The Oil Drum: Net Energy

Discussions about Energy and Our Future

The IEA WEO 2008 from the Perspective of Biophysical Economics

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*Editor's note: the following post is by Dr. Charles Hall and his Phd student David Murphy (EROI Guy), and is part of our on-going series reviewing the World Energy Outlook 2008, recently published by the IEA. It is also the first post of a new 'channel' on The Oil Drum: TOD:EROI, where we will be posting essays, papers, and analysis on the biophysical aspects of energy. Our intent is to be a real time central clearinghouse for biophysical/net energy research and ideas. We have debated on calling it EROEI - Energy Return on **Energy** Invested, but have decided to keep it consistent with the acronym from the energy literature. The post below critiques the neoclassical economic assumptions underpinning the IEA report and proposes future 'energy watchdog' reports utilize an alternative approach grounded in biophysical concepts.*

This week's IEA report, predicting 106 mbpd of oil production in the year 2030, and various price forecasts along the way, gives us more of the same from our international energy institutions whose fundamental assumptions remain broadly unquestioned. It is an open but critical question why anyone would continue to take conventional (neoclassical) economic theory seriously given the events of the last month, not to mention the repudiation of the “Washington consensus” by just about all Latin American countries and the many articles that have been written recently (and not so recently) that debunk some or all of the basic neoclassical assumptions (e.g. Leontief, 1982; Hall et al., 2001; Gowdy and Erickson, 2005; Bouchard, 2008; Galbraith, 2008; Nadeau, 2008 - - from many others). Nevertheless in this report we see the IEA, after making a good initial statement about the reality and importance of peak oil, revert back to predicting future oil supplies based on the same unproven neoclassical economic theories, including, most basically, an assumption of intrinsic growth of demand for oil at 1.6 percent per year indefinitely (click here for a review of the modeling in the WEO). This economic theory has allowed for the continued abuse of the words ‘proven’ and ‘probable’ when predicting reserve quantities, and in this case, has led the IEA to report that ultimate recoverable reserves from conventional sources total 3.5 trillion barrels, and from unconventional sources upwards of 6.5 trillion barrels. This report, and economics more generally, completely lacks the understanding that those numbers are not only quite unproven but irrelevant and useless by themselves, for the important number is not “how many barrels are in the ground” but “how many of those barrels will be gained at a significant energy profit for society.” In effect, the notional figure of 106 mbpd gives the impression that oil's net benefit to society will continue and even grow into the future.

The analyses presented by the IEA assume that only dollars will need to be invested (and $24 trillion at that). But oil, like anything else, requires real resources to procure, and it will be obtained only in proportion to how much real resource (energy, steel etc) is spent in getting it. The main problem is that geology, not the market, holds the key, and the geology of earth is getting more and more parsimonious in two ways: quantity and quality. Both of these concepts impact the energy return on investment (EROI) of national and global oil and gas supplies. First, the IEA is almost certainly correct in stating that as time progresses an increasing proportion of global oil supplies will have to come from fewer supergiant and giant fields within OPEC, as efforts to expand production worldwide has failed to keep pace with the depletion of non-OPEC fields in e.g. the U.S, Great Britain, Norway and elsewhere. This will influence EROI because these existing huge, old OPEC "elephants" are seriously aging and require more and more energy to maintain pressure through injection of, for example, seawater into the lower parts of these fields. Second, as time progresses and the best oil has been found and produced (for example North Ghawar vs. South Ghawar) an increasing proportion of new fields brought into production yield oil that is more difficult to access as well as heavier and more sulfur-laden, requiring more energy to produce, refine, transport (for example, Stuart Staniford reported how the oil in Saudi Arabia is becoming harder to access). The combination of quantity and quality reductions has led to decreasing Energy Return on Investment (EROI) which has not in any way been compensated for by technology or increased drilling rates. These ideas have been well understood since at least Hall and Cleveland (1981), whose results were published on the first page of the Wall Street Journal but quickly forgotten by the financial community and most of the scientific community.

Just to give you a rough idea as to where we are at present with respect to EROI, "according to legendary oilman Charles Maxwell" on The Money Show, most countries report that it costs from $55 (Saudi Arabia) to $70-90 (Russia and most of OPEC) to $90 (Iran and Venezuela) to produce a barrel of oil. That is a lot of money but underneath the surface also represents a lot of energy. Recent work in our lab suggests that when you divide the energy produced by the energy used by oil and gas industries (data is available for only a few countries such as the US and UK) that these industries use about 17 MegaJoules (MJ) per dollar spent in 2006. This is the energy intensity per dollar spent for seeking and producing oil. This compares to about 14 MJ per dollar for heavy construction and about 8-9 MJ per dollar as a societal average, so it seems to be in the right ballpark. If we assume 5 percent inflation since 2006 we might expect there to be used about 16 MJ per dollar spent by the oil and gas industries in 2008. So if it takes Saudi Arabia $55 to produce a barrel then $55 times 16 MJ/$ equals about 880 MJ required per barrel. For Venezuela, which requires $90 a barrel, this number would be 1440 MJ required per barrel. Since a barrel of oil contains about 6164 MJ of energy, the EROI would be about 7:1 for Saudi Arabia to 4.3 for Venezuela or Iran. These estimates, although crude, indicate the seriousness of the problem and sound a clarion call for opening up data banks all around the world to greater scientific scrutiny while also calling for companies to make their energy, as well as dollar, costs explicit and public.

