ATLANTIC COUNCIL
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ISSUEBRIEF

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AUGUST 2011

Energy in Food

Introduction: Commercially Supplied Energy In Food

How much energy does it take to put a meal on a plate? Here's the best answer that I've come up with so far: it takes about the equivalent of one third pound of oil to produce, harvest, process, transport, store, package, and prepare every pound of food on the planet. This does *not* include solar radiation and other natural energy used by plants and animals or energy used to travel to shop for food or to dispose of food waste. The bulk of the energy used across the life cycle of food is fossil fuels, and most of it is oil.

The quoted figure for energy food intensity is a global average. There are huge variations depending on location, mode of production, transportation, distribution, cuisine and diet, and other variables. In the United States, total energy use in the food life cycle stands at around 10.25 quadrillion BTU (quads), the equivalent of some 260 million tons of oil. This corresponds to about eleven percent of total primary energy or about thirty percent of the oil consumed by the nation. Energy intensity of food in the United States is about 1.22 pound of oil equivalent per pound, much higher than the global average.

Only about twenty percent of the energy is used to actually produce food. Home refrigeration and food preparation are responsible for thirty to thirty-three percent and processing and transportation use about fifteen percent each.

Diets in populous countries such as China and India contain less animal products, which are very energy intensive, and more cereals, fruit, and vegetables, which are less energy-demanding. Traditional farms such as those in Africa and farms using large tracts of land produce less energy-intensive food. In many countries food travels smaller distances to reach markets and is less pre-processed and packaged in comparison with the United States and other developed nations.

The quantity of food used per capita across the globe is also a bit less than in the United States: about 3.7 pounds per person per day, compared to about 4.1 pounds in the United States.

Quantity does not necessarily affect the energy content of the food basket. The type of food, the distance travelled, the mode of production, and other factors can have a greater impact.

"Food miles" can also be misleading about energy intensity. "Food miles" are simply the distance food travels from the location where it is grown to the location where it is consumed, not total energy use. In the United States, processed food travels on the average about 1,300 miles and fresh produce spins the wheels for 1,500 miles before being consumed. However, depending on the type, mode of production, and transportation, food originating literally on the other side of the globe can be less energy demanding than foodstuffs coming from the field across the road. A 2006 study points out that certain kinds of food supplied to the UK from New Zealand are less energy intensive than the ones grown in the UK. Even after accounting for shipping, lamb imported from New Zealand requires seventy-five percent less energy than UK lamb, and so do apples (about forty percent), onions (twenty-three to twenty-five percent, and dairy products (fifty percent).

These figures are just snapshots based on information from varied sources, ranging from the United Nations Food and Agriculture Organization to US government departments to the International Energy Agency to scholarly articles. But even if these estimates of food energy intensity diverge fifty percent from the true amount, there are some serious implications to consider.

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Energy is Not "Cost" But a Factor of Production

Consider the need to assess the true role of energy in the food life cycle. One way to look at this role is to take into account the so-called "Granger causality" between energy and product, which evaluates whether growth in output causes more energy to be used or vice versa. Most studies now indicate that it is greater energy use that leads to increase in product, not the other way around, which means that energy use is actually an engine of growth.

This should hardly be surprising in the food supply cycle, since without first expending energy there would be no product at all. In the economy the bulk of energy is used productively, and energy efficiency is increasing as evidenced by falling GDP energy intensity. There are few reasons to believe that the case of food and energy is different. However, in food supply compared to other economic activities, one should probably evaluate more carefully the impact which energy savings programs and policies may have on output, and opt for output-neutral solutions whenever possible.

Energy Efficiently Substitutes For Labor and Land, Drives Food Supply Globalization

One of the most amazing features of modern food supply is how much labor and land energy saves. Hunter-gatherers spent almost all their time looking for food and needed a square mile or more to sustain a person. In neolithic Mexican agriculture, it took about 1,150 hours of toiling and 166 Mcal of energy to produce 4,400 pounds of corn. By 1980, the American farmer used just 6.3 hours to do the same (a 180+ fold reduction), while energy consumption had grown 19+ fold. Some estimates put the land needed today to support a person at 200 square yards or less. In a nutshell, in food supply energy appears in the role of capital, substituting for labor and land and intensifying the sector beyond the boundary that traditional agriculture cannot leap over.

Beware of any advice that asks you to limit the use of capital in food supply without properly assessing and dealing with the potential consequences. In its role of quasi-capital, energy is also a key factor for the globalization of food supply. Farmers of the world, welcome to the global village and to global competition.

