The Promise and Perils of Biofuels[i]

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The world is running out of *cheap* fossil energy and biofuels are being touted as America's fuels of the future. Some dismiss the current energy crunch as nothing more than another short run phenomenon, arguing that we have used but a small fraction of the earth's total fossil energy reserves. While there is truth to this argument, it masks far more than it reveals. Most of the remaining reserves of oil and natural gas are buried deep beneath ocean floors or in other places very difficult to find and to reach. The remaining reserves of coal likewise will be very costly to mine and to burn, particularly without seriously degrading the environment. The industrial era of the past 200-years has been fueled by *cheap* energy, first by wood from abundant forests and then by fossil energy from easily accessible sources. But the days of old-growth forests, oil gushers, surface veins of coal are gone. There are simply no sources of *cheap* energy left to support continued industrial development. Rising energy costs will fundamentally transform our economy and our society.

The basic nature of the problem is perhaps most clear in the concept of *peak oil*.[1] Petroleum geologists observed several decades ago that peaks in production from specific oil fields typically occurred when approximately half of the recoverable oil in a field had been extracted. After the peak, production continued but only at a diminishing rate. Historically, the time lag between discovery and peak production has averaged about 30-40 years. It takes time to get started drilling and to drill a sufficient number of wells to reach peak production. Beyond the peak, production continues, but the older wells yield less oil, and as residual reserves decline, new wells typically are deeper, more costly, and less productive.

U.S. oil discoveries peaked in Oklahoma and Texas in the late 1930s and early 1940s. U.S. petroleum production peaked in 1971, and has been declining ever since.[2] The new oil fields in Alaska caused but a temporary "blip" in a persistent downtrend. In spite of rhetoric to the contrary, the United States has been powerless to reduce its dependence on foreign oil. The peak in *global* oil discoveries occurred in 1962, indicating a peak in global production sometime in the early 2000s. Experts disagree about when the peak will actually occur, with estimates ranging from as late as 2025 to as early as 2005. Global production has been essentially flat since 2005, in spite of record oil prices, so the peak may have already occurred. Even the major oil companies, such as BP, Exxon-Mobile, and Chevron-Texaco, have begun to focus their attention on energy alternatives for the future.

The experts generally agree that we have not come close to depleting the earth's petroleum reserves. In fact, we have only used about one-fourth of the earth's total reserves, since about half of total is not considered to be recoverable. The problem is that recovery costs will continue to

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increase and production will continue to decline for as long as we continue to use oil. Even if new technologies are found to recover more of total reserves, the remaining flow of oil from now on seems destined to be far slower and more costly than in the past.

The inevitability of increasing costs of energy can be seen most clearly in the relative amounts of “old energy” required to extract “new energy” from various alternative sources. Energy is required to drill, mine, extract, crush, distill, refine, and carry out all of the other processes necessary to turn “potential energy” into “usable energy.” Regardless of today's relative dollar and cent costs, alternative energy sources that require more “old energy” to create “new energy” ultimately will be more costly.

Oil produced in the U.S. during the 1940s yielded more than 100 kcals of energy for each kcal of energy used in extraction, a net energy ratio of over 100-to-one.[3] By the 1970s, with deeper, less productive wells, the ratio had dropped to 23-to-one. Today's production from 1970s discoveries yields about 10 kcals of “new energy” for each kcal of “old energy.” And the efficiency ratios are even lower for newer discoveries. Falling net energy ratios and rising energy costs have now made alternative sources of petroleum competitive with current production. For example, oil from tar sands in Alberta Canada are currently being brought into production, in spite on net energy ratios of less than 8-to-one. Liquefied coal and oil shale also have net energy ratios in the 8-to-one range.

All non-petroleum sources of fossil energy face futures very similar in nature to petroleum. Natural gas supplies may be the next to peak after oil, as it is a good substitute for oil in many uses. If coal is used to replace the shortfalls in oil and natural gas, the energy obtained by extracting oil from the coal might well be less than the energy required to mine the coal within 50 years, even if we don't run out. The world isn't running out of fossil energy, at least not yet, but it is running out of *cheap* fossil energy. With global population projected to double within the next fifty years and with booming industrial economies in China and India, dramatically rising energy prices almost certainly will be required to ration the dwindling fossil energy reserves.

Development of *renewable* energy will not prevent continued high and rising energy costs over the next century. All of the renewable alternatives to fossil energy – nuclear, wind, water, photovoltaic – will be less abundant and more costly than today's fossil energy, in terms of net energy produced and dollar and cent costs. Net energy ratios for most renewable energy sources range between 6-to-one to 8-to-one, still below current ratios for most petroleum and natural gas. Cheap and abundant energy has shaped the past two hundred years of human society. The next two hundred years will be shaped by the scarcity and high cost of energy.

