The Background to Our Research on the Future Production of Fossil Fuels by Country

Steve Mohr
Associate of the Institute for Sustainable Futures,
University of Technology Sydney, P.O. Box 123, Broadway, NSW 2007, Australia

Abstract

This paper sets out briefly the background that led to my PhD research on forecasting global production of the three main fossil fuels: oil, gas and coal. Also described is the extension of this research, in collaboration with a number of co-investigators, which resulted in the publication of the paper: Mohr et al. (2015), Projection of world fossil fuels by country. This led in turn to the paper by Wang et al. published in this issue of *The Oil Age: Production outlook for global fossil fuel resources*.

The Editor of *The Oil Age* suggested that background information on how these studies came about might be of interest, given that our findings on likely global fossil fuel production differ markedly from that generally assumed. In particular, we suggest that the total global production of all fossil fuels combined, under our 'best-guess' scenario, might reach a *resource-limited* production peak as early as about 2025.

Academic background

I start by noting that I have a somewhat conflicted academic background. Initially I studied a Chemical Engineering degree, hoping - with the idealism of youth - that I could contribute to creating a more sustainable future. I have always had a strong notion of conserving resources since my early degree days. The oft-cited R/P ratio for oil of 40-ish years resonated with me, indicating that within my working life there would need to be an alternative to oil.

When I entered my third year of university I had my first semester without a mathematics subject. I realised I loved mathematics. I therefore changed tack, and enrolled in a Mathematics degree, focusing heavily on pure mathematics and avoiding as best as possible anything practical. During this rebellion, the quote by G. H. Hardy resonated with me: *"No discovery of mine has made, or is likely to make, directly or indirectly, for good or ill, the least difference to the amenity of the world."*

Choice of research topic

With my batteries recharged following the Mathematics degree, I decided to complete the Chemical Engineering degree as closure, so I could move into mathematics without regrets.

One of the subjects that I had to complete was a research component topic. I asked around various professors, and found that Geoff Evans was willing to let me loose. I came up with an idea for, and happily dismissed as completely impractical, a possible engine running off hydrogen peroxide. With research time on my hands, Geoff suggested that I look into oil resources as a justification for the engine. This led me to stumble upon Colin Campbell and Jean Laherrère's seminal work, as well as the hugely impressive work by Robert Hirsch.

While finishing the engineering degree I had enrolled in a maths honours with the intention of undertaking a maths PhD. I faced a dilemma, continue down the pure maths path that my friends were travelling and try to become a maths lecturer, or continue to look at fossil fuel production? I eventually chose to abandon my maths honours and proceed with a chemical engineering PhD under my supervisor Geoff Evans. It was not a topic he was currently researching, but I managed to convince him to let me proceed with this.

With Robert Hirsch's report front and centre in my mind, I started down the track of trying to see how the transition to a sustainable world could occur, and here the key question was timing: what was future fossil fuel production going to look like?

In the first couple of months of the PhD I wanted to create a model of all energy sources, and see if it was possible to go from a predominately fossil fuel based world to a sustainable world smoothly. Sadly, a distinct lack of time resulted in the scope of the work being reduced, to only looking at the fossil fuels.

One of the questions asked early in the PhD was whether a Hubbert curve was realistic or not. In my first couple of approaches I tried to focus on finding more of a theoretical approach to 'how does the production occur'; and hence to try and figure out how to aggregate local production to see what the world production would look like. I accessed the reasonably easy to obtain UK oil and gas production data to look at the production profile of a typical field. And I used the UK's example of the changing size of the fields over time, namely big fields early, then medium sized fields, then all the little fields, coupled with the field profile, as key components for the model.

For coal, I found obtaining data to be very painful. I ultimately settled on getting Australian New South Wales (NSW) coal production by mine to try and determine how to replicate total production in a region. This was far from ideal; data from somewhere like France or the UK would have been better, but I could not source these data. Even for NSW data, I had to plead with the NSW Coal Authority to gain access to folders filled with hand-written coal production data for each of the mines, and to manually translate the data.

