Gasoline for Lunch

Learner Packet

Summary: Learners explore the role of energy in food systems, with a focus on comparing “traditional” systems (relying on solar energy and biomass), and “modern” industrial systems that rely on fossil fuels. Activities include identifying energy sources used for everyday foods, calculating the amount of gasoline needed to produce one’s food, and comparing efficiencies in different food systems. The lesson includes reading selections, formative assessments, and math conversion activities. *(Time: 255 minutes)*

CONTENTS

Following this activity sequence supports inquiry-based instruction:

Activity 1) Energy Sources and Transformations in Everyday Foods

Consider the following:

calorie (abbreviation: cal or kcal): A unit of measurement for heat and the energy stored in food. Also called a gram calorie or small calorie. When applied to food, the term calorie actually means **a kilocalorie** ("kilo" means 1,000).

- If you eat a cracker, what kind of energy was used to get it to you?
- How many calories[1] are in the cracker?
- Where does your body get the energy to digest the cracker?
- If you run in place to burn off the calories, what kind of energy are you using?

Introductory reading: Sources of energy

All living things require energy in the form of food to survive. Animals eat plants and other animals for food. Plants get their food from the sun through the process of photosynthesis; a process that transforms solar energy, water, and carbon dioxide into simple sugars and oxygen.

Photosynthesis:

water (H_2O) + carbon dioxide (CO_2) $\xrightarrow{\textbf{sunlight}}$ sugar (glucose – $C_6H_{12}O_6$) + oxygen (O_2)

Humans also require energy to get food. To produce their food, humans use different sources of energy, including **solar energy** (the sun)**, physical energy** (muscles, fueled by the chemical energy in food), and **fossil fuels** (primarily oil to create diesel fuel to run machines). For example, if you grow tomatoes in your home garden and plant them by hand, you are using solar and physical energy. But if you used a gas-powered tiller or other equipment, then fossil fuel energy is used. **What kind of energy is being used in each picture?**

Example	Energy Source	Energy transformations*
Berries growing in the wild.	Sun	Solar energy to chemical: The sun provides light that plants convert to food through the process of photosynthesis.
You eat something, then go for a walk later.	Calories	Chemical to mechanical: Food provides chemical energy that the body converts to movement (mechanical energy).
A farmer uses machinery to harvest corn that is then used for cattle feed.	Fuel made from petroleum Sun	Chemical to mechanical: The potential chemical energy is released by combustion in the engine to power the machine and provide mechanical energy (movement). Radiant to chemical: Through photosynthesis, the sun's energy is converted into potential chemical energy in the form of **sugars.**

**Instructors: See the lesson "Energy Forms and Transformations" for a complete, hands-on introduction to this topic.*

[1] In scientific use, "calories" referring to food are often written with a capital C since they are "large calories." We use small "c" throughout the

Activity 1) Energy Sources and Transformations in Everyday Foods

Directions

1. In left column of the table below, list 3-5 foods you have eaten in the past few days.
2. In the other columns, describe the role each energy source played in producing the food. Consider stages such as growth, processing, and transportation.
3. When you are done, compare your answers with others' using these questions:

   a. What kinds of fossil fuel energy were used to produce your food?

   b. Where does this energy come from?

   c. Do you eat any foods that have not used any fossil fuels as an energy source?

Food	Sun (photosynthesis)	Physical energy	Fossil fuels	Optional: Examples of transformations
Soda	High fructose corn syrup in soft drink used solar energy to grow corn.	Humans harvested corn and operated machines to produce the soft drink and can.	Electricity was used to operate machines in a factory; fuel was needed to power trucks for transportation.	

Activity 2) You Can't Turn Up the Sun

Introduction

To create food, light energy from the sun must be transformed or converted into other forms of energy. Plants capture solar energy (in the form of photons) and convert it into sugars; this is the process of photosynthesis. This conversion is shown by the following formula:

Transformation and **conversion** are other words for "change."

