Energy Use in the US & Global Agri-Food Systems: Implications for Sustainable Agriculture

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05 June 2010

During the 20th century, access to cheap and abundant sources of energy helped transform the world in countless ways. Extraction of fossil fuels led to a massive expansion in economic growth and agricultural production, and was one of the bases of a six-fold increase in human population. Petroleum, the most sought after fossil fuel, had the largest role in this transformation.

Because of its versatility and liquid form, oil is today the world's primary transportation fuel (Heinberg 1) and leading source of energy (Brown 27). Less than 200 years ago, however, all of the planet's food energy was derived from the sun through photosynthesis (Pimentel, Pimentel & Karpenstein-Machan 3) and almost all work was done by human or animal muscle power (Heinberg 2). Practically all of our energy presently comes from non-renewable resources whose stocks are being depleted at an ever-faster rate.

The benefits we derive from oil are so numerous and of such great convenience that we have built our entire way of life around its use. Now we are entering a period of declining oil supplies and rising prices that threaten not only food security for increasing numbers of people globally, but also many aspects of political and economic stability as well -- a new phenomenon for a world that became accustomed to growing supplies of oil and relatively stable prices. Unless we begin quickly to a move away from fossil fuel dependence to a different energy regime and a radical lifestyle and societal change, the transition to a post-petroleum world could be devastating for Americans and people throughout the world. Food, the basis of all life, will be at the forefront of this upheaval.

Agriculture is one of many features of modern life that have been drastically altered by the availability of cheap and abundant oil. The American and most other agri-food systems are almost entirely dependent on fossil fuel energy for everything from food production to transportation to food preparation and storage. The structure of industrialized agriculture under a capitalist system, aided and abetted by government policies, including that of the United States, has spurred the expansion of farm specialization and consolidation, monocultures, the delocalization of agricultural production, and the adoption of industrial farming practices (Altieri 78-9). The technological innovations of the Green Revolution drastically reduced a farmer's labor input time and greatly increased agricultural yields. Thanks to modern mechanization, the time input necessary to raise a hectare of corn is 110 times less than that required by hand-produced crops (Pimentel 464). Since 1950, the world grain harvest has more than tripled. This growth in productivity resulted from a ten-fold increase in fertilizer use, a near tripling of land irrigation, and the development of high yielding crop varieties (Brown 36-7). Countering the benefits of modern industrialized agriculture is the massive amount of fossil energy needed to power the petroleum-fueled farm machinery and to produce indispensable fertilizers and pesticides. Increases in production notwithstanding, the shift to industrialized agriculture has brought about a host of ecological and social problems in its wake.

The increase in globalized food production, which has come at the expense of local production, is possible only for as long as cheap energy supplies can subsidize the transportation of goods across long distances. The price of food will inevitably climb as oil becomes more and more expensive and drives up the cost of production and transportation. This will disproportionately impact the world's poor, especially those who depend on food assistance and cheap North American grain. Only by taking steps toward creating a sustainable food system of a radically new kind can we hope to attenuate the looming crisis in agri-food systems in this country and abroad. As Patricia Allen argues, any effort to create a truly sustainable food system must take into account the relationships humans have with each other as well as with their environment, which they have molded and influenced in many significant ways (1). Agricultural dependence on fossil fuels is a man-made problem. It will take not just scientific and ecological solutions but also deep-rooted structural and institutional changes as well as lifestyle changes on the part of individuals, their governments, and societies to transition to a more sustainable, non-petroleum based food system which oil depletion and rising costs will inexorably force on us. Before dealing with the implications of oil depletion and rising costs for the agri-food system and human survival, a closer look at the dominant role oil plays in the agri-food system is in order.

Oil is a finite natural resource whose global rate of production will eventually peak and begin an inevitable decline.

