The Political Economy and Ecology of Biofuels

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Background

The huge increase in oil and other fuel prices over the last few years and a concern that we have reached (or will soon reach) peak oil—after which oil extraction begins to decrease—have created renewed interest in alternative sources of energy. These include solar, wind, ocean wave and tidal flow, geothermal, and biofuels. Sometimes lip service is given to the need for greater energy efficiency, changes in lifestyles (including the ecologically irrational over-reliance on automobiles and living far from one's job), the need to redesign economic activity from the factory floor to office buildings and homes, and the need for affluent societies to move away from ever higher levels of consumption. However, a radical analysis of actually putting these into effect would lead to questioning the very basics of how capitalism works.

Alternative fuel sources are attractive because they can be developed and used without questioning the very workings of the economic system—just substitute a more "sustainable," "ecologically sound," and "renewable" energy for the more polluting, expensive, and finite amounts of oil. People are hoping for magic bullets to "solve" the problem so that capitalist societies can continue along their wasteful growth and consumption patterns with the least disruption. Although prices of fuels may come down somewhat—with dips in the business cycle, higher rates of production, or a burst in the speculative bubble in the futures market for oil—they will most likely remain at historically high levels as the reserves of easily recovered fuel relative to annual usage continues to decline.

The use of biological materials—coming from recently living plants—as fuels has a long history. Many a night did early humans sit around a wood fire to cook food, keep warm, and protect themselves from predators. In the early years of settlement of the Great Plains of the United States by European immigrants during the nineteenth century, dried buffalo manure was gathered and used as fuel. Today wood is still used as a fuel source in some countries, dried cow manure still collected in India for that purpose, and crop residues in many parts of the world are used for cooking and/or heating. In addition, the natural gas (methane) produced from small-scale liquid manure (animal and human) systems has been used for years in China and India for lighting, heating, and cooking. Additionally, for decades sewage treatment plants in northern climates have used natural gas produced during the treatment process to heat the vat during the cold seasons to increase efficiency of the micro-organisms in the plant or to produce electricity.

The production of drinks with high alcohol content from grains, grapes, sugarcane, potatoes, etc., also has a long history, providing various fermented beverages such as beers and wines and then later the distilled alcohol products such as whisky, vodka, and rum. And for decades Brazil has produced ethanol (a type of alcohol) through distilling the results of sugarcane juice fermentation.

Biofuel basics

The idea behind biofuels is that plants capture the energy of the sun and produce substances—sugars, starch, oils, cellulose—that can be harvested and then converted into sources of energy for us to use. Growing plants to produce fuel is supposed to be more ecologically sound because—in contrast to oil and gasoline that pump new carbon dioxide into the atmosphere when burned—when biofuel energy is used the carbon dioxide that returns to the atmosphere is simply that which had recently been removed by plants.

The United States is currently facing a liquid fuel crisis more than a generalised energy crisis. Thus, the greatest current interest is in the production of the liquid fuels ethanol and biodiesel that can be used to power automobiles and trucks. There are three aspects to biofuels: the biological material used (the feedstock), the process for conversion of the feedstock to fuel, and the actual type of fuel produced.

The four main types of biofuels are: (*a*) direct combustion (of wood products, crop residues); (*b*) ethanol (produced from sugars, starches, or cellulose); (*c*) biodiesel (produced from oil crops or waste cooking oil); and (*d*) methane (natural gas, produced from digestion of animal manures or human sewage). Direct combustion is the simplest way to derive energy from biological materials. It requires the least amount of processing—only chipping or shredding to create smaller particles that burn more easily. The residues may be dried or burned at their natural water content. This type of fuel can be used to heat water or buildings or to produce electricity through steam generation. The feedstocks for direct combustion are mainly crop residues and wood chips.

