

## Thinking Clearly about Biofuels: Ending the Silly “Net Energy” Controversy

The age of petroleum is ending. If we are to make sound choices about our energy future, we will have to think clearly and carefully. The silly “net energy” argument revolving around fuel ethanol offers a textbook example of how not to think about alternative fuels. For over 25 years a small but vocal group of critics has argued that ethanol from corn has a negative net energy. Simply stated, they argue that more fossil energy (defined as petroleum, coal and natural gas) is used to produce ethanol than is delivered when ethanol is burned. Their viewpoint has been widely disseminated and is a major perceived drawback to ethanol. Net energy analysis is simple and has great intuitive appeal. It is also dead wrong and dangerously misleading. Here is why.

The critics’ most recent paper<sup>1</sup> concludes that corn ethanol has a -29% net energy. Net energy is defined as ethanol’s heating value (a fixed, known quantity) minus the fossil energy inputs required to produce the ethanol. For accounting convenience, the authors add up all fossil energy inputs as equivalent: one megajoule (MJ) of coal equals one MJ of petroleum equals one MJ of natural gas. This is the fundamental premise of net energy and it is completely wrong. All MJ are not created equal and cannot be added in this way. If all MJ were equal, then energy markets would reflect that fact. But the energy markets do no such thing. At current energy prices, a MJ of natural gas is worth about 3.5 times a MJ of coal, and a MJ of petroleum is worth more than five times a MJ of coal. Clearly, all MJ are not created equal.

These market realities reflect another underlying, fundamental reality: we do not value energy *per se* but rather the services or “qualities” that the energy provides. For example, the energy in coal cannot directly light our homes. Coal must be converted to electricity in a power plant in order to provide many desired energy services. About 1 MJ of electricity is produced for every 3 MJ of coal burned. The “net energy” of electricity is therefore electricity energy out minus the coal energy used, approximately -200%, much worse than the corresponding figure for ethanol. Are we going to turn off the lights because electricity has a terribly negative net energy? The logic of the “net energy” argument would say “Yes!”.

Thus the underlying premise of the net energy argument is wrong. The “net energy” metric is mistaken at the very core—not at its margins. Different energy carriers cannot be compared on straight energy basis. In the real world, the different “qualities” of different energy carriers must be considered. Apples are good for making apple juice; apples are not good for making orange juice. Petroleum is uniquely suited for making liquid fuels; neither coal nor natural gas are nearly so well-suited to make liquid fuels. Thus it is silly, misleading and even dangerous as a public policy guide to use net energy to compare liquid fuel alternatives.

Comparisons of alternatives are central to science and sound policy decisions, but unfortunately the net energy advocates have never published a single comparison of

ethanol with other liquid fuels. It is not difficult to do such calculations. Using precisely the same net energy methodology and assumptions of the ethanol critics, one quickly finds that gasoline has a net energy that is less than -45%. Thus ethanol is actually superior to gasoline in its (I repeat: irrelevant) net energy metric.

So are there better metrics than net energy to compare alternative fuels? There is room for discussion on this issue, but two complementary metrics suggest themselves. First, alternative fuels (eg, ethanol) can be rated on their ability to displace petroleum, our most pressing *energy security* policy issue. One barrel of oil yields approximately 0.85 barrels of liquid fuels (gasoline, diesel, etc) when refined. It also requires about 0.1 additional “barrels of oil equivalent” in the form of both coal and natural gas to discover, produce, refine and distribute gasoline and diesel, etc. In contrast, one barrel of petroleum “invested” to produce corn ethanol will give us about 20 barrels of liquid fuel on an equivalent energy basis—greatly extending supplies of petroleum. Cellulosic ethanol has similar numbers and these values will improve as technology improves.

Second, ethanol could be rated on the total greenhouse gases produced per km driven, our most pressing *climate security* policy issue. Corn ethanol currently achieves modest greenhouse gas reductions, but new technologies in the field and biorefinery operations are reducing greenhouse gas emissions. Cellulosic ethanol will reduce the life cycle greenhouse gas emissions per km driven by over eightfold compared to gasoline—a huge improvement.

So what have we learned? If we are to make wise decisions as we embark on this brave new world of alternative fuels, we will need to carefully choose our metrics of comparison. We want attractively priced alternative fuels that will reduce total petroleum use and also provide environmental improvements versus gasoline and diesel. These are appropriate metrics for biofuels and other alternatives. Useless, misleading and dangerous metrics such as net energy must be eliminated from our discourse on fuel alternatives.

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1. David Pimentel and Tad W. Patzek *Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower* Natural Resources Research Vol. 14, No. 1 (2005) pg. 65-76.