GLOBAL OIL PRODUCTION PREDICTED TO PEAK AT 2040

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"The term 'Peak Oil' refers to the maximum rate of oil production in any area under consideration, recognising that it is a finite natural resource, subject to depletion." Colin Campbell, Founder of the Association for the Study of Peak Oil and Gas (ASPO).

King Hubbert, a geophysicist at the Shell laboratory in Houston, Texas, wrote a paper in 1956, with predictions for the peak year of US oil production. This estimate is shown in Figure 1 and has subsequently been shown to be essentially correct, based on information available at that time. The only significant modification to this was due to the subsequent discovery of Alaskan oil which peaked in 1985 (see Figure 2).

At the world scale oil production depends upon six primary factors which are summarised here:

1 Resource size (how much of it is there in the ground?)

2 Access to the resource (are you able to produce it?)

3 Technology (how much of it can you recover and at what cost?)

4 Investment (will the equipment be installed?)

5 Market imperfections, these include:
OPEC Cartel
Government Regulations and duties
Revenues, security of supply, CO_2 emissions

6 Demand (price, technology, fuel substitution)

In 2006 the world produced more oil than ever before; by 2006 a total of about1 Trillion bbl (10^{12} bbl) of oil had been consumed (Figure 3) and reserves of about another 1Trillion bbl had been identified. This figure gives no indication whether the peak has been reached already, or when it will be reached in say, 10 or 30 years time, or provide information on the likely breadth or extent of the peak into the latter part of the 21st century.

The likely future supply of oil will be dependent on the economic price and availability, discussed below in Figures 4,5 and 6.

Oil resources differ widely as a function of their economic price and availability, with oil shales representing the highest values in both economic price and availability (Figure 4). The economic price will mean that they are exploited only as a last resort and especially in view of the large requirement for water