Greater Energy Use in Food Supply Does Not Necessarily Mean Higher Food Cost

Consider further the need to properly quantify. Food energy intensity must be evaluated across its life cycle on a case-by-case basis. Reasonable policies aimed at improved energy efficiency in food supply should be consistent with the specific features of the cycle. For example, it is often pointed out that an increase in energy prices directly influences the cost of both fertilizer and food. What is rarely pointed out is the fact that an increase of the price of an input to a productive process can only lead to increase of the *unit cost* of the output if the rate of cost increase exceeds the rate of output increase. In the case of food, this would happen if energy efficiency across the food life cycle grows more slowly than the price of energy. There is little evidence that this is the case in the long run: in fact, food energy intensity has been declining in the United States since the late 1970s. Despite being very energy intensive, food of US origin is globally competitive because of its relatively *low unit cost*, a tribute to the excellent *productivity of energy*.

Efforts to Reduce Food Energy Intensity Work Best Beyond Food Production

It also matters how and for what purpose energy is used in the food supply chain. Food production requires large amounts of fertilizer and diesel fuel. Fertilizer is responsible for about forty-five to fifty percent of the commercial energy used in agricultural *production* and diesel fuel constitutes around twenty to twenty-five percent. However, food production typically only consumes a fifth of the energy across the food life cycle. Refrigeration and preparation, transport, and packaging are together responsible for over 60 percent of the energy "content" of food. Consequently, programs designed to enhance home appliance energy efficiency may fight food energy intensity more cost-effectively than efforts to cut energy use in food production. Besides, the desired effect could be achieved without impacting food supply at its origin. The same is valid for food container recycling, more efficient packaging, and similar endeavors. Trying to cut down food miles might even be counterproductive, since more miles do not necessarily mean higher food energy intensity.

The Impact of Fossil Fuel Use in Food Supply and Ways to Mitigate it

The single most important drawback in the energy-food entanglement is the source of energy. Today, it is mostly fossil and therefore often seen as finite resource unwisely used as capital. Emissions from intensive agriculture are of concern, too. However, the rumors about the death of industrial food supply are exaggerated. Even in countries where agriculture is very intensive, energy use in the sector does not exceed 3.5 to 5 percent of total primary supply. For example, French fisheries, agriculture and forestry use only 1.5 percent of total primary energy supply to the country (2008). The share of these sectors in total final energy consumption is just 2.5 percent. In other developed countries, energy use in these sectors is at comparable levels, and not all of this energy is used for food production. Only about 1.5 percent of fossil fuels are used to produce ammonia, the main source of nitrogen in fertilizers. Natural gas, the key input in ammonia manufacturing, is abundant. And all of this does not even take into account the huge potential for improving energy efficiency in the food life cycle beyond production, without affecting primary food supply. Similarly large energy savings can be achieved by removing barriers in international trade and investment that distort inputs, costs and prices and make food more energy intensive.

Those concerned with climate change should recall that deforestation is a major suspected culprit. Cutting down trees to expand fields leads to more emissions and less carbon sinks, while intensifying farm operations on already arable land keeps the sink intact. Advances in farm *technology* may reduce energy *and* land use simultaneously. This is the case in the United States, where energy use on farms (direct and indirect) peaked in the late 1970s and has declined since then by over 25 percent. Energy used to produce fertilizer has declined in the United States over the same period of time by more than 30 percent. In 1997, farmland was 42.2 percent of the total land area of the United States. By 2007, it had dropped to 40.8 percent. A good chunk of the freed land has gone to development, but some has reverted to forests. In the meantime, farm output of most products has increased and the United States continues to be the world's top exporter of grains, poultry, meat, and many other kinds of food.

Conclusions and Recommendations

These notes only provide cursory comments on the relationship between energy and food. Energy use in the food life cycle is exceedingly complex and varied, specific to the kind of product, operation, and market. Being fully globalized, food life cycle is a puzzle far beyond the scope of this message. Some points still seem worth making:

- Food energy intensity should be considered in the context of energy being a productive force similar to other factors of production, not just "cost."
- The relationship between energy and food prices is not straightforward. More energy intensive does not necessarily mean inefficient or more expensive. In the long run, other things being equal, food prices would rise as a result of increases in energy prices only if improvements in life cycle food energy efficiency lag behind. The relationship is similar to that between the cost of any other productive input (such as labor or land) and the unit cost of a product. Increased food demand and changes in food type and quality preferences are more likely to cause price increases than higher prices of energy. Barriers to investment and trade in food are probably stronger drivers for food price increases than the cost of energy.
- Concerns about fossil energy in the food life cycle are valid, but often overstated or misplaced.
- Many proposed solutions for reducing food energy intensity would affect its supply and cost in a manner different from the intended one.
- Policy and trade solutions that only address parts of the food life cycle, negatively impact food production, reduce competition, or create investment and trade barriers in agriculture and food supply are suspect medicines that could be worse than the ailment.

Modern food supply is a worldwide industry and the food market is a global one. Energy has been the key to both shaping the industry and making distant markets available to producers. Advanced energy technologies in food supply are one of the factors that have helped make food more abundant and affordable. On the other hand, policies looking at reducing food energy intensity are often fractious along national borders, of limited scope along the food life cycle, and prone to negatively impacting food production. It is time to look for a more coherent approach to an issue that affects the daily bread of every human being on the planet.

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