Ethanol is a liquid that can be used to fuel automobiles and, thus, has received a lot of attention. In the United States it is usually mixed with gasoline at 10 per cent ethanol, but there are engines capable of operating with 100 per cent ethanol. Ethanol is produced commercially by fermenting the sugar from high-sugar crops (especially sugarcane) or by converting the starch in crops such as corn and cassava into sugars and then fermenting the sugars. The conversion of starch to sugar is fairly simple, but it is still much more costly to produce ethanol from high-starch plants than from high-sugar plants. Once the fermentation is completed, the ethanol, at only 10 per cent of the mix, must be distilled four times to enrich it to 99.5 per cent for use as an additive to gasoline, requiring a very high quantity of energy.

Almost all the ethanol in the United States is produced using corn grain as the feedstock. At the end of 2007 there were 134 facilities producing approximately seven billion gallons of ethanol. An additional 66 plants were being built while 10 existing plants were being expanded. An estimated 20 per cent of the 2007 corn crop was used to produce ethanol and it is expected that this will reach 30 per cent within a few years, although it might be significantly higher (see below). Ethanol produced using corn grain as the feedstock is the overwhelming percentage of biofuel currently used in the United States.

The “holy grail” of ethanol production is to find an economically feasible process for the conversion of cellulose into ethanol. Cellulose is a structural material of plants and most plant parts contain plentiful amounts of this substance. It has been suggested that crop residue left over after harvest or grasses such as switchgrass—grown for the purpose of harvesting for its cellulose content—would be good stocks for the purpose of production of ethanol (once the price of the conversion process is cheap enough). At some point it may be economically feasible to use wood or grasses as a feedstock for ethanol production. How much energy will be actually gained in the process is still up in the air. Regardless of whether energy is gained in the process or not, the conversion of cellulose to ethanol will take about eighty pounds of plant material to make one gallon of ethanol—more than 3.5 times the weight of corn grain needed to make an equivalent amount of this agrofuel.

Biodiesel fuel can be produced from vegetable oils from such plants as soybeans, oil palm, and rape (canola). Biodiesel is a more common biofuel in Europe, but is also produced in small quantities in the United States.

Methane (natural gas) is usually produced by digesting liquid animal manures or sewage sludge in the absence of oxygen and capturing the gas produced. For a number of years dairy farms using lagoons for collection of manure have produced electricity by capturing and burning the methane produced during the digestion process.

There are other processes and end products for biofuels. For example, one important process is pyrolysis—the high temperature decomposition of a feedstock like switchgrass in the absence of oxygen. The end product of this process can be synthetic diesel or syngas (synthesis gas)—a mixture that contains hydrogen and carbon monoxide and can be burned to produce energy or be converted to methanol (another liquid alcohol). The left over char can then be applied to land or burned for the energy that it still contains.

As described above, the term biofuel is applied to fuels derived from many different materials from wood products to manure. The term agrofuels as used in this article will refer only to the fuels produced by using crops grown in agricultural systems—whether or not the crop can be used for human food. Because of its importance in the United States and the various negative effects it is having, the remainder of the article will focus primarily on ethanol production from corn grain. However, reference will also be made to other agrofuels.

The energetics and economics of agrofuels

Ethanol is a liquid fuel that contains about two-thirds of the energy value of a comparable amount of gasoline. It is commonly blended in the United States as E-10 (10 per cent ethanol, 90 per cent gasoline) because no modification of the engines of most cars is needed. However, the ethanol industry is pushing to have more automobile engines capable of using E-85 (85 per cent ethanol, 15 per cent gasoline), and some states are mandating a mixture greater than 10 per cent. Ethanol can't be shipped together with gasoline in pipelines because it separates from the mixture when moisture is present, so it must be trucked to where it will be mixed with gasoline.

There is considerable controversy about the amount of energy gained when producing agrofuels in general and especially for ethanol made using corn grain as the feedstock. Almost all ethanol produced in the United States uses corn as the feedstock. A huge amount of energy is used to produce ethanol—from the energy that goes in to the production of the corn, its transportation to the ethanol plant, the fermentation, and the distillation. Energy used in corn production includes labour, machinery, diesel fuel, fertilisers (about one-third of the total used in production is just for nitrogen fertiliser), seeds, irrigation, pesticides, and transport.

