The Oil Drum: Net Energy

Discussions about Energy and Our Future

REVIEW: A Preliminary Investigation of Energy Return on Energy Investment for Global Oil and Gas Production

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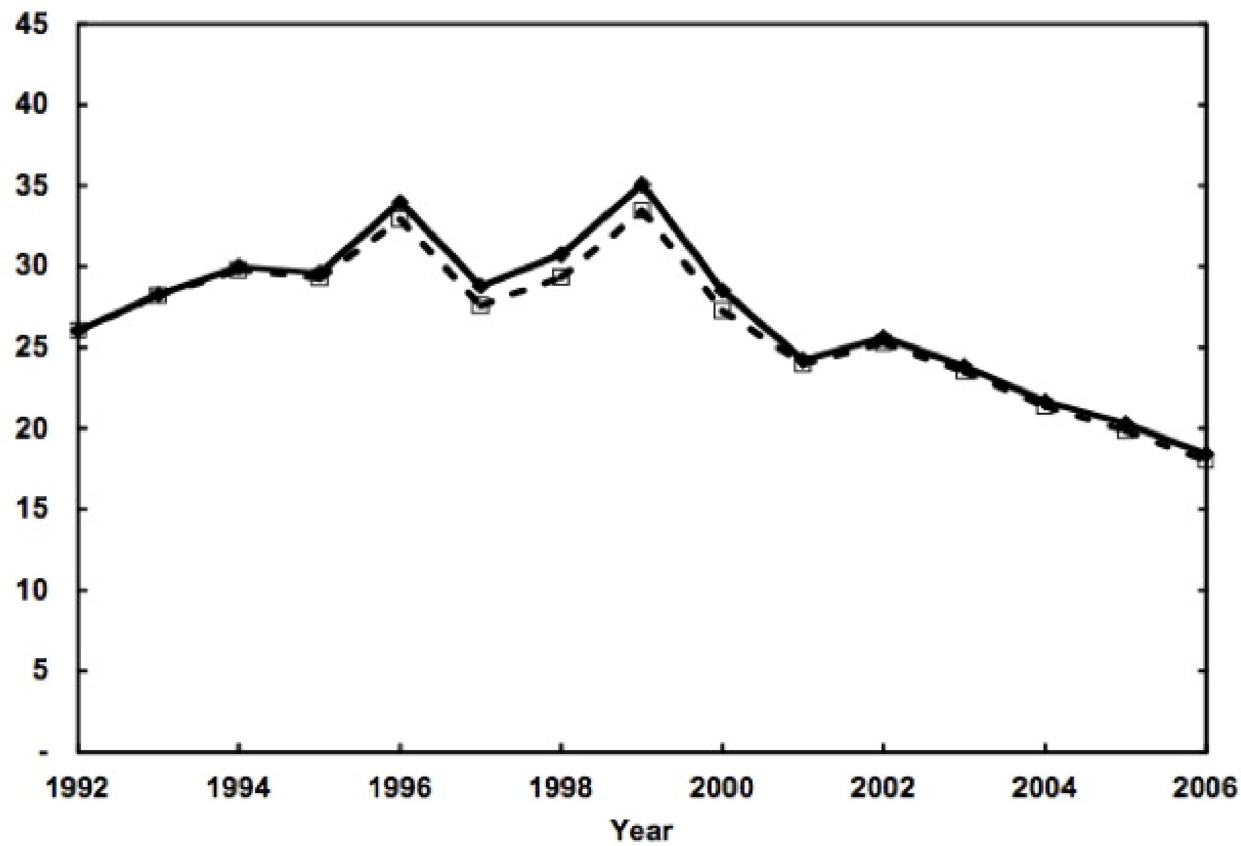
This post reviews a paper by Nate Gagnon, Charles Hall and Lysle Brinker titled: “A Preliminary Investigation of Energy Return on Energy Investment for Global Oil and Gas Production,” published recently in the peer-reviewed journal *Energies*. The lead author was my colleague for two years at SUNY-ESF and the second author is currently my Ph.D. advisor and has published numerous guest posts here on The Oil Drum. See here for a list of previous posts relating to work by Dr. Charles Hall, and here to download a full-text PDF of this paper.

