The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Why EROI Matters (Part 1 of 6)

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This is the first of a six part series of guest posts by Professor Charles Hall of the SUNY College of Environmental Science and Forestry and his students and collaborative researchers. Professor Hall previously posted on TOD, "At $100 Oil, What Can the Scientist Say to the Investor?"Professor Hall has endeavored to update and improve the state of net energy analysis as he believes (as do I), that future energy policy decisions should at least be guided, if not directly steered using biophysical principles. The opinions on the importance of net energy analysis as a tool for addressing our looming energy crisis are quite disparate, but without some science grounded in physical principles, we are left to rely on the market. The unfolding international credit crisis highlights the dangers of relying on strictly fiat monetary measures for biophysical planning – credit and debt can be created with no underlying physical foundation.

This first post is composed of 2 pieces. First is an introduction and an explanation by Dr Hall why EROI analysis is important. The second part lays out a request to theoildrum.com readership for helping contribute to this net energy data effort. This post will be followed every Tuesday in April with Dr. Halls students preliminary analysis on four energy sectors: 1)conventional fossil fuels, 2) Nuclear fuels 3) solar fuels and 4)geologic sources. Please try and help Dr. Hall with this meta-analysis with suggestions, criticism, and sourced comments. This first post has no data, so there will be an opportunity for readers to discuss any theoretical issues regarding EROI and net energy analysis before starting into the actual numbers next week.

Why EROI matters

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Making investment decisions

Society usually makes its economic decisions, at least those not predicated by personal greed at the expense of others or strictly political considerations, on economic analysis and most explicitly via either non government market decisions or governmentally-administered cost-benefit analysis. Probably most decisions are made by people in the financial markets who seek to gain the best economic return on their economic investment. Probably most of these people believe that their own best judgments, while of course subject to the vagaries of the market, are the best way that we can prepare for the future. There is an implicit assumption, probably believed by most market analysts, that if they (collectively) make good financial decisions, based on market information, market projections and good hunches, then we collectively (i.e. society) will make the best investments possible. Although there are certainly good rationales that such analyses make considerable sense, in many cases it is not so clear to me that they are an effective guide to the future of energy supplies. This is because 1) few understand the degree to which most technologies today are principally a means of subsidizing whatever it is we do with still-cheap petroleum 2) today's price signals are unlikely to be especially influenced by future conditions when today's most abundant and cheapest fuels are likely to be much less available, for either geological (depletion) or political reasons 3) current prices of energy in the U.S. are greatly influenced by various subsidies 4) there is painfully little transfer of information from the (rather limited) scientific community that has examined the large picture of energy to the financial communities. We propose to improve the information flow on these issues from the scientific community to the general financial community as well as to the policy world more generally.

Why peak oil matters

Our society is overwhelmingly dependent upon oil, which supplied about 40 percent of US energy use in 2007, and natural gas, which supplied another 25 or so percent. Global values are similar. It has also been dependent upon their growth in supply to support additional economic growth, even with some efficiency improvements. As of this writing there is considerable concern about whether "peak oil" (meaning the point for a region, a nation or the world at which oil production no longer increases year by year but enters a plateau or decline) has occurred for the world or might soon. If this is true then the "end of cheap oil" might be, or might soon be, upon us. Natural gas might not be too far behind, especially in North America. Because of the critical importance of this petroleum for essentially everything we do economically there are major concerns as to what the financial implications might be. A thoughtful although possibly extreme view of the implications of peak oil on the American Economy has been presented by Gail Tverberg at: http://www.theoildrum.com/node/3382#more . An assumption of some who examine this issue is that since all that we do economically in the US is based on cheap oil and gas then the absence of that cheap oil and gas will have enormous economic implications. Do conventional economics and conventional economic models and tools work only when it was possible to readily expand the petroleum supply? There is a strong view held by myself and others (see references at end) that because our main economic concepts were derived during a period of our expanding ability to do everything – i.e. that more or less regardless of policy we were able to pump more oil out of the ground readily to implement whatever we were trying to do, that conventional economic approaches may have much less relevance during times of contracting supplies. In other words, are finances beholden to the laws of physics? I think yes. Thus the question becomes: can we supplement or improve upon our ability to do economics and financial analysis by using procedures that focus more on the energy available (or not) to undertake the activity in question? I next attempt to make that case.