Photosynthesis: water (H_2O) + carbon dioxide (CO_2) —**sunlight**→ sugar (glucose – $C_6H_{12}0_6$) + oxygen (O_2)

Animals (including humans) eat plants and store the calories (energy) in their bodies. This energy is converted into mechanical energy (muscle power) to perform everyday activities as shown below:

food energy stored in plants → chemical energy → mechanical energy (movement)

You can't turn up the sun

You may know that many plants go dormant when the weather turns cold and that they begin growing again when temperatures get warmer. (You may not experience some of these changes if you live in a climate without distinct seasons.) Solar energy has some unique properties:

- The sun provides both heat and light energy.
- The number of hours of daylight varies depending on latitude and season.
- Humans cannot change the rate at which solar energy flows. In other words, you can't "turn up" the sun. However, humans can concentrate, capture, and store solar energy.

Since we can't "turn up" the sun, humans have developed ways to increase the amount of food available. In this activity, you will explore ways humans have done this throughout history with a focus on the introduction of new energy forms into the food production system.

Directions

1. On the following pages are four short reading selections about different periods in the history of the food system. Your instructor may assign one to you or a group. Preview your reading selection by reviewing headings, pictures, vocabulary boxes, and other elements.

2. Read your selection and prepare a summary using the **Graphic Organizer** on the next page. (You can also write the notes on large paper, then present your results as part of a timeline.)

Questions after all sections are presented:

a. What was new or surprising?
b. How are the events in each selection connected?
c. In what ways have changes in energy use moved us towards or away from a **sustainable food system**? (Definition: "A food system that maintains health, sustains the environment, preserves our cultural fabric, and benefits the regional economy" (University of California Davis, 2006).)

Activity 2) You Can't Turn Up the Sun

Time period of my selection: ____

1. Summarize ways food was grown in this time period. Consider tools, energy sources, farming methods, and other factors.

2. Are any of the tools, energy sources or farming methods described still being used today? Consider your community/region as well as the larger world. Give an example.

3. What are the benefits and drawbacks about growing food in the ways described in your selection? Give examples in the table below. Describe whom or what is affected.

Benefits	To whom/what?
Drawbacks	**To whom/what?**

Continue >

Activity 2) You Can't Turn Up the Sun

4. Identify the role each type of energy source played in the food system of your time period. *Note: Use the left column to take notes on other time periods.*

Describe if and how this energy source played a role in the food system in this time period:				
Time period	Sun (photosynthesis)	Mechanical energy from living things (animals)	Mechanical energy from non-living things	Fossil fuels

5. Give an example of an energy transformation in the food system from this period. Include the energy source, a description of how it was transformed, and the outputs (useful materials or wastes that resulted). An example (applicable to all time periods) is provided.

a. Energy Source	**b. Energy transformations**	**c. Outputs**
Sun	Radiant to chemical: The sun provides light energy in the form of photons that plants convert to food through the process of photosynthesis.	Oxygen, sugars, and food for humans and other species.

Activity 2) You Can't Turn Up the Sun

Selection A) 8000 BCE: The Agricultural Revolution

Before the agricultural revolution, (about 10,000 years ago, or 8,000 BCE[2]), humans lived as hunters and gatherers and some populations today still live in this manner. This meant that people either gathered and ate available plants or killed animals that ate those plants. The energy flow in this food system reflects the food chains found in nature, where the sun serves as the main energy source. Plants produce food from the sun (through photosynthesis), herbivores eat that food, and then other animals eat those animals. In this system, humans either ate plants (such as fruit, roots, or wild grains) or ate animals that ate those plants (such as rabbits). In this way, human food supply was completely dependent on the energy flow provided by the sun.

To process and store food in these early days of agriculture, people used metabolic energy (muscles) to pound grains into flour and heat energy (fire) was used to cook foods. Solar energy was used to dry foods such as berries and grains.

