Future oil supply: the changing stance of the International Energy Agency.

A submission by ODAC to Professor David Mackay, Chief Scientific Advisor at the Department of Energy and Climate Change, regarding evidence on the supply of and demand for oil.

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Abstract

The IEA was established in 1974 with a mandate to promote energy security amongst its members, namely the states of the OECD, and to advise those members on sound energy policy. Its recent forecasts of the medium and long term prospects for oil supply, however, have wavered, alternating from optimistic to pessimistic and back again. For policy-makers, such inconsistency is difficult to deal with. Here the ODAC group examines firstly whether the changing outlooks seen in its forecasts of 2007, 2008, 2009 and 2010 truly reflect an underlying change in the facts, and secondly whether the substantive criticisms of the 2008 forecast subsequently made by other analysts have yet been addressed.

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Introduction

The IEA was established as the formal body for supplying information and analysis on matters of global primary energy to the member states of the OECD. As such, its view of the likely future of oil supply is key to the formulation of both national policies in those states, and of commercial policies adopted by industry, whether as consumers or as producers of energy. These views are published annually in the 4th quarter in the *World Energy Outlook (WEO)*, and annually in the 1st quarter in the *Medium Term Oil and Gas Markets (MTOGM)*. WEO takes a long-term view to 2030, while MTOGM takes a medium term view to 2015. Different teams produce the two series of reports.

In 2008, as the world entered recession, WEO 2008 declared that sufficient investment could ensure adequate supplies out to 2030, but it included this unprecedentedly sombre observation:

"On present trends, just to replace the oil reserves that will be exhausted and to meet the growth in demand, between now and 2030 we will need 64 mb/d of new oil-production capacity, six times the size of Saudi Arabia's capacity today."

This comment was in stark contrast to the IEA's previous stance, which can be summarised as foreseeing no supply problems out to 2030. Consequently, WEO 2008 initiated a great deal of comment in both the press and other interested parties.

It came as a surprise that in WEO 2009, the IEA reverted to its earlier, more optimistic outlook. It projected a steady rise in oil production, from about 83 million b/d in 2008, to 87 million b/d in 2015, and to 103 million b/d in 2030. In this projection, it noted that the increase is primarily expected from OPEC states, whose output would rise from 36 million b/d in 2008 to almost 54 million b/d in 2030. The non-OPEC supply of conventional oil was expected to decline between 2008 and 2015, while global non-conventional oil supply would rise. WEO 2009 continued:

"In principle, OPEC's recoverable resources are big enough and development costs low enough for output to grow faster than this, but investment is assumed to be constrained by several factors, including conservative depletion policies."

MTOGM 2010 has now gone even further. Although projecting only to 2015, it has revised global oil supply capacity upwards during that period, and now includes a rise in non-OPEC total supply (i.e. including non-conventional oil, which was excluded in the WEO assessment of non-OPEC output).

These sequential reversals of opinion, from positive to negative and back again, were accompanied in November 2009 by comments from a "whistle-blower" within the IEA ranks. The Guardian reported (Guardian, 2009):

"The world is much closer to running out of oil than official estimates admit, according to a whistleblower at the International Energy Agency who claims it has been deliberately underplaying a looming shortage for fear of triggering panic buying. The senior official claims the US has played an influential role in encouraging the watchdog to underplay the rate of decline from existing oil fields while overplaying the chances of finding new reserves.

The allegations raise serious questions about the accuracy of the organisation's latest World Energy Outlook on oil demand and supply to be published tomorrow – which is used by the British and many other governments to help guide their wider energy and climate change policies. In particular they question the prediction in the last World

Economic Outlook, believed to be repeated again this year, that oil production can be raised from its current level of 83m barrels a day to 105m barrels….

A second senior IEA source, who has now left but was also unwilling to give his name, said … the fact was that there was not as much oil in the world as had been admitted. "We have [already] entered the 'peak oil' zone. I think that the situation is really bad," he added."

At the same time, the Global Energy Systems group at Uppsala University in Sweden, headed by Prof. Kjell Aleklett (the so-called "Uppsala group") issued its analysis of the IEA's methodology. This concluded that certain assumptions by the IEA on future production rates appeared to be optimistic at best. This analysis was widely circulated and subsequently published (Aleklett et al., 2010), but the questions it raised have not to ODAC's knowledge been publicly addressed by the IEA.

