Fuel for Food:

Energy Use in the U.S. Food System

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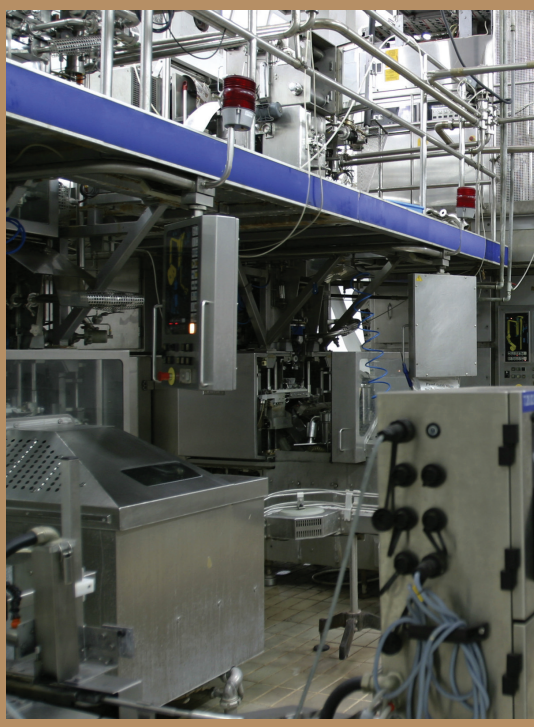


Photos: Thinkstock & Wegmans

- In 2007, the U.S. food system accounted for almost 16 percent of the Nation's energy budget.
- Between 1997 and 2002, over 80 percent of the increase in annual U.S. energy consumption was food related.
- Population growth, higher per capita food expenditures, and greater reliance on energy-using technologies boosted food-related energy consumption.

Energy is used throughout the U.S. food system. From the manufacture and application of agricultural inputs, such as fertilizers and feed, to building and powering the machines that turn wheat into bread and hogs into bacon, to making and running the toaster and frying pan used by the consumer at home or by the short order cook at the diner, energy fuels the U.S. food system.

An ERS analysis of food system energy use indicates that, while total per capita U.S. energy consumption fell by 1 percent between 2002 and 2007, food-related per capita energy use grew nearly 8 percent as the food industry relied on more energy-intensive technologies to produce more food per capita for more people.

Examining U.S. Food System Energy Use

Using a framework known as input-output material flow analysis, ERS researchers traced energy use by the U.S. food system, measuring the direct energy used to power machinery, as well as the "embodied" energy used in building and distributing the machinery. Thus, the fuel used to manufacture tractors and to run them on farms was measured. Likewise, the ERS analysis accounts for the electricity to power the microwave oven in the home and the energy used to build and distribute the appliance to consumers.

The input-output analysis framework also includes the energy embodied in other inputs to the food production and marketing system, such as fertilizers, shipping crates, and packaging materials. Energy flow analysis captures both direct and indirect energy flows of the entire food chain, from growing and processing the food, to grinding the plate scraps in a garbage disposal.

The two most recent U.S. benchmark input-output accounts from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) show that energy use by the U.S. food system grew at more than six times the rate of increase in total domestic energy use between 1997 and 2002. A projection of food-related energy use based on total U.S. energy consumption and food expenditures in 2007 and on the benchmark 2002 input-output accounts suggests that the U.S. food system accounted for 15.7 percent of total U.S. energy consumption in 2007, up from 14.4 percent in 2002.