As the U.S. Environmental Protection Agency points out, "Ethanol production is a relatively resource-intensive process that requires the use of water, electricity, and steam. Steam needed to heat the process is generally produced on site or by other dedicated boilers. Of today's [2006] 110 ethanol production facilities, 101 burn natural gas, 7 burn coal, 1 burns coal and biomass, and 1 burns syrup from the process to produce steam."[1]

When all the energy requirements of production through processing to ethanol are considered most estimates indicate a relatively small energy gain—anywhere from zero (or negative) to perhaps 20 per cent. David Pimentel of Cornell University and co-workers have found that there is actually a net loss of energy.[2] In other words, they estimate that more energy goes into making ethanol than is actually available in the ethanol produced. A large energy loss commonly happens when converting one fuel source into another type of energy—for example, only about one-third of the energy in coal is recovered as usable electricity in coal-burning electric generating plants. But one of the main interests in agrofuels is that they are supposed to free or lessen the dependence on other sources of energy! It appears that the whole process is primarily one of converting natural gas, coal, plus other fuels (for example, diesel to power tractors, natural gas to make nitrogen fertiliser, coal to power ethanol production plants) into ethanol by growing, harvesting, and processing crops.

But let's assume one of the optimistic estimates that there is actually a 20 per cent net gain in energy when producing and converting corn grain to ethanol. This means that 6 gallons of ethanol must be produced to have a net energy gain of 1 gallon of ethanol. Since it takes about a bushel of corn to produce 2.5 gallons of ethanol, a 150 bushel per acre corn yield translates into 375 gallons of total ethanol produced, but about 63 gallons of net new ethanol energy (with the same energy content as about 43 gallons of gasoline)! Just the cost of the feedstock corn, at the current price of over five dollars a bushel, means that one of the major input costs comes out to about twelve dollars per gallon [(150 bu ´ $5 per bu)/63 gallons net new ethanol energy] of *new* energy as ethanol. And that's assuming an actual net energy gain! (There were 87 million acres of corn harvested in the United States in 2007, with a total yield of 13 billion bushels and a per acre yield of 151 bushels per acre. Approximately 2.8 billion bushels were used to produce approximately 7 billion gallons of ethanol.)

Although a large percentage of the U.S. corn crop is still used for animal feed (close to half in 2007), let's put the numbers in the perspective of human food. Approximately 500 pounds of grain can supply a person with sufficient calories for a year. (People should, of course, eat a varied diet and not just grain, but this provides a way of understanding the implication of using so much grain to produce fuel.) One hundred and fifty bushels from one acre, at 56 pounds per bushel, is a yield of approximately 4.2 tons of corn, enough to satisfy much of the nutrition of sixteen people. So, even given the optimistic energy conversion used above, the 63 gallons of *net new* ethanol produced (the equivalent of about 42 gallons of gasoline)—enough for about two full tanks of fuel for an SUV—will use the grain that could supply the calories needed by sixteen people for a year if used directly as food. And, of course, under the more realistic estimate of net energy, there is a loss of energy and all the grain is wasted.

Even using one of the optimistic estimates of a net gain in energy when producing ethanol from corn grain and biodiesel from soybeans, the maximum possible contribution of biofuels can be only a small percentage of fuel used for transportation. If the *entire* U.S. corn and soybean crops in 2005 had been used to produce agrofuels, the optimistically estimated net energy gain would have been equivalent to only about 2 per cent of U.S. gasoline usage and 3 per cent of diesel consumption.[3]

In addition to the relative price of corn grain to oil, the economics of agrofuel production is strongly influenced by the system of incentives and subsidies that have been gradually put in place over the years since the 1970s. With a direct subsidy of 51 cents per gallon of ethanol blended with gasoline (because one bushel of corn can yield 2.5 gallons of ethanol this subsidy is equal to $1.43 per bushel of corn) plus other incentives (see below), most plants can economically produce ethanol with corn at $7 per bushel as long as oil prices are over $100 a barrel. Over the last few years corn prices went mainly up, but they frequently spiked and dipped (as did oil prices).

