The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

EROEI Short #1: Boundaries & Calculations

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This is the first in a series of short articles that strive to continue the ongoing discussion here on the concept of Energy Return on Energy Invested.

Energy Return on Energy Invested (EROEI)* is a problematic concept. As Cutler J. Cleveland has noted, "It is impossible to precisely identify and quantify all those factors [that contribute to the energy input to energy production], or to unequivocally categorize them as either physical or economic factors." [1] Despite this difficulty in calculation, the importance of the figure is clear: it is axiomatic that if EROEI is less than 1—that is, if it takes more energy input than the produced energy output—then substantial reliance on that form of energy is not a valid foundation for modern civilization.

** I have chosen the term "Energy Return on Energy Invested" over its analogs "Energy Return on Investment" (EROI) and "Net Energy" (which is equal to EROEI – 1). The terms are interchangeable (with the noted adjustment for "Net Energy"). My rationale is that EROEI explicitly spells out what it stands for better than the other two terms—EROI risks confusion with financial return on investment, and Net Energy is similarly not self-explanatory. That said, the intent of this disclaimer is this: the terms are essentially interchangeable, so use whichever you prefer, I don't claim that one (let a lone the one that I have chosen) is the only correct term . . . let's avoid arguing over terminology and discuss the concept.*

The principle difficulty in calculating EROEI is the desire to define a boundary of energy inputs that will be included in calculations. At one extreme, only the direct energy inputs to energy production may be considered—e.g., the energy required to lift oil from its reservoir to the surface. This approach has the clear advantage that the considered energy inputs are finite and readily quantifiable. The downside is an EROEI figure that fails to accurately represent the actual energy surplus or deficit of process. On the other extreme, the string of energy inputs can be regressed infinitely: e.g., the energy to grind the rice to feed the farmer to raise the chickens to feed the merchant captain who piloted the ship that transported the molybdenum used in the manufacture of the oil rig is a necessary prerequisite to producing the resulting oil! While this infinite regression approach (of which the above example is only a simple example) theoretically captures the true energy inputs for accurate EROEI calculation, it is also clearly impossible to quantify.

Howard Odum attempted to address this problem with his attempt to calculate "Emergy" (embodied energy), originally intended to address ecosystems, but also applicable to human society and economies. [2] While attempts to implement the emergy methodology to produce an

empirical figure have met with some success in balancing the need to incorporate energy inputs with the need to limit those inputs within quantifiable boundaries, confusion continues in the specific methodology of emergy. [3] While at one point there was an effort to create an ISO standardized methodology for emergy accounting by the London Group on Environmental Accounting, this effort seems to have failed. [4] Despite the assertion that emergy provides a global, standardized means to account for energy inputs, and therefore to calculate an accurate value for EROEI, no such standard has emerged. [5] Ultimately, this failure of a methodology to practically AND accurately account for energy inputs is testament to the fundamental tension between the demands of infinite regression of energy inputs and the need to limit accounted energy inputs to within a practicable boundary.

A standardized, yet accurate and implementable method of calculating and comparing the EROEI of energy sources is critical to our energy future—understanding Peak Oil, evaluating alternatives to oil, and proposing viable policy measures all depend on at least some resolution of this issue. Where (if anywhere) can we draw the line, beyond which energy inputs don't need to be counted? Can we effectively use proxies to model the totality of energy inputs without actually counting all of them individually? The next two installments in this series of short articles on EROEI will address those issues.

[1] http://www.eoearth.org/article/Energy_return_on_investment_(EROI
[2] http://en.wikipedia.org/wiki/Emergy
[3] Id.
[4] http://www.energybulletin.net/6224.html; search of the LGEA website and the broader internet failed to unearth an ISO standard for emergy accounting.
[5] http://en.wikipedia.org/wiki/Emergy#Emergy_accounting_and_emergy_.22anal... ("However because emergy involves the combination of heterogeneous energy forms, D.M.Scienceman now only refers to Emergy Synthesis, preferring to see the notion of "emergy analysis" as an oxymoron")