

water is piped to local residents and to a local farm and intended for landscape watering. Other techniques involve using either rain sensors or soil moisture sensors. A recent University of Florida study of rain sensors found that the devices can save consumers enough money to pay for themselves within the first year [114]. Other research shows the value of soil moisture sensors. These devices are more precise than rain sensors because watering is conducted only if the soil moisture level drops below the specified point [112]. These devices can also pay for themselves in the first year [112]. The University of Florida's Institute of Food and Agricultural Sciences has developed a flier that explains some of the simple steps that residents can take to reduce the amount of water that they use on their lawns [115].

1.4.5 Energy and Food

1.4.5.1 Food Production

Food production and distribution are very energy- and water-intensive processes, and they also generate significant amounts of GHG emissions. One of the factors of the energy intensity of food is that it takes many calories of energy to produce one calorie of energy in the form of meat. For example it takes approximately 57 calories of energy to produce 1 calorie of lamb compared to 1 calorie of inputs to create 4 calories out corn [116].

Food prices had been dropping over the past 80 years or so [117], but prices of some foods recently began to skyrocket [118, 119]. During the Great Depression, food spending represented 25% of a family's disposable income. In 2007, that amount had dropped to 10% [117]. Rising fuel, fertilizer, water, production, storage and transportation costs in the food sector will put upward financial pressure on the American family's food budget.

Energy is required to produce, transport, store, and process food. For some food, the farm to table trip is very energy efficient, but for other foods this process is extremely energy and water intensive.

Food prices are rising, in part, because of the competition between food and fuel now taking place across America. High demand for biofuel feedstock has driven up the prices of the many grains and legumes typically consumed by humans [120].

Water, used to irrigate crops and perform a variety of operations in food production, contains a large amount of embodied energy. Energy is required to pump, transport, and purify water.

Agriculture is a major user of ground and surface water in the United States, accounting for 80 percent of the Nation's consumptive water use and over 90 percent in many Western States [121].

A brief look at each component of the food system and the energy characteristics of each component will be helpful in comprehending the problems and designing and implementing solutions.

Ratio of Energy Input to Food-Energy Output

Lamb	57:1
Beef cattle	40:1
Eggs	39:1
Swine	14:1
Dairy (milk)	14:1
Turkey	10:1
Chicken	4:1
Corn	1:4

Source: Tables 2 and 4 from *Sustainability of Meat-Based and Plant-Based Diets and the Environment* by D. Pimentel and M. Pimentel in *J. of Amer. Clinical Nutrition*, 78(suppl) p. 660S–663S.

1.4.5.2 Food Transportation

The average American meal travels over 1,500 miles from the farm to our tables in trucks, trains, and airplanes—some of this food comes from California, some comes from Mexico, some comes from Chile, and other food comes from other locations around the country and around the world. All of this transportation of food depends on oil. The doubling of oil prices from \$70/barrel in early July of 2007 to \$145/barrel in early July of 2008 has driven up transportation costs for all industries [122].

More locally produced food will reduce our food costs, reduce the amount of fuel we consume in the food production process and reduce GHG emissions. A large percentage of the food purchased in Alachua County comes from outside the County.

Alachua County's agriculture production, in terms of dollars, represents about 13% of the amount spent on food in the County. In other words, even if we assume that every morsel of food that is grown in Alachua County is consumed here, 88% of the food expenditures in Alachua County would be spent on products grown outside the County. This is an estimate based on information from the United States Department of Agriculture and the Florida Department of Agriculture. See Appendix A for details.

1.4.5.3 Food Storage

Temperature control is important to keep many of our food products safe and to help extend their shelf life. Coal and natural gas are the major energy sources used to produce the electricity used by most refrigeration units. As these energy prices rise, so does the price of electricity. The price of coal has risen from \$45 per ton in early July of 2007 to \$115 per ton in early July of 2008 [123]. Natural gas prices averaged \$7.00 per million cubic feet in 2007 and are expected to average more than \$17.00 per million cubic feet in 2009 [124, 125].

