Down to the Bottom Line: Energy

When we hear the well-known phrase that the fittest survive, we usually think of claws, teeth, beaks, and so on in connection with adaptation to specific niches in nature. In addition to that a general concept of fitness would include mental attributes including our insight. An important insight today is to improve our understanding of energy, and this brings us down to the bottom line, i.e. to energy.

Energy is the ability to do work; it is found everywhere, in radiation, matter and life, and all living entities - be they individuals, species or nations - they all attempt to incorporate more energy into their own system. However as the environment changes constantly, adaptations also must change, to sharpen or re-adapt our ability to retain access to energy flows and to do so more effectively than competitors. Only on this basis can the fittest survive.

Although conditions change, the earth, with a steady supply of solar energy, tends to maintain overall homeostasis, and any kind of living entity consuming more energy than nature can provide sustainably challenges the steady state. Even if it can do so only for a short time, it puts itself in debt to nature. As debt-collector nature operates with both negative and positive feedbacks. In this case positive and negative do not mean good or bad but rather processes that respectively reinforce or dampen an activity. Negative feedbacks restore an energetic equilibrium, for example when abundant wild herbivores graze a field on a savannah and the yearly drought comes, the growth of the grass stops and the herbivores move to other grounds, where there is fresh grass. Next year, when they come back to the first field, energetic equilibrium is restored and a new yield of grass is waiting.

Let's assume the field is fenced in and grazed by cattle, which are managed by people. If the cattle are plentiful, they may graze the grass down to the roots when the drought of the year comes. That will start erosion, and if there is no pause in the grazing, more soil will erode, and the more erosion the less soil for the roots, and thus lesser roots and more erosion, until the field becomes as barren as a desert. This exemplifies positive feedback, which means that a system moves further and further away from its original (in this case steady) state; this takes place, if the influence of negative feedback is prevented, which in this case is done by unbroken grazing. If the cattle are not moved, they will die, and by this imagined example we see the necessity of negative feedback to maintain the stability of a system.

During cultural evolution, humans have found ways to stop many natural negative feedbacks and the paying of energy debts. Instead the debt has been allowed to pile up in the direction of enormous threatening positive feedback, which humans roll before them like an ever-growing snowball. By weapons and tools, humans began already during the Paleolithic to improve and empower technology to increase their net energy profit, and thus they could expand their habitat and finally migrate to all continents. Given losses to predation, famine and other checks, by spear and tools they still managed to gain energy surpluses, and to expand their species' range. By the spear and other tools and finally agriculture, humans pushed back against various earlier negative feedbacks and postponed the pay back. As exemplified by this exercise such a system can be maintained only as long as there is an expanding resource base of energy; if that fails, negative feedback catches up in the direction of re-establishing the former steady state. Indeed, humans' continuous success in forcing various ecosystems to yield ever more and more to raise their net energy surplus, is a key to viewing the humans' path through history. In modern times, the process has added soil loss, depletion of the best fossil fuels and the dumping of waste products, such as CO_2, into the atmosphere and biosphere to the debt. In today's world the question is not "do we have to pay back the borrowed energy surplus?" but "shall we do it voluntarily or be forced to?"

In order to run society we currently use both nonrenewable and renewable energy. Both kinds are limited relative to expanding human needs. The nonrenewables (coal, oil, gas and uranium) come from geological layers; these are gradually emptied and cannot be refilled. As they approach serious depletion, it seems apparent that the lack of precaution will quite likely cause destitution of a scale never before experienced by humanity. The fossil fuels have allowed human numbers and aspirations to be built up, but the flip side is their depletion pulls the rug out from under what we have come to expect and rely upon. Modern myth tells modern humans, including modern politicians, that the grandeur of our technology will no doubt come up with some fix. Why? Because it is in this myth that the future appears bright, and no human wants to contemplate the opposite. However, most of our technical fixes of the past, such as making fertilizers to replace lost soil nutrients, have come from petroleum, which appears to be a one shot deal, and global production, which has recently peaked and began a decline, seems unlikely to be reversed.