EROI of Global Oil and Gas Production



ABSTRACT: Economies are fueled by energy produced in excess of the amount required to drive the energy production process. Therefore any successful society’s energy

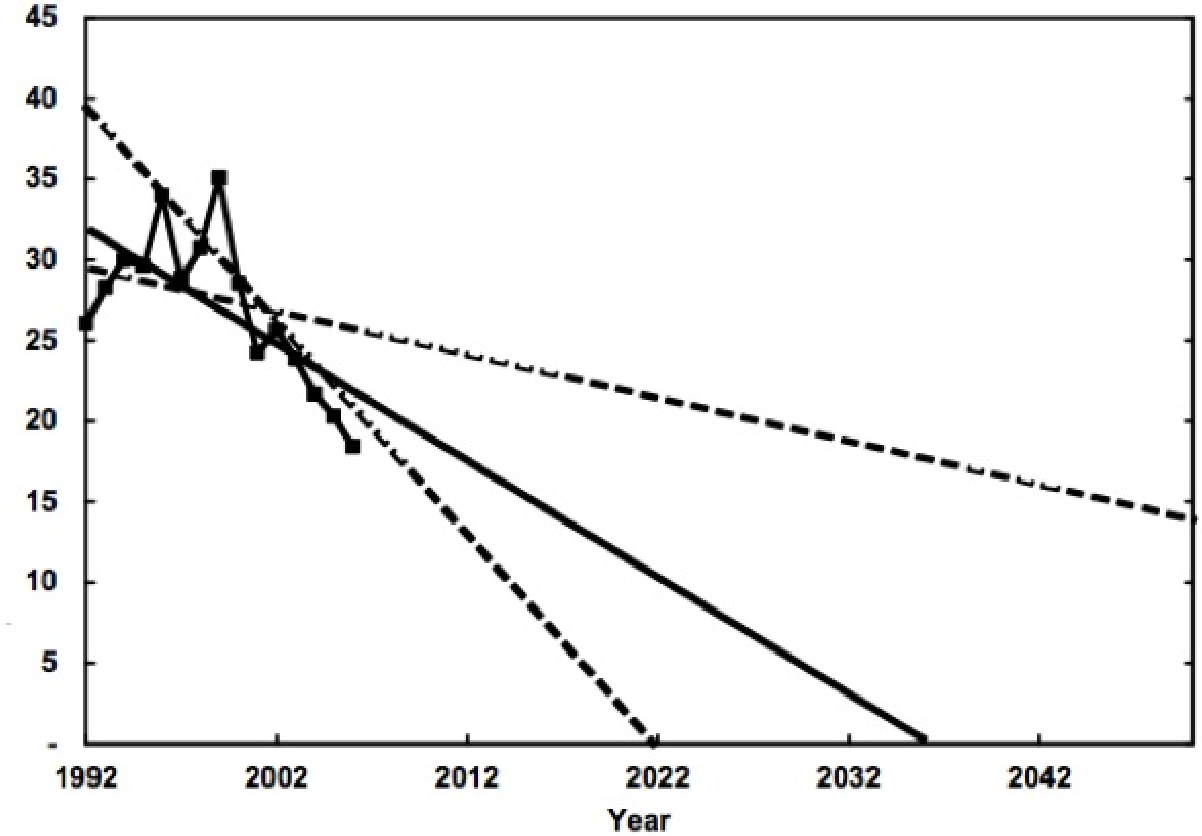
resources must be both abundant and exploitable with a high ratio of energy return on energy invested (EROI). Unfortunately most of the data kept on costs of oil and gas operations are in monetary, not energy, terms. Fortunately we can convert monetary values into approximate energy values by deriving energy intensities for monetary transactions from those few nations that keep both sets of data. We provide a preliminary assessment of EROI for the world's most important fuels, oil and gas, based on time series of global production and estimates of energy inputs derived from monetary expenditures for all publicly traded oil and gas companies and estimates of energy intensities of those expenditures. We estimate that EROI at the wellhead was roughly 26:1 in 1992, increased to 35:1 in 1999, and then decreased to 18:1 in 2006. These trends imply that global supplies of petroleum available to do economic work are considerably less than estimates of gross reserves and that EROI is declining over time and with increased annual drilling levels. Our global estimates of EROI have a pattern similar to, but somewhat higher than, the United States, which has better data on energy costs but a more depleted resource base.

