Ethanol: Less Than Meets the Eye

by Howard Hayden

Biomass is one of exactly two major contributors to renewable energy, the other being hydropower. But producing biomass for energy production is mostly not a very productive use of land. Moreover, there has been an ongoing dispute. On one side are Pimentel (Cornell) and collaborator Patzek (Berkeley) who say that ethanol (EtOH) production is energy-negative, and on the other is Shapouri (USDA) who says that EtOH production is energy-positive by some 24 percent.

Therefore, I was startled to read a quotation from a just-published paper in *Séance* [*Science*] by Farrell *et al.* "Our best point estimate for average performance today is that corn ethanol reduces petroleum use by about 95 percent on an energetic basis and reduces GHG [greenhouse gas] emissions only moderately, by about 13 percent."[1]

To replace gasoline with ethanol would require planting corn over 51 percent of the total U.S. land area.

At first brush, this comment seems to contradict *both* sides of the dispute. Upon further look, it says very little. The problem boils down to this: How is one to allocate all of the energy inputs and energy outputs associated with EtOH production? For example, how about the energy used in producing fertilizer, the energy used in delivering the fertilizer, and the energy used to feed the farmers doing the work? How about the energy that remains in the by-products used for animal feed, and the energy inputs they displace? Farrell *et al.* say of this latter topic:

"The studies that correctly accounted for this displacement effect reported that ethanol and coproducts manufactured from corn yielded a positive net energy of about 4 MJ/l to 9 MJ/l."[1]

The heat content of a liter of EtOH is 25 MJ, so they are saying that the net positive energy is something between 16 percent and 36 percent of the total. The arithmetic is grade-school level, but the decision-making about energy allocation is always dicey and always contestable.

Basically, Farrell *et al.* just wrote a computer program to do the elementary arithmetic. They took no data, made no measurements. All they did was to look at the analyses done by various people, and decide to use Shapouri's data. But what about that 95 percent figure cited above (ethanol reduces petroleum use by about 95 percent on an energetic basis)? Basically, all they are saying is that farmers use energy from coal, natural gas, and other to produce the EtOH, but petroleum supplies only 5 percent of the energy.

Of course, what they did *not* discuss was productivity—how much energy results each year per unit of land area. The same issue of *Séance* has a companion article[2] that, despite reading like a sales pitch, discusses productivity in arcane units: megagrams (Mg) of dry matter per hectare per year, for which they cite numbers ranging from 8 to 22. Using 15 MJ/kg for the heat content of dry matter and 3.16×10^7 seconds per year, we get 4,750 (thermal) watts per hectare (approximately 1,900 thermal watts per acre) for their estimate of 10 dry Mg per hectare per year.

But Shapouri's figure for the EtOH produced per hectare is about 1,980 year-round average thermal watts (approximately 800 thermal watts per acre). Now let's broaden the perspective. In a year, one can expect a year-round average solar thermal power on a hectare to be 2 million watts. Of that, roughly 0.25 percent is converted into biomass energy, and roughly 0.1 percent becomes energy in the ethanol.

Co-products

Mike Brown is a fervent EtOH supporter who mixes one good equation with poor understanding on his website.[3] He provides some useful numbers:

"In the year 2000 there were 9,915,051,000 bushels of corn produced in the United States. Rounding off the production figures, 7 billion went to feed livestock. The remaining 3 billion went for other uses including exports. Assuming we could convert 10 billion bushels of corn to ethanol at the standard rate of 2.5 gallons per bushel, that would be 25 billion gallons of ethanol annually. . . .

"Our livestock wouldn't starve with this program. After you distill the alcohol from the corn, you wind up with distillers dried grains (DDG). *Essentially, it is the starch portion (about 70 percent) of the corn kernel that is converted into ethanol.* All the remaining nutrients in corn, such as the protein, fat, minerals, and vitamins are concentrated and come in the form of distillers grains, which can be fed to livestock wet or dry [emphasis added]."

But just like ourselves, cattle need energy to survive, roughly 7,500 calories

(31 MJ) per day for an average-size cow.[4] If you extract 70 percent of the energy in the corn, that 70 percent isn't available to feed the cattle. Roughly speaking, if three bushels of corn are used to produce EtOH, the DDG that can be fed to cattle has as much energy as one bushel of corn fed directly. There is no free lunch, even for cattle.

Mike Brown reminds us "that ethanol isn't produced by using *other* ethanol. In the big distilleries, it's produced by using natural gas as a heat source. On the farm, it's produced by burning wood, corncobs, corn stover, and the like."

True enough, but farms simply don't have enough corncobs and the like to produce industrial quantities of EtOH. So it boils down to big distilleries that get the energy from natural gas. Oh.

Assuming (very optimistically, with Shapouri) that there is a net gain of 24 percent of energy in producing EtOH, it would require 23×10^{18} joules from natural gas to provide as much energy as we get from petroleum, and that would be added to our current consumption (20.7×10^{18} joules) of natural gas.

