Peak Coal: the Olduvai perspective

Posted by Luis de Sousa on January 10, 2011 - 11:49am

Peak Coal. Some folks have begun eagerly researching this topic and writing about its timing, now that talk of Peak Oil is all around. The different outlooks on how and when the peak will occur are disparate, ranging from next year to a time many decades in the future. This post tries to view this debate in a different, wider perspective, and deals with the following issues:

- Applying the Hubbert Method to Coal;
- Looking at Ultimate Reserves for Coal;
- Coal and its place in the Olduvai picture;
- Implications for stakeholders;

This post is largely a follow up to Dave Summers' Future Coal Supplies: More, Not Less!

***Pre scriptum**: Within days of preparing this post, Dave Rutledge updated his report on ultimate coal extraction using Logit and Probit transforms rather than Hubbert Linearization. I have yet to become familiar with this method, and, although Rutledge reaches essentially the same results as previously, the remarks made here shouldn't be directly applied to his update.*

Introduction

Lately there has been a mild, but growing, level of hype about the coming epoch of peak world coal extraction. As with any other non-renewable resource, the amount of coal consumed every year by mankind can't grow forever. A day will come when growth will stop and a terminal decline sets in; the only question is when. Authors such as Patzek and Croft have been hasty to predict the timing of peak coal as almost immediate. As with many other things, imminent events draw wider attention than more distant ones.

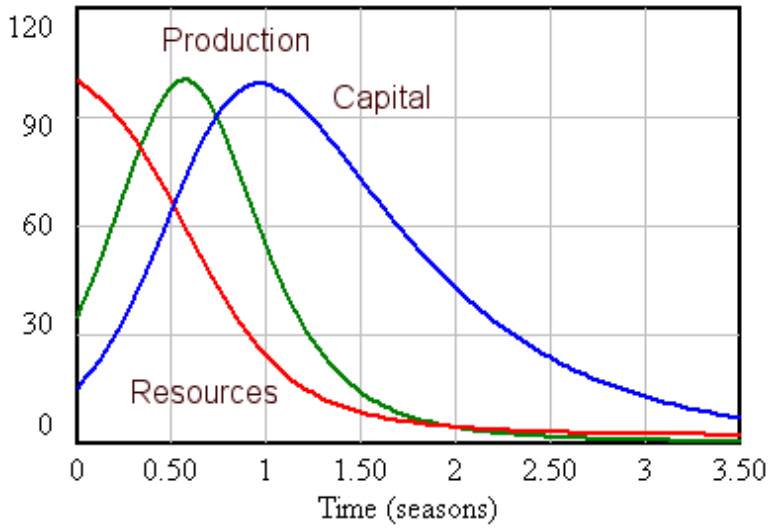
Dave Rutledge might have been the first to produce such a forecast, with the conclusion that coal extraction will come to a peak in 15 years. Kjell Aleklett's research group reached the conclusion that an all-time maximum would occur in about 10 years. But by bringing the peak forward to 2011, Tad Patzek drew the attention of, and gained the honour of coverage by a magazine the caliber of National Geographic. What is common to all these forecasts is that they all derive an ultimate reserve figure which is well below the numbers quoted in official statistics (about 900 Gtoe), and that's where the controversy starts.

Applying the Hubbert Method to Coal

One thing which is generally common to these short term predictions for peak coal is that they incorrectly use the Hubbert Method. The process popularized at The Oil Drum as Hubbert Linearisation, whereby a logistic curve is adjusted to past production in the P/Q vs. Q plane, is but one step of this method and is not intended to determine reserves by itself (P is annual production, Q is cumulative production). As explained by Kenneth Deffeyes in his book *Beyond Oil*, the linearisation process must be applied to exploratory drilling and discovery volumes before

being applied to production. Prior to the production phase, a clearer idea about the ultimate reserve size must be developed, for there's no guarantee that a logistic curve applies, even in the case of oil.

What the discovery linearisation process does is something a bit more refined than simply providing a more accurate figure for ultimate reserves. It actually provides a picture of the **production** build-up signal that precedes the logistic **capital** signal that Ugo Bardi explained in bridging oil production to the Lotka-Volterra population model. With crude oil, the production signal matches the accumulation of resources prior to extraction, mainly the reserve itself, but also includes the investment of human expertise and the development and use of equipment. The capital signal can be seen as the usefulness obtained by society from the oil extracted. Reconstructing the discovery signal provides at least a proxy for this productive capacity accumulation that must precede the capital build up.



The Mind sized Hubbert model of resource depletion. Click for Ugo's article.