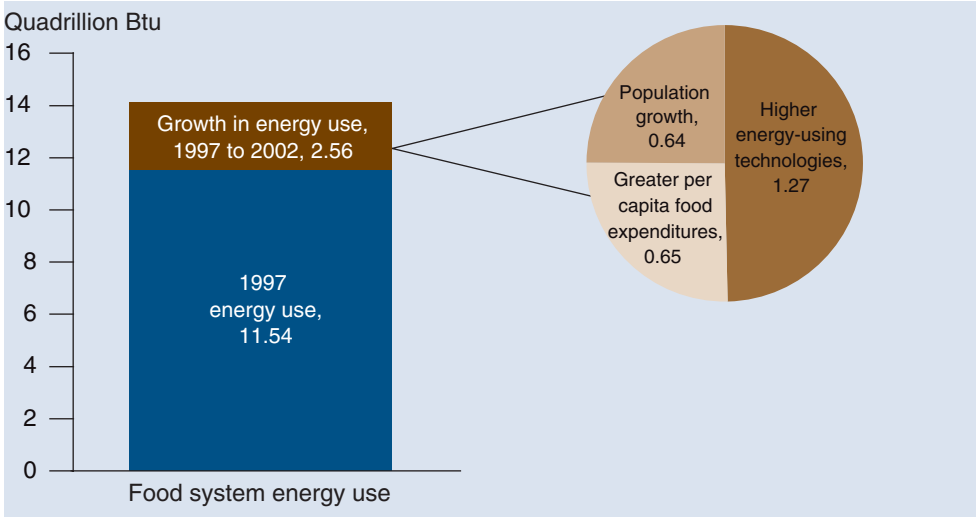
Three Factors Drive Increased Energy Use

For greater accuracy, ERS researchers used the survey-based benchmark input-output accounts from 1997 and 2002, rather than the 2007 projections, to discern the largest or fastest growing users of energy and the factors that sparked increased food-related energy use. Between 1997 and 2002, energy use in the U.S. food system grew from 11.5 quadrillion Btu (qBtu) to 14.1 qBtu (British thermal unit—a standard measure of thermal (heat) energy). This 2.6-qBtu increase accounted for over 80 percent of the rise in total U.S. energy use between 1997 and 2002.

Three factors were responsible for the jump in food-related energy use:

- **Population growth accounted for 25 percent of the higher food-related energy use in 2002 versus 1997**. The U.S. population grew by more than 14 million (5.1 percent) over the 5-year period. More mouths to feed means increased production of food and food-related items, ranging from fertilizers to frying pans, pushing energy used by the food system up by 0.64 qBtu.
- **Higher food expenditures also boosted U.S. food system energy use by 25 percent**. The amount of food marketed to U.S. consumers, measured in real (adjusted for inflation) dollars, increased 6.6 percent per capita between 1997 and 2002, according to BEA data. In 2002, the mix of commodities marketed to U.S. consumers included a greater proportion (in real dollar terms) of foods that used less energy, such as fresh produce and fish, and a smaller proportion of more energy-intensive commodities, like processed fruit and vegetables, pork, and beef. This changing mix, however, was accompanied by the substantial increase in food marketed per capita to U.S. consumers, resulting in a net increase in total food-system energy use of 0.65 qBtu.
- **The use of more energy-intensive technologies accounted for about half of the 1997-2002 food-related energy increase.** Businesses and households look for efficiency gains, so the relative costs and substitutability of energy and labor are major determinants of the amount of energy used by the U.S. food system. Between 1997 and 2002, businesses faced increasing labor costs, while energy prices were lower and far less volatile than they have been since 2002. A shift from human labor to energy-using equipment occurred for all food and food-related commodity groups, except pork.

The U.S. food system used 2.56 qBtu more energy in 2002 than in 1997



Source: USDA, Economic Research Service.


Courtesy of Rose Acre Farms

Modern, state-of-the-art hen houses are one example of the shift from human labor to energy-using technologies common throughout the U.S. food system.

The egg industry illustrates the long-term trend of substituting energy-intensive technology for labor. High-technology, energy-intensive hen houses, and more use of liquid, frozen, and dried egg products (instead of whole eggs) increased energy use per egg by 40 percent in 1997-2002. Processed egg products are widely used by the foodservice industry and by processors as ingredients in other foods, such as mayonnaise and baked goods.

The story is much the same in kitchens across the country. Consumers are relying on blenders and food processors instead of knives and chopping blocks, and self-cleaning ovens have replaced EASY-OFF® and elbow grease. Modern appliances, while sometimes more energy efficient, still require energy to manufacture and operate. ERS estimates that food-related home energy use increased by 3.9 percent per meal between 1997 and 2002.

