TRENDS IN COUNTRY AND GLOBAL ENERGY INDUSTRY OWN USE AND PRODUCTION BETWEEN 1960-2010

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Background

The concept of net energy has been around for decades and came into prominence after the first oil crisis in 1973. One common metric of net energy is “energy return on (energy) invested” (e.g., at the mine mouth, $EROI_{MM}$, also known as gross energy ratio (GER) (Hall et al., 1986). $EROI_{MM}$ is equal to energy extraction divided by the energy inputs required for that extraction. All things being equal, an energy resource with higher $EROI$ is more economical as $EROI$ and price are inversely related (King, 2010; King and Hall, 2011). Thus, tracking trends of $EROI$ over time provides insight as to whether energy is getting more or less costly (in terms of energy inputs) over time. Declining $EROI$ implies resource depletion is “winning” over gains in extraction technology and efficiency.

Further, studies of preindustrial societies imply that societies need to increase complexity to solve new problems, and that this complexity necessitates increased energy consumption (Tainter, 1988). Thus, $EROI$ is one metric for assessing if our energy supplies are capable of sustaining and increasing societal complexity.

Methods

Here we calculate the $EROI_{MM}$ of various countries and for production of two primary energy supplies: (i) crude oil plus natural gas liquids (NGL) and (ii) natural gas.

We use ‘energy industry own use’ (EIOU) data from the International Energy Agency (IEA) as an estimate of the direct energy consumed by the energy industry to produce energy, e.g. the consumption of oil or gas in order to produce the same. We do not yet include estimates of indirect energy inputs that represent embodied energy in capital (e.g., materials, services) and labor (e.g., salaries). Both direct and indirect energy represent substantial portions of inputs to fossil energy extraction (Guiflard et al., 2011).

Observations

- The total (world) average ratio value is around 10-20. 25 of the 36 total countries have values near to this, and 10 of the 16 countries with production values reaching more than 10^6 net TJ/yr do as well.

- Trends across countries vary between generally unchanged and volatile. Relevant selected profiles are noted in color to the left. Of note are the U.S. (almost flat) and Russia (volatile but decreasing): high production values do not preclude volatility in $EROI_{MM}$. The Netherlands, U.K., and a few other countries also display great volatility, but of a nature that seems to be primarily the result of earlier time periods of peaks in production coupled with lower EIOU.

- U.S. values for production and EIOU values dominate the world averages, which would otherwise collectively show a long-term trend towards more rapidly increasing values.

Discussion:

• Some ratio profiles are consistent with known price and $EROI$ information.
  1. Saudi Arabia’s (top right) high values are consistent with lower oil prices.
  2. The sharp drop in the US ratio value (bottom right) following 1980 could possibly correlate to increased drilling activity following the 1979 Oil Crisis. This trend is also consistent with the findings of Guiflard et al. (2011).

• Reported EIOU data for the US stop in 1996. The rising trend until then could possibly imply greater efficiencies in energy return as a result of higher investments in the 1970s.

• Overall, the long-term trend in ratio values shows a sharp decrease followed by a period of more slowly falling values. This pattern is consistent with Tainter’s (1988) suggestion of decreasing resource extraction efficiency.

References


Future Work

- Look at ratios for other primary sources of energy (electricity, coal, total energy, and the world).

- Compare these calculations to existing data for EROI and EIR. EIR is a proxy measure for EROI based on prices that similarly takes into account both direct and indirect energy inputs. These comparisons will help us understand how fast, or if, energy production (via EROI) is using more capital intensive inputs versus direct energy.