According to petroleum geologist Colin Campbell, the peak of oil production is passed when about half of the total resources have been extracted. Richard Heinberg notes that the basic concept of Peak Oil is derived from observations over the past 150 years of all older oil fields which have peaked and then declined in output (12). Indeed, the United States, once the world’s biggest producer of oil, reached its peak of oil extraction in 1970 and has since experienced declining output (Heinberg 12). Today, 90 percent of the United States’ oil deposits have been extracted and the country, once a net exporter of oil, now imports over 65 percent of its oil (Pimentel 459). Worldwide, the discovery of new oil deposits peaked in the 1960s and since 1981 the amount of oil extracted has surpassed the amount discovered by an increasing margin (Campbell). According to the oil giant ChevronTexaco, 33 of the world’s 48 major oil-producing nations are already experiencing declining production (Heinberg 13). There is uncertainty, however, as to when exactly global oil production will reach its peak. Some experts believe we have already reached Peak Oil while almost all agree that it will occur sometime during the first half of this century.

Although other sources of energy exist, such as nuclear, coal and wind power, none of these can produce liquid fuels. Some have hailed crop-based ethanol as a replacement for petroleum, but the negatives of ethanol production seriously outweigh any potential benefits. In 2007, one-fifth of the United States’ entire grain harvest was transformed into ethanol, but the 8.3 billion gallons of ethanol produced that year could only supply less than 4 percent of the country’s automotive fuel (Brown 39). Moreover, it takes 65 percent more energy to produce 1000 liters of ethanol than the energy that is derived from those 1000 liters. Thus, ethanol production has a negative energy balance (Pimentel et al. 15-6). Diverting a large portion of the U.S. grain harvest to ethanol production has serious ramifications for the world’s poor. Worldwide, grain prices have increased dramatically, with the price of wheat more than doubling in 2007, setting off food riots in countries across the globe that same year (Brown 40). Ethanol production in its current form has no place in sustainable agriculture because it actually presents a net energy loss and because it is pricing food out of reach for the world’s poorest people.

In 2002, the U.S. food system consumed 17 percent of the country’s total fossil fuel use (Eshel & Martin 2). The availability of seemingly unending fossil fuel resources has led to the highly unsustainable situation whereby “the U.S. food system consumes ten times more energy than it produces in food energy” (Pfeiffer 4). Much of the food system’s heavy dependence on fossil fuels stems from the capitalist structure under which it operates. United States government policies have also encouraged the expansion of large corporate farms and farm specialization by subsidizing over production and the export of goods to international markets. Although large specialized farm owners benefit from economies of scale, they must in turn increase their use of synthetic chemical inputs and petroleum fueled farm machinery, creating a serious dependence on fossil fuels. The use of synthetic fertilizers accounts for 20 percent of energy use on American farms (Brown 34), and annually one billion pounds of pesticides are applied to farms across the nation (Pimentel 463). The dramatic increase in urbanization over the past century, coupled with a move away from mixed farming systems in favor of concentrated animal feeding operations (CAFOs) has deprived farms of natural sources of fertilizer and resulted in the massive expansion of commercial fertilizer use (Pimentel 464). The capitalist system encourages the food system’s unhealthy reliance on fossil fuels because as long as oil is cheap and plentiful, large profits can be made by ensuring the system remains unsustainable.

Farming itself is the least profitable and least energy intensive segment of the entire economy of agriculture. Of the roughly 2,000 liters of oil required per year to feed each American (Pimentel 459), only one-fifth of that energy is actually used for agriculture, with the rest going toward transport, processing, packaging, marketing, and food preparation and storage (Brown 35). The transformation of farm products into consumer commodities, along with the provision of farm inputs, are the biggest moneymakers in the American food system, and not surprisingly, the sectors dominated by large agrifood corporations. Farmers operating under the capitalist system must sell their products on the open market, which usually means selling to the large transnational corporations that dominate the market. Similarly, there are a handful of large companies that produce the fossil fuel-dependent farm inputs purchased by American farmers. Today, farming only accounts for 10 percent of the total food dollar, while 25 percent pays for farm inputs and 65 percent for transportation, processing and marketing (Lewontin 95). A century ago, the value added by farming was closer to 40 percent of the food dollar and most farm inputs were produced by the farmers themselves by using draft animal power, storing seeds, and using animal manure for fertilizer (Lewontin 95).