Such rapid reversals of the opinions of the IEA, which represent in some sense the "official" view of the OECD, coupled with detailed external criticism and evidence for internal dissent, create obvious uncertainties for the makers of UK oil energy policy for both industry and government. This is particularly so when some alternative projections still suggest that cheap oil supply may well become constrained within five years. In this advice ODAC discusses the factors that apparently changed in the mind of the IEA, so that policy makers may understand where the main uncertainties lie, and those factors where new evidence may alter projections. These factors can be summarised as depletion, demand and efficiency, and investment and supply. We also review the issues raised by the Uppsala group. Finally we briefly note how the new economic environment may be shaping both supply and demand during the next decade.

1. Depletion

WEO 2008 was the first in this series of annual reports to quantify the world-wide rate of decline in oil field production. This was perhaps the primary cause for its sombre perspective.

When an oil field first goes on-stream, the rate of production rises rapidly to a plateau level which may be maintained for several years, or even decades for some super-giant fields. The annual production rate then starts to decline for various physical reasons, such as pressure loss and water breakthrough. On average, the annual production from an oil field starts to decline when less than one third of its reserves have been produced.

The IEA have analysed this phenomenon in detail. From their confidential database of field reserves and production rates, they obtained a set of 580 declining oil fields, representing 58% of global oil production. They found an overall decline rate of 5.1% p.a.. Similar analysis around the same time by Hook et al. (2009) found a decline rate of 5.5% from a similar-sized, confidential data set.

The IEA extrapolated their 580-field dataset to estimate that total production from all the world's *declining* conventional oil fields is falling by 6.7% p.a., and would have been 9% if remedial investment had not been made in many fields. For convenience, most analysts assume that this decline is exponential, i.e. production from post-peak fields falls by the same percentage each year, which is close to reality in most cases.

The effect of declining production from the current suite of producing oil fields is well illustrated by the IEA's projection for future demand and supply, in their Figure 11.1 of WEO 2008, which we reproduce below as Figure 1:

