Net Energy/Full Cost Accounting: A Framework for Evaluating Energy Options and Climate Change Strategies

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The evaluation of energy options is fraught with confusion, partly because strictly market-based evaluations are not comprehensive enough to capture the full range of costs and benefits of alternatives. A more appropriate framework for evaluating energy options involves estimating the "net energy" or "energy return on investment (EROI)" of each option (Cleveland et al. 1984). Figure 1 defines EROI, net energy, and the related concepts of energy capture efficiency and energy payback time. A potential source of energy whose energy cost of production exceeds the energy yield has a negative net energy (an EROI less than 1) and is therefore not a source of energy at all. For example, the discovery of large oil fields in the early decades of the 20th century sustained an EROI of 25:1 into the 1970's, a net yield capable of fueling the rapid economic growth of the 20th century (Cleveland, 2005). On the other hand, the EROI of ethanol from corn is in the range of 0.8 to 1.2, barely a real source of energy at all (Patzek 2004, Farrell et al. 2006).

A key consideration in this framework is estimating all the (direct plus indirect) energy costs (labeled "B" in figure 1) and including them in the calculation. Many of these costs are external to the market system. For example, current fossil fuel production entails huge external costs and "perverse subsidies" (Myers and Kent 2001), including impacts on the global climate. Mountaintop removal for coal mining has significant environmental and social costs external to the market, including massive pollution and loss of valuable ecosystem services like water supply, recreation, and carbon sequestration. While these costs are (and will continue to be) difficult to estimate, significant progress has been made in recent years in identifying and estimating them in both monetary and energy terms (Costanza et al. 1997). Adequate inclusion of these external costs lowers the EROI of fossil fuels significantly.

The most likely energy future entails a peaking of world oil production in the near future and shifts to alternative fuels. Societal decisions about which alternative fuels to invest in are critical to both our continued economic prosperity and improved stewardship of the Earth's natural capital. It is essential that we account for the full costs of these alternatives and make the market send more accurate signals about the choices facing us. To do this in a way that leads to real progress requires comprehensive, full cost accounting, and a comprehensive evaluation of the EROI of energy alternatives. Our ability to do this accounting has been steadily improving, but significant progress still needs to be made. This will require a commitment at the national scale to the framework and an investment in the necessary research and analysis. The benefits of applying this framework will also be significant. It would save trillions in bad investments in energy technologies that are not real energy sources at all, but which appear to be viable due to hidden external costs, subsidies, and other forms of political support. It would also make clear the real costs and benefits of actions to control climate change and help guide our economy to a more sustainable and desirable future.

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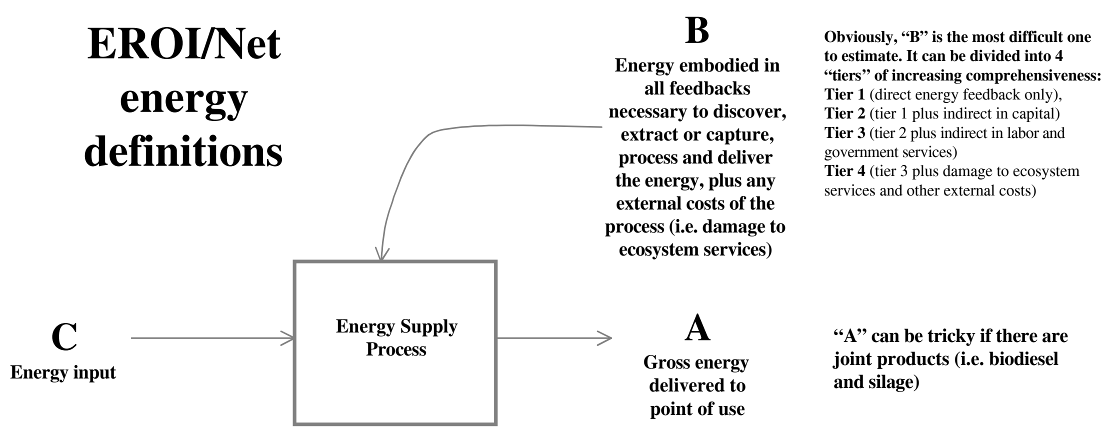

With A, B, and C all converted to energy of the same quality:

Energy Return on Investment (EROI) = A/B
Net Energy = A - B
Energy Capture Efficiency = A/(B+C)
Energy Payback Time = time for flow of A to equal lump sum of B

Figure 1. Definitions of EROI, Net Energy, Energy Capture Efficiency, and Energy Payback Time.