It would obviously be better to use nuclear energy, of course, but what about land use? To produce EtOH with as much energy as we use in transportation would require 1.1 billion acres (454 million hectares) devoted to high-yield corn production, complete with all the things environmentalists hate—fertilizer, irrigation, and pesticides. That's about 1.8 million square miles (4.6 million square kilometers), some 51 percent of the land area of the 50 states.

Howard Hayden, publisher and editor of The Energy Advocate*, is Professor Emeritus of Physics at the University of Connecticut. This article is reprinted from* The Energy Advocate *(February 2006), P.O. Box 7595, Pueblo West, Colo. 81007.*

Notes

1. Alexander E. Farrell, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare, Daniel M. Kammen, "Ethanol Can Contribute to Energy and Environmental Goals," *Science*, Jan. 27, 2006, Vol. 311, No. 5760, pp. 506-508. Thanks to Alex Weber of Taiwan for this reference.
2. P. Hallett, David J. Leak, Charles L. Liotta, Jonathan R. Mielenz, Richard Murphy, Richard Templer, Timothy Tschaplinski, "The Path Forward for Biofuels and Biomaterials," *Science,* Jan. 27, 2006, Vol. 311, No. 5760, pp. 484-489.
3. www.mikebrownsolutions.com/ethanol.htm
4. Basal metabolism of cattle is given by $70kcal/day(m[kg])^{0.75}$www.asft.ttu.edu/ansc 5001/TTVNCOURSE-Lecture4.doc

Letters

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Thanks for an interesting article.

I had no idea that the Lyndon LaRouche movement was still viable and only ran across this article doing a google search to determine evidence of intense neutron fluxes that may have left evidence in meteorites.

Charles Cagle
Singularity Technologies, Inc.
Salem, Ore.

Pre-Columbian Journeys Published in English

To the Editor:

In my book review of *La Cola del Dragon* in the Winter 2005-2006 issue of *21st Century,* I neglected to mention that large sections of the book by Paul Gallez had been published in English by Dr. Nito Verdera, who put online (http://www.cristobalcolondeibiza.com/) a treasure trove of materials regarding pre-Columbian contact between the "old" world and the "new."

For example, on the location of the mysterious land of "Punt," in the news again recently with the discovery of some well-preserved ships in caves in Egypt. Academia places it very close to Egypt, since they obsessively repeat the mantra that the Egyptians were not a seafaring nation. Verdera shows Gallez's hypothesis that the Land of Punt was in Peru, is at least as good as the rest of them, and then adds a few facts of his own:

- The first known voyage to this region is that organized by the pharaoh Sahure of the fifth dynasty (circa 2550 B.C.).
- The pharaoh Asa (Isesi) followed Sahure's example. Around 2400 B.C., he also sent out his fleets to the Land of Punt. One of the princesses of the sixth dynasty was placed in her tomb, ready for her journey to the Land of the Dead, wearing a lip coloring with an antimony base. The nearest place where antimony was mined is Madagascar, hardly around the corner.
- The Harris Papyrus, kept in the British Library, says that the pharaoh Ramses III sent an expedition of 10,000 men to Punt in 1180 B.C.
- Queen Hatshepsut (1501-1482 B.C.), whose deeds are engraved in the temple of Deir-el-Bahari, which she ordered to be built in Thebes to honor Amen-Ra, sent out an expedition made up of at least five large ships with 30 oarsmen in each of them. They sailed from somewhere on the Red Sea and were away for three years.

One of the many illustrations from the website of Dr. Nito Verdera: A combination of a sundial and clock. The string is at the angle of your latitude, or co-latitude. If you know your direction, you can then tell the time (on both the vertical and horizontal surface); if you know the time, you can find your direction.

Egyptian scholars do not agree on the location of the Land of Punt. Some of them suggest Eritrea, others Somalia, Zimbabwe, Hadhramaut, or India. However, all these places are much too close to the Red Sea to justify the length of the voyage: three years according to all the relevant Egyptian records.

Gallez locates the Land of Punt in South America, probably, in the Puno region of Peru, on the shores of Lake Titicaca, which yields 70 percent of Peru's annual gold production, together with antimony, mercury, zinc, tin, and cobalt. Old gold and antimony mines can be found in the area, although archaeologists disagree as to their exact age. The boats used to sail on Lake Titicaca, made of cattail (a long-stemmed, reed-like, grassy plant of the Typhaceous family, with a cylindrical ear) are so similar to those used in ancient Egypt, that Thor Heyerdahl went to Puno to recruit workers to build his papyrus boat, *Ra II,* on the banks of the Nile.

Verdera points out, that as matters stand now, Gallez's theory is just as acceptable as any of the other sites suggested for the Land of Punt.

Rick Sanders
Leesburg, Va.