Ethanol plants with relatively high production costs were idled when corn prices spiked until the corn/oil price ratio became more favourable. Most U.S. corn farmers also grow soybeans and the actual amount of corn versus soybeans planted depends not only on the expected prices for each crop but also on each crop's production cost. With projected prices of the two crops and with the cost of nitrogen fertiliser close to tripling over the past year, this year many farmers decided to plant less corn and more soybeans, which can supply their own nitrogen.

There are a number of ways that the agrofuel industry is subsidised. A few key examples are:

Federal legislation signed into law last year (in the so-called Energy Independence and Security Act of 2007) has ethanol production increasing to at least 9 billion gallons in 2008 and to 36 billion gallons of agrofuel a year by 2022. Although 21 billion gallons of this mandate will supposedly come from currently experimental ("advanced" or "second generation") sources, the remaining amount would still result in a doubling of corn grain ethanol from its 2007 production level. The mandate for fuel producers to use gradually increasing amounts of ethanol through 2022 creates an artificial demand for ethanol that helps maintain higher prices than otherwise would occur. (In Europe the current target is to use 10 per cent agrofuels fuels by 2020.)

Import tariffs of 2.4 cents a gallon plus another 54 cents a gallon for certain countries of origin (mainly Brazil), serving to keep the ethanol price higher than it would otherwise be, were estimated to be worth over $1 billion a year to the industry in 2006 and are projected to rise to $3 billion.

There is a subsidy of 51 cents a gallon, as mentioned above, for ethanol blended with gasoline (the Volumetric Ethanol Excise Tax Credit, or VEETC).

Some states have their own subsidy on top of the federal subsidy.

There is a small producer tax credit for ethanol and biodiesel for producers with under 60 million gallons of annual production.

And finally, there is the direct subsidy for corn producers.

It is estimated that the total subsidy for U.S. ethanol production in 2008 will cost $9–11 billion, or $1.10–1.30 per gallon of ethanol produced![4] This is about double the direct per gallon subsidy received by ethanol producers.

As this article goes to press the new five-year U.S. Farm Bill has become law. It includes the following features regarding subsidies for agrofuels: (a) a decrease of 6 cents on direct subsidy to ethanol production (it will now be 45 cents a gallon); (b) maintenance of the 54 cents a gallon tax on imported ethanol; (c) a $1.01 a gallon direct subsidy for ethanol derived from cellulose; (d) $320 million in loan guarantees for construction of “advanced” agrofuel production plants; and (e) funding to support farmers near ethanol plants using cellulose to experiment with crops to supply the feedstocks. Thus, while some changes have been made in the system of subsidies for agrofuels, the general thrust in the direction of using agricultural crops and land to produce feedstock for ethanol production has been increased.

The biofuel industry is highly concentrated in the United States, with Archer Daniels Midland (ADM) controlling 1 billion gallons of production per year out of a total current capacity of over 8 billion gallons per year. The top three producers (ADM, POET, and Verasun) control close to 40 per cent of the U.S. ethanol market. And ADM has been buying up troubled farmer-owned ethanol biofuel cooperatives as well as investing in new capacity.

As of April 2008 the 147 ethanol facilities had a total capacity of 8.5 billion gallons of ethanol. Capacity for another 5 billion gallons was under construction—as new plants or expansions of existing plants—for a total capacity by the end of the year of 13 billion gallons.[5] Assuming average corn yields, that capacity could consume 5.2 billion bushels, the amount of corn grown on approximately 35 million acres! The U.S. Department of Agriculture predicts that corn will be planted on 86 million acres this year, with a total production of 12.1 billion bushels, 1 billion less than 2007. Thus ethanol production capacity could use 40 per cent of the 2008 U.S. corn crop! This will maintain an upward pressure on corn prices even if all of the added processing capacity isn’t utilised.

Politics of agrofuels

The development of the large ethanol production capacity in the United States is quite a sordid affair, with ADM playing the leading role. ADM, a $44 billion a year company, is one of the world’s largest buyers, sellers, and processors of grains and oil crops. It has based much of its profit making on federal government largess. In 1995 the conservative Cato Institute issued a policy analysis on ADM profiting from government programs. It was estimated that 43 per cent of the company’s profits came from products heavily subsidised by the government and that every dollar of profit from the production of ethanol costs taxpayers $30.60.