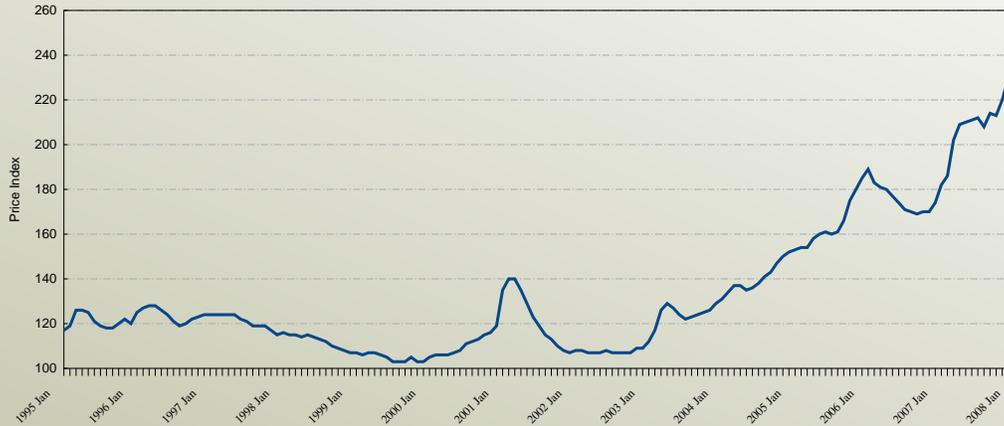
1.4.5.4 Food Production

The food industry is a highly mechanized industry that depends on many machines. On the farm, tractors and other machines are prevalent. Food processing relies on machines to perform a variety of tasks like milk processing, fruit and vegetable packaging, and meat rendering. All these machines rely on expensive energy (fuel or electricity) to operate.

1.4.5.5 Fertilizer

The Composition and Importance of Fertilizer Significant amounts of energy are required to mine, process and transport fertilizers. Fertilizer imports are growing, requiring more fuel to bring

Figure 1.10 Fertilizer Price Index in the United States—1995-2008



Data compiled from the archives of the National Agricultural Statistics Service. Retrieved from <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1002>

The U.S. Department of Energy states that 900 of the next 1,000 power plants built in the U.S. will be gas fired power plants. This is expected to put upward pressure on natural gas prices.

them to the American farm. The three major fertilizers (macronutrients) needed for strong, healthy and productive plants are nitrogen (N), phosphorus (P) and potassium (K). Our food supply is heavily dependent on these fertilizers. Nitrogen fertilizer is made from natural gas, driving up demand for natural gas. One study suggested that the largest energy input for the production of corn was nitrogen-based fertilizer [116].

The supplies of these nutrients, like many other natural resources, might not grow with increasing demand over the next century. Competition for these resources is rising rapidly and every year, more of these nutrients are being imported, some from very unstable regions of the world.

Fertilizer plays a significant role in the production of biofuels, a growing liquid fuel for the transportation industry. The crops used in the production of biofuels require large amounts of fertilizer. Increased demand, a declining supply of the raw materials, competition from other parties for the raw materials used in the manufacture of nitrogen, and increasing imports have caused fertilizer prices to increase by 228 percent since 2000 (see Figure 1.4.5.5). This price increase means the cost of fertilizing an acre of average-yield U.S. corn rose from about \$30 to \$160 [126].

Nitrogen Natural gas is the largest component of the nitrogen production process. Most of the nitrogen manufacturers in the U.S. closed over the past decade and imports are rising. The USDA reports that nitrogen imports accounted for 62% of nitrogen used in 2007 and the percentage is rising [127]. The top five nitrogen producers in 2002 were China, India, the United States, Russia and Canada [128]. U.S. demand for natural gas is growing, but U.S. natural gas production can't keep up with demand. The U.S. Department of Energy states that 900 of the next 1,000 power plants built in the U.S. will be gas-fired power plants [129]. There is also a very high demand

from developing countries as they move up the economic ladder. Together, these forces are expected to put upward pressure on natural gas prices and, in turn, on fertilizer prices.

Natural gas supplies are declining. According to Lee Raymond, former Exxon Mobil CEO (one of the largest natural gas companies in the world), North American natural gas production has peaked (2005) and is in decline [130]. The largest natural gas reserves are located in Russia and the Middle East.

Phosphorus Phosphorus is available in the United States, but the limited supplies here are declining. According to the United States Geological Survey, the United States holds about 3.4 billion tons of phosphorus reserves (6-7% of the phosphorus reserves in the world) [131]. Morocco holds 2 billion tons and China holds 13 billion tons [131]. The price of phosphorus is rising fast [132].

Potassium Potash fertilizer is the commonly used term for the soil fertilizer forms of potassium. Most all of the potash fertilizer used in the U.S. is imported. The USDA reported that 88% of the potash consumed in 2007 in the U.S. was imported [133]. The price of potash has risen dramatically in recent times.