The earliest method used to increase food production supply was clearing land and removing other plants, in order to grow crops such as barley, wheat, and corn. The amount of solar energy did not change during this time, just the amount of **edible** plants that received it. By removing unwanted plant species for crops, humans altered the ecosystem. This resulted in an overall increase in available food energy but at the same time affected both native plant and animal species.

Selection B) 4000 BCE-1800s: Increased use of physical and mechanical energy

By 4000 BCE people were using wheels and mills powered by flowing or falling water (mechanical energy). These mills provided another energy source to grind grains and process food.

Around 3500 BCE, farmers began using energy provided by animals, such as oxen. These animals were used to drag simple plows to loosen the soil and clear the land to prepare it for seeds. In 1000 CE, the invention of the heavy plow was a major technological advancement.

Over the years, plows, yokes, and other basic farm tools changed and grew more powerful as people developed new ways to harvest energy from water, wind, and animals.

Ancient Egyptian plow, circa 1,200 BCE

2 "BCE" means "Before the Common Era", considered to begin in the year "0." Since this was about 2,000 years ago, the year 1000 BCE is actually 3,000 years ago. (Add 2,000 to the BCE year to find out how many years ago the event occurred.) "CE" means the "Common Era"; 600 CE is the year 600.

Activity 2) You Can't Turn up the Sun

Selection C) 1800s: Introduction of fossil fuels

The basic energy source for agriculture did not change until the introduction of fossil fuels during the late 18^{th} century. This shift towards a new energy source began when James Watt, a Scottish inventor, developed the "modern" steam engine in 1765. These early engines were used to power the growing factories of the Industrial Revolution, a time of transition to factory-made textiles, steel, and other goods.

The first use of a gasoline-powered tractor was in 1868, more than 100 years after Watts first invented his engine. The introduction of gasoline-powered machines enabled farmers to expand their agricultural operations even further.

Selection D) 1950's- 1970's: The "Green Revolution"

Starting after World War II, agriculture underwent a drastic transformation commonly referred to as the Green Revolution. The main changes included:

- The introduction of new hybrid food plants that depended on inputs of human-made fertilizers and pesticides
- An increase in the size of farms and the introduction of bigger machinery
- An increase in monocropping (farming a single type of crop)

These changes required dramatic increases in the amount of fossil fuels.

- Fossil fuels were required to power the new, larger machines for the bigger farms. New machinery allowed farmers to plow more land, harvest more crops, and process more grains.
- Fossil fuels were used to produce fertilizers. For example, producing 2.5 pounds of nitrogen fertilizer from the nitrogen gas in the atmosphere requires the energy equivalent of 1.4 to 1.8 liters of diesel fuel (Pfeiffer, 2003).
- Fossil fuels were used to manufacture pesticides, which were increasingly needed for the large-scale, single-crop farms. Traditionally, farms had a diversity of crops, and this helped maintain a healthier ecological balance that prevented one kind of pest from dominating. But the rise of monocropping eliminated this natural control, making farms more dependent on inputs of pesticides.
- The Green Revolution featured the development of new hybrid plants specifically for the monocrop farms. These varieties could give higher yields but only with applications of fertilizers, pesticides, and other energy-intensive inputs.

All in all, the Green Revolution increased the energy flow to agriculture by an average of fifty times the energy input of traditional agriculture. These changes have had profound environmental and social impacts. (See the lesson "Life Before Ketchup" for an historical overview of the food system.)

Activity 3) Reading Selection: Fossil Fuels in the Food System

Introduction: What do you already know about energy in the food system?

Producing many foods takes multiple steps including production, transportation, processing, and packaging. Each of these steps requires energy. In today's food production system, this energy mainly comes from fossil fuels.