Predicting energy supplies and the importance of EROI

There are many, notably those associated with TheOilDrum and the Association for the Study of Peak Oil (ASPO), who believe that they can predict the amount of oil and gas that will be available in the future. This can be readily gleaned from their web sites. The news is not good, especially over the next few decades. Other, different views are available of course, both from the US Energy Information Agency and Cambridge Energy Research Associates, but even their probably inflated estimates would only extend the time until peak, not cause it to disappear. In addition their predictions seem to have lost a lot of credibility due to the recent analysis of Morton, who showed that all of their price predictions in the past 8 years have failed miserably.

Most economists are not too concerned about peak oil (if they think about it at all) because they believe that markets will generate substitutes from which markets will choose. But today's markets often give very misleading signals about the potential of various fuels. The boom and bust of ethanol is an obvious example. I have been working on this issue for 40 years and have no idea what might be an adequate qualitative and quantitative substitute for petroleum except possibly and with enormous difficulty something based on electricity.

One potentially useful alternative or supplement to conventional economic analysis is net energy analysis, which is the analysis of how much energy is required to make a unit of the energy in question. Net energy is sometimes called energy surplus, energy balance, or, as I prefer, energy return on investment (EROI) (Hall 1972, Hall and Cleveland 1981, Cleveland et al.1985, Hall, Cleveland and Kaufmann 1986). Its advocates, including me, believe that net energy analysis offers the possibility of a very useful approach for looking at the advantages and disadvantages of a given fuel and offers the possibility of looking into the future in a way that markets seem unable to do. Its advocates also believe that in time real market prices must approximately reflect comprehensive EROIs, at least if corrections for quality are made and subsidies removed. Thus can we make market decisions based on biophysical, rather than market, economic analysis? At a minimum I believe that biophysical analysis can add a great deal of insight to traditional market analysis.

The current literature on net energy analysis, such as it is, tends to be mostly about whether a given project is or is not a net surplus, that is whether there is a gain or a loss in energy from e.g. making ethanol from corn (see June 23, 2006 issue of Science Magazine for a fairly thorough discussion of this issue). The general criteria used by much of the current debate is focused on the "energy break even" issue, that is whether the energy returned as fuel is greater than the energy invested in growing or otherwise obtaining it. If so then the general argument seems to be that the fuel or project "should be done", and if not then it should not. Obviously this issue is clearest when one might be discussing whether the fuel requires more energy for its production than is delivered in the product, a claim held by several of the participants (most notably Pimentel and Patzek 2005 discussed in the above issue of Science) in the current debate about corn-derived ethanol. Others (summarized in e.g. Farrell et al., 2006) argue that ethanol from corn has a clear energy surplus, with from 1.2 to 1.6 units of energy delivered for each unit invested. Further aspects of this argument center around whether one should include co-products (such as residual animal feed), the quality of the fuels used and produced (liquid – presumably more valuable -- vs. solid and gaseous, for example) and whether or not to consider the energy required to compensate for environmental impacts in the future e.g. for the significant soil erosion occasioned by corn production. Such arguments are likely to be much more important in the future as other relatively low quality fuels are increasingly considered or developed to replace oil and gas, both of which are likely to be more expensive and probably less available in the not so distant future. If, of course, the alternatives require much oil and or gas for their production, which is usually the case, then an increase in the price of petroleum will not necessarily make the alternatives cheap and more available as a fuel. And, as we have seen, the use of biomass fuels an have enormous and generally adverse ripple effects though the world's food and environmental systems that were completely unpredicted by narrow market analysis.

Why EROI matters—what information can it give about the future

I believe that EROI can give the investor or the publics a great deal of information that markets cannot. These are summarized below:

1) Markets can give you information only about the cost of exploiting a fuel, which usually today has nothing to do with making or even necessarily finding it in the future. Case in point is petroleum: today globally we find only one barrel for each 4 or 5 that we extract, so that we are basically pumping out known reservoirs. Hence we are not paying, assuming that we could, the cost of finding the replacement or of making some substitute. We are just emptying our tanks. Time trends and predictions of EROI can give you a much better insight into what the costs relative to the gains are likely to be in the future.