Figure 1

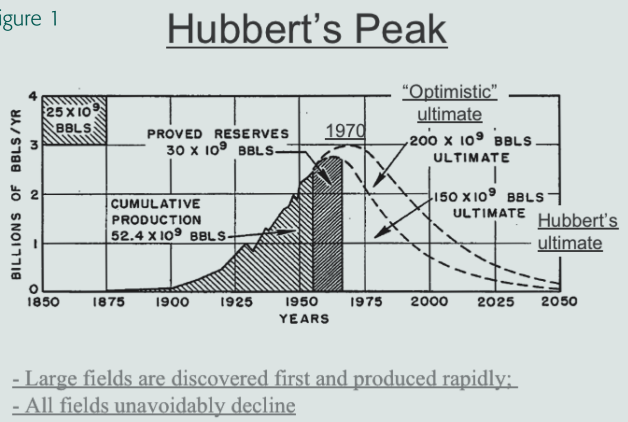


Figure 2

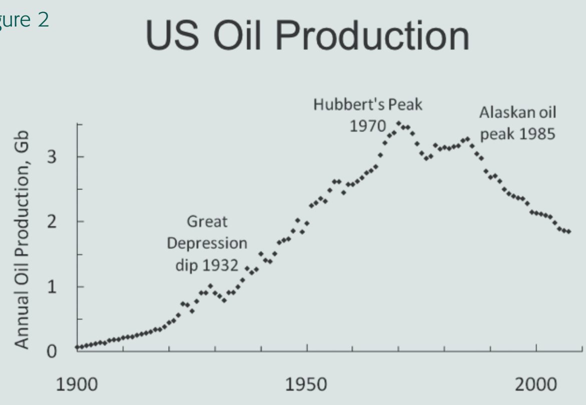


Figure 3

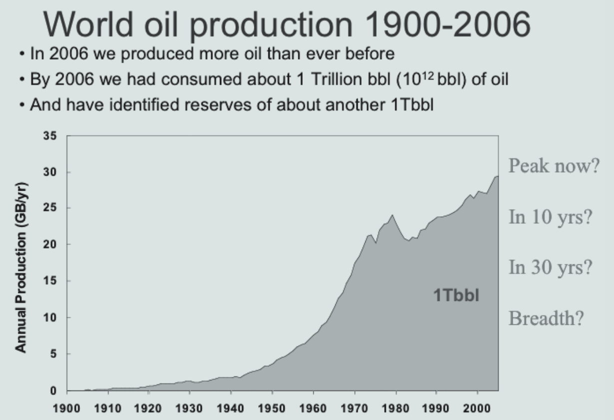
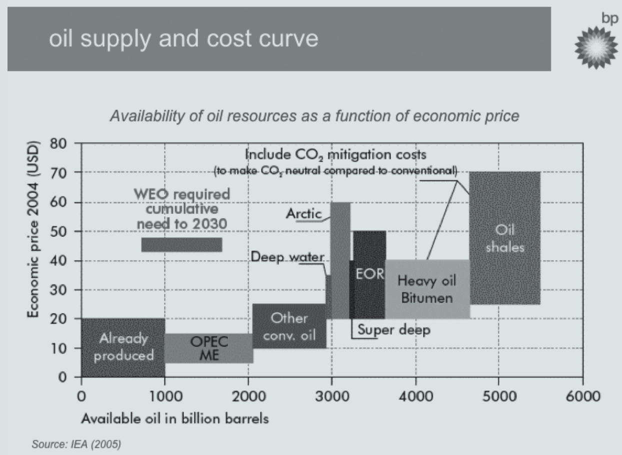


Figure 4

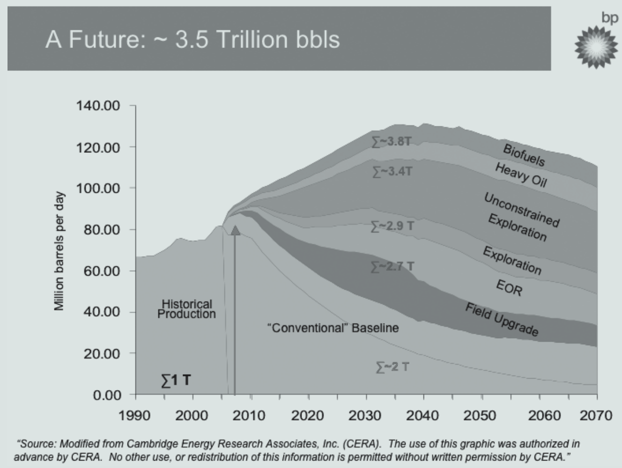


and the environmental damage associated with recovery of oil from this source of supply.

The future estimates of the results of further exploration, notably including "Unconstrained Exploration", are indicated in Figure 5, indicative of an upper maximum potential supply scenario, based on work by Cambridge Energy Research Associates Inc (CERA). This summarises potential contributions to the future supply of oil beyond 2006. This is over and above an estimated 'conventional' baseline of a total of 2 Trillion bbls, generating an estimated maximum of 3.5 Trillion bbls by 2070, peaking at 2040.

Unconventional liquids shown in Figure 6 also have potential to replace conventional sources of oil up to a maximum of 118 Mbd by 2030, dependent on their price and availability.

Figure 5



IN SUMMARY THE FOLLOWING POINTS ARE EMPHASISED:

Sufficient liquid hydrocarbons can be produced to meet projected demand for many decades;

Conventional crude production may well peak at some point in the next several decades

If so, political, social, and economic reasons will be as important as resource or technology;

Conventional crude will be supplemented by alternative sources of liquid hydrocarbons:

