



To **Collect**, **Transform** and **Distribute** a resource takes developing a whole system and operating its processes. Energy return on energy invested, $EROI = ER/EI = \beta$, compares outputs to inputs of matching energy quality. If the energy output is only compared only to the direct energy input the comparison is valid if all their other energy costs and impacts are the same. The total ROI for any physical production process, includes all the embodied resource costs of developing, maintaining, operating and financing it too.

In a steady state system without impacts the investments equal the costs, $EI_1 = SL_1 + PL_1$ and the inputs equal the product plus losses $EP_n = EP_{n+1} + EL_{n+1}$. The diagram is intended to represent flows as combining all factors having embodied energy, material and financial impacts.

The timeline symbols refer to the input of venture capital (EV) and the development and aging of resources and techniques. Real investments tend to be made to initiate and stimulate the venture (EV) and returns ($ER_0 < ER_1$) by self-investment in the operations (EO) providing financial returns (EF). The usual objective is to develop an optimal level of ER to minimize other costs and accumulate enough financial return to do it again when resources are depleted or the system is outmoded. That “use it and move on” model of the hunter-gatherer method is itself becoming outmoded, of course, and finding a way to operate successions of technologies in a sustainable way is one of the reasons for looking at the details of whole systems and their whole resource investment life cycles.

When ER declines over time the diminishing returns can be reversed with increasingly costly technology. That may hide the change in the environmental responsiveness (ρ) corrected for constant technology quality. In practice that may be most conveniently estimated using the embodied and direct energy costs of the technology as a measure of quality, and compared to the resource returned, ignoring the profits. The idea is to isolate the physical performance of the resource and the physical performance of different technologies relative to each other, to consider their sustainability independent of the profits generated, which may be quite variable and distort the apparent sustainability of the long term investment strategy.