2) Nevertheless energy investments on the whole probably cannot fail to give the investor a profit. If costs go up, so will prices. If depletion of high quality fuels occurs whatever energy is left is likely to be worth more. Society as it has existed for 100 years simply cannot operate without energy, probably more or less as much as it can get. But while the investor might be satisfied the general economy will suffer, and indeed that is beginning to happen. I believe that even the sub-prime mess is about increasing oil prices increasingly removing once-discretionary income that had allowed the speculation.

3) Essentially all information that we have indicates that the EROI for our major fuels (solar may be an exception) are declining over time, so that in the future society will be having to invest much more money and energy into getting the necessary fuel to run the economy than we do now (e.g. Hall et al. in press). Thus we can tell investors that this is not a good time to invest in additional Caribbean hotels, new restaurants and so on. Both society and individual people will be spending far more of their income on just getting the energy to make the economy work, , resulting in a serious diminution of discretionary income and everything dependent upon it (e.g. Hall et al. in press, http://www.theoildrum.com/node/3412)

4) EROI can be used to help evaluate which alternative fuels are likely to be the most viable economically in the future (See the “balloon” graph in the above post)). Those investors who had used EROI information to guide investments in the last few years avoided being burned in the corn-based ethanol boom and bust. Similarly, science can tell you now that we have not yet broken down cellulose on a commercial scale, and that to maintain the conditions where this has been done in the laboratory on a large scale is extremely difficult. So much for the present-day advocates of switchgrass and other cellulosic alcohol. Maybe we can do it, but should we bet the house on a maybe?

5) EROI can be combined with estimates of the total magnitude of resources to indicate which fuels are likely to be able to make significant additions to US energy resources. For example, rapeseed is an attractive potential for biodiesel but the entire area in which rapeseed can be grown with a significant net energy gain probably is not enough to make a substantial contribution to the US liquid fuels budget.

6) Environmental issues can be included in EROI analyses, allowing a more comprehensive analysis of EROI. For example if growing a biofuel causes soil erosion the energy cost of making fertilizer to restore the fertilizer can be readily factored in.

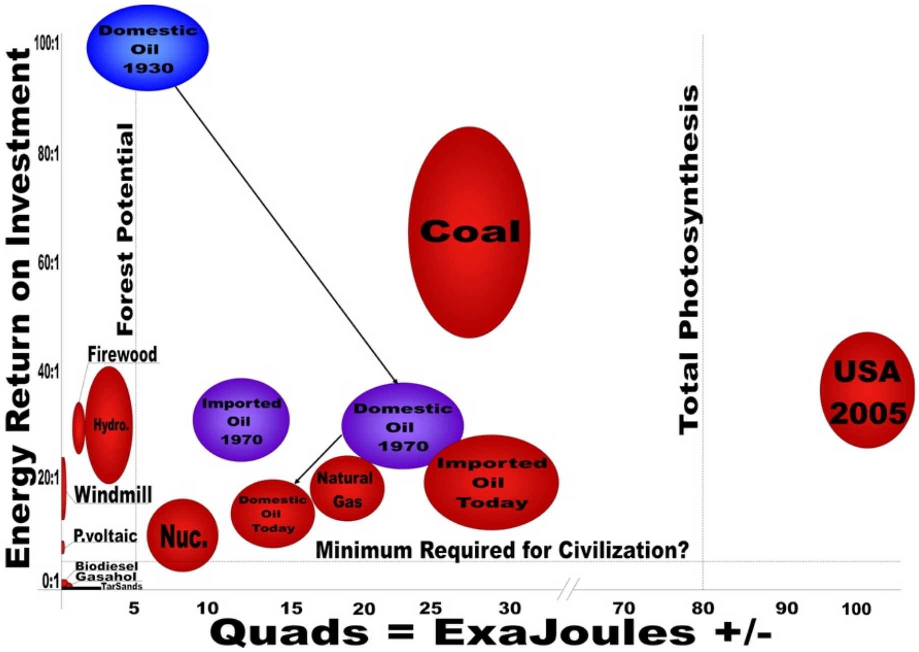
Thus there are many reasons that good energy and EROI analysis can help guide the policymakers, investors and interested members of the public.