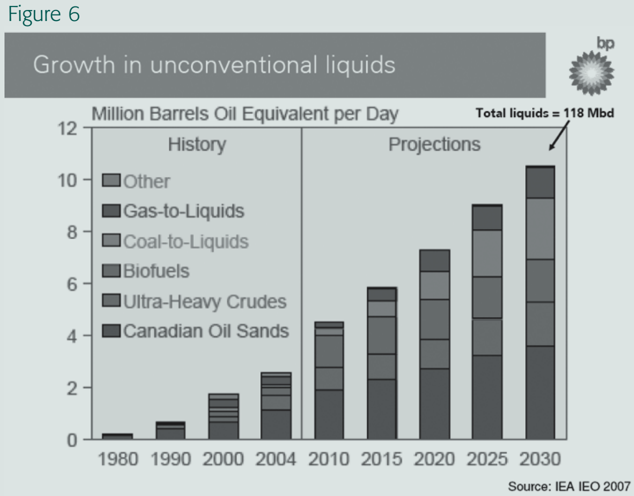
Heavy oil, tar sands, shale oil, biofuels, coal-to-liquids, gas-to-liquids;

The extent will depend upon technology, economics, and regulation, driven by security of supply and CO_2 concerns;

Long timelines are involved to develop significant capacity;

A peaking in total liquids will be demand-driven, not supply driven.

Figure 6



Sufficient liquid hydrocarbons can be produced to meet projected demand for many decades

HAVE WE PASSED PEAK OIL AND WHY DOES IT MATTER?

PEAK OIL

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Commentators have been predicting an imminent peak and terminal decline in the global production of conventional oil, resulting in major economic dislocation, with non-conventional sources being unable to 'fill the gap' in the time available, although forecasts of this type have proved incorrect. The combination of extreme price volatility, declining production in key regions and ominous warnings from market analysts, have also increased concerns about oil security. The 2008 World Energy Outlook from the International Energy Agency (IEA, 2008) has looked closely at production trends for individual fields. They concluded that to offset depletion and meet anticipated demand, new capacity equivalent to 64 million barrels/day (mbd) will be needed before 2030 – or six times the current output of Saudi Arabia. While the IEA do not forecast a peak in global supply before 2030, they express serious reservations about whether the required investment will be forthcoming. Many commentators are equally sceptical about whether the required resources exist, or whether they can be accessed over the next 20 years.

The pessimism of the IEA contrasts with a lack of concern by the UK Government. The possibility of a peak in global oil production was not mentioned in the first report of the Committee on Climate Change. Most oil companies are dismissive of this idea, while environmental NGOs appear reluctant to discuss it for fear of being discredited if forecasts of an imminent peak prove incorrect. This reluctance may be traced to the 1972 'Limits to Growth' report which gave over-simplistic forecasts of imminent resource depletion that failed to take account of the potential for substitution and technical change. As a result, depletion has become a secondary concern, with most attention focused on climate change. A peak in global oil supply would have serious economic and social implications and make it more difficult to manage climate change and also provide strong incentives to develop coal-to-liquid technologies.

ASSESSING RESERVES

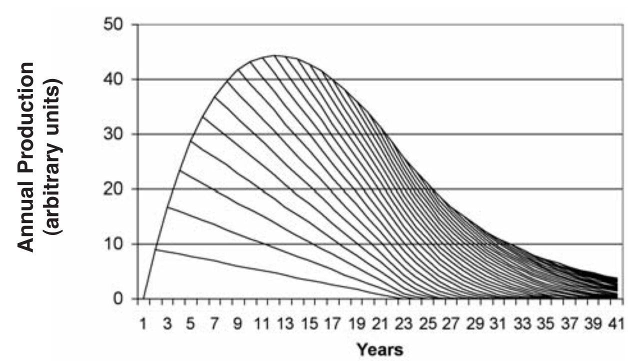
The assessment of oil depletion is handicapped by poor data. Reserve estimates are inherently uncertain, and are complicated by inconsistent definitions and the lack of third-party verification. OPEC figures are mistrusted, but account for the bulk of the world's remaining reserves and form the basis of authoritative publications such as the BP Statistical Review of World Energy. Most sources in the public domain provide estimates of 'proved' reserves which are highly conservative and provide little warning of resource depletion. Proved reserves for the UK have changed little since 1988, although production has halved since 1999. The BP Statistical Review shows global proved reserves increasing steadily over the past 25 years although a widely-cited independent database maintained by IHS Energy shows 'proved and probable' reserves declining since the mid-1980s. As the BP 'proved' reserves are now comparable to the IHS 'proved and probable' reserves, one of them is incorrect. These sources also present differing global conclusions about the future security of supply.