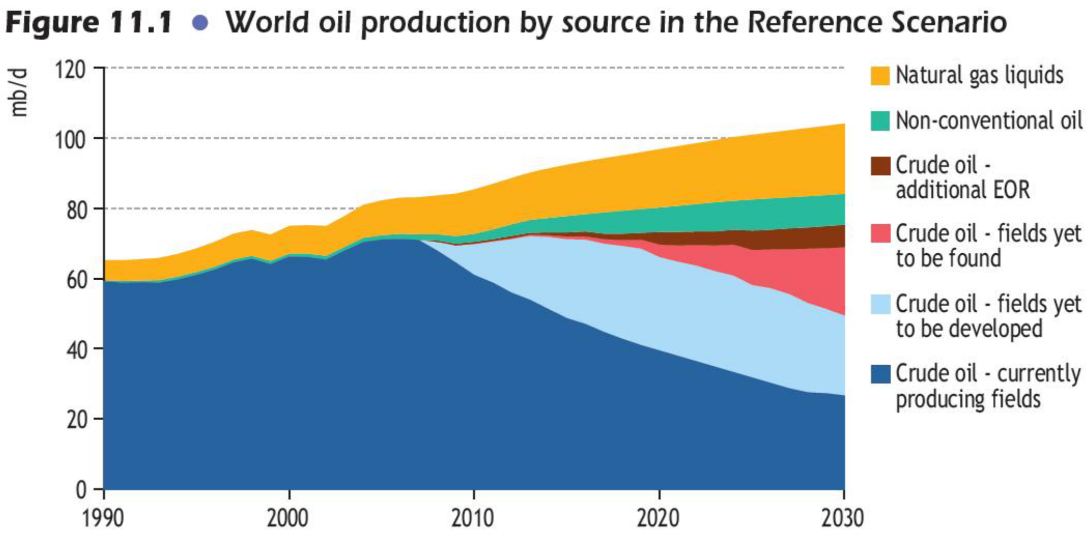

Figure 1: World oil production by source 1990-2030, from WEO 2008

Production from the global set of producing fields at any given time is always declining. The IEA used the most recent data, which would be from 2007, so the dark blue sector is in decline from 2007 onwards. The pale blue sector represents fields already discovered but not yet developed, and so it includes both current development projects and so-called “fallow fields”. Fallow fields are the set of discoveries not yet scheduled for development. ODAC notes that some will probably never be developed, depending upon future economics, local infrastructure, technology developments or political change, but nevertheless they figure in the formal discoveries data. After adding estimates for non-conventional oils such as oil-sand production and synthetic oils made from gas or coal, and for additional oil to be produced from old fields by EOR techniques (Enhanced Oil Recovery, for example in-fill drilling or gas injection), the IEA was left with a large proportion of demand in 2030 which would have to be met from fields not yet discovered – the pink sector in Figure 1.

IEA projections of oil demand and supply are driven by projections of population growth and economic growth, and a fixed relationship between gross domestic product (GDP) and oil consumption. In simple terms, the IEA’s philosophy is first to estimate demand, and then to determine how this might be matched by supply (with numerous iterations reflecting the effects of expected price movements). The risk in such an approach is that unrealistic assumptions may enter into supply projections, in order to meet a pre-determined level.

At this juncture, we note a simple but very important point when considering future global oil supply.

What matters is not the volume of reserves in the ground, which have been relatively steady for some years, but the rate at which it can be produced. If the global body of fields is in declining production, the only possible remedial actions which can raise supply are making and producing new discoveries of cheap oil, or applying high technology at great cost in old fields – so-called EOR, which makes the oil no longer so cheap.

It is therefore the remorseless decline in production rates which ODAC believes will produce the peak in the supply of cheap oil in the relatively near future.

This was the situation which set the scene for the sombre assessment of WEO 2008. The IEA concluded that the era of cheap oil is over. New discoveries with a capacity equal to six Saudi Arabias would be required by 2030 to meet expected demand. We believe that would be quite extraordinary in the light of average rates of discovery over the past two decades. Conventional crude oil production was projected to increase by only 5 million b/d between 2007 and 2030, because most new capacity would only off-set the decline from older fields. Yet the IEA nevertheless stated that demand could be met if sufficient investments were made in discovery and production.

Today, the remaining resources of conventional oil are increasingly concentrated in a few OPEC states. Although other potential oil resources such as oil shales, oil sands and synthetic gas or coal conversion are large, they are not cheap. And although better technology and increased investment can release more oil from old fields, that oil as noted above is consequently also no longer so cheap.

WEO 2008 did not quantify the total annual decline in global conventional crude oil production, but in the MTOGM of July 2008, the IEA estimated that the drop was 3.5-

3.7 million b/d each year, or some 5% p.a.[2]. Two other independent estimates of global decline rates at the time, by UKERC (2009) and CERA (2008), were 4.1% and 4.5% respectively, equating to an annual loss of around 2.9 to 3.2 million b/d of conventional crude oil supply.

However, this year, in MTOGM 2010, the IEA has reduced their estimate of the annual decline to 3.1 million b/d. If this can be treated as a production increase of about half a million b/d each year, it represents an extra 10 million b/d by 2030. We are unable to test whether this change is supported by the assumed reserves, or by so-called reserves growth due to higher investment and future technology, but an extra 10 million b/d would clearly remove a lot of supply-side stress.

The IEA's lower estimate of decline rates might reflect a change of mind arising from better data, but it may simply be an effect of the current recession, as follows. When prices were at their peak in mid 2008, producers maximised output even at the cost of neglecting well maintenance and good oilfield practise. The subsequent lower prices allowed the resumption of good oilfield practise and less aggressive exploitation, leading to an apparent reduction in depletion. If prices rise and supply becomes more constrained, this may reverse again.

To summarise this section:

- The IEA, the OECD's official energy watchdog, has been inconsistent in its long-term outlook, swinging from positive to negative and back again;
- The IEA methodology may have a bias towards "finding" future oil supply to match its demand forecast;
- The driver of peak oil is not the volume in the ground but the rate of supply, and most fields are in decline;
- Finding the required volume of new discoveries as estimated by the IEA is frankly, in ODAC's view and in that of many geologists, highly improbable.