Part II

REQUEST FOR HELP TO READERS OF THE OIL DRUM

I have been involved in attempting to examine the relation of energy costs and gains of various living creatures (e.g. migrating fish, trees growing at different places on a mountain) and of energy used by humans (e.g. petroleum, coal, nuclear, biomass) for most of my professional career, that is since 1968. Various publications on this issue are available at my website (http://www.esf.edu/efb/faculty/hall.htm) . It is my opinion that such energy return on investment (EROI) analyses are critical for how we understand our future energy possibilities and also about how we should make investment decisions about energy now. For example, from the perspective of society (but not necessarily the individual investor) it might appear to make a lot of sense to invest in oil at the present time, when substantial amounts of oil might be forthcoming and prices are good, but if in fact what we are doing is simply accelerating the depletion of existing reserves, rather than finding new reserves, then the net effect is simply robbing tomorrow's Paul to pay for today's Peter. i.e. accelerating the negative effects of oil depletion at some future time. What we really need to do is to decide what might be optimum investments based on (for our purposes) the EROI for the present and as projected to the future.

EROI is of course not by itself a sufficient criterion to make decisions about which energy resources should or should not be developed, encouraged, subsidized or whatever, but it is an important criterion. Obviously if an energy resource requires more fuel, or nearly the same amount of fuel of a higher quality, to create as is gained from its development then that is probably by itself sufficient reason to recommend against its production. In addition, other things being equal, it makes sense to develop that fuel which has the highest EROI. Of course it is rare that other things are equal. The most important additional criteria is the potential magnitude of the resource. In the United States, for example, really high quality geothermal sites (such as the Geysers in California) are rare, although low quality sites, with much lower or essentially negative EROIs, are abundant. The second most important additional issue is probably environmental issues, and our analyses attempt to assess each of these. Other issues that might also need to be addressed include: availability of, and impact upon, labor, land requirements, financial issues and so on.



*"Balloon graph" representing quality (y graph) and quantity (x graph) of the United States economy for various fuels at various times. Arrows connect fuels from various times (i.e. domestic oil in 1930, 1970, 2005), and the size of the "balloon" represents part of the uncertainty associated with EROI estimates. (Source: US EIA, Cutler Cleveland and C. Hall's own EROI work in preparation)**Click to Enlarge**.*

The results of our long term and recent analyses have been published recently on TOD (http://www.theoildrum.com/node/3412) as "The balloon graph", a graph indicating the quantity (amount used in the U.S. per year for various years) and quality (EROI) of the main and possible fuels used in the U.S. What we want to do next is to utilize the considerable experience of the readers of the oil drum to criticize and, especially, expand upon our recent efforts to summarize what is known about the EROI, potential magnitude and environmental impact of various fuels. If you are interested I have prepared a preliminary summary of what we were able to summarize about existing studies of these issues for many different fuels. This summary was prepared by a month long study of about a dozen Graduate and undergraduate students at my College (The College of Environmental Science and Forestry of The State University of New York –i.e. SUNY ESF) in May and June of 2007. While I felt that the study was fairly exhaustive our preliminary results have been criticized in various ways, especially from the perspective that "There must be more studies than you have found". I agree, and seek your help in this endeavor. So we will present in TOD our summary in four sections in four successive postings of TOD and we seek your input. The rules of engagement are simple: if you know of additional studies that would reinforce or refute (or anything else) our basic analyses then post them to TOD. We seek especially objective results that are published in peer reviewed journals (the normal gold standard of science) and we seek to avoid self aggrandizing reports by interested parties –i.e. someone with something to sell -- or the opposite. We are also seeking actual measured analyses vs. hypothetical assessments of where the technology might be headed. We also would welcome the responder's opinion of the piece put forth.

We are also attempting to develop at this time, independently, a more explicit protocol for deriving EROI and associated criteria. We recognize that a lot of the difference amongst different estimates for the same fuels at this time are definitional and especially relate to the boundaries used, an issue that we are attempting to deal with independently. An example of the confusion we face relates to the messages that came in to the earlier posting on TOD of our “balloon graph” where as one responder (mkwin) states that there was a new study indicating that the EROI of the Forsmark nuclear power in Europe was some 93 returned for one invested. But the next responder (Chris) stated that since the enriched fuel had been provided by France, where some 3 of 21 or so nuclear plants were required to enrich the fuel used by the 21 plants then the maximum EROI would be about 7 to 1, something, more in line with our own earlier conclusions. Or is it? So we will see how this goes, filter the responses and try to get a more substantive basis for our various EROI estimates from the results. So if you are interested in this issue read on.

The four sections that will be posted are: 1) conventional fossil fuels 2) Nuclear fuels 3) geological sources and 4) biomass fuels.

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