UNDERSTANDING PEAKING

The mechanisms underlying the 'peaking' of oil supply from a region are well understood. Production from individual oil fields peaks and declines as a result of falling pressure. Most of the oil tends to be located in a small number of large fields which are discovered early in the exploration process, with subsequent discoveries being smaller and requiring greater effort. The production from the small fields that were discovered late is insufficient to compensate for the decline in production from the large fields that were discovered early – leading to a regional peak in production (Figure 1). Comparable patterns have been observed in 54 of the 65 largest oil-producing regions, including the North Sea, although numerous technical, economic and political factors complicate the trend.

The same skewed distribution of oil resources is observed at the global level. The IEA estimates that there are 70,000 oilfields in production

Figure 1 Stylised model of a regional peak in oil production



Note: Each triangle represents the production from a single field. It is assumed that fields are developed in declining order of size, with each field being 10% smaller than the previous.

worldwide, but in 2007 approximately half of global production derived from 110 fields, one quarter from 20 fields and as much as one fifth from 10 fields, with 7% of production derived from a single field – Ghawar in Saudi Arabia. Most of the 20 largest fields have been in production for several decades and 16 of them have passed their production peak.

About 80% of today's oil flows from fields discovered before 1973, the majority of which are in decline. Globally, production from existing fields is declining at 4.5% to 7% per year, implying that 3-4.5mbd of new capacity must be commissioned every two years simply to keep production flat (eg a new North Sea). Annual production has exceeded annual discoveries every year since the early 1980s and the gap is growing progressively larger. Most regions have been extensively explored, the average size of new discoveries has substantially declined and the remaining prospective areas are either inaccessible (eg the Arctic) or politically sensitive (eg Iraq). All forecasts suggest an increasing dependence upon OPEC, but reserve estimates for key countries such as Saudi Arabia are disputed (Simmons, 2005). The decline in new discoveries is partly compensated by 'reserve growth' at existing fields, but the causes of reserve growth are poorly understood and the growth observed in the past may not continue into the future.

FORECASTING PEAKING

Forecasts of a peak in conventional oil production rely on methods pioneered by M King Hubbert, a former employee of the Shell research laboratories. Hubbert assumed that the oil production from a region over time could be approximated by a 'bell shaped' curve, with the area under the curve representing the total quantity of oil that would ever be extracted. In the mid-1950s, when US oil production was rapidly increasing, Hubbert used this simple model to forecast that production would peak between 1965 and 1970 and decline rapidly thereafter. This forecast has since proved remarkably accurate – US production peaked in 1970 and has fallen every year since, despite discoveries in the Gulf of Mexico and Alaska.

However, Hubbert's forecast was partly a lucky accident and his methods have numerous weaknesses. For example, they neglect economic and other variables that influence oil discovery and production and are applied to regions that are not geologically homogeneous. As a result, they can underestimate the recoverable resources for a region and provide overly pessimistic forecasts of future supply. Many studies that rely upon these methods lack adequate statistical support and use proprietary databases which are difficult for others to check. Given these difficulties, the best response is to use simulations to test the sensitivity of the results to key assumptions. For example, Kaufmann and Shiers (2008) examined how the predicted date for a global peak depends upon assumptions about the quantity of oil remaining and the rates of production increase and decrease. In 85% of their simulations, they found the peak occurring sometime between 2010 and 2032, with the latter requiring highly optimistic assumptions about the amount of oil remaining.