The dramatic rise in monocultures and the increasingly globalized scale of agricultural production have essentially destroyed the localized food infrastructure in the United States. For example, in 1870 almost all the apples consumed in Iowa were produced locally, but a little over a century later that number had dropped to 15 percent (Pfeiffer 25). In the United States today, less than five percent of food is locally produced (Pfeiffer 68), and so our food travels an average of 1,500 miles before being consumed (Pimentel 467). The transportation of food from farm gate to dinner plate constitutes

14 percent of the energy used in the entire food system (Brown 35). Transporting a head of lettuce from California to New York City by refrigerated truck requires 4,140 kcal of fuel per head of lettuce, while actually growing the head of lettuce consumes only 750 kcal of fossil energy (Pimentel 467-8). Given that 90 percent of global transportation is fueled by oil or oil by-products (Heinberg 4), declining oil supplies will most likely impede the transportation of produce internationally, and even across the United States. Fresh produce imports from the Southern Hemisphere will likely be one of the first casualties of rising fuel prices. Ultimately, higher transportation costs will be reflected in the price of goods, placing many of the items we enjoy today out of the reach of a majority of people. On the surface, the United States might appear to be food secure, but a cutoff in transportation would lead to serious local shortages of food and other goods.

Oil production will inevitably decline and eventually come to a halt once all accessible oil deposits have been exploited. As this trend intensifies, industrial agriculture in its current form will become impossible. Already, since 1985, fertilizer production worldwide has declined by 23 percent because of fuel shortages and high prices (Pimentel et al. 12). This downward trend will likely continue as petroleum becomes increasingly expensive. Sadly, much of the world’s soil has been so degraded by the use of chemical fertilizers and pesticides that without the continued use of these synthetic inputs, the land cannot produce yields large enough to feed the world’s population (Heinberg 5). One study has shown that in the United States, soil is being lost at a rate 10 times faster than it can naturally be replaced (Hough). Fossil fuel fed irrigation is leading to water scarcity as countries overpump their underground aquifers to the point of depletion. Irrigation currently accounts for 70 percent of all water use and 19 percent of farm energy use in the United States (Brown 69). Once groundwater sources are largely depleted, the amount of land available for cultivation will diminish substantially.

Another limiting factor of post-peak agricultural production is population growth. Over the past decade the per capita availability of cropland has declined by 20 percent worldwide (Pimentel 461), and still, 78 million people are added to the planet each year. It will prove increasingly difficult to feed the world with diminishing fertile land and water resources.

Ironically, while 862 million people in the world suffer from hunger and malnutrition, another approximately 1.6 billion people suffer from excessive caloric intake (Brown 107). In the United States, it is usually the most marginalized among us, the poor and minority groups, who experience obesity and a lack of nutritious food in their diets. The sale of processed food, which makes up 82 to 92 percent of food sales, is entirely subsidized by fossil fuels. By exploiting the availability of cheap energy, the agri-food industry has created a situation in which the most processed, energy intensive food is also the cheapest. The average American consumes a diet of 3,747 kcal a day, which is greatly in excess of the FDA recommended intake of 2,000 to 2,5000 kcal per day (Pimentel 459). By simply reducing their caloric intake and consuming less processed food, Americans could greatly reduce the fossil fuel energy used in food production. Of course, in order to be able to start eating healthier, everyone must have access to nutritious foods, which is not the case in the current agri-food system. Another potential energy savings could come from a transition to diets that are lower in meat and dairy consumption and more seasonally based. Currently, one third of the calories in a typical American diet come from animal sources (Pfeiffer 22). A strictly vegetarian diet of equivalent caloric intake, however, consumes 33 percent less fossil fuel energy (Pimentel 459). These are only a few of the simple lifestyle changes that Americans could adopt to reduce their consumption of fossil fuels.

On small farms across the country, agricultural techniques are being implemented to reduce dependence on fossil fuels. Harking back to the days of pre-industrialized agriculture, some people have advocated a return to the use of draft animals as a replacement for fuel powered farm machinery. In a post-petroleum world, animal and human muscle power could very well be the most accessible forms of agricultural labor power. Although one horse can help manage 25 acres of farmland a year, that one horse in turn requires one acre of pastureland and 1.5 acres of hayland for its maintenance (Pimentel 464). Furthermore, the additional land that would be required to grow food for draft animals is currently being cultivated to produce food for humans. This needed cropland for draft animals will come from that presently reserved for humans.

