The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Review Response: Depletion and the Future Availability of Energy Sources

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Two weeks ago I posted a review of an article with an optimistic view on the future availability of oil. Written by R. Aguilera, R. Eggert, C. Gustavo Lagos and J. Tilton and published in the Energy Journal of the International Association of Energy Economists. After a short correspondence Dr. Aguilera and his team have been kind enough to respond to the five points of disagreement I raised in my review. Their response is shown below. I hope our readers can react respectfully as to create a meaningful discussion.

Abstract of Aguilera et al. (2009)
"This study assesses the threat that depletion poses to the availability of petroleum resources. It does so by estimating cumulative availability curves for conventional petroleum (oil, gas, and natural gas liquids) and for three unconventional sources of liquids (heavy oil, oil sands, and oil shale). The analysis extends the important study conducted by the U.S. Geological Survey (2000) on this topic by taking account of (1) conventional petroleum resources from provinces not assessed by the Survey or other organizations, (2) future reserve growth, (3) unconventional sources of liquids, and (4) production costs. The results indicate that large quantities of conventional and unconventional petroleum resources are available and can be produced at costs substantially below current market prices of around US$120 per barrel. These findings suggest that petroleum resources are likely to last far longer than many are now predicting and that depletion need not drive market prices above the relatively high levels prevailing over the past several years.(Aguilera et al. 2009, page 141)"

Response by R. Aguilera, R. Eggert, C. Gustavo Lagos and J. Tilton

Thank you for the opportunity to comment on your review of our article. I have organized my response around your five concluding statements. At the end of my comment, I also make several additional points.

1) The data from USGS (2000) of the yet to be found estimate in 102 geological provinces has been used to estimate the future potential in 835 geological provinces which were not assessed in USGS (2000), resulting in an additional 539 billion barrels of expected discoveries by Aguilera et al. (2009) in addition to the 939 billion barrels estimated by the USGS (2000). The original USGS (2000) is too optimistic as it implies that the declining discovery curve which has been declining since the 1960s will turn around. This methodology produces an estimate of 539 billion barrels,

which is also too optimistic.

> Extrapolating discovery data can provide useful information, but does not consider reserves that are created through reserve growth. The latter is much less costly and less risky than exploration. The USGS has found that, about 10 years into the study, their estimates for new discoveries are behind schedule. On the other hand, actual reserve growth has been much larger than they anticipated (even growth of 2P reserves; see Charpentier, 2005). This means that investors have chosen to invest in development of previously discovered fields, instead of exploration. Therefore, the fact that the USGS undiscovered estimates are not being realized as fast as expected does not necessarily mean that their estimates are overly optimistic (see Klett et al., 2005 for an evaluation of the study). The Hubbert curve pattern of expected discoveries, shown by the blue line in Figure 2 of the article review, was never predicted or even implied in the USGS study.

2) Aguilera et al. (2009) have double counted reserve growth because they made the incorrect assumption that the USGS (2000) did not apply a reserve growth function for the estimate of yet to be discovered fields.

> We are aware that the USGS only applies reserve growth to known volumes and that their undiscovered volumes are already ‘grown’. However, it is important that reserve growth be applied to both known and undiscovered volumes, since undiscovered volumes may experience future growth in the same way known volumes are growing at present. For example, recovery factors of oil are likely to continue to increase, so that will apply to known volumes as well as presently undiscovered volumes.

3) A large number of factors that limit production have not been incorporated, including the availability of water and natural gas which play a large role in the production of unconventional crude oil.

> We recognize that those are very important factors, along with other serious environmental impacts of unconventional oil production. The role of advancing technology will be crucial in reducing the need for inputs such as water and gas, while mitigating environmental damage. However, our paper did not aim to address these challenges in detail. We simply wanted to estimate how much could be available at average costs of production.
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> Still, our paper does mention the caveat:
> “..despite the considerable efforts by governments around the world to internalize over the past several decades the external costs associated with energy production, such as environmental pollution and global warming, there is still considerable disagreement over just how large the remaining external costs are. For this reason, we have not attempted to include external costs in our cost estimates. As a result, the full social costs of fossil fuels production are higher than the reported production costs.”
>
> The paper also mentions some of the points raised by your readers:
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> “..there are challenges associated with unconventional resource production. First, the ‘energy returned on energy invested’ ratios (EROEI) are much lower than for

conventional petroleum. Second, unconventional sources are usually more expensive and so less economical, mainly because they are harder to extract and refine. Third, the environmental problems are more serious. Heavy oil, oil sands, and oil shale production cause much higher amounts of greenhouse gas emissions than conventional petroleum."

4) A direct comparison between the production of conventional and unconventional oil has been made while production mechanisms for these types of oil differ significantly, leading to a comparison between apples and pears.

It is typical for supply curves to include different sources of liquids in one curve (e.g. conventional oil, heavy oil, oil sands, oil shale, deepwater, CTL, GTL, etc). See, for example, the IEA (2008) curve to which you refer. This consolidation is appropriate, first of all, because the different production mechanisms are reflected in the reported production costs. More fundamentally, we and others include both conventional and unconventional hydrocarbons on the same availability curve because conventional and unconventional resources substitute for one another in actual fuel use.

5) It is incorrect to take historic production costs from a single to a set of years in a given oil province and extrapolate them into the future to obtain future costs. Costs are likely to change permanently in the future as cost decreases due to technological innovation have largely played out, and cost increases are expected to play a bigger role. These changes are expected because of declining quality of the remaining oil, more remote and politically difficult locations of extraction, and smaller and smaller fields in these locations.

In the paper, we describe the uncertainty over how production costs change over time as a race between the cost increasing effects of depletion and the cost-reducing effects of technological advancement and substitution among energy sources. Given this uncertainty, we only made an attempt to estimate static availability curves. We mention this caveat, stating that rising costs over time would shift our curves upward and falling costs would shift them downward. On this point, we are far from certain that "cost decreases due to technological innovation have largely played out."

Since we're reporting 2006 production costs, they're going to be lower than those of the latest IEA (2008) supply curve. If you compare our costs to their IEA (2005) version, they're similar. Recent estimates by others also compare to ours (e.g. Deutsche Bank, 2009; Farrell, 2008).

"Going beyond your five concluding points, we have some additional comments:

First, the first sentence in your article review does not accurately summarize the conclusions of our study. We did not conclude that the "recent high oil price spike was an aberration"; rather we concluded that depletion need not drive prices above the relatively high levels of the recent past. There are a number of other (political, environmental, and social) reasons prices could rise but geologic depletion is not one of them.

Second, rather than take the USGS (2000) estimates at face value, we critically reviewed the study and determined that it's based on geological and statistical procedures recognized as being valid throughout the world. For this reason, we decided to use their estimates as a starting point.

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