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Communication

Comment on the 'Uppsala critique'☆

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HIGHLIGHTS

- We examine the criticisms made by Aleklett et al. of the IEA oil production outlook.
- The authors incorrectly compare depletion rates from regions and groups of fields.
- The reductions to future oil production the authors consider necessary are not valid.

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ABSTRACT

This paper discusses the criticisms of the IEA World Energy Outlook raised by Aleklett et al. (2010), often referred to as the 'Uppsala critique'. The major argument of Aleklett et al. is that the rates of depletion, the ratio of annual production to remaining resources or reserves, assumed by the IEA in certain categories of fields are unreasonable. In this paper, we call into question the reductions in future global oil production that Aleklett et al. argue are necessary: they have incorrectly applied a depletion rate for all fields within a region to different subsets of fields within a region. The more minor reductions to future global oil production that Aleklett et al. argue are needed because of the IEA modelling of the production of bitumen and natural gas liquids are also examined briefly.

1. Introduction

Aleklett et al. (2010) analysed the central oil production projection generated by the International Energy Agency (IEA, 2008) in its 2008 World Energy Outlook (WEO). Aleklett et al. consider that the IEA's outlook is unduly optimistic for four principle reasons, in that it

1. included an optimistic increase in production from discovered but undeveloped fields;
2. included an optimistic increase in production from undiscovered fields;
3. included optimistic assumptions for natural bitumen recovered by in situ technologies up to 2030; and
4. included an increase in future production of natural gas liquids (NGLs) which is not matched by a commensurate increase in natural gas production, with production of NGLs expressed in volumetric and not energetic terms.

This has subsequently been referred to as the 'Uppsala critique' (by e.g. Miller, 2011), and it continues to be used to criticise the outlooks produced by the IEA (see e.g. Chapman, 2014). This short comment piece thus seeks to investigate the validity of these criticisms.

2. Background to depletion rates

Aleklett et al. (2010) estimate that the first two of the points above alone warrant a reduction of 19.4 million barrels per day (mb/d) in production by 2030 from the levels suggested by the IEA in its 2008 WEO (106.4 mb/d).[1] The reasoning behind both of these points is the IEA's use of what Aleklett et al. consider to be unrealistically high 'depletion rates'.

The depletion rate in its most general sense is the ratio of annual production to some proportion of the resource base within a field, country, or region. The resource can be a variety of different

[1] These production figures include all sources of conventional and unconventional oil, NGLs, processing gains, and unconventional liquids (such as coal-to-liquids and gas-to-liquids), but exclude biofuels. Aleklett et al. (2010) quote the 2030 production level generated by the IEA as 101.5 mb/d. The difference from the level actually given by the IEA (106.4 mb/d) results from their modification of reporting NGL production on an energy-equivalent basis (i.e. in million barrels of oil equivalent) rather than as a volume. This is discussed in more detail below.

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estimates: the *ultimately recoverable resource* (URR), the *remaining ultimately recoverable resources* (RURR), or existing reserves. The RURR is the difference between the URR and cumulative production up to any given date. By the normal definitions RURR estimates consist of the sum of remaining reserves (see below), potential future reserve growth, and undiscovered resources (see e.g. Sorrell et al., 2010).

If the URR is used on the denominator of the depletion rate, then the denominator is essentially fixed.[2] If the RURR is placed on the denominator, then as annual production proceeds, this denominator will change as cumulative production is subtracted from the remaining resources.

It has been well established that annual production from most oil fields rises to a maximum, reaches a peak or plateau, and then declines (Höök et al., 2009). Over these stages of a field's life, the depletion rate tends to increase prior to the peak in production and reach a maximum value at the peak. If it is assumed that the subsequent decline in production from that field will be exponential (a common assumption, but one which is not always correct (Sorrell and Speirs, 2010)), then the rate of depletion remains constant at exactly the assumed decline rate.

The behaviour of regional depletion rates is slightly different, as there are additional volumes of oil that can be included within the URR or RURR of the region from which no production has occurred. For example, there may be large volumes of undiscovered oil estimated to exist within a region. These volumes would be included in the regional URR or RURR, but would not have contributed to total annual production from that region. Consequently, it is important to recognise that the depletion rate for a region ought to be less than the weighted sum of the depletion rates of the producing fields within that region.

Another example of an important potential addition to the URR or RURR of a region is the volume of oil held in fields that have been discovered but not developed. When there are also no existing plans for them to be developed, these are sometimes called 'Potential Additional Resources' (by DECC, 2013), or alternatively 'fallow fields'. Although the volumes in these fields are often small, they can have an important impact on a calculated depletion rate, especially in a mature country or region.[3] A much more detailed discussion of the dynamics of depletion rates is provided by Höök et al. (2009).