ADM's chairman, Dwayne Andreas (whose son had to serve time in prison, along with two other company executives, over a feed additive price-fixing scheme), gave vast sums of money to both Republicans and Democrats from the Nixon administration through the Clinton years. At the time of the sentencing of the corporation's executives the *New York Times* (July 10, 1999) described Andreas's influence as follows: "For decades, the grain giant was run as a virtual family fiefdom under the iron-fisted control of Dwayne Andreas, one of the nation's most politically powerful executives, who is known to Presidents and prime ministers alike."

He bought access to presidents and to the leadership of both the House and Senate. The amount of money that Andreas spread around to politicians was substantial and the contributions continued for many years. When OPEC restricted oil shipments in the late 1970s, a waiver was pushed through Congress by the Carter administration to exempt 10 per cent or more ethanol (E-10) from the four cent per gallon federal tax.

The story continues in like fashion up to the present with massive and continuing lobbying campaigns to influence Congress as well as the various administrations. Some political figures, like former senator Robert Dole, became especially identified with ADM and with pushing government support for ethanol production. This led to infusions of government monies to build new ethanol plants (some of which went bankrupt), give ethanol producers free corn (in the mid 1980s), and create subsidies of various types (discussed above) that exist to this day.

The ecology of agrofuels

The rapid and large increase in the price of oil has made the use of alternative liquid fuels more attractive, especially with the substantial governmental subsidies they receive. However, the use of large quantities of potential food crops—especially corn (maize) and soybeans, but also including such crops as oil palm—to produce fuels is a major contributing factor to the current world food crisis.[7] The rising prices for all basic foods has, of course, hit the poorest countries the hardest—especially those that import significant quantities of their food—although the poor in every country in the world have been hurt. There have already been food riots in many regions and concern has been expressed for the future stability of some thirty-three countries. To a certain extent food prices must increase as the oil price increases because large quantities of energy are used for so many agricultural inputs from fertilisers and pesticides to production and use of farm machinery. But as the price of oil increases relative to feedstock prices it becomes increasingly profitable to convert food crops into fuel. As Lester Brown has put it, “The line between the food and energy economies is becoming blurred as the two begin to merge. As a result, the world price of grain is now moving up towards its oil price equivalent. If the food value of a commodity is less than its fuel value, the market will move it into the energy economy.”[8] And with oil prices around $125 a barrel at the time of writing (May 16, 2008), ethanol produced from corn is cheap compared to gasoline refined from oil.

In addition to the deleterious effects on the food supply of the poor, there are a number of ecological problems associated with the production of agrofuels. These will be discussed below with the example of corn grown to process into ethanol.

Ecological Issues during Crop Production: Water Quality and Quantity

A recent report from the National Academy of Sciences concludes: “If projected future increases in use of corn for ethanol production do occur, the increase in harm to water quality could be considerable.”[9] Much of the corn is grown with irrigation. However, water is becoming less available as the Oglalla Aquifer, underneath the high plains portion of the Great Plains from Texas to South Dakota, is being used up faster than it can possibly be replenished. Also the water in many of the rivers in dry areas has been depleted by a long-term dry period. Corn grown in this region uses 2,000–3,000 gallons of irrigation water to produce one bushel of corn. (When rainfall is included, the total amount of water used is over 5,000 gallons!)

Growing corn leads almost inevitably to elevated levels of nitrate entering the ground and surface waters as fields drain into streams and rivers. The low-oxygen “dead zone” stretching westward from the mouth of the Mississippi is believed to be caused mainly by the excess of nitrates. This is expected to worsen if more corn is grown as a response to the agrofuel boom.[10] Nitrates also are a problem in the drinking water of a number of communities—large and small—in the Midwest. In addition, large amounts of herbicides and insecticides are used in corn production and these chemicals or their decomposition products are commonly found in groundwater beneath cornfields. Greater emphasis on corn will only mean greater amounts of water pollution.