[2] Pages 7 and 42 of the MTOGM report

2. Demand and Efficiency

In MTOGM 2010, oil demand growth is lower than in previous IEA studies. This reduction is heavily dependent on the assumption that oil-use efficiency gains will now be 3% p.a. rather than the 2% value that the IEA has used over the last 15 years (i.e. global GDP is expected to require 3% less oil per unit of GDP each year as industrial efficiency rises). It may be that the IEA is extrapolating another recessionary effect. Fuel efficiency is expected to rise during a recession because companies idle their most fuel-inefficient plant and vehicles. The IEA indicates that the effect of moving from 2% to 3% in annual efficiency gain is a reduction of 2.1 million b/d in demand by 2015.

ODAC would suggest that while there is little evidence of a long-term change in fuel-use efficiency at the moment, such an improvement would be expected during a recession. We expect that the next up-turn in the economy will see efficiency rates fall back to lower values as the less efficient plant which is currently mothballed is brought back into production.

3. Investment and Supply

WEO 2008 projected a global oil supply of 92 million b/d by 2015, excluding biofuels and processing gains. This forecast fell to 86.6 million b/d in WEO 2009. MTOGM 2010 now projects a much higher supply by 2015 of 91.9 million b/d, which we believe includes 2.5 million b/d of biofuels. The MTOGM 2010 base case shows slightly lower OPEC capacity during this period compared to its previous estimate (IEA 2009b), but a slight rise in OPEC's *spare* capacity.

MTOGM 2010 now expects higher crude supply growth primarily from Latin America (chiefly Brazil), the Canadian oil sands and Iraq. Brazil may remain on track for fast-track development of the new and giant sub-salt fields, but insufficient evidence is cited for Iraq and Canada. The Petrobras budget for Brazil's development of the deep-water sub-salt fields has been cited as $286,000 per b/d of installed capacity (Energy and Capital, 2009), which suggests very high oil prices would be required before net profits are generated. Consequently, we are doubtful that these fields can lower oil prices.

Although Iraq has indeed signed "*a raft of new contracts with IOCs*", the remaining infrastructure is widely reportedly to be degraded and inadequate for growing production and exports. Iraq remains a politically unstable country where any disaffected group could, and probably would, hold oil production hostage, by attacking surface pipelines and other installations. Bluntly, we would expect the contracting operators to be declaring force majeure at frequent intervals.

Canadian tar sands output is only marginally profitable at current prices – the cost has been cited as $65/barrel (Oil and Gas Journal, 2010), and a proposed expansion by Shell would cost $143 thousand per barrel/day of installed capacity (Upstream Online, 2010), taking 6 years to amortise even before considerations of the cost of capital. Quite apart from these huge investment costs, increasing difficulties regarding environmental damage, water and gas supply, and skilled labour shortages, the very long lead times involved in oil sand projects make rapid expansion beyond some 6-7 million barrels/day by 2030 implausible. Oil sands are therefore not a source of cheap oil, nor even of large annual production in the next two decades.

The IEA notes in MTOGM 2010 that, "*Running out of oil is not the issue, rather the ability of the industry to mobilise investment quickly enough…*". We agree that there is plenty of oil, but believe the issue to be more fundamentally the rate at which that oil can be produced when most fields have declining production rates. The IEA remains firmly of the view that sufficient money will install sufficient oil production capacity to match expected demand. ODAC accepts that this is the case, but expect that the *cost* of installing and protecting sufficient capacity to meet the demand for $75 oil will actually drive the cost of oil to much higher levels.

4. The Uppsala critique

Aleklett et al. (2010), the "Uppsala Group", analysed the IEA's projections for future conventional crude oil production. The IEA divides all oil production into six types, namely (i) crude oil from currently producing fields, (ii) crude oil from discovered but undeveloped "fallow fields", (iii) crude oil from fields yet to be discovered, (iv) extra crude oil produced by the application of new technology to old fields (EOR techniques), (v) non-conventional oil, and (vi) natural gas liquids (NGLs). We note that NGLs, which are primarily gaseous hydrocarbons heavier than methane, have little role as components of transport fuel, which is the major use of oil (and for this reason some analysts exclude them as a component of oil).