The current “oil boom” in rural America, particularly in the Midwest, is a direct result of the end of cheap energy. To many people, biofuels seem to be an answer, if not *the* answer, to America's growing dependence on fossil energy, particularly oil imports from the Middle East. Only the most naïve believe that the full cost of U.S. dependence on foreign oil is fully reflected in prices at the gas pumps. With the growing economic and human costs of U.S. military involvement in the Middle East – the only major oil-producing region that has not yet peaked – politicians have been quick to support anything that might reduce our reliance on imported oil.

Ethanol and biodiesel can be produced domestically from renewable sources and present fewer environmental risks that do most alternative sources of *liquid* energy. Biofuels are also touted by politicians and government officials as a promising source of employment and economic development for chronically depressed rural communities. On the surface, biofuels appear to be good for everyone.

So with government subsidies and protective tariffs of a dollar a gallon or more, ethanol plants have begun to spring up all across rural America. In early 2006, the Renewable Fuels Association reported 95 ethanol plants already in operation – 46 farmer-owned – capable of producing four billion gallons of ethanol a year, with another 31 plants under construction.[4] USDA estimated that ethanol claimed 18% of the 2005 U.S. corn crop and has risen to claim about one-third of the corn crop by 2006. By the end of 2006, The Earth Policy Institute (EPI) identified 116 plants in production, with 79 additional plants under construction.[5] Based on plans already in place, ethanol could claim more than half of the U.S. corn crop by 2008. An agricultural "oil boom" clearly is under way.

But are biofuels really the answer, or even an answer, to the most important questions of high cost energy? Admittedly, ethanol and biodiesel are alternative sources of *liquid* energy – the type of energy currently in shortest supply. If biofuels were simply promoted as such, there might be nothing deceptive or misleading about their growing popularity or political support. However, biofuels are being promoted as the key to energy independence while in fact ethanol and biodiesel can never *significantly* reduce U.S. reliance on imported oil. And perhaps most important, biofuels are not a *sustainable* source of either renewable energy or rural economic development. It's easy to understand why American farmers are willing to accept all of the government subsidies for bioenergy production. Other businesses are being heavily subsidized by government, so why not farming? But neither biofuels nor government subsidies offer realistic solutions to our growing foreign energy dependence or to the chronic economic crisis in rural America.

The ultimate potential for biofuels is clearly quite limited. Some people, such as David Pimentel of Cornell University, have been studying ethanol and biodiesel intensively since the energy crisis of the 1970s.[6] He and others estimate that if all of the solar energy collected by all of the green plants in the U.S. could be *magically* converted into fossil energy, it would replace only about one-half of the fossil energy currently consumed annually in the United States. Agriculture accounts for only about one-third of all green plants, meaning that total solar energy captured by agriculture amounts to only about *one-sixth* of U.S. fossil energy use.

In addition, only about one-fifth of solar energy captured by agriculture is harvested as high-energy food crops, such as corn and soybeans. The total energy in all *food crops* amounts to only *one-thirtieth* (one-fifth of one-sixth) of total fossil energy use. Petroleum makes up about one-third of total fossil energy use, meaning that total energy captured by food crops is equivalent to about *one-tenth* of the total U.S. petroleum use.[7] A recent National Academy of Science report indicated that if the total U.S. corn and soybean crops were devoted to biofuels, ethanol could supply about 12% of current gasoline use and bio-diesel about 6% of current diesel use.[8] The National Academy of Science estimates are completely consistent with the solar energy estimates of Pimentel and others.

In addition, it takes fossil energy to produce agricultural crops and to transform those crops into biofuels. Here the experts disagree, at least to some extent. Some estimates indicate that ethanol results in a *net energy* deficit, suggesting the kcals of fossil energy used in ethanol production exceeds the kcals of bioenergy produced. Others estimate a net energy surplus of about 50% or 1.5 kcal of "new bioenergy" for each kcal of "old fossil energy" used. Using this more favorable ratio, replacing 12% of gasoline usage with ethanol, the total U.S. corn crop, would require about 8% of the total fossil energy currently used in the United State. The "old fossil energy" includes fertilizers, pesticides, and fuel to produce the corn and the electricity and other fuels needed to process and distill it. So, the *net* energy gain from turning the U.S. corn crop into ethanol would not be 12% but instead only about 4% of current fossil energy use. Bio-diesel comes out only slightly better in terms of gains in net energy.