1.4.5.6 Agriculture Efficiency

The efficiency of food production is an important topic to consider when trying to reduce energy and water usage and GHG emissions. Some foods are very efficient in their use of resources to produce a nutritious meal and other foods are very inefficient.

Fruits, vegetables, grains, and nuts tend to be very efficient foods in terms of energy and water use. Animal based foods are heavy users of energy and water and the production of animal based foods generate an inordinate amount of GHGs. The United Nations states that livestock farming is responsible for 18% of the carbon dioxide equivalents emitted worldwide, more emissions than the entire transportation sector [134]. Although the volume of methane released from agriculture is less than the volume released in the transportation sector, each unit of methane has about 25 times the global warming potential as carbon dioxide [59].

To get a feel for the energy consumption difference between a meat-based diet and a plant-based diet, think about the difference between an inefficient home and an Energy Star® (very energy efficient) home built in Florida.

The inefficient home (meat-based diet) would have a dark heat-absorbing roof, no insulation in the attic or walls, single pane metal-framed windows, a 20-year old refrigerator and air conditioning system, electric heat, an electric water heater, poorly sealed windows and doors and no shade trees. The Energy Star® home (plant-based diet) would have all the latest energy efficient features and products and consume much less energy.

The United Nations states that livestock farming is responsible for 18% of the carbon dioxide equivalents emitted worldwide, more emissions than the entire transportation sector [134].

1.4.5.7 Livestock Farming vs Crop Farming

Livestock farming is a very inefficient method of producing food when compared to crop farming. Our community could substantially reduce its energy consumption and GHG emissions by moving toward a plant-based diet.

The production of animal protein requires about eight times the fossil fuel energy as the production of plant protein [135]. On average, animal protein production in the U.S. requires roughly 28 kilocalories (kcal) of fossil fuel energy for every kcal of protein produced for human consumption. Beef production requires 54 kilocalories of fossil fuel for every kcal of protein produced [135, 116].

1.4.5.8 Land Use

Producing animal protein is a land-intensive and inefficient process. Fifty-six percent of U.S. agricultural land is used to produce beef. An acre of land can produce 20,000 pounds of potatoes or 165 pounds of beef [136] (see Table 1.12)

1.4.5.9 Water Use

Livestock farming is very water intensive. There are various estimates of the amount of water needed to raise cattle, and part of the complication is determining how much food they eat and how much water is needed to grow the food. One estimate is that each kilogram of beef requires 3,682 liters of water, most of which is needed to grow the food that cattle eat [137]. Another study made a rough estimate that a kilogram of beef requires 15 metric tons of water (15,000 liters) [138]. Another estimate, from David Pimentel, is a bit more controversial and suggested that that grain-fed beef production requires 100,000 liters of water for every kilogram of food [135], but more recent work by the same researcher suggested that the number is 43,000 liters of water per kilogram of beef [139]. Pimentel's also estimated that raising broiler chickens takes 3,500 liters of water to make a kilogram of meat. In comparison, Pimentel estimated that soybean production uses 2,000 liters for each kilogram of food produced; 1,912–1600 liters for rice; 900 liters for wheat; and 500–630 liters for potatoes [135, 139]. Although there is great variation in the estimates, the conclusion remains that beef requires an enormous amount of water per kilogram of food—and water requires energy for pumping and treatment.

1.4.5.10 Greenhouse Gas Emissions

The United Nations Food and Agriculture Organization states that the livestock sector generates more GHG emissions, as measured in carbon dioxide equivalents, than the transport sector. The livestock

Table 1.12 Land Requirements Per Unit of Edible Energy for Selected Foods

----- Land Requirements ----- ----- (square meters per 1,000 calories)-----			
	Cultivated Crops	Perennial Crops	Total
Animal Products			
Meat and Eggs			
Beef, lean cuts	9.2	45.4	54.6
Beef, all cuts	5.3	25.9	31.2
Chicken, lean cuts	14.3	0.0	14.3
Chicken, all cuts	9.0	0.0	9.0
Eggs	6.0	0.0	6.0
Pork, lean cuts	17.9	0.0	17.9
Pork, all cuts	7.3	0.0	7.3
Dairy			
Milk, skim	2.2	6.8	9.0
Milk, whole	1.2	3.9	5.0
Plant Products			
Fruits	0.0	2.3	2.3
Grains	1.1	0.0	1.1
Oils	3.2	0.0	3.2
Pulses	2.2	0.0	2.2
Sugar	0.6	0.0	0.6
Vegetables	1.7	0.0	1.7

Source: Table 2 from *Testing a complete-diet model for estimating the land resource requirements of food consumption and agricultural carrying capacity: The New York State example* by C. J. Peters, J. L. Wilkins, and G. W. Fick in *Renewable Agriculture and Food Systems* 22(2), p. 145–153, 2007

sector produces approximately 18% of worldwide GHG emissions [134].