Directions

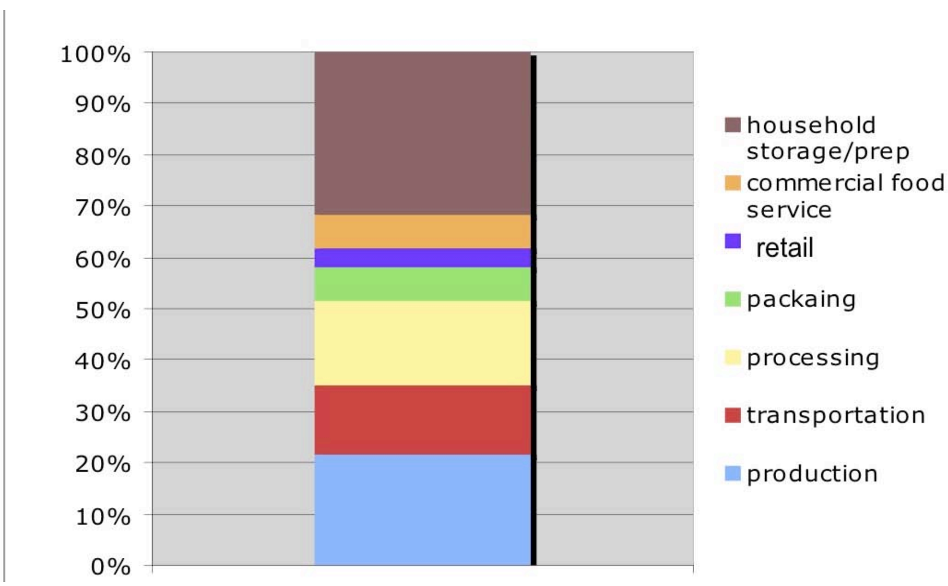
1. The table below lists the stages in the food system. Each stage uses a certain percentage of the total fossil fuels used in the food system (not the total fossil fuels used for all purposes). Column A gives examples of where the fossil fuels are used in the food system.
2. In column B, write in your estimate of the percentage of all fossil fuels used in the food systems at that particular stage. Remember, this is a *percentage* of all fossil fuels used in the **food system**, not all fossil fuels used overall.
3. In column C, give examples of how energy is used (for example, to heat food).
4. In column D, give examples of the outputs to the environment and the impacts.
5. Compare your response with a partner.

A) Food system stage	B) % of fossil fuels used in this stage	C) Examples of energy used	D) Outputs and impacts
Agricultural Production			
Transportation			
Processing Industry			
Packaging Material			
Food Retail			
Commercial Food Service			
Household Storage & Preparation			

Activity 3) Reading Selection: Fossil Fuels in the Food System

Correct responses: The table and graph below show A) the food system stage, B) the percentages of all fossil fuels used in the food system at that stage, C) examples of what the fossil fuel energy is used for, and D) some of the outputs and impacts.

A) Food system stage	B) % fossil fuels used	C) Examples of energy use	D) Outputs and impacts
Agricultural Production	24%	Of all energy used in this stage, 40% is used for producing synthetic fertilizers and pesticides; 25% is for diesel fuel; 35% is for other uses such as irrigation	Carbon dioxide (CO_2); methane (CH_4). Excessive fertilizer run-off creates algae blooms and eutrophication, which can kill other aquatic life forms
Transportation	13.5%	Gas and diesel fuel are used to transport foods from manufacturers to store and from stores to your home	Carbon dioxide emissions. Traffic impacts; impervious surfaces and their impacts on waterways
Processing Industry	16.4%	Electricity (often powered by coal) is used for processing steps such as baking, drying, slicing, and freezing	Carbon dioxide emissions; food waste; packaging
Packaging Material	6.6%	Making packaging requires energy (electricity) as well as raw materials to make glass, plastics, aluminum, and paper products. Disposing of wastes requires fuel for trucks	Carbon dioxide emissions. Packaging waste: plastic, cardboard, etc. (Some wastes can be recycled.)
Food Retail	3.7%	Stores use electricity for refrigeration, freezing, and other uses	Carbon dioxide emissions; packaging; heat waste
Commercial Food Service	6.6%	Cooking and preparing food for restaurants, schools and other institutions consumes natural gas and electricity	Carbon dioxide emissions; food waste; packaging; heat waste
Household Storage & Preparation	31.7%	Operating refrigerators, freezers, stoves, ovens, and dishwashers uses electricity and natural gas	Carbon dioxide emissions; food waste; packaging; heat waste