The President and others have touted the potential of switch grass, sugar cane, and other energy crops and production of ethanol from plant cellulose. However, utilizing crop residues for fuel rather than returning them to the soil depletes soil productivity and high-energy crops require higher fossil energy inputs. Others claim new technologies are on the horizon that will improve net energy ratios, but even a doubling of efficiency would not significantly change the basic conclusions. No matter what source we choose or how efficiently we convert solar energy captured by agricultural plants into biofuels, we eventually must fact the fact that we simply cannot possibly replace more than a small fraction of our current use of petroleum or total fossil energy with biological energy.

In addition, we cannot devote the whole of agriculture to offsetting shortfalls in fossil energy production. Prices of food are already rising because of high grain prices and anticipation of even higher prices ahead. Americans may not be priced out of the food market for a while, but people in less wealthy nations will not be so fortunate. Farmers all around the world are abandoning the production of crops for humans because it is becoming more profitable to produce fuel for automobiles. Unfortunately, the bioenergy boom is not benefiting the poor farmers of the world. The new energy crops are being grown by wealthy investors who buy land from farmers who can't afford fertilizers or pesticides, or is simply appropriate land in areas where ownership is ill defined. The wealthy people of the world still have the money to buy fuel for their cars and pay the higher costs for feed to produce their meat, milk, and eggs. But the poor people of the world, many of whom were driven off their subsistence farms by our exports of government-subsidized grain, now find themselves unable to compete with our SUVs in the marketplace for food. We eventually will have to ask, how much more of agriculture will our sense of human decency allow us to divert from food to fuel?

Even if we could ensure that the poor people of the world would be well fed, we should still be concerned about the future of people in rural communities. The current energy boom in rural America has all of the characteristics of another rural catastrophe in the making. Crop prices are already near record high and livestock prices are rising to record highs. Farmers are planting corn fencerow-to-fencerow and taking land out of conservation programs. Land prices are exploding, farmers and rural residents are borrowing money against their land to finance investments in bio-fuel plants, and rural communities are betting their future on a return to boom times in agriculture. Those of us old enough to remember the 1980s, should realize that we have seen this all before.

We may not know the outcome for certain, but we certainly know the risks. In the 1980s, it was a booming export market, rather than a booming energy crop market, that took prices to record levels. The prospects of new prosperity turned usually conservative farmers and rural residents into a bunch of "riverboat gamblers." Farmers borrowed heavily against their land at record high interest rates to finance expanded production. But export markets dried up and prices plummeted leaving farmers with large land payments they had no way to make. Farm foreclosures, bankruptcies, and suicide were commonplace in most American farming communities. Many residents of rural communities shared in the suffering – economically and socially – as agricultural suffered through a decade of depression. Some rural communities, like some farmers, simply did not survive.

But how can the same thing possibly happen this time, if the energy crisis is real and the days of cheap energy are in fact gone? It can happen again because several of the new fossil energy alternatives are much more abundant and energy efficient than are biofuels, and the gap is more likely to widen than narrow in the future. Tar sands, gasification of coal, and oil shale are about four times as *net energy* efficient as biofuels. They require far less "old energy" to create "new energy." The current net energy ratios of tar sand, coal gasification, and oil shale are in the 8-to-one range compared with biofuels ratios of 2-to-one, at best. It just takes far larger investments and far longer periods of time to build the infrastructure necessary to bring these sources into production. More than one-hundred ethanol plants have been built since latest energy boom began, while the first oil from the tar sands of Alberta is just beginning to flow. Environmental challenges are not dampening the enthusiasm of investors in alternative sources of fossil energy, which means they probably know more about the political realities of energy than the rest of us.

As energy becomes the limiting factor of economic development, the dollar and cent prices of energy from different sources will be determined by their energy efficiency. At that point, bioenergy from agriculture will become the most costly energy in the marketplace and demand for biofuels crops will fall like a rock. Do I know this will happen? No, but I certainly know it could happen, because I have seen something very much like this happen before.

The future of American agriculture is in producing food, not fuel for automobiles. Even if new energy crops are produced and current net energy ratios are improved, biofuels can never be a significant replacement for fossil energy. Even when other fossil energy sources are depleted, biofuels will not be able to compete with wind, water, and photovoltaic cells in terms of net energy efficiency. Biofuels are simply a means of converting the *immobile* energy used in agriculture, such as natural gas and electricity, into a very limited amount of *mobile*, liquid energy.

