficient natural resources exist to fuel such [reference scenario] long-term growth in production and trade, but there are formidable obstacles to mobilising the investment needed to develop and use them.[106]

The WEO 2006 Alternative Policy Scenario

3.125 The *World Energy Outlook 2006* describes an 'alternative policy scenario' which would reduce the growth of energy use and greenhouse gas emissions. More than 1400 energy saving policies were considered. Examples relating to oil and

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104 International Energy Agency, *World Energy Outlook 2006*, p. 37.

105 International Energy Agency, *World Energy Outlook 2006*, p. 37ff.

106 International Energy Agency, *World Energy Outlook 2006*, pp 73 and 162.

transport include strengthened fuel efficiency standards for motor vehicles; more use of hybrid cars; some modal shift from air to high-speed rail travel in Europe; and expansion of the European Union emissions trading scheme to other sectors, including civil aviation. The policies assume only technologies which are already commercially proven.[107]

3.126 In the alternative policy scenario total energy demand grows by 1.2 per cent per year instead of 1.6 per cent in the reference scenario. By 2030 it is 10 per cent less than it would be in the reference scenario. Similarly, energy-related carbon dioxide emissions still grow, but by 2030 are 16 per cent less than they would be in the reference scenario.[108]

3.127 In the alternative policy scenario global oil demand reaches 103 million barrels per day in 2030 - 20 million barrels per day more than the 2005 level, but 13 million barrels per day less than the 2030 reference scenario level. Transport sector measures create close to 60 per cent of the oil savings, and more than two thirds of the transport sector savings come from more fuel efficient vehicles.[109]

3.128 A key finding of the alternative policy scenario is that the energy saving measures yield financial savings that far exceed the initial investment cost for consumers. Investment by consumers - for example, in energy-saving appliances or vehicles - is increased, but investment by energy suppliers is reduced more, with a net gain. The total investment required to meet demand for energy services is reduced. In all net oil importing countries, energy-saving investment in the transport sector is more than repaid by the savings in oil import bills. Government intervention would be needed to mobilise the necessary investment.[110]

3.129 The alternative policy scenario also mitigates the risk to secure oil supply, which will come as oil and gas production become increasingly concentrated in fewer countries.[111]

3.130 According to the IEA, achieving the alternative policy scenario will require a strong commitment by government to implement the policies. Implementing only the top dozen policies would achieve 40 per cent of the alternative policy scenario's avoided carbon dioxide emissions by 2030. An almost identical priority list would emerge if the dominant concern was energy security. The IEA stresses the urgency of

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107 International Energy Agency, *World Energy Outlook 2006*, pp 167, 169, 172, 227 and 262. Carbon capture and storage is not included on the grounds that it has not been commercially demonstrated: p. 171.

108 International Energy Agency, *World Energy Outlook 2006*, pp 42 and 49.

109 International Energy Agency, *World Energy Outlook 2006*, p. 42.

110 International Energy Agency, *World Energy Outlook 2006*, pp 42, 193 and 204.

111 International Energy Agency, *World Energy Outlook 2006*, p. 186.

the task, because of the long lead times needed to mobilise the necessary investment.[112]

Comment

3.131 The International Energy Agency is a global peak body with 26 developed nation members including Australia and the USA. Its *World Energy Outlook 2006* is the work of almost 200 experts. Its warnings about the unsustainability of a 'business as usual' energy future are serious. Its call to action is clear and uncompromising. Australia needs to respond appropriately.

General comment on peak oil concerns

3.132 The concept that oil production will peak and decline, and there will be a post-oil age, is well accepted. The argument turns on when the peak will come, and how serious its economic effects will be.

3.133 'Early peak' commentators have criticised what they regard as overoptimistic official estimates of future oil supply with detailed and plausible arguments. The committee is not aware of any official agency publications which attempt to rebut peak oil arguments in similar detail.

3.134 Affordable oil is fundamental to modern economies. The risks involved are high if peak oil comes earlier than expected, or if economies cannot adapt quickly enough to the post-peak decline. The 2005 'Hirsch report' for the US Department of Energy argues that peak oil has the potential to cause dramatically higher oil prices and protracted economic hardship, and that this is a problem 'unlike any yet faced by modern industrial society.' It argues that timely, aggressive mitigation initiatives will be needed:

> Prudent risk management requires the planning and implementation of mitigation well before peaking. Early mitigation will almost certainly be less expensive that delayed mitigation.[113]

3.135 The essence of the peak oil problem is risk management. Australian governments need better information from which to decide a prudent response to the risk.