In addition to nitrogen and pesticide pollution of water, intensive corn production using conventional tillage systems encourages significant amounts of soil to be lost by erosion. While there is a definite trend toward systems requiring no or reduced tillage, there are still a lot of corn soils ploughed annually that are very vulnerable to soil degradation by erosion.

Ecological issues during ethanol production from corn grain

Air pollution: ADM is one of the largest polluters of the environment, scoring third on the 2008 Political Economy Research Institute’s list of the hundred worst corporate polluters.[11] The company's ethanol plants are not the only source of ADM's air pollution, however a final construction permit for modification of one of its ethanol plants gives some idea of the air pollution from production of this "clean" fuel. The plant is expected to have annual air emissions of 540 tons of volatile organic compounds (VOCs), 1.5 billion tons of sulphur oxides, 1.2 billion tons of carbon monoxide, 840 tons of nitrogen oxides, and 150 tons of hazardous air pollutants.[12] While ethanol use in automobiles in place of gasoline decreases emissions of carbon monoxide and possibly other pollutants, it increases the emissions of volatile organic compounds. The increase in ozone and smog in California's air following the switch from MTBE (a known carcinogen) to ethanol as a fuel additive is apparently one of the side-effects of ethanol use.[13]

Water consumption/pollution: Assuming significant amounts of water recycling (which takes energy), it takes about five gallons of new water to produce the fermentation mix to make one gallon of ethanol. An ethanol plant that produces a hundred million gallons a year will use about the same amount of water needed by a town of five thousand people. The fear of excess water withdrawal from the aquifer has caused significant opposition to plants in some communities. In addition, there are approximately five to thirteen gallons of wastewater to dispose of for each gallon of ethanol produced. This wastewater can do substantial damage if discharged directly into waterways and it needs to be treated to reduce the pollutant content.

Problems with other agrofuels

This article has concentrated on the situation in the United States where ethanol, produced from corn grain, is far and away the most important agrofuel. However, there are also social and ecological problems with the use of other agrofuels as well. An article in *Science* concludes that even though some agrofuels may produce less greenhouse gases than gasoline, they "have greater aggregate environmental costs than gasoline" when air and water pollution, soil degradation, and social effects are considered.[14]

The Brazilian use of sugarcane as the feedstock for ethanol production makes a lot more sense than using corn grain as the feedstock—there is actually a net energy gain when starting with cane! However, the air pollution associated with ethanol production and from automobile exhaust fumes as well as water pollution from ethanol plants means that there are significant environmental drawbacks.[15] It, of course, also uses land that could be better used to supply food for a malnourished population.

The conversion of tropical forests in Indonesia and Malaysia to grow oil palm, mainly to supply the European desire to have a “green” biodiesel fuel source, has created substantial environmental damage. This has occurred mainly through the cutting down and burning of forests and then disturbing the forest floor as the oil palm is planted. This has caused massive amounts of the greenhouse gas carbon dioxide to be transferred into the atmosphere in addition to converting a biologically diverse forest ecosystem into a monoculture. It is estimated that over four hundred years of growing oil palm for biofuel is required to “pay back” for the carbon dioxide transferred to the atmosphere by converting the forest for this production.[16] Thus, producing the feedstock for supposedly “green” biofuel causes major ecological degradation.

The growth of the agrofuel industry with the diversion of so much of the U.S. corn crop to ethanol production and the use of soybeans for biofuel production sets off a chain reaction abroad that creates forest destruction. According to a recent *Time* magazine story,

In Brazil…only a tiny portion of the Amazon is being torn down to grow the sugarcane that fuels most Brazilian cars. More deforestation results from a chain reaction so vast it’s subtle: U.S. farmers are selling one-fifth of their corn to ethanol production, so U.S. soybean farmers are switching to corn, so Brazilian soybean farmers are expanding into cattle pastures, so Brazilian cattlemen are displaced to the Amazon. It’s the remorseless economics of commodities markets. “The price of soybeans goes up,” laments Sandro Menezes, a biologist with Conservation International in Brazil, “and the forest comes down.” (“The Clean Energy Scam,” March 28, 2008)

There is a one dollar subsidy for each gallon of biodiesel blended into regular diesel for export from the United States. This has led to the following ridiculous “splash and dash” situation: “Splash and dash is where biodiesel is carried to the US by ship—sometimes from Europe—purely to add a drop of ordinary diesel and take advantage of public money being handed out on any refining done on America” (*Guardian*, April 9, 2008).