Fossil Fuels Used in Food System Stages

(Heller and Keolian, 2000)

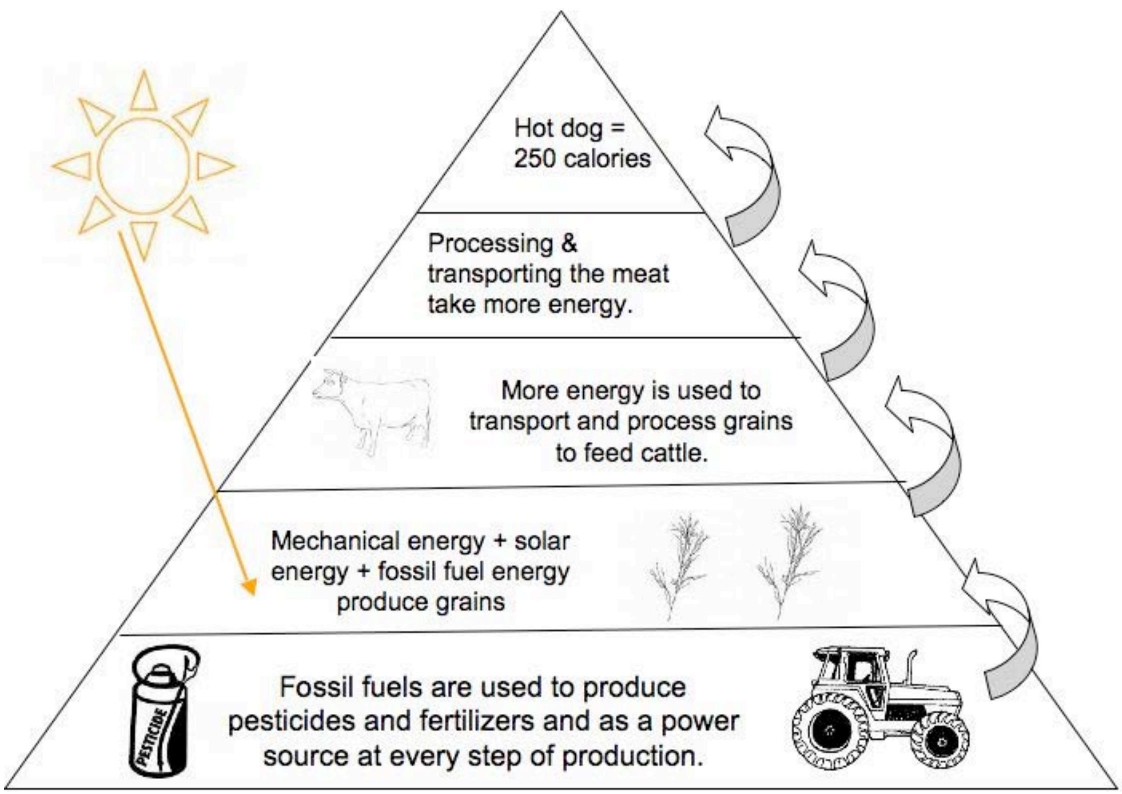
Note: The order of food system stages corresponds with the order of the bars in the graphic (from top down).

Activity 3) Reading Selection: Fossil Fuels in the Food Systems

The current-day food system requires large amounts of fossil fuels. Let's consider cereal. The grinding, milling, wetting, drying, and baking of a breakfast cereal requires about four calories of energy for every calorie of food energy it produces. A two-pound bag of breakfast cereal burns the energy equivalent of a half-gallon of gasoline (Manning, 2004). That does not include the fuel used in transporting the food from the factory to a store near you or the fuel used by millions of people driving to stores.

