The Cloudy Calculation of Energy Return Ratio

Lack of standards means the answer isn't always clear.

BY CHARLES BERTUCH, P.E.

Energy Return Ratio, the energy output of a device divided by the energy input required to manufacture it, is often used as an argument for or against alternative energy technologies and fuels. While on the surface it makes sense not to expend excess resources in the name of conservation, it turns out that methods of ERR calculation vary widely, and different researchers often reach different conclusions on the subject.

Some have taken the position that ERR is the key factor when comparing the societal or economic benefits of alternative energy-generating technologies or fuels. The July 2011 issue of *PE* magazine included an article that referenced the ERR for photovoltaic panels as less than 1.0. If more energy is required to manufacture a generating device than it will produce over its lifetime, is it actually reducing our dependence on conventional electricity generation?

When calculating ERR, determining the energy content of a product is relatively straightforward. Standards have been established defining the physical properties, including BTU content, of most fuels. Similarly, there are standardized test methods to rate the generation capacity of PV panels, wind turbines, and other devices. There are discrepancies, however, in ways to determine the energy required to manufacture a fuel or device. Fuel ethanol and PV panels provide two illustrative examples.

Many passenger automobiles are capable of burning blends of up to 85% ethanol (E85) and gasoline. The primary method of ethanol production is the fermentation of corn, although other feedstock such as switchgrass and sugar cane can be utilized. The development of ethanol as a transportation fuel has received government subsidies based on its potential as an alternative to traditional fossil fuels.

There are a number of research projects that examined the ERR of corn-based ethanol production. A 2004 study by the Department of Agriculture calculated an ERR of 1.67, which basically means that a gallon of ethanol provides 167% of the energy put into its manufacture. This is in sharp contrast to a 2003 study by Cornell University that calculated an ERR of 0.71, which concluded that "29% more energy is used to produce a gallon of ethanol than the energy in a gallon of ethanol." Both studies took into account fuels used to farm, energy needed to produce fertilizer and pesticides, average farm electricity use, and the energy needed to convert corn to ethanol. The Cornell study, however, included factors such as the annual personal fuel consumption of farm laborers (2.5 hours of labor per acre, with an average person using 8,100 liters of oil equivalents per year); energy used in the manufacture of the concrete used to construct ethanol refineries; and the energy used to manufacture stainless steel tanks and piping in refineries.

Dramatic differences are also noted in calculations of the ERR for photovoltaic solar panels. The PV industry receives significant government subsidies such as rebate programs and tax credits.

Although energy conservation projects such as PV installations are typically evaluated based on payback or life cycle cost analysis, there are few explicit analyses of PV ERR. The State University of New York College of Environmental Science and Forestry published a literature review that concluded ERRs for commercially available PV systems range between 3.75 and 10. A study by the CleanEnergy Action Project showed an average PV ERR of 6.6 (depending on available sunlight at the point of use). The 2006 study by the International Energy Agency cited ERR figures for PV systems ranging between 8 and 17.9, based on projected electricity production and the energy required for PV manufacturing, installing, and dismantling.

Different findings point to a lack of clear standards in assessment of ERR. If the energy used to manufacture the steel that is used to build an ethanol refinery is considered, should the fuel used to drive the foundry worker to the steel mill also be included? The energy to manufacture the car the foundry worker drives? There needs to be recognition that a society must consume resources to perpetuate itself, but where to draw that line can be subject to bias of the researcher.

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Criteria other than ERR should be used when evaluating the inherent value of products intended as alternatives to traditional fuels and generating technologies. Economic benefits of proposed projects may still be positive, regardless of their ERR. Societal benefits, such as reduced pollution, limiting our dependence on overseas oil supplies, or support of local agriculture and industry are also relevant when considering whether government support is warranted.

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