Jatropha, a plant that grows on marginal lands in India and Africa, has been touted as a feedstock for biodiesel that can be grown by small producers without harming their production of food. (Its seeds contain 30 per cent oil, about the same as rapeseed.) It is capable of producing a relatively large amount of oil that can be converted to biodiesel. However, “marginal” lands frequently support livestock, even if it’s at a low level of production. In addition, substantial amounts of water are needed to establish the crop wherever it is grown and under arid conditions the yield of oil per acre is small. It has significantly higher yields and will be more economical to produce on better lands with use of irrigation—putting pressure on the use of land to grow food. Another problem is that the plant is poisonous and has been responsible for accidental poisoning of children and livestock in India. A British company, D1, has planted jatropha on about 475,000 acres (192,000 hectares) in India and Africa (*Guardian*, April 9, 2008).

Tree plantations have been promoted for use with yet-to-be-proven economically viable cellulose conversion to ethanol. The proposal is to use quick growing species—some genetically engineered—that would then be clear-cut and more trees planted. However, this converts a diverse ecosystem into a monoculture. Additionally, GMO trees that grow faster have been developed and there is always the threat that they will become invasive and take over other land in addition to where they are planted.

The use of crop residue to produce ethanol from cellulose has been promoted as a possible major source of feedstock for agrofuels—with an estimated 500 million tons available annually in the United States. If all of the available crop residues in the United States were harvested and converted to ethanol, the production (assuming a conversion of 80 pounds of biomass to 1 gallon of ethanol) would provide a total of 12.5 billion gallons, although some 21 billion gallons out of the mandated 36 billion of ethanol to be produced by 2022 is supposed to come from conversion of cellulose. (Of course, the amount of actual new energy added will probably be zero.)

Crop residues, it is important to recognise, serve an important role in maintaining the fertility and general health of soil. Nutrients in residues are recycled back to the soil for uptake by future crops. Residues also help to build up and maintain soil organic matter—one of the key aspects to healthy soils. In addition, residues on the surface of the soil in reduced tillage systems greatly lower the amount of soil erosion—decreasing water pollution while maintaining fertile soil in place. Some scientists believe that a portion of crop residues from some crops can be used without adversely affecting the health of the soil. However, given the importance of increasing organic matter in soils—to improve their quality and to store carbon for the purpose of keeping it out of the atmosphere—the use of substantial amounts of crop residues for agrofuels may have significant negative effects on agricultural production as well as the environment.

Grasses such as switchgrass or reeds, for example the giant reed native to West Asia, have been proposed as a future feedstock for either direct combustion (as a pelletised product), or for cellulose conversion to syngas or ethanol. The attractiveness of using a grass or other perennials for feedstock is that the soil can be left unploughed for many years. Although they would need nitrogen and other fertilisers for maximum yield they may not need the intensive pesticides used on many agricultural crops. However, one issue recently raised in a UN conference report is that “Some of the most commonly recommended species for biofuels production are also major invasive alien species" (*International Herald Tribune*, May 20, 2008). Great caution is therefore recommended before introducing species that may become major pests—crowding out native species or using huge amounts of water.

Direct combustion of switchgrass would yield ten times or more of the energy used in its production—a very good result! However, converting to ethanol probably results in a net loss of energy. Conversion to syngas may well provide net new energy.

Mixed species of grasses and legumes have been proposed for use instead of a monoculture of switchgrass. This would have a lot of ecological advantages, with the legumes providing some nitrogen to the grasses (so less nitrogen fertiliser would be needed) and maintaining a high degree of plant diversity. However, it should be kept in mind that a significant amount of grassland is currently being used to feed a huge number of cattle, sheep, and horses—about 60 million acres used to grow hay and some 780 million acres for grazing livestock. With much of the land in forests or in difficult terrain, probably around 350 million acres of the grazing area could actually be harvested mechanically. If a significant amount of this land is diverted to grow grasses for energy purposes, how will the animals now raised on this land be fed?