The Uppsala Group found that the IEA's projections for future oil production from currently producing fields and from the application of EOR technology were plausible. The IEA's projected production from fallow fields and yet-to-find fields, however, was found to be at implausibly high rates. These cases are described below[3].

Discovered, undeveloped "fallow fields"

WEO 2008 forecast production of 220 billion barrels (Gb) from fallow reserves of 257 Gb. The Uppsala Group divided these fallow fields into four groups, divided by their OPEC or non-OPEC and onshore or offshore location, and calculated the *depletion rate* required for each group of fields if their production rate is to match the IEA projection. The depletion rate is here defined as the percentage of remaining reserves produced each year. If post-peak field production declines exponentially (q.v.), then the post-peak depletion rate is the same as the production decline rate.

Aleklett et al. (op. cit.) showed that the greatest regional depletion rate in the world today appears to be in the UK North Sea, at 6.9%, although both they and we stress that this is not a theoretical upper limit, merely an empirical observation. The high UK value can be interpreted as a function of the aggressive development of this region. Aleklett's calculated depletion rates for the new Saudi developments at

[3] For completion, we note that Aleklett et al. (2010) cast some doubt upon the projection in WEO 2008 for Canadian oil sand production by 2030. This doubt arises more from lack of justification by the IEA for their model, rather than from any more fundamental constraints.

Khurais and Manifa were 1.8% - 2.5% by 2030. Other calculated depletion rates quoted by Aleklett et al. are about 2.4% for Russia, 2.6% for USA, 3.0% for Indonesia and 5.5% for Mexico, which together give a good feel for current rates.

Aleklett et al.'s analysis found that the WEO 2008 projection implied average depletion rates by 2030 of 4% for OPEC offshore fields, over 15% (and rising) for both OPEC and non-OPEC onshore fields, and 13% (and rising) for non-OPEC offshore fields. Such high depletion rates, compared to observed values today, are at face value implausible and cannot be merely asserted or assumed. The assumption that OPEC will produce its onshore reserves faster than the UK currently exploits its offshore reserves seems to be untenable on present evidence. We suppose that the IEA did not calculate the depletion rate that their production model required, but simply assumed that these fields could supply what demand required.

In their analysis, Aleklett et al. (op. cit.) effectively suppose that all fallow fields are developed immediately. In practice, the development of these fields will be staggered, but without a model to describe how much oil reserve is brought on-stream each year, a more sophisticated model cannot be built. Such a model would have smaller developed reserves in the earlier years, and consequently a higher depletion rate than Aleklett calculated, but by 2030 it would be arithmetically identical to Aleklett's model. This change would, if anything, actually make the IEA's case slightly less plausible, with earlier and more prolonged high depletion rates. ODAC therefore accepts Aleklett's conclusions.

Aleklett et al. (op. cit.) further observed that WEO 2008 considered a body of 1874 fields. To develop these by 2030 implies an average development rate of 8 fields brought on-stream each month. We believe that such a pace is extraordinary, although not physically constrained, and to be achievable would require extraordinary investment.

Undiscovered yet-to-find fields

WEO 2008 gives very little supporting data for this group of fields, other than an assumed 114 Gb of undiscovered reserves. Aleklett et al. (op. cit.) extrapolated past discovery rates to propose that rather more, as much as 149 Gb, might be discovered in the period 2008-2030. However, noting a typical 5 year lead time in developing a discovery, they only considered discoveries up to the year 2024, which could total 121 Gb, only a little more than the IEA's estimate.

There was insufficient information for the Uppsala group to divide the IEA's new discoveries into OPEC/non-OPEC and onshore/offshore groups, and the rate of discovery is an assumption, which may or may not be reasonable. However, treated as a single group, the depletion rate required by WEO 2008 is over 9% in 2030. As with the fallow fields, this would imply achieving an extraordinarily high production rate from reserves of this size.

Aleklett et al. (op. cit.) felt that the "rate of development" of new discoveries implicit in WEO 2008 was unreasonable. It is unclear whether this refers to the time taken to bring new discoveries on-stream or the rate of production. Aleklett et al. re-modelled the yet-to-find at a lower "rate of development" from 2019, said to match the speed of development and rate of depletion of the whole North Sea, in order to obtain their estimate of practical production from yet-to-find fields in 2030 discussed later.

