

energy is unavoidable, but only that which is not consumed to produce energy is available to sustain our industrial, transport, residential, commercial, agricultural, and military activities. The ratio of the amount of energy we put into energy production and the amount of energy we produce is called “energy return on investment” (EROI).¹⁰

This concept differs from “conversion efficiency,” which compares the amount of energy provided as a feedstock to a conversion process

(such as an electric power plant or petroleum refinery) with the amount remaining after conversion. Physics dictates that this figure is always less than 100 percent. In contrast, EROI can be very high (e.g., 100:1, or 100 units of energy produced for every 1 unit used to produce it—an “energy source”) or low (0.8:1, or only 0.8 unit of energy produced for every 1 unit used in production—an “energy sink”). Society requires energy sources, not energy sinks, and the magnitude of

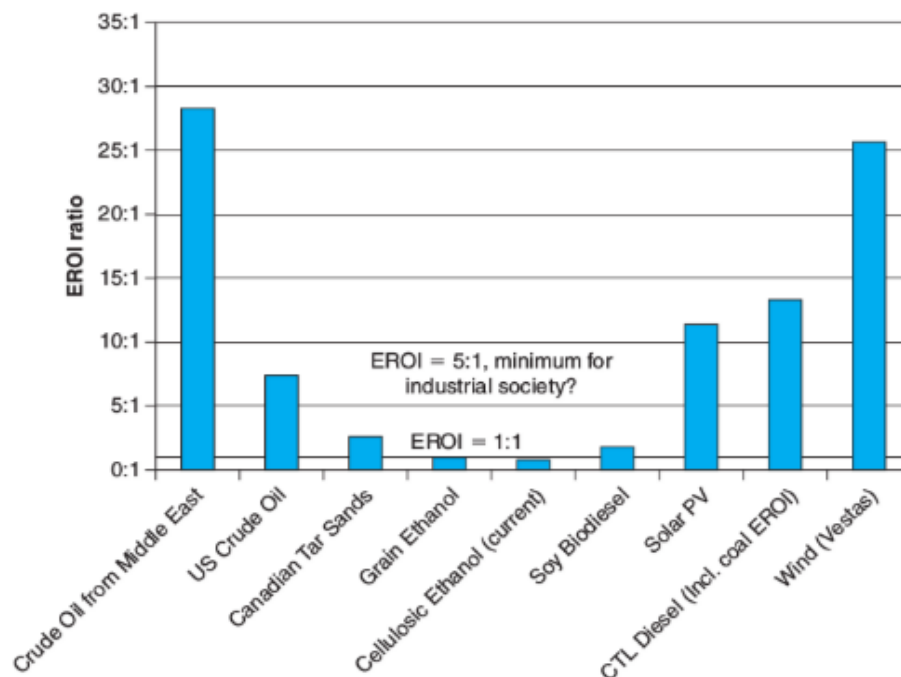


FIGURE 3 Estimated EROI of selected alternatives.

Note: EROI measurements are not standardized; the shading indicates ranges from various studies. PV = photovoltaic; CTL = coal-to-liquids; Vestas = Vestas Wind Systems.

Sources: P. J. Meier and G. L. Kulcinski, *Life-Cycle Energy Requirements and Greenhouse Gas Emissions for Building-Integrated Photovoltaic*, Fusion Technology Institute (2002); National Renewable Energy Laboratory, *What Is the Energy Payback for PV?* DOE/GO-102004-1847 (2004); Vasilis Pthenakis and Erik Alsema, “Photovoltaics Energy Payback Times, Greenhouse Gas Emissions and External Costs,” *Progress in Photovoltaics* 14, no. 3 (May 2006), 275–280; Luc Gagnon, “Civilisation and Energy Payback,” *Energy Policy* 36, no. 9 (September 2008), 3317–3322; Cutler Cleveland, “Net Energy from the Extraction of Oil and Gas in the United States, 1954–1997,” *Energy* 30 (2005), 769–782; Charles A. S. Hall et al., “Peak Oil, EROI, Investments and the Economy in an Uncertain Future,” in *Biofuels, Solar and Wind as Renewable Energy Systems*, David Pimentel, ed. (Springer Science, 2008); Vestas Wind Systems, *Life Cycle Assessment of Offshore and Onshore Sited Wind Power Plants Based on Vestas V90-3.0 MW Turbines* (Denmark, 2005); Alexander E. Farrell et al., “Ethanol Can Contribute to Energy and Environmental Goals,” *Science* 311 (January 27, 2006).