Although the agrofuel boom has produced employment in the processing of feedstocks to fuels, it has had decidedly negative overall social effects. As mentioned above, the diversion of such a large quantity of food crops to produce fuel feedstocks is one of the factors that led to the large increases in crop prices and has significantly contributed to the current food crisis. In addition, people using forests for gathering or small-scale slash and burn agriculture are pushed out as companies take over the land, destroy the forests, and plant monocultures of crops for agrofuel or new pastures to replace those converted to grow agrofuel crops.

The rise in crop prices has also led to an increase in land prices that leads to poor people being pushed off land they may have occupied without clear legal title. In addition, it is hard for small to medium-size farms to compete for the purchase of very high-priced land with private capital that is investing for speculation or large highly capitalised industrial-scale farmers. This also drives up the prices for land rental. Even in the heartland of the corn belt, Iowa, farmers rent more land than they own—in 2002 some 60 per cent of their land was rented and close to 25 per cent of their net income went to pay rent. The increase in the value of land caused by the increase in crop prices (partially a result of diversion of so much of the corn crop to provide ethanol feedstock) has led to the doubling of rents over the last year. The increase in farmland values in other countries gives a decided advantage to wealthier farmers and investors over small and medium-scale farmers.

Conclusions

The desire to find a “magic bullet” to solve the expensive fuel problem, as well as the spectre of a decline in availability, has led to a rush to embrace and promote agrofuels. The groundwork for this path was laid by influential commercial interests—most notably ADM—over a period of decades. It was an approach that has also had significant support from farming interests concerned about low crop prices and by environmentalists who saw agrofuels as a way to lower CO2 emissions as well as lessen the use of MTBE as a fuel additive. Environmental groups jumped on the bandwagon as did corn and soybean growers. Even some oil companies have jumped on the bandwagon, with BP creating its own biofuels division. And the Rockefeller family is currently trying to convince Exxon to develop a biofuels division. Local interests in corn and soybean growing states also saw processing plants to produce ethanol and biodiesel as a way to bring jobs to rural communities.

And the beauty of the agrofuel boom was it would have all these beneficial effects without causing any real changes in how people live or any questioning of an economic system that by its very nature must keep on growing. However, now that significant amounts of crops are being grown for feedstocks for this industry the negative social and environmental effects are becoming readily apparent.

The use of agricultural land to grow crops for fuel should not occur until after a satisfactory diet is made available to every person in the world. With the world’s population projected to increase from the current 6.7 billion to over 9 billion people by mid-century, all farmland will be needed to provide food, even with projected increases in yield per acre. When all sources of energy are figured in to grow and process crops, most of the current generation of agrofuels break even or lose in energy terms. Thus, with small net gain or even a loss, the pollution associated with growing and processing the crops, and the effects that the use of these crops have on the prices of food crops, many people—even in the environmental community—are starting to question the wisdom of the exuberant development of biofuel capacity. Even Republicans in Congress are starting to have second thoughts about the very high mandates for ethanol production and have asked the EPA to ease the requirements in the law signed into effect only months ago (“Corn Ethanol Loses More Support,” *Wall Street Journal*,May 3, 2008).

There are ecologically sound responses to high-energy costs and declining oil availability. Some require small modifications such as changing to more energy efficient light bulbs or driving a little slower on the highways. Use of wind, geothermal, solar, and wave generation of electricity—each not without its problems—offer much better alternative energy sources than the use of agrofuels. While practices and products that result in greater energy efficiency and the use of more benign energy sources are important, in the long run more profound changes are needed in all aspects of human life—from the type and arrangement of housing, to the development of better public transportation, to new production systems requiring less energy, to reduced purchases of non-essential gadgets. Whatever changes are needed, it is clear that agrofuels should play at most a very minor role, if any, in dealing with decreasing availability of oil and its high price.

Notes

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