Recommendation 1

3.136 The committee recommends that Geoscience Australia, ABARE and Treasury reassess both the official estimates of future oil supply and the 'early peak' arguments and report to the Government on the probabilities and risks involved, comparing early mitigation scenarios with business as usual.

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112 International Energy Agency, *World Energy Outlook 2006,* pp 249-251.

113 Hirsch, R.L. Bezdek R.& Wendling R, *Peaking of World Oil Production - impacts, mitigation and risk management,* 2005, p. 6.

3.137 The committee cannot take sides with any particular suggested date for peak oil. However in the committee's view the possibility of a peak of conventional oil production before 2030 should be a matter of concern. Exactly when it occurs (which is very uncertain) is not the important point. In view of the enormous changes that will be needed to move to a less oil dependent future, Australia should be planning for it now.

3.138 Most of the official publications mentioned in this report seem to regard the 'long term' as extending to 2030, and are silent about the future after that. The committee regards this as inadequate. Longer term planning is needed. Even the prospect of peak oil in the period 2030-2050 - well within the lifespan of today's children - should be a concern. Hirsch suggests that mitigation measures to reduce oil dependence 'will require an intense effort over decades…'

> This inescapable conclusion is based on the time required to replace vast numbers of liquid fuel consuming vehicles and the time required to build a substantial number of substitute fuel production facilities… Initiating a mitigation crash program 20 years before peaking appears to offer the possibility of avoiding a world liquid fuels shortfall for the forecast period.[114]

3.139 As more nonconventional oil is brought on stream, peak oil is postponed. But this prospect should not be a cause for complacency. The later the peak, the more has been invested in enlarging the oil-dependent economy in the interim (assuming business as usual), and the fewer options there are for easily moving away from it later (since a later peak implies that more of the non-conventional oil resource has already been used).

3.140 The committee does not think it is adequate to dismiss these risks simply by saying that conventional oil can be replaced by oil from coal at $40 per barrel (see paragraph 3.110). The main concern about this is that oil from coal, if there is no carbon capture and storage, would be significantly more greenhouse intensive than conventional oil. But carbon capture and storage has not yet been commercially proven,[115] so it is premature to rely on it. (Chapter 6 notes arguments that carbon capture and storage is 'well on the path of being proven' – see paragraph 6.129).

3.141 The 2004 Commonwealth Government energy white paper *Securing Australia's Energy Future* paid little attention to these issues. It discussed the possibility of short term supply disruptions, but gave only a few words to the question

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114 Hirsch, R.L. Bezdek R. & Wendling R, *Peaking of World Oil Production - impacts, mitigation and risk management,* 2005, pp 6-7 and 65.

115 IEA, *World Energy Outlook 2006*, p. 170.

of long term resource availability.[116] It does not appear that the possibility of long term resource constraints influenced its policies.

3.142 This was perhaps reasonable in 2004. Given the way the energy future debate has moved since then - shown most strikingly by the warnings in *World Energy Outlook 2006* - the committee considers that Australia's energy policies need to be updated. As stressed in the *World Energy Outlook 2006*, the policies that reduce our dependence on oil are the same policies that reduce our exposure to the risk of supply disruptions. Many of them are the same policies that reduce greenhouse gas emissions.

3.143 The committee acknowledges present government-sponsored energy efficiency initiatives, in particular the activities of the Commonwealth-State Ministerial Council on Energy to promote the National Framework for Energy Efficiency since 2004.[117] However these initiatives were focussed on stationary energy. There has been little movement to curb the growth of oil use in transport - possibly because that is a harder task.

3.144 The committee considers that more needs to be done to reduce Australia's oil dependency in the long term and to move Australia towards the alternative energy future described in the *World Energy Outlook 2006*. This is desirable regardless of peak oil predictions - to mitigate the costs of the expected long term decline in Australia's net oil self-sufficiency; and to mitigate the risks of supply disruptions as oil production becomes concentrated in a declining number of major oil-producing countries, some of which are politically unstable.