Unfortunately, the current euphoria over biofuels could turn out to be a very costly distraction from the more important task of agriculture, which is producing food for people. People are biological beings and simply cannot live without food from biological sources. We can't eat the electricity produced by wind, water, and photocells. Our current industrial food system, instead of producing a surplus of biological food energy, uses about 17% of the total fossil energy used in the United States, in addition to all of the energy it collects from the sun. Our current food system requires about ten kcals of fossil energy for each kcal of food energy produced. Much of the energy deficit is in food processing and distribution, but even takes about three kcal of energy at the farm level to produce one kcal of food. The highest priority for American agriculture should be producing more food with less fossil energy, not producing fuel for SUVs.

Unfortunately, the current energy boom in agriculture and higher prices for agricultural commodities provides a powerful incentive for farmers to continue with the energy-intensive, industrial production methods which pollute the natural environment and degrade the natural productivity of the land, making the transition to a sustainable agriculture even more difficult. Environmentally fragile land is being brought out of conservation uses, grasslands are being plowed to plant crops and soil regenerating crop rotations are being abandoned to plant corn and soybeans, or in many cases, mono-crop corn.

The challenge confronting Americans and the whole of humanity is to reverse this process before it is too late. There is a logical, viable alternative to today's energy intensive industrial agriculture. A strong and growing sustainable agriculture movement today includes farmers who identify with organic, biodynamic, holistic, bio-intensive, biological, ecological, and permaculture, as well as many who claim no identification other than traditional family farmer. These farmers and their customers share a common commitment to creating an agriculture that is capable of maintaining its productivity and value to society indefinitely. They understand that farms must be ecologically sound and socially responsible, if they are to be economically viable over time. A sustainable farm ultimately must rely on renewable solar energy and renewable human energy for its economic productivity.

These farmers rely on green plants to capture and store solar energy and to regenerate the organic matter and natural productivity of the soil. They use crop rotations, cover crops, intercropping, managed grazing, and integrated crop and livestock systems to manage pests and to maintain the natural fertility of their soils. Sustainable farmers market raw or minimally processed foods to local customers, saving much of the energy typically consumed in processing, packaging, storage, and transportation. These farmers and their customers reflect a sense of ethical and moral commitment to preserve and protect the human resources of society and the natural resources of the earth – to leave things as good as or better than they found it. Total fossil energy use probably could be reduced by up to one-half, using existing sustainable agriculture and food technologies. A reasonable public investment in sustainability research could yield far greater energy reductions. The highest priority for agriculture in the future is to produce more food with less non-renewable energy, in a world that is running out of affordable fossil energy.

We have perhaps a fifty-year window of opportunity to transform agriculture from a fossil-energy dependent system of food production to a food system that functions on renewable solar and human energy. We simply cannot afford to waste much more time and energy using an energy-intensive agriculture to produce fuel for automobiles. And we simply cannot afford to take agriculture through another roller-coaster ride of economic euphoria and bitter disappointment that leaves our farmland depleted, our waterways polluted, and rural our communities in decline and decay. Our farms and rural communities need to be about the important business of finding ways to produce food for more people in a world with less fossil energy. The real promises of biofuels are few and the perils of biofuels many. And time is running out for farmers, rural residents, and for our society to sort through the false promises and confront the real perils.

End Notes

[1] For the basics of Peak Oil, see *The Community Solution*, http://www.communitysolution.org/peakqanda.html
[2] *Wikepedia*, the free encyclopedia, "Hubbert Peak Theory," http://en.wikipedia.org/wiki/Hubbert_peak
[3] Richard Heinberg, *The Party's Over: Oil War and the Fate of Industrial Societies* (Gabriola Island, BC, Canada: New Society Publishers), 152.
[4] Christopher Cook, "Business as Usual," *The American Prospect*, online edition, April 8, 2006, http://www.prospect.org/web/page.ww?section=root&name=ViewPrint&articleId=11322
[5] *Lester R. Brown, "*World May Be Facing Highest Grain Prices in History*," Earth Policy Institute,* January 5, 2007, http://www.enn.com/today_PF.html?id=11972.
[6] From a presentation by David Pimentel, Cornell University, at *Local Solutions to Energy Dilemma*, New York City, April 28-29, 2006. Revised to account for increased energy use from earlier estimate of solar energy collected as two-thirds of fossil energy use, published in David and Marcia Pimentel, *Food, Energy, and Society* (Niwot, CO: University Press of Colorado), 1996.
[7] Pimentel, *Food, Energy, and Society*.
[8] As reported by Alexei Barrionjevo, "It's Corn vs. Soybeans In A Biofuels Debate," *New York Times*, July 12, 2006.