Households Are Biggest Energy Users in the Food Chain . . .

In 2002, U.S. households used 3.94 qBtu of energy on food-related tasks—28 percent of total food system energy use. ERS research indicates that a typical U.S. household would have used about a half million more Btu per person in 2002 than in 1997 for the same foods.

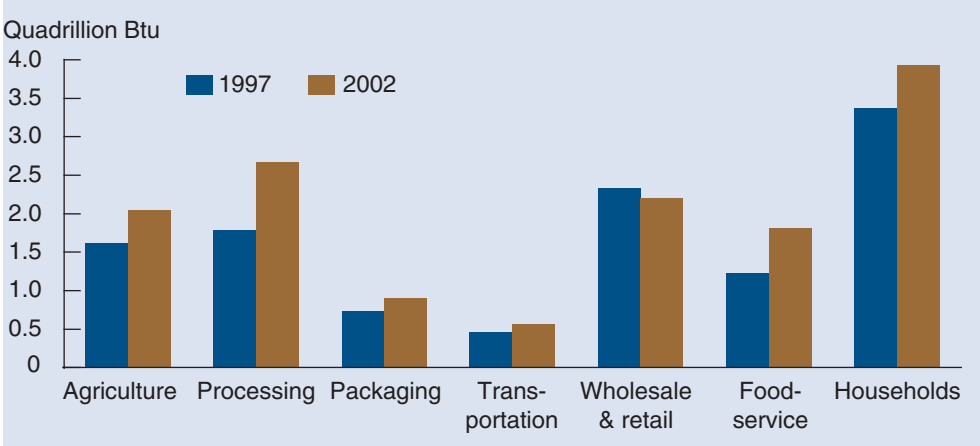
More households adopted labor-saving technologies to save time and effort on food preparation and cleanup. In 1985, 18 to 64 year olds spent an estimated average of 49 minutes on cooking and cleanup per day. Bureau of Labor Statistics' data indicate average cooking and cleanup times per household fell to 31 minutes per day in 2008.

The share of U.S. households with energy-using dishwashers, microwave ovens, and self-cleaning ovens increased substantially between 1997 and 2005, providing more evidence of an energy/labor tradeoff. At the same time, the percentage of U.S. households with two or more refrigerators increased from 15.2 percent in 1997 to 22.1 percent in 2005; there were 9.2 million more households with two or more refrigerators in 2005 than in 1997.

. . . But Food Processors Showed the Largest Increase

Although households used the most food-related energy, food processing had the largest growth in energy use between 1997 and 2002. Both households and foodservice establishments increasingly outsourced manual food preparation and cleanup to

Energy use by food processors surpassed wholesale/retail energy use in 2002



Source: USDA, Economic Research Service.

manufacturers. In 2002, food processors used 2.67 qBtu of energy, up from 1.79 qBtu in 1997.

Since the late 1990s, consumers have demanded more convenience foods that involve more processing and preparation services by a processor, services that would otherwise be done by households. "Single serving" and "quick" have ranked among the top 10 claims on new packaged food products since 2001.

Foodservice establishments also are looking for convenience and are purchasing ready-to-heat soups, entrees, and other foods that require more processing services by manufacturers. The number of food preparation jobs in the foodservice industry declined by about 16,000 between 1996 and 2000.

To accommodate the foodservice industry's growing demand for processing services, the food manufacturing industry added only 4,800 new food preparation jobs but substantially increased energy consumption. Between 1997 and 2002, food processors' energy use (direct and embodied) grew 49 percent, a larger increase than any other segment of the food system. This increase amounted to 2.7 million Btu per person, or roughly the heat energy equivalent of an additional 24 gallons of gasoline per person annually. As a result, the food processing industry surpassed the wholesale/retail industry, moving into second place behind households as the largest user of energy in the food system.