Recommendation 2

3.145 The committee recommends that in considering a less oil dependent policy scenario, the Government take into account the concerns expressed in the World Energy Outlook 2006, namely -

- **current trends in energy consumption are neither secure nor sustainable;**
- **energy policy needs to be consistent with environmental goals, particularly the need to do more to reduce fossil fuel carbon dioxide emissions.**

Will market forces sort things out?

3.146 The question must be asked: if peak oil is a potential problem, what is the role of government in solving it? A strong theme in the 'economic optimist' response is: if

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116 'In the longer term, concerns also exist about the longevity of oil supplies.' The point is raised but not further discussed. Australian Government, *Securing Australia's Energy Future*, Dept of the Prime Minister and Cabinet, 2004, p. 119. The possibility of replacement by oil from gas, coal or shale is mentioned briefly at pages 22, 41 and 124.

117 This involved expenditure of about $33 million over three years to deliver a package of energy efficiency measures across the residential, commercial, government and industrial sectors. See communiques of the Ministerial Council on Energy, 27 August 2004, 27 October 2006, at www.mce.gov.au

and when there is a peak of conventional oil, this is still not a concern: as conventional oil becomes scarcer, market forces will act to bring substitutes on stream in a timely way when the price is right.

3.147 The committee does not agree with this, for several reasons:

- Given the huge investment needed to adapt the economy to a less oil-dependent future, and the long lead times involved, it is possible that price signals resulting from increased scarcity of oil will occur too late to spur alternative developments in a timely way in the quantities required.
- Government initiative is needed to promote investments which are regarded as socially desirable, but which have a longer payback period than private actors are used to.
- There are high barriers to entry for alternative fuels in that the refuelling network must be in place. Arguably government initiative is needed to promote change - as government has accepted with its current initiatives to promote alternative fuels.[118]
- Some responses on the demand management side require policy choices on very long lived public infrastructure. The consequences of decisions made now on how to develop road and rail networks for the sake of fuel efficiency will be with us in 50 years. The shape of new urban development, which has a dominating effect on the amount of car use, is effectively permanent. These decisions are made by government, and they should have a longer time horizon than private economic agents usually consider.

3.148 The IEA argues that government initiative is essential to promote the changes suggested in the Alternative Policy Scenario discussed above. This applies even though the payback period for many demand-side initiatives is very short. The reasons for this are:

> Compared with investment in supply, end-use efficiency improvements in the transport, industry, commercial and residential sectors involve many more individual decision-makers… The most effective way of encouraging investment in energy efficiency improvements in these circumstances is well-designed and well-enforced regulations on efficiency standards, coupled with appropriate energy-pricing policies… it is highly unlikely that an unregulated market will deliver least-cost end-use energy services. Market barriers and imperfections include:

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118 For example: initiatives to promote a target of 350 million litres of biofuels production per year by 2010; various measures in the 2004 Commonwealth Energy White Paper; recently introduced incentives to promote use of LPG. See Australian Government, *Alternative Transport Fuels and Renewable Energy*, *August 2006 Update*, at http://www.pmc.gov.au/initiatives/docs/alternative_fuels.pdf

• Energy efficiency is often a minor factor in decisions to buy appliances and equipment.

• The financial constraints on individual consumers are often far more severe than those implied by social or commercial discount rates or long-term interest rates….

• Missing or partial information regarding the energy performance of end-use equipment or energy-using systems.

• A lack of awareness regarding the potential for cost-effective energy-savings.

• The decision-makers for energy-efficiency investments are not always the final users who have to pay the energy bill. Thus, the overall cost of energy services is not revealed by the market… A market cannot operate effectively when the value of the goods or services being bought is unknown or unclear.[119]

3.149 These comments are made about energy in general, but also apply as relevant to the use of oil - for example, in encouraging more fuel efficient vehicles. Similar points are made in the Commonwealth Government's 2004 energy white paper.[120]

3.150 The committee agrees that government initiative will be essential to move towards a less oil-dependent future.

119 International Energy Agency, *World Energy Outlook 2006,* pp 193 and 210-11.

120 Australian Government, *Securing Australia's Energy Future*, Dept of the Prime Minister and Cabinet, 2004, p. 107.