As the title of this article indicates, the authors estimate the energy return on investment (EROI) for global oil and gas "production." The first thing to note is that the calculation is actually for the EROI of global exploration, development, and production (commonly called E+P or "upstream") – a much more comprehensive estimate than just production. They estimate that the EROI of global oil and gas E+P in 2006 was roughly 18:1 (above figure). To establish these estimates the authors rely on three datasets: a) the Energy and Information Administration (EIA), and b) the British equivalent of the EIA, and 3) John S. Herold, Inc., a privately managed database consisting of data on total "upstream" costs (i.e. all costs up to the point the oil comes out of the ground) of publicly traded energy firms around the world.

The crux of their analysis depends on the conversion of money numbers into energy numbers. Since global energy costs are not maintained in energy units, but in economic units only, they derived an energy intensity value for each dollar spent in the energy industry. These numbers, derived independently for the energy industries within the U.S. and England, were about the same: roughly 20 MJ per dollar for both countries in 2005. The energy intensity numbers were multiplied by the estimates of money spent to get rough estimates of energy cost of energy production.

In addition to estimating the current upstream EROI of global oil and gas, they extrapolated three trends from their time-series estimates of EROI and show global EROI declining to 1:1 between either 2022 or sometime in the very distant future, with the best estimate being about three decades away. To do this, the authors forecast linearly the historic trend of global EROI, which is, as the authors acknowledge, a forecasting methodology fraught with problems. Nonetheless, the forecasts provide a thought-provoking view of what may happen if society continues along a "business as usual" path.

Linear extrapolations of historic EROI trends



The authors also attempt to answer the question “What are the reasons for the decline in EROI estimates, especially since 1999?” They offer two solutions: 1) technology is seemingly being outpaced by depletion, and/or 2) increasing the annual drilling rate decreases the drilling efficiency. The drilling intensity decreased during the early and mid 1990s when EROI was actually increasing, but has increased since 1999. This has led to a sharp decrease in drilling efficiency (barrels found/produced per well drilled). Their best guess is that both options are operational, a contention with which I am inclined to agree. Improved technology is increasingly used in E+P activities, including, of course, drilling. So the fact that the EROI of E+P has declined over the past 10 years indicates that easier-to-access resources, i.e. high EROI resources, are increasingly rare (if found at all), because even with increasing technology and drilling efforts, we are witnessing declining EROI.

Lastly, the authors address the major assumptions they have made while performing their analysis. This is a crucial step in most large numerical analyses and, unfortunately, one that is often overlooked. The assumptions are:

1) “changes in monetary expenditures indicate changes in energy expenditures.”
2) “energy intensities are the same the world over.”
3) “We assume a constant energy intensity in the US after 2002, and constant energy intensity in the UK prior to 1998 because there are no data available for those time periods.”

The second assumption is the most problematic from a scientific perspective because upstream costs vary widely from deep offshore, to tar sands, to shallow offshore, to onshore drilling. The application of energy intensity numbers, which are derived directly from cost data, from one area of the world to the rest of the world is potentially flawed. But in reality, this is a reflection of one of the conclusions the authors derive from their work, i.e. WE NEED MORE/BETTER DATA. The fact of the matter is that although the authors had access to three extensive data sets, two public and one private, they were still able to access data for only 40% of the world's oil production. Furthermore, many of the data sets that are unavailable to public scrutiny are the most important, i.e. that from Saudi Arabia, Russia, Iran, and every other Nationalized Oil Company.

Some interesting quotes from the manuscript:

> This [Herold] data base accounted for about 40% of the oil produced in the world in 2006.

> What is clear in the Herold data base is that the amount of oil and gas produced per dollar spent between 1999 and 2006 shows a decline. In 1999 the industry produced about one tenth of a barrel of oil equivalent (boe) per 2005 dollar spent globally in exploration, development and production. By 2006 that number had declined to approximately 50%.

> It is important to note that the data we used in this analysis group oil and natural gas production together, since they are commonly produced from the same reservoirs. However, the effort required to pump oil out of the ground is generally much greater than that required to bring natural gas to the surface. We therefore expect that the true EROI of oil is somewhat lower than our results suggest, while that of conventional natural gas is higher.