

The Decline of Global Energy Return on Energy Invested (EROI) and Its Economic Consequences

Topic: Input-Output Analysis-Modelling - ESP (2)

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As global energy demand continues to rise, evaluating the sustainability of energy production becomes increasingly important. The importance of energy to economic activity and human well-being, together with the concerns about the sustainability of energy production, has prompted the United Nations to include the provision of clean, affordable and modern energy for all people as one of the Sustainable Development Goals for 2030 \citep{ungeneralassembly_transforming_2015}. This recognises the fundamental importance of sustainable production and use of energy.

This study investigates the impacts of rising energy consumption within the energy sector on the global economy. We use data from national input-output tables to calculate Energy Return on Investment (EROI) indicators for 76 countries using an expenditure-based approach, as well as for the world as a whole, covering the period from 1995 to 2020. In principle, the EROI is measured by dividing energy output by energy input:

$$\text{EROI} = E_{\text{out}}/E_{\text{in}}$$

This raises the question of what exactly should be included in E_{out} and what should be included in E_{in} , that is, what should be considered the boundaries of the energy system. The framework presented by \cite{hall_eroi_2014} divides EROI into the four categories and this paper uses the definition of societal EROI, which considers all the gains and costs of energy within a society. For the purposes of comparing EROI between countries and analysing the economic impacts on the global economy, societal EROI is the most adequate measure, as it is the most comprehensive and inclusive notion.

These findings reveal that EROI distribution follows a power law: while most countries exhibit low EROI values, only a small number of well-endowed countries exhibit a high EROI. The global EROI decreased at an annual rate of 1.6% over the period 1995 to 2020. If this trend continues, the energy sector would need to expand by nearly 24% by 2050 to satisfy the same final demand as in 2020, whereas global all-sector production would need to increase by 2.6%. This suggests that a declining EROI could be a considerable drag on global economic growth in the coming decades. On the other hand, global EROI actually increased in the period from 2012 to 2020, likely due to the declining costs and expanding deployment of renewable energy, although it remains uncertain whether this marks a permanent reversal of the long-term downward trend.

Thus, national EROI was calculated for 76 nations from 1995 to 2020, based on expenditure data from the OECD input-output tables, and the results indicate that the large majority of countries have a societal EROI between 1 and 3. These numbers are low compared to previous studies, but this result is attributed to the fact that the EROI measure used in this study exhaustively includes direct and indirect inputs to energy production in an infinite regression throughout the economy, and is therefore a more comprehensive measure than those commonly reported in other studies. A handful of countries were found to have an EROI below 1.

Although some earlier studies attach great importance to this particular EROI level, this threshold is not considered to have additional significance. Only a small number of countries were found to have a national EROI above 5, generally nations rich in resources such as oil or with geographical

advantages for renewable energy sources such as hydroelectric. As such, the EROI distribution appears to follow a power law.

EROI in most nations has been decreasing throughout the period, with particularly notable decreases in large oil producers such as Saudi Arabia and Nigeria, and in Europe and China, which together represent a large share of the global economy. Therefore, the decrease in energy efficiency implied by these results has serious implications for the energy sector and the global economy.

References

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