In 2005, 22 percent of U.S. households had two or more refrigerators

Year	Dishwasher	Microwave oven	Self-cleaning oven	Two or more refrigerators
		Million housing units		
1993	43.7	81.3	NA	14.4
1997	50.9	84.2	44.7	15.4
2001	56.7	92.1	48.2	18.1
2005	64.7	97.7	62.9	24.6
		Percent of total households		
1993	45.2	84.2	NA	14.9
1997	50.1	83.0	44.0	15.2
2001	53.0	86.1	45.0	16.9
2005	58.2	87.9	56.6	22.1

NA = not available.

Source: USDA, Economic Research Service using data from the Residential Energy Consumption Survey, Energy Information Administration, U.S. Department of Energy.

Foodservice Establishments Had Big Jump in Energy Use, Too, but Not All Industries Used More Energy

Although the foodservice industry outsourced much of its food preparation services between 1997 and 2002, industry energy use increased 47 percent—the heat energy equivalent of roughly 16 gallons of gasoline per person. The proliferation of coffee shops and eating places—with buildings to construct or renovate, equipment to manufacture, new kitchens to run, and buildings to light, heat, and cool—has added to energy use by the food system. In 2002, 479,000 food and beverage service establishments operated in the United States, up 7 percent from 1997. By 2008, this number increased to 546,000.

At other points along the U.S. food supply chain, changes in energy use were more moderate. The share of total food-related direct and embodied energy use by agriculture rose to 14.4 percent in 2002, up slightly from 14.0 percent in 1997. Agriculture ranked fourth among the seven food system industry groups in increased food-related energy use over the 5-year period.

Kathy L. Lipton, USDA/ERS

Food processors had the largest growth in energy use as they took on more of the food preparation tasks, such as peeling and shredding carrots, previously done in homes and foodservice kitchens.

The roof of the Hannaford Supermarkets store in Augusta, ME, features a large array of solar panels, reducing the amount of utility power purchased each year by about 50,000 kilowatts.

Gordon Chibroski, courtesy of Hannaford Supermarkets

Packaging and freight services are energy intensive but still use considerably less energy than other food system industries. Energy use by packaging and freight service firms over the 5 years increased 22 and 24 percent, respectively. The trend toward fewer and larger farms and processing plants led to greater use of freight services and substantial increases in the average distance per domestic shipment of all foods between 1997 and 2002. Longer average shipping distances translate to more transportation fuel per unit of food.

In contrast to all the other food-related industries, energy use by wholesalers and retailers declined over the period. Foodservice industry growth may have cut into the demand for retail services. At the same time, rapid consolidation of grocery store chains in 1997-2002, resulting in fewer stores with larger square footage of retail space, coupled with more energy-efficient lighting, heating, and cooling equipment, also may have contributed to declining energy use by food retailers.

Future Trends Hard To Predict

The ERS energy flow analysis looked at three distinct points in time (1997, 2002, and 2007); the results cannot be used to determine a pattern or trend in food-related energy use. Many factors can and will affect energy use by the food system. Adjustments in how Americans spend their food dollars, for example, could reduce future food-related energy use.

Based on 2002 energy technologies, if households choose to substitute a portion of their at-home meat and egg consumption with expanded fish and fresh vegetable consumption, for example, there could be substantial savings in energy usage. However, the energy savings would be less if the commercial fishing industry and/or the fresh vegetable industry relied on more energy-intensive methods to meet a large increase in expenditures on fish and fresh vegetables by U.S. households.

Prices are often the most direct influence on consumer purchases and producers' practices. If energy prices increase, for example, and labor costs and the availability of time for home food preparation do not change, companies and households will explore opportunities to trade off the now-more-expensive energy for less costly labor and time and will seek opportunities to use energy more efficiently.

Consumer attitudes about energy conservation can also alter the outlook for the level and direction of future U.S. food system energy use. For some consumers, knowledge of the energy flows associated with different food choices may influence food purchase decisions. As this segment of consumers grows, so, too, will its impact on the food system's energy use.

This article is drawn from . . .

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