In the case of coal the production signal cannot be easily reproduced. The identification of reserves has been very widespread both in time and in space, since it occurred as the Industrial Revolution progressed. Secondly the emergence of oil as a considerably more convenient fuel, because of its energy density and liquid properties, produced a non-negligible substitution process, especially in the transport sector. In more recent years, coal, which had been displaced by oil in boilers and furnaces, has in its turn started replacing oil in electricity generation. Assuming that the Lotka-Volterra production signal for coal followed a regular logistic curve seems, at the least, debatable. Those eager to apply the Hubbert Linearisation process to coal extraction must first justify, with evidence, that the logistic production development model justifies this approach.

Looking at Ultimate Reserves for Coal

An alternative way to apply the logistic curve is the one performed by Jean Laherrère. Instead of directly adjusting a logistic curve to conform to past production, Jean tries first to get a picture of the ultimate reserve by consulting available databases. After reaching a solid figure (today 700 Gtoe), he then produces a logistic curve obeying that reserve value and finds the best fit to past production. The magical step in this approach is assuming that coal production will henceforth follow an orderly, unconstrained logistically predicted path. Though this method is still open to criticism, since the geological knowledge may be incomplete, this is a much more sensible approach. Given the impact of the impending oil decline, a flat out bell shaped extraction forecast

may not be that far from reality.

The famous coal report produced by the Energy Watch Group (EWG) was to a large extent based on the use of a similar technique, although applied at a regional level. But it also produced an ultimate reserve estimate that was somewhat below official figures.

And this is the base of Dave Summers' critique: the direct application of curve fitting methods to past production will likely neglect reserves that are not present in accounting books, simply because productive resources haven't yet been gathered to bring them online (e.g. Botswana). In other cases it's the change in productive reserves to impractical resources that may have been caused by a non-geological decrease in reserves (because of politics or cost), as in his home country of Scotland. The best of these examples may well be Mozambique, a country that is expected to become the second-largest world coal exporter within the decade [Google translation here]. Consulting a publicly available resource data base such as BP's annual statistical review, will reveal that the word Mozambique doesn't even appear, nor its resources; thus the reserve volumes may be something that the non-Portuguese speaking media is largely unaware of (for the uninformed Mozambique was a Portuguese colony, gaining independence in 1975).

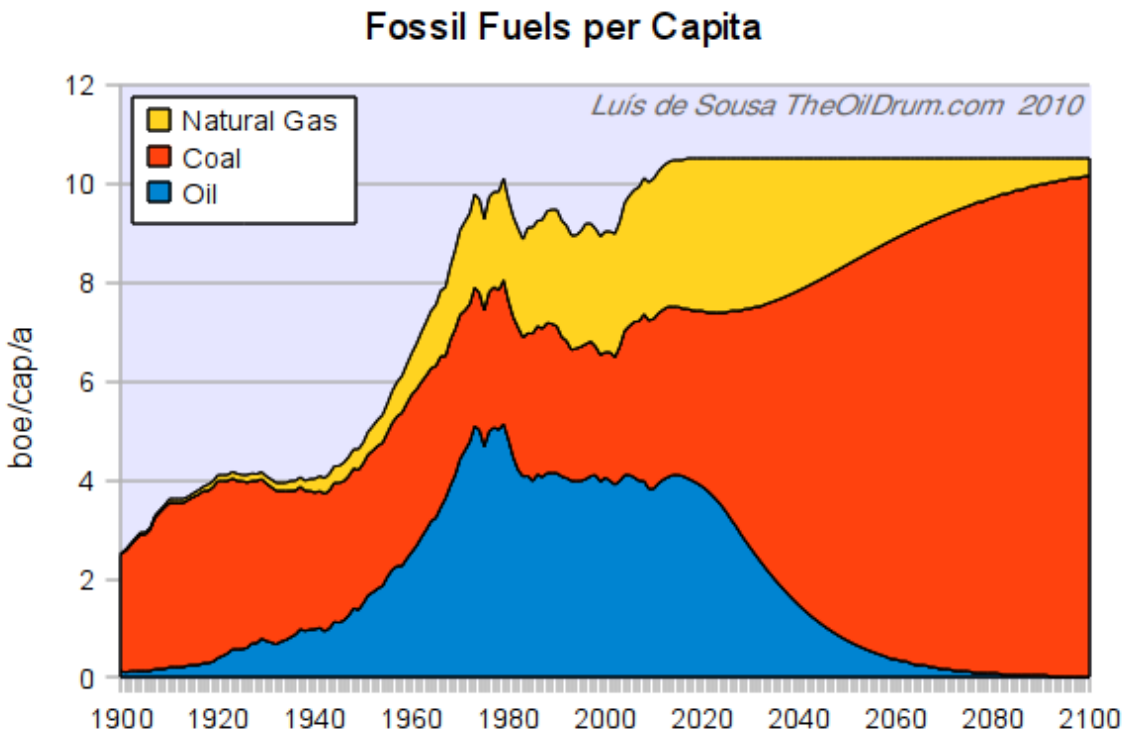
But there's also the other side of the coin: extraction of coal has frequently been impacted by state subsidies. In some regions of the world, not only has coal extraction not been abandoned, but it has been provided with additional resources to continue production. Perhaps the most striking of these is the case of Germany, a state that is presently spending 2 000 million euros per year on its coal industry. That translates into 42 €/ton, and these are direct money deliveries, not feed-in tariffs such as those made available for renewable energy industries.