In terms of getting data, I probably spent a third of my time collating data, and typically would work to four p.m. on the PhD, and then work the evenings trying to collate the data. The hardest by a long margin were the coal production data. Geoff and I ended up paying the UK Mineral statistics to photocopy the old coal records, then I manually entered the data into Excel. The effort needed to create the datasets is one of the reasons I am passionate about supplying the data in electronic supplements of my articles, to make it easier for subsequent researchers.

In terms of the fossil fuel estimates of their ultimately recoverable resources (URR's), I have always been keen to be as agnostic as possible

on these. So the low estimates used in the modelling correspond to URR data from Colin Campbell, Jean Laherrère and Dave Rutledge, while the high estimates generally reflect BGR/WEC/Rogner numbers.

I was keen to use the BGR numbers for all the fossil fuels, but found that their numbers for coal didn't appear reasonable, to the point where I questioned their validity. The coal numbers I finally used do not sit well with me, but were at the time the best I could create, and I stand by them. It saddens me that the WEC is now simply reproducing the BGR estimates for coal, and I think it is important that researchers start to question how much sensibly recoverable coal the world actually possesses. This is difficult, since the bulk of the coal resources exist in a small number of countries, but it feels to me as if coal resources are 'an elephant in the room'.

To give an example here: the UK data have substantially increased estimated coal resources recently and yet this fact goes by mostly unnoticed. Compare this to the OPEC nations increasing their oil reserves, a change which has been heavily critiqued. It beggars belief to me, that when it comes to coal the general statement of `hundreds of years of coal' seems to be an unshakeable belief, which requires no justification. I passionately believe that considerable research is needed in the coal resources space so as to shed some light on what are the plausible recoverable coal resources.

One of the key important components for me was for the model to be as granular as possible, so that the projections generated could be transparent. That said, for each typical country and resource, it might take half an hour or so of work to determine the appropriate parameters to put into the model. As a result, countless evenings and weekends were spent creating the projections.

Collaboration

When I was looking for collaborators to the work, Jianliang Wang at the Chinese University of Petroleum in Beijing was amazing at providing Chinese resource data and production numbers to underpin the Chinese projections. Both James Ward and Gary Ellem where adamant that CO2 emissions needed to be included. I cannot thank James enough for his effort in figuring out the conversion factors to apply. Collaborating with these others was a godsend, not only did it reduce the work load substantially, but it also re-motivated me to finish the work.

Reaction to our work

Since the publication of our results in Mohr et al. (2015), the paper has been cited in a number of journal papers. To-date though, the feedback on the paper has been limited. No other researcher has come back to us to ask about, let alone, question our results; and certainly no-one from the 'mainstream' energy forecasting organisation, such as the IEA, EIA, etc., have done so. We would of course look forward to such conversations.

Longer term, I am hopeful that I can create and ideally maintain projections of all mineral resources into the future, including resources such as iron ore and copper (which I have already written papers about), and lead-zinc (a work in progress).

References

BGR (2015). *Energy Study 2015. Reserves, resources, and availability of energy resources.* (19) – 172p., Hannover. https://www.bgr.bund.de/EN/Themen/Energie/Produkte/energy_study_2015_summary_en.html;

Campbell, C. and Laherrère, J., (1998). *The end of cheap oil.* Scientific American, March.

Hirsch, R. L., Bezdek, R., Wendling, R., (2005). *Peaking of World oil production: Impacts, Mitigation and Risk Management.* U.S. Department of Energy, National Energy Technology Laboratory.

Mohr, S. H., Wang, J., Ellem, G., Ward, J., Giurco, D., (2015). *Projection of world fossil fuels by country.* Fuel, Vol. 141, pp 120-135.

Rogner, H-H., Aguilera, R. F., Archer, C., Bertani, R., Bhattacharya. S. C., Dusseault, M. B., et al. (2012). *Energy resources and potentials.* In: Global energy assessment – toward a sustainable future. Cambridge (UK), New York (NY, USA): Cambridge University Press, International Institute for Applied Systems Analysis; pp 423–512.

World Energy Council (WEC) (2016). World Energy Resources, 2016. https://www.worldenergy.org/publications/2016/world-energy-resources-2016