It is important to remember that this is a rough estimate of the EROI for total "upstream" costs, i.e. exploration, development, and production of new wells, and so a calculation of the EROI for simply producing wells within Saudi Arabia would be considerably higher. (I.e., it is possible that seemingly high EROI is only 'at the margin', (on wells and infrastructure put in place long ago), and is masking a deterioration in the EROI of 'new' oil and gas requiring new energy and resources to harness). Nonetheless, the cost of getting energy has been increasing greatly of late which implies that the world is approaching a point at which the energy required to get new oil will be a substantial part of, and eventually all of, the energy found within the barrel. At this point the oil age will be over, regardless of the amount of oil left in the ground or the price that the oil commands. This concept exists partially and inadequately in economics as diminishing returns, but an advantage of EROI over diminishing returns is that with a good historical data set, EROI allows the calculation of a rough cut off point. This suggests that the IEA's prediction of 106 mbpd in 2030, whether true or not, will not have equivalent impact on society as the readers of the WEO 2008 report might infer.

Many economists will say that EROI undervalues the role that technology will play in accessing deeper and poorer quality reserves. But as we have stated, EROI in the US obtained at least 100 barrels of oil from each barrel invested in going after it in the 1930's but only about 10 for one in about 2000, despite the tremendous increases in technology (Cleveland et al., 1984, Cleveland 2005). Therefore, in the US, and subsequently the world, geologic limits have trumped technological advances, and so we reiterate: ***the arguments about how much oil is left in the ground misses the point - what is important is not the total oil remaining but how much we can get out at a significant energy profit***. Unfortunately this amount is likely not large, and this increasing differential between gross and net will only exacerbate Peak Oil. Economics will eventually reflect decreasing energy profits, and even though the price of oil has dropped below what it costs to produce a barrel in many oil-producing countries this will only guarantee larger oil production problems in the (not far off) future. Fancy economic theory will have no ability to change these physics (Hall et al., 2008). As usual, in the long run Mother Nature holds the high cards.

Neoclassical economics and economists have reigned supreme despite their dismal track record of late, as evidenced by governments turning to the same economists who got us into the credit crisis situation to get us out. It used to work better: economies expanded simultaneously with an expansion of economic departments and economic theory. It looked like the theories worked, although since more and more oil was being pumped out of the ground perhaps any theory could 'seemingly' work. Capitalism may be a giant Ponzi scheme once fueled by ever more investors and ever more oil at its base, but this has ceased, most likely forever (see here for a definition of Ponzi scheme). The economic theories became ever more analytically elegant as they got further and further from reality. Our most prestigious economics departments not only did not teach very much about oil or grain or other sources of real wealth but increasingly not even about money. Rather their focus was far too often complex econometric models using rather stupid starting assumptions (e.g. Nadeau, 2008). Acceptance of graduate students was increasingly taken based on their math skills rather than their ability to understand real commodity paths. Wall Street followed the lead of our major economists. As we have seen in other disciplines, such as ecology, there has been massive conflation of mathematical and analytical rigor with scientific rigor.

The basic theories of neoclassical economics breaks many conventional rules of science: for starters the boundaries are wrong, the laws of thermodynamics are not respected and the whole edifice is based on "sets of more or less plausible but entirely arbitrary assumptions" about the economy that were chosen based on an inappropriate physical analogy and that were analytically tractable (Leontief, 1981; Hall et al., 2001; Nadeau, 2008). In fact why should economics be a social science at all? Real economies are about the flow of real materials and the energy required for those flows and materials. Earlier economists (the physiocrats and the classical economists such as Adam Smith and David Ricardo) understood the physical base for wealth and made no such foolish assumptions, nor should we.

If one were to ask a physicist or chemist or engineer about how something was made in our society they would probably begin with analysis of the resources required for its manufacture and then the energy required for that manufacturing. But economists, in their Cobb-Douglass production functions, use only capital and labor: $P = f(K,L)$, and sometimes not even labor. Why?

The economist Dennison (1979, 1989) in many papers wrote that about half of the increase of production over time in the US cannot be explained by the increase in capital and labor. He explains that the statistical error (residual) associated with correlating capital and labor with production is "innovation" (technology), something dear to the hearts of economists. But when Kümmel (1982, 1989) adds in energy, as any real scientist would, this error disappears and the increase in energy turns out to be more powerful than either capital or labor (also see Hall et al. 2001).

Instead of the kind of economics that dominates today what we need is a biophysical approach to our economic system, one that is based on real physical and biological production and distribution possibilities (Cleveland et al., 1984; Hall and Klitgaard 2006). The first International Meeting on Biophysical Economics was held in Syracuse, New York in October of 2008 and there is interest in setting up chapters in at least 6 European Countries. We are attempting to generate case histories, analyses and a textbook, but the road is difficult since conventional neoclassical economics is so firmly entrenched. But if the events of 2008 are a glimpse into the future, then the transition to this kind of economics is inevitable, and along the way it will render moot a good part of the analysis in this weeks IEA document. We would do well to understand and guide this transition.

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