In essence, there's a big question mark on ultimate coal reserves.

Coal and its place in the Olduvai picture

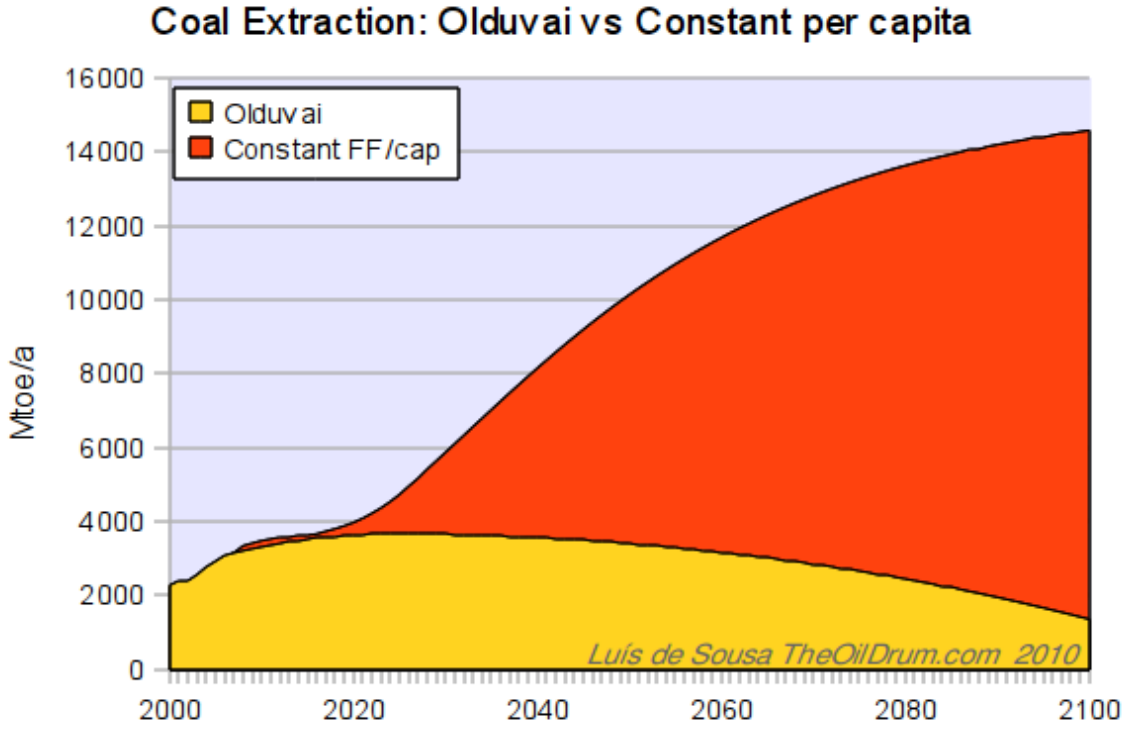
This debate can, however, be put under a completely different perspective if considered at the light of the Olduvai Gorge Theory. World fossil fuels consumption per capita crossed over 9 boe/capita/annum in 1970 and since then has remained on a bumpy plateau; with marginal exceptions, this variable has since bounded between 9 and 10 boe/cap/a, reaching almost exactly 10 boe/cap/a in 2009. Richard Duncan postulated in 1989 that this plateau would end in the not too distant future; and in the referenced 2008 assessment fossil fuel levels per capita were forecast not to rise above 10.5 boe/cap/a, beginning a decline after 2020 that would slash that figure by 50% by 2050.

The 2008 assessment was performed using the EWG coal forecast, but even if coal is indeed not as scarce as Dave Rutledge, Kjell Aleklett *et al.* claim, for how long can the Olduvai Plateau last? Turning this question around, how much coal is needed to maintain this plateau until 2050? Or to 2100?



The Olduvai fossil fuel outlook with coal filling the gap up to 2100 for a constant consumption of 10.5 boe/cap/a.