As noted above, the denominator can also be taken to be remaining reserves, in which case the depletion rate is simply the inverse of the commonly quoted R/P ratio. However, a number of different *reserve* estimates could be used. Reserves are a subset of the ultimately recoverable resources, and are those volumes of oil that are currently technically and economically producible and which have a defined probability of being produced. The various reserve definitions that could be used have been well documented (see e.g. McGlade and Ekins, 2014; McGlade, 2012; Sorrell et al., 2009), but of most importance is the difference between 'proved' (1P), 'proved and probable' (2P), and 'proved, probable and possible' (3P) estimates. Broadly speaking 1P estimates are the most conservative, and most frequently used in the R/P ratio, while 2P estimates are the median estimate of the reserves for a given field, country or region. Since 1P estimates are more conservative than 2P estimates, a depletion rate using 1P reserves on the denominator will tend to be larger than the one using 2P. This applies whether the denominator of the depletion rate ratio is solely reserves, or an estimate of the URR of which reserves are a subset.

3. Depletion rates calculated by Aleklett et al.

Aleklett et al. (2010) use the RURR in their depletion rates i.e. annual production on the nominator and URR minus cumulative production up to that year on the denominator. They first estimate depletion rates in different regions over extended time periods, relying on historical production and their own estimates of the URR in each. In the North Sea for example, they estimate that the URR was initially 75 Gb, and had a depletion rate that rose at around 0.2–0.3%/year from 1975 to 2000 and plateaued at around 6%. Of the regions analysed, they calculate that the depletion rate in the UK has plateaued at the highest level (around 6.9%) and has been around 2–3% for Middle Eastern countries.

It is unclear whether Aleklett et al. (2010) have used 1P, 2P or 3P reserve estimates in their URR estimates. In the following discussion, it is assumed that Aleklett et al., when they compare depletion rates for different categories of fields and regions, have relied on consistent reserve definitions; if they have not done so, then this is a fundamental error that would undermine their conclusions. Aleklett et al. (2010) also do not make it clear to what extent undiscovered oil and reserve growth have been included in their regional URR estimates.

Aleklett et al. (2010) next look at the depletion rates that are implicitly assumed by the IEA for two categories of fields in its 2008 WEO. These two categories are undiscovered fields and 'discovered but undeveloped fields'. The latter of these categories is further disaggregated into four groups: undeveloped onshore OPEC fields, undeveloped offshore OPEC fields, undeveloped non-OPEC onshore fields, and undeveloped non-OPEC offshore fields. The estimates of the RURR that Aleklett et al. use on the denominator of the depletion rates for these four groups and for the undiscovered category (which they investigate on a global level only) rely upon resource estimates provided by the IEA. Aleklett et al. estimate the implied depletion rate by dividing the IEA's projection of annual production from each category of field by the remaining ultimately recoverable resources at those fields (i.e. the URR minus cumulative production). They conclude that the IEA has assumed depletion rates that rise well above 12% in three of the four groups of discovered but undeveloped fields and rise to just below 10% for the category of undiscovered fields.

The IEA indicates that the resource estimates for all four of the more disaggregated groups within the category of discovered but undeveloped fields rely upon data from the consultancy IHS CERA. Data from IHS CERA is for 2P reserve estimates (as stated explicitly by the IEA, 2008), and so the URR estimates used in the depletion rate calculations by Aleklett et al. (2010) for these four groups contain only 2P reserves. The resource estimates do not appear to include any potential volumes coming from the technical drivers of reserve growth, such as the potential use of enhanced oil recovery (although this is unclear), and they have been selected so that the URR has an undiscovered resource component equal to zero (as the groups strictly contain only fields that have already been discovered).

For the URR used in the undiscovered category, Aleklett et al. (2010) have taken the volume that the IEA (2008) indicates is '*the projected discovery of 114 billion barrels of reserves worldwide over the projection period*'. In other words, the URR estimate used by Aleklett et al. is the total volume of oil projected to be discovered globally between the end of 2007 and 2030. It is unclear what definition of 'reserves' is being used for this estimate of 114 Gb, and it is also unclear whether it includes any volumes of reserve

[2] The URR should, strictly speaking, be defined and estimated so that it is a fixed value (McGlade, 2012). However, historic estimates of the global URR have tended to change over time (see e.g. Ahlbrandt, 2006); this discussion is not relevant to the arguments set out in this paper.

[3] These 'Potential Additional Resources' do not have a 'reasonable timetable for development' (or similar) (SPE, 2008) that is required for them to be classified as reserves. Equally they are not undiscovered, and so we classify them here as reserve growth. Reserve growth has multiple drivers, but in this paper it is important to clarify that it can come from: volumes in fallow fields, the use of advanced technologies such as enhanced oil recovery, changes in geological understanding, as well as from numerous definitional changes (see McGlade, 2012 for a more detailed discussion).