Non-conventional oils

For completion, we note that Aleklett et al. (2010) cast some doubt upon the projection in WEO 2008 for Canadian oil sand production by 2030. This doubt arises more from lack of justification by the IEA for their model, rather than from any more fundamental constraints. By 2030, total world production of non-conventional oils is projected at around 8.8 million b/d in WEO 2008, and 6.5 million b/d by the Uppsala group, an insignificant difference.

Discussion of Section 4

WEO 2008 projected global oil production of 101.5 million b/d by 2030, including conventional crude oil, non-conventional oil, NGLs and processing gains. The Uppsala group's analysis produced a total of just 75.8 million b/d. The greatest discrepancies in volumetric terms were in fallow fields (22.5 vs 13.6 million b/d) and yet-to-find fields (19.2 vs 8.7 million b/d). There were lesser differences in both non-conventional oils and NGLs, and no difference in currently producing fields or additions by EOR.

We believe that Aleklett et al. (2010) are correct in their analysis. The production rates required in WE) 2008 are unfeasibly high, up to twice as high as any regional rates observed today. Although there is strictly speaking no physical limit – one could theoretically drill thousands of wells in every field and produce them at any desired rate – there are very obvious economic constraints that limit current depletion rates and will likewise limit future rates. A significant increase in global depletion rates would inevitably raise the cost. We therefore conclude that the IEA, and policy-makers, cannot rely upon fallow fields, yet-to-find fields or oil sands and other unconventional liquids to fill the spreading oil gap between what the world might demand (at reasonable prices), and what other sources of oil can provide.

5. Effects of the Global Economy

Two questions are frequently asked of peak-oil modellers in organisations such as ODAC, namely "When will the peak arrive?" and "What effect will the global recession have?"

To the first, we have several answers. Like our own death, the peak is inevitable, but its timing can only be estimated within reasonable limits. We expect the peak to be a bumpy plateau, possibly for a decade, within which the actual peak will not be identifiable until some years afterwards. Oil production has been essentially flat since early 2005, despite prices that started at $50/b, climbed briefly to $147 and presently stand at $75. Those price changes neither raised nor lowered production, nor resulted in increased rates of discovery worldwide (outside Brazil) in a flush of new investment. We agree that the world is not running out of oil, but the rate at which it can be extracted is falling. Oil will always be obtainable at a price, but that price may become unaffordable. Consequently, peak oil production will be decided by its price.

Debates about whether the peak will be driven by inadequate supply, or by declining demand, are only a different way of stating the role of an affordable price. It is our present expectation that a price crunch could well occur by about 2015, based upon those projects already in hand which define the maximum possible oil production capacity by then. A crisis by 2020 appears almost inevitable on present evidence.

An oil price crunch would depress demand, the price would slow down economies, and supply would consequently fall. This might become a cyclic phenomenon that repeats several times, of the growth and collapse of oil supply, oil price and the world economy.

The effect of the current recession is difficult to foresee. It has depressed current oil demand (although not, we note, prices), but it has also resulted in long delays in current projects. These projects, with lead times of perhaps 3-6 years, are what would have offset declining production by 2015. Our concern is that if the global economy does start to grow by 2015, then oil consumption will also spurt as the least efficient plant and vehicles are brought back into service, as new plant is commissioned and as new vehicle orders appear in states such as China and India. Today's oil production capacity is likely to have declined by at least 15 million b/d by 2015; the new projects will not be ready. This sets the scene for a price crunch and economic reversal.

6. Conclusions

ODAC is concerned that the IEA, a primary source of forecasting used to map out the UK's oil policy, has been inconsistent in the past, and is currently exceedingly optimistic. We do not question the integrity of the IEA, but we do note that their forecasts can be read as attempts to fill a forecast demand, rather than an *a priori* calculation of what oil production might be possible and at what price.

The peak of cheap oil will not be caused by running out of oil, but by the declining rate of production from the global suite of fields. That decline can only be offset by bringing new fields on stream. Any other solution increases the cost of oil, and hence does not affect the peak of cheap oil.

The technical analysis performed by the Uppsala Group raised huge questions about the rate of future supply that might be obtainable from both currently discovered but undeveloped fields and from new discoveries yet to be made.

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