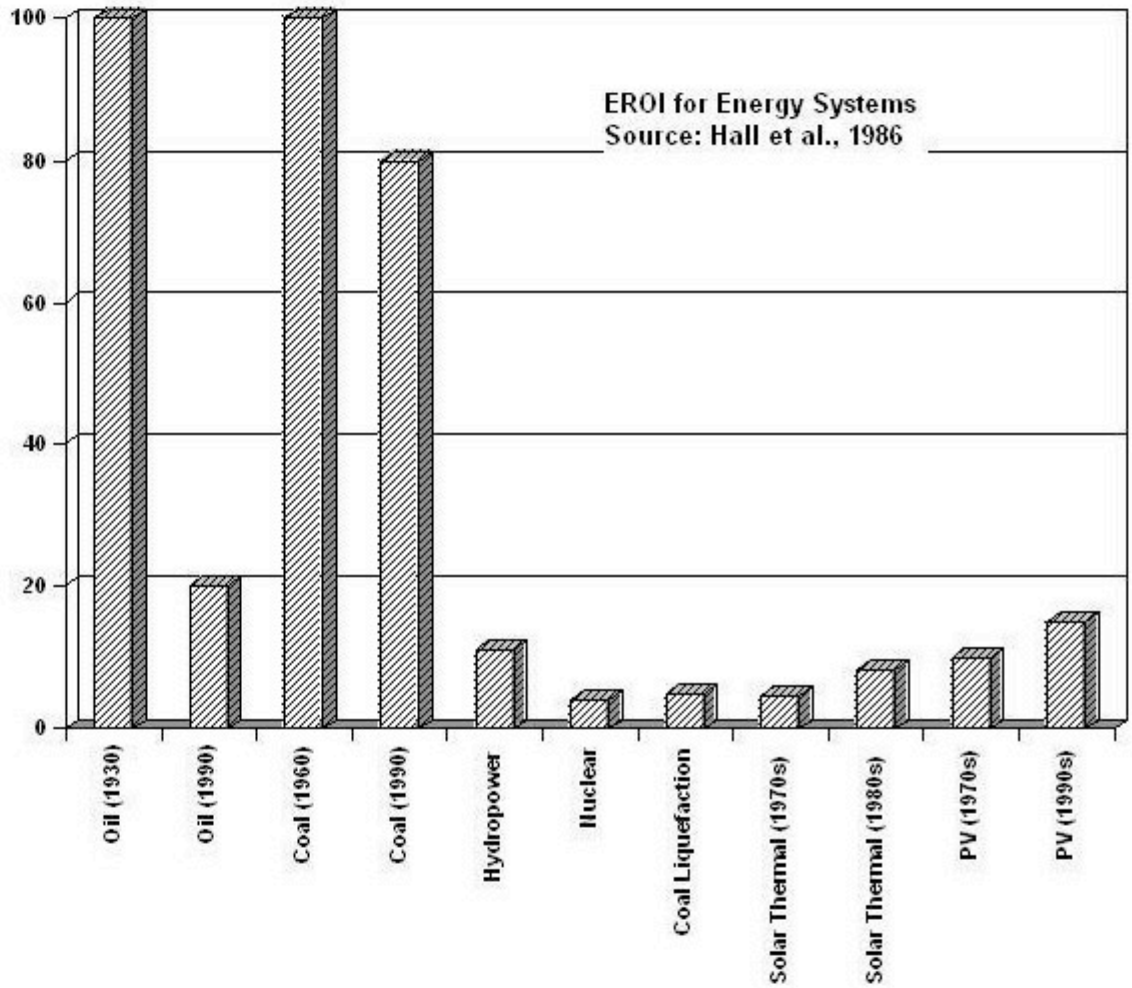
Renewable energy results from solar energy being captured on the surface of earth by: biomass, wind, water motion and sunlight. All these can, alone or in combinations, form renewable energy systems. They are of course the resources that allowed our ancestors to survive. However, the notation 'renewable' easily, but misleadingly, conveys a sense of easy and infinite availability. Biomass depends on earth's biocapacity, which is flexible, depending on man's use of nature, but also limited, since photosynthesis has limits. Due to overexploitation of the biosphere, the biocapacity of Earth is now decreasing, and the most alarming thing in this is that politicians do not discuss it.

Some other renewable energy sources, such as hydropower, are also limited, but others are abundant, like sunlight and wind. Unfortunately, those that are abundant are also diffuse and irregular. Thus, abundance does not grant ready and easy availability.

A good way to assess the availability of both nonrenewables and renewables in conceivable and quantifiable mathematical terms, is the concept of EROI, energy return on investment. EROI renders an accounting of how much energy we get after having invested energy to extract it and is calculated by the following equation:

$$\text{EROI} = \frac{\text{Energy returned to society}}{\text{Energy required to get that energy}}$$

To simplify the interpretation of the equation we assume that the numerator and denominator stem from the same source. The ratio can then be expressed as "30 barrels of oil returned from one barrel used to get it". The balloon graph describes the situation in the USA, a fair representation of the world too, because of the complex interdependency of the global economy. The EROI for world oil declined from 30:1 to 20:1 during the first years of the 2000s. For the USA it was about half of that.



As the diagram shows it took only one barrel of oil in the 1930s in the US to get 100 barrels. In the 1970s the situation was different; then it took one barrel to get about 30 barrels, and by 2000 when it took one barrel to get around 14 barrels. So the extraction of oil demands more and more investment of energy as time goes by even with all the technical improvements. Still, the total use of energy increases over time. In 2005, the USA used more energy than the total of all photosynthesis within its borders.

All balloons in the diagram representing renewables have low EROI. Solar energy has surprisingly low EROI, and that is not because there isn't plenty of sunlight, but because there is no known good way to get it cheaply, so there is no large-scale economy based on its availability. It costs too much to get it, especially when needed storage is included.

In real economies, energy comes from many sources. The situation is complex, which is exemplified by the subsidization of bio-fuels: some studies indicate that there is more fossil energy used to produce one litre of the biofuel ethanol than is contained in it, and no studies show that the ratio is as high as even two for one. The inconvenient truth is that most energy extraction, delivery and use are today subsidized by fossil fuels. Thus the situation will be very difficult as the high quality fossil fuels run out. But modern humans, as a part of modern myth, use these valuable fossil fuels as if there was nothing to worry about, and do not appear to see the big changes waiting just ahead. This brings us back to the question about paying back our energy debt to nature, i.e. the transition to a low scale society, "shall we do it voluntarily or be forced to?" If our politicians do not take precaution, the transition will be forced upon us by human calamities never experienced on a worldwide scale before. One most natural precaution ought to be a large-scale thriftiness in our use of nonrenewable energies.

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