Nevertheless, an increasing number of farmers across the country are choosing to adopt organic farming techniques. In the organic farming system, the need for synthetic fertilizers and pesticides is replaced by the use of crop rotation and leguminous cover crops, which naturally replenishes nutrients back into the soil. The application of compost and manure produced on the farm can replace the need for synthetic fertilizers to a large degree. Moreover, a shift to minimum and no-till agricultural practices on about two fifths of U.S. cropland has helped reduce direct use of petroleum based fuel on

American farms by 3.5 billion gallons from 1973 to 2005 (Brown 34).

Although the knowledge needed to transition to localized, sustainable agriculture exists, the current structure of power relations and resource control in the United States prevents the widespread move away from fossil fuel based agriculture. Those in positions of power within the United States government and in agribusiness have no interest in altering a system from which they greatly benefit. Without a change in the status quo, however, small local and sustainable producers will have a difficult time competing against the fossil fuel subsidized overproduction of agribusiness which finds its way into our grocery stores. The adoption of sustainable agriculture can only be truly transformational if we broaden its scope to focus on the relationship between social, economic and ecological factors within the agri-food system. In order to move away from conventional agriculture, it is necessary to understand why it functions the way it does and who are the winners and losers in the equation. Sustainable agriculture is not just about practicing organic farming techniques, but rather it is a way to address the structural inequalities in the current agri-food system and to guarantee that all people have access to nutritious and affordable food. Although this vision of sustainable agriculture might seem Utopian and unrealistic given the current nature of things, it is the only acceptable way to ensure the wellbeing of the planet and its inhabitants.

The fact of the matter is that the present agricultural system cannot be maintained for much longer. Decreasing oil production and rising oil prices will effectively bankrupt the American agri-food system. Without petroleum and all of its benefits, there will be little choice but to revert to a system of local, organic production and consumption. The experience of Cuba with peak oil could possibly serve as a model for a transition to post-peak agricultural production. Cuba, which lost the majority of its oil imports and half of its food imports with the collapse of the USSR, now produces almost all of its food organically (Pfeiffer 56). Urban gardens are an important source of produce, providing over 60 percent of the vegetables consumed by Cubans (Pfeiffer 61). The example of Cuba shows that it is possible to feed an entire nation with organic agriculture, but it also demonstrates the hardships involved in moving away from fossil fuels. In the first few years after the Soviet Union’s collapse, the average Cuban’s daily caloric intake decreased by 36 percent and protein consumption by 40 percent, while undernourishment increased by 15 percent (Pfeiffer 57). It must be noted that Cuban government policies played a critical role in helping to ensure that the collapse of industrialized agriculture did not turn catastrophic. There has also been a change in attitude towards farming amongst the Cuban people. Cubans now see farming as an important and profitable endeavor and many families have migrated to rural areas to become farmers or have started urban gardens (Pfeiffer 60).

Peak oil is a real phenomenon with the potential to turn our entire world upside down. Modern industrialized agriculture is headed for disaster and unless we begin immediately to change our patterns of agricultural production and consumption, many people will suffer. At the individual level, a lifestyle change is needed whereby we start to consume local products, rely less on oil-powered modes of transportation, eat lower on the food chain, have fewer children and reconnect with the land by participating in the growing of our own food. Structurally there ought to be a return to localized, small-scale photosynthesis-based, appropriate-tech agricultural production and an end to the domination of economic and power structures that place profit above all else. Broad based culture change will be a necessary component of any successful transition to a post-petroleum world. We can no longer afford to live isolated from one another and from nature. Of course, the rate of oil depletion is an unknown variable, and as Richard Heinberg observes the time interval before peak oil occurs will likely be too short to painlessly adapt to a new energy regime and way of life (3). However, if the United States, which is the world’s top oil consumer, can drastically reduce its use of oil, we might be able to buy time for the world to transition to a post-petroleum era (Brown 45). Clearly, weaning ourselves off of our addiction to oil will not be easy, but the alternative will be much worse.

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