1.4.5.11 Recommendations

1. Encourage Alachua County residents to switch to low energy/water use diets.
2. Develop education programs to teach people how to transition to low energy and low water use diets. This is an opportunity for local chefs, bakers, grocers and other food professionals to expand their businesses and create a new and exciting products and services in Alachua County.
3. Encourage residents to grow their own food.
4. Support Community Supported Agriculture (CSA) programs.
5. Increase the amount of food grown and sold locally. Many local jobs will be created in the farming industry in Alachua County and local tax revenues will increase.
6. Increase the number of farmer's markets in Alachua County.
7. Increase the amount of land available for farming in the County.
8. Develop education programs to teach residents about farming, pest control, water use and storage, etc. These programs will create many local job opportunities.
9. Encourage the creation of organic, low energy and low water use farms.
10. Encourage farmers to use permaculture farming techniques.
11. Plant native fruit and nut trees/bushes in Alachua County public spaces, not more ornamentals.
12. Encourage citizens to plant edible food gardens and orchards.
13. If necessary, lease Alachua County or conservation land to farmers at low rates to encourage farming.
14. Develop a farming internship program to teach prospective farmers how to create and manage a sustainable farming enterprise. An example program is conducted by the Intervale Center, in Burlington Vermont, which has a sustainable farming internship program [140].

15. Work with grocers to develop a system showing the approximate energy content and GHG emissions associated with all food products to help shoppers choose low-energy and low-emissions food. A great business opportunity for a local business to develop a system that can be used on a national scale.
16. Purchase local foods that are in-season to cut transportation energy requirements
17. Develop relationships with regional farmers and cooperatives to encourage a robust food system in North Central Florida.
18. Encourage the use of solar energy to produce the energy needed on farms.
19. Conserve energy by making fewer shopping trips, buying bulk food, filtering water instead of buying it in containers, and purchasing fresh foods that don't need refrigeration
20. Encourage low-water farming methods to reduce energy and water consumption.
21. Create a comprehensive countywide compost program designed to increase the use of compost and reduce the use of, and dependence on, synthetic fertilizers. An example program is run by the Intervale Center in Burlington, VT, which has an impressive compost system [141].
22. Create a *North Central Florida Food Zone*—a geographical area within which residents maximize their local sustainability. Encourage Alachua County residents to purchase as much of their food from the "Zone" as possible. Set goals for the community to increase the amount of purchases from The Zone over time. For example, 25% by 2010, 50% by 2015, etc... This concept is similar to some of the Renewable Energy Portfolio Standards where states set.

1.5 Increasing the energy efficiency of local food systems

Below is an outline of possible actions by local and regional government in support of a modernized food supply system. Some of these actions can be started immediately, and others may take years, or never, to unfold. Some are best implemented by government agencies themselves, while most are system wide processes that will benefit from recognition, support, guidance, or oversight.

Assumptions

Appendix A

Estimated Local Food Economy

Alachua County imports most of its food, and that importation requires fuel for transportation and sometimes energy for cold storage. A upper bound for the percentage of locally grown food that is consumed in Alachua County can be determined by comparing the small amount of food grown in the county relative to the amount of food consumed here. The following is a very rough estimate.

A) Value of agriculture products grown in Alachua County and sold in Florida in 2002:	\$58,665,000 [†]
B) Alachua County population in 2000 per BEBR:	217,955 [‡]
C) Annual Alachua County agricultural value per capita per year (A/B):	\$269.16
D) U.S. weekly food spending per person (all household average, 2004):	\$40/week/person
E) Maximum percentage of local food sold in Alachua County (C/D):	12.9% [*]

[†]Table 9.22 from *Florida Statistical Abstract 2007* by the Bureau of Economic and Business Research at the University of Florida. The order form for the report or CD is available from <http://www.bebr.ufl.edu/publications/data/Abstract2007>

[‡]Table 1.12 from *Florida Statistical Abstract 2007*.

^{*} *Household Spending on Food—2004* by the U.S. Department of Agriculture. Retrived from <http://www.ers.usda.gov/publications/err11/err11c.pdf>, see also <http://www.ers.usda.gov/Publications/ERR11/>