The Oil Drum: Net Energy

Discussions about Energy and Our Future

Implications of Energy Return on Investment, Peak Oil and the Concept of "Best First"

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The following is a post by both Dr. Charles Hall and EROI Guy. Most of the material comes from a recently published book chapter titled "Peak oil, EROI, investments and the economy in an uncertain future." The book can be found here. Dr. Charles Hall is a professor of Systems Ecology at the College of Environmental Science and Forestry in Syracuse, New York, and has written about energy issues many times on The Oil Drum, found here.

The enormous expansion of the human population and the economies of the United States and many other nations in the past 100 years have been accompanied by, and allowed by, a commensurate expansion in the use of fossil (old) fuels, meaning coal, oil and natural gas. To many energy analysts that expansion of cheap fuel energy has been the principal enabler of economic expansion, far more important than business acumen, economic policy or ideology although they too may be important (e.g. Soddy 1926, Cottrell 1955, Georgescu Roegan 1971, Odum 1972, Kummel 1982, Kummel 1989, Jorgenson 1984 and 1988, Hall et al. 1986 (and others), Dung 1992, Ayres 1996).

While we are used to thinking about the economy in monetary terms, those of us trained in the natural sciences consider it equally valid to think about the economy and economics from the perspective of the energy required to make it run. When one spends a dollar, we do not think just about the dollar bill leaving our wallet and passing to some one else's. Rather, we think that to enable that transaction, that is to generate the good or service being purchased, an average of about 8,000 kilojoules of energy (equal to roughly the amount of oil that would fill a coffee cup) must be extracted from the Earth and turned into roughly a half kilogram of carbon dioxide (U.S. Statistical Review, various years).

History has shown that removing the energy supply from the economy will cause it to contract immensely or even stop. Cuba found this out in 1991 when the Soviet Union, facing its own oil production and political problems at that time, cut off Cuba's subsidized oil supply. Both Cuba's energy use and its GDP declined immediately by about one third, all groceries disappeared from market shelves within a week and the average Cuban lost 20 pounds (Quinn 2006). Cuba subsequently learned to live, in some ways well, on about half the oil as previously, but the impacts were enormous. While the United States has become more efficient in using energy in recent decades, most of this is due to using higher quality fuels, exporting heavy industry and switching the way we define economic activity (e.g. Kaufmann 2004). Many other countries, including efficiency leader Japan, are becoming substantially less efficient (Hall and Ko, 2007, LeClerc and Hall 2007, Smil, personal communication).

So if energy is required for economic growth and maintenance, then the important question is how much oil and gas (i.e. energy) is left in the world? The answer is a lot, although probably not a lot relative to our increasing needs, and maybe not a lot that we can afford to exploit with a large financial and, especially, energy profit. Therefore a more precise question might be, “How much oil is left that will yield a large energy profit?" Energy return on investment is a way to answer the latter.

Energy Return On Investment (EROI or EROEI) is simply the energy that one obtains from an activity compared to the energy it took to generate that energy. The procedures are generally straightforward; simply divide the Energy Gained (Out) by the Energy Used (In), resulting in a unitless ratio. The running average EROI for the finding and production of US domestic oil has dropped from greater than 100 kilojoule returned per kilojoule invested in the 1930s to about 30 to 1 in the 1970s to between 11 and 18 to 1 today. This is a consequence of decreasing energy returns as oil reservoirs are depleted and as energy costs increase as exploration and development are shifted deeper and offshore (Cleveland et al. 1984, Hall et al. 1986, Cleveland 2004). Even that ratio reflects mostly pumping out oil fields that are half a century or more old since we are finding few significant new fields. In other words we can say that new oil is becoming increasingly more costly, in terms of dollars and energy, to find and extract. The increasing energy cost of a marginal barrel of oil or gas is one of the factors behind their increasing dollar cost, although if one corrects for general inflation the price of oil has increased only a moderate amount.

The same pattern of declining energy return on energy investment appears to be true for global petroleum production. Getting information on global oil production is very difficult, but a study currently submitted for publication indicates that the global EROI for petroleum production has been declining over the past 8 years and is currently about 18:1 (Gagnon and Hall, submitted). In fact, if the rate of decline continues linearly for several decades then it would take the energy in a barrel of oil to get a new barrel of oil. While we do not know whether that extrapolation is accurate, essentially all EROI studies of our principal fossil fuels do indicate that their EROI is declining over time, and that EROI declines especially rapidly with increased exploitation rates (e.g. drilling).

This decline appears to be reflected in economic news also. In November of 2004, The New York Times reported that for the previous three years oil exploration companies worldwide had spent more money in exploration than they had recovered in the dollar value of reserves found. Therefore it is possible that the energy “break-even” point has been approached or even reached for finding new oil. Whether we have reached this point or not the concept of EROI declining toward 1:1 makes irrelevant the reports of several oil analysts who believe that we may have substantially more oil left in the world, because it does not make sense to extract oil, at least for a fuel, when it requires more energy for the extraction than is found in the oil extracted.

Declining EROI rates for US and World oil exploration and production indicate that our [society’s] ability to weather the coming peak oil storm will depend in large part on how we manage our investments now. From the perspective of energy, there are three general types of investments that we make in society. The first is investments into getting energy itself; the second is investments for maintenance of, and replacing, existing infrastructure; and the third is discretionary expansion. In other words, before we can think about expanding the economy we must first make the investments into getting the energy necessary to operate the existing economy, and into maintaining the infrastructure that we have, at least unless we wish to accept

the entropy-driven degradation of what we already have. Declining EROI means that the required investments into the second and especially the first category are likely to increasingly limit what is available for the third. In other words, the amount of energy and dollars spent supplying the energy for economic maintenance will likely increase, while the remainder left for discretionary purposes will likely decrease.

Declining EROI is mainly a consequence of the "best first" principle. This is, quite simply, the characteristic of humans to use the highest quality resources first, be they timber, fish, soil, copper ore or, of relevance here, fossil fuels. This is because economic incentives are to exploit the highest quality, least cost (both in terms of energy and dollars) resources first, as was noted 200 years ago by economist David Ricardo (1821). For instance, the peak in finding oil was in the 1930s for the United States and in the 1960s for the world, and both have declined enormously since then. An even greater decline has taken place in the efficiency with which we find oil; that is the amount of energy that we find relative to the energy we invest in seeking and exploiting it. The pattern of exploiting and depleting the best resources first is occurring for natural gas as well. US natural gas originally came from large fields in Louisiana, Texas and Oklahoma. Its production has moved increasingly to smaller fields distributed throughout Appalachia and, increasingly, the Rockies. The largest fields that traditionally supplied the country with natural gas peaked in 1973, and then as "unconventional" fields were developed second by drilling a vast amount of wells, a somewhat smaller peak occurred in 2007.

In summary, there are three related forces that may reshape societies and economies around the world: peak global oil production, declining EROI of global oil exploration and production, and the "Best First Principle". They imply that we no longer have the ability to substantially increase oil production without substantially increasing the amount of oil used to get that oil, and finally, that any new discoveries will invariably cost increasing amounts of money and energy to produce. The interplay of these three forces will most likely limit the amount of money designated for discretionary spending, while increasing the amount of money and energy needed just to sustain economic function.

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