Energy Return on Energy Invested and Net Energy

By Jim MacInnes
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Most of us are familiar with the concept of return on investment (ROI) for financial assets, such as in a 401k, etc. We begin by investing a certain amount of money and over time, hopefully, we'll end up with an even greater amount.

This same idea with can be used when investing energy. That is, how much energy, not money, must be invested in order to develop even more energy-producing assets.

For example, in the very early years of oil field development we could invest one barrel worth of oil (energy) in order to develop an oil field that might produce say….100 barrels during this oil field's lifetime. In this case, the Energy Return on Energy Invested (EROEI or simply EROI) can be computed as shown below.

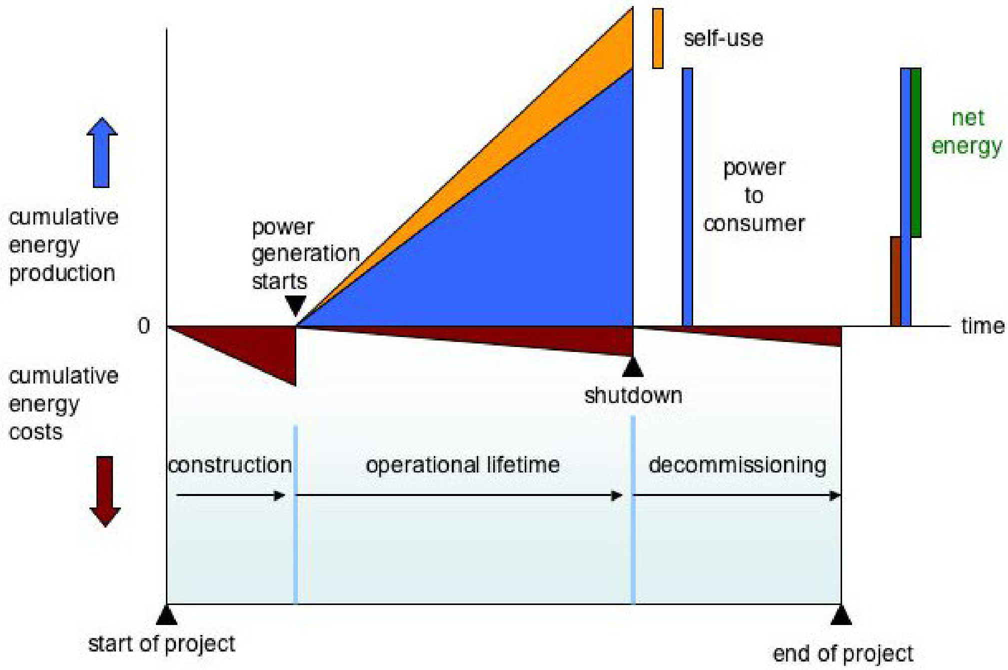
$$\text{EROI} = \frac{\text{Energy Returned to Society}}{\text{Energy Required to get that Energy}} = \frac{\text{100 barrels of oil}}{\text{1 barrel of oil}} = 100$$

Another way to look at this is to compute the Net Energy. That is, the Energy Returned to Society less the Energy Required to get that Energy.

Net Energy = 100 barrels of oil - 1 barrel of oil = 99 barrels of oil

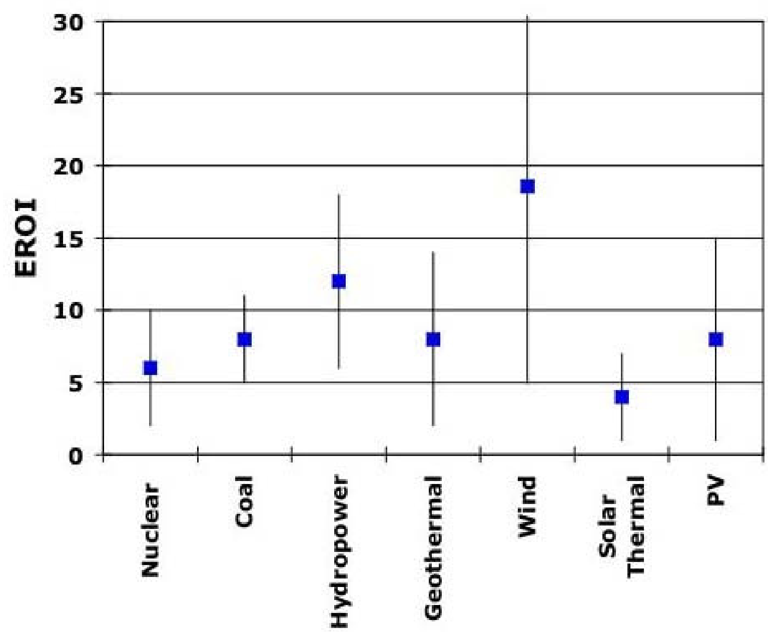
These are important concepts that can be applied to many different types of energy supplies from biodiesel to oil and gas wells to wind turbines.

The diagram below shows how this works when building, operating, and decommissioning a power plant. We start with the energy required during construction, move on to the energy consumed during its lifetime of operation called 'self use', and conclude with the energy needed to decommission the plant at the end of its useful life. These are all energy outflows. On the positive side, energy produced by the plant over its lifetime is shown as 'power to consumer.' The cumulative energy production divided by the cumulative energy expenditures is the EROI. The Net Energy is the cumulative energy production less the cumulative energy costs.



EROI and Net Energy diagram for building, operating and decommissioning a power-generating project. Reprinted with the permission of Dr. Ida Kubiszewski and Dr. Cutler J. Cleveland, The Encyclopedia of Earth.

The diagram below shows the EROI's for various electric power generators. Here are the EROI's for several other energy sources such as: oil and gas at 11–18 to 1; corn based ethanol at 0.8 –1.6 to 1; and, biodiesel at 1-3 to 1.



EROI of various electric power generators. Reprinted with the permission of Dr. Ida Kubiszewski and Dr. Cutler J. Cleveland, The Encyclopedia of Earth.

The EROI of fossil fuel extraction has shown a long-term history of decline. This is because when developing fossil fuel resources the large, easy-to-develop reserves are extracted first, in line with the 'best first' economic principle. As these fuels are consumed, it takes more and more energy to extract remaining reserves and, the EROI and Net Energy decline in accordance with the law of diminishing returns. Those diminishing returns place physical limits on the percentage of natural resources that are ultimately economically recoverable. After all, would it ever make sense to consume one existing barrel of oil in order to develop a new one?

Energy conservation and efficiency measures are necessary to help address our energy needs, but they are not sufficient. We must still consume 'energy' to do 'work' as dictated by the laws of thermodynamics. We will be discussing this in our next report.

Jim MacInnes has worked as a power engineer for the company that designed and construction managed the Ludington Pumped Storage facility. He is a licensed professional engineer in Michigan, a member of the IEEE Power and Energy Society and the International Society for Ecological Economics. He served on the Great Lakes Offshore Wind Council and was named as a Michigan Green Leader by the Detroit Free Press. He holds BSEE and MBA degrees from the University of California.