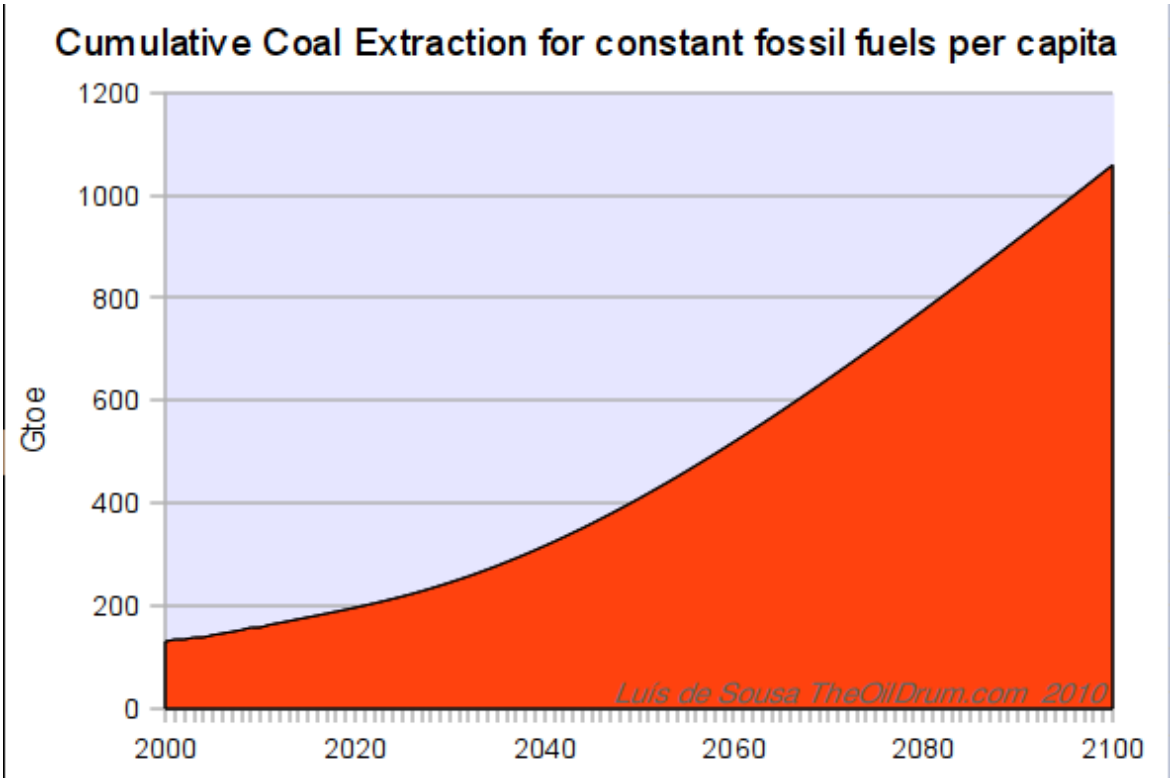
This graph provides the first step towards answering the question. To give a sense of proportion, this scenario can be compared with that used in the 2008 Olduvai assessment.



Energy Watch Group's Coal forecast used in the 2008 Olduvai assessment compared to the constant 10.5 boe/cap/a scenario.

For a constant fossil fuel/capita scenario to be sustained over those time intervals, world coal extraction would need to double in the next 25 years and reach triple the levels of today by 2050. By the century's end extraction would need to be over 10.5 Gtoe/a. To put this in perspective, it would have to provide almost 3 times the primary energy levels provided today by oil.

After having made these considerations, the role of reserves can finally be assessed. The next graph shows cumulative extraction volumes required, based on the above constant fossil fuel per capita scenario.



Cumulative world coal extraction to match the constant 10.5 boe/cap/a scenario.

The size of the needed Ultimate Reserve can be inferred from this graph; assuming a roughly symmetrical extraction profile, it can be computed by multiplying by 2 the commutative figures at the time when the Olduvai Plateau ends. Extending the plateau to 2050 will require an Ultimate Reserve that would have to be over 800 Gtoe; to reach 2070 it would have to be nearly 1300 Gtoe; a reserve value of 2000 Gtoe is reached before 2100.

Implications for Stakeholders

What stakeholders should take home from this discussion is that coal will not be able to replace the other fossil fuels. Whether extraction peaks in 2011 or in 2050, the probabilities of coal on its own being able to help the world avoid the Olduvai cliff are slim at best. Certainly, this fossil fuel can still become more relevant as a fuel in some regions of the world. This can occur in the US for instance, if reported reserves are anywhere near a geological reality. In such places, coal can provide time for a smoother transition to a fully renewable energy paradigm, but on a global scale, the panorama is entirely different.

Especially for states or nations that are net importers today but do not possess realistic reserve perspectives, the use of coal is more a thing of the past than of the future. Coal will continue to be an indigenous energy source *par excellence*, not only for its lower energy density when compared

to oil (which makes transport difficult) but also because of its narrow international market, which is less than 10% of all coal consumed globally. Voracious demand from China (the consumer of 50% of the world's annual extraction, at about 3 times the levels used in the US) and India (a consumer of 8% of world use, which is about the same as the EU) promises to quench this frail market. But that's another story.

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