PRICES AND ALTERNATIVES

The lack of transparency in the global market, the uncertainty over the size of the resource and the concentration of production in a small number of large fields all suggest that the time profile of prices could be discontinuous, with costs increasing rapidly only when the large fields are depleted. Higher prices will encourage exploration and improvements in technology, but given the scale and the required investment in the associated lead times, depletion could easily outpace technical change. Higher oil prices will also provide incentives for exploiting non-conventional oil resources, such as tar sands, as well as the development of alternatives such as biofuels, coal to liquids and gas to liquids. While the technical and economic potential for these is subject to debate, each requires much more energy to extract, refine and distribute than conventional oil. A more immediate question is how quickly these alternatives can be developed, since the size, capital intensity and longevity of any fuel supply infrastructure means that a long lead time is required for the development of alternatives. Since this also applies to fuel-using equipment and infrastructure, the scope for rapid demand reduction is also constrained. A widely-cited report for the US Department of Energy concluded that major shortfalls and economic disruption can only be avoided by initiating a 'crash programme' to develop alternatives some twenty years *before* a peak.

IMPLICATIONS

If a peaking of conventional oil supply is likely within the next twenty years, then investment in demand reduction and supply alternatives needs to begin now. Failure to do so could lead to significant economic disruptions – although premature action could also prove costly if the peak is delayed. Much of the risk will need to be borne by governments since price signals are unlikely to stimulate the investment needed. The current economic recession worsens the situation, since it has led to many supply projects being cancelled or delayed, creating the risk of supply shortfalls when demand recovers.

Developed economies are entirely dependent upon low-cost transportation, with the potential for serious disruption if prices rise rapidly. Transport is almost entirely oil dependent, with little prospect of diversification in the immediate future. Natural gas liquids offer a temporary way forward, but would increase overall gas dependency, while electric/hybrids offer another, but would require substantial increases in renewable generation and/or nuclear power if carbon emissions are to be contained. Global food production is also heavily reliant upon oil-based mechanisation, petrochemicals and fertilisers. While peak oil advocates may be excessively pessimistic about possible solutions, to neglect the risks altogether is highly irresponsible.

References

IEA. (2008). "World Energy Outlook 2008." International Energy Agency, OECD: Paris.

Kaufmann, R. K. and L. D. Shiers. (2008). "Alternatives to conventional crude oil: When, how quickly, and market driven." Ecological Economics, 67:3, pp. 405-11.

Simmons, M. R. (2005). *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy* John Wiley and Sons.

DURING DISCUSSION THE FOLLOWING POINTS WERE RAISED:

Electrification of motor transport is uneconomic; it would be better in the short term to improve the efficiency of combustion engines. The displacement of oil for use in transport by electric vehicles would require a massive investment. In order to be able to rely on the introduction of more electric vehicles in the future we should have decided to renew our nuclear power stations very much earlier. We no longer have this option available to us in the short term. The availability of oil is not the issue, the availability of energy is. Two approaches have been presented, the macro approach discussing estimates of the likely total amount of oil available and the micro approach concerned with an explanation of the contradictions between differing company estimates for peak oil. These estimates drive the science agenda since if oil is going to run out in the short term this will impact on geopolitical issues such as the need for sequestration which will be less important in the absence of oil. However, there is a massive disconnect between the current rate of oil depletion and the need to minimise climate change. Oil should be reserved exclusively for transport where it is responsible for 14% of greenhouse gas emissions and stationary supplies of energy should come from other sources.

Energy comes in many forms but there is an essential requirement for fuel in a liquid form. For example, in the USA corn ethanol is a very popular fuel. Price control should be used to help to reserve the use of oil for transportation and thus help to extend its availability further into the future. Peak oil is only the peak of what has been discovered, however the peak of the ultimately recoverable resources of oil is ultimately of more importance. OPEC do not insist on the production of relevant data and it is not possible to interpret the data they produce reliably. Peak oil is therefore currently based on what is actually produced. The Middle East is currently producing less than the rest of the world. Two decades hence most oil will be coming from that region. If we wait for oil to run out before reacting this will be a disaster.

In addition to actions driven by Climate Change many other initiatives are currently required such as investment in biofuels, battery technology for electric vehicles, renewable energy (wind, wave, solar), nuclear power and unconventional resources (tar sands). However better data are required to a common reporting standard.