Meat production requires yet more energy. Animals such as beef cattle eat mostly grains (Gurian-Sherman, 2008). Meat production thus requires energy to grow these grains, process them into feed, and transport them to feedlots. Grain-fed meat from factory farms is highly inefficient from an energy standpoint. It takes thirty-five calories of fossil fuel to make a calorie of beef this way; sixty-eight calories to produce one calorie of pork (Pfeiffer, 2003).

Other steps, such as butchering, processing, and transportation take more energy. For example, when food from Europe is imported to the USA by plane, it takes 127 calories of energy (aviation fuel) to transport 1 calorie of food energy across the Atlantic (Church, 2005).



It takes about 40 kcal fossil energy to produce 1 kcal of beef protein. A 250-calorie hot dog requires 10,000 calories of fossil fuel inputs, equal to about 1/3 of a gallon of gas.

Activity 4) Time vs. Energy: Comparing Efficiencies in Food Systems

biomass: Plant matter that gets energy from the sun.
kilowatt (abbreviation: kW): One thousand watts. A watt is the standard measure of electrical power.
horsepower (abbreviation: HP): a unit of power equal to 550 foot-pounds per second (745.7 watts).

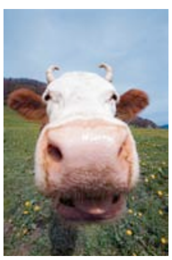
"Traditional" agriculture: less energy, more time

"Traditional" food systems that rely on human and animal labor are fueled by **biomass** (plant matter that gets energy from the sun). It takes about four calories of biomass to produce one calorie of "new" food for human consumption. Producing 2,500 calories (an average daily adult caloric intake) thus takes about 10,000 calories of biomass.

Producing food from human and animal labor requires up to five hours of labor to supply the daily diet for one person. The introduction of fossil fuels has dramatically increased the amount of food that can be produced in a unit of time. For example, in the United States, the amount of corn produced per hour of labor is 350 times higher today than the Cherokees could produce with traditional agricultural methods- human and animal labor (Giampietro & Pimentel, 1994). This is seen in the following calculation. (See Activity 5.)

- Human work output in agriculture per hour = 0.1 HP, or 0.074 kilowatt (kW).
- One gallon gasoline = 31,000 Calories (food calories or kilocalories)[3]. An engine converts the gas into 8.8 kW of energy (assuming 20% efficiency).
- 8.8 kW/.074 kW/hour = 118.9 hours, or about 3 weeks of human work at 40 hours/week.

"Modern" agriculture: less time, more energy



In terms of yield of food per unit of human time and energy, food production has become more efficient with the introduction of fossil fuels, used for gas-powered machinery and fertilizers (also made with fossil fuels). For example, between 1950 and 1984, during the "Green Revolution", world grain production increased by 250% (Kindell & Pimentel, 2004). But this required more energy inputs. Between 1945 and 1994, energy input to agriculture increased four-fold, yet crop yields only increased three-fold (Pfeiffer, 2003).

The increased reliance on fossil fuels came with environmental and cultural costs, including higher prices for inputs (seeds and machinery), environmental contamination from fertilizers and pesticides, soil erosion, reduced biodiversity, and the loss of traditional knowledge and methods for producing food. "Modern" agriculture (along with other aspects of the economy) has been criticized for failing to consider the value of this cultural knowledge and ecosystem services in its definition of "efficiency" (Costanza et al., 1997).

The input of energy in "modern" agriculture is fifty times higher than in traditional agriculture. In terms of overall energy input, food production is actually *less* efficient than traditional methods. Every calorie of food produced requires ten calories of fossil fuel energy. A comparison appears below.

	Energy input	Converted to . . .	Food energy output	Benefits	Drawbacks
"Modern" food system	10 calories in fossil fuels	Mechanical energy from machines	1 calorie of food	More food in less time	Environmental and cultural impacts
Traditional food system	4 calories of food	Mechanical energy (metabolism and physical movement)	1 calorie of food	More food per unit of energy. Environmental and cultural benefits	Less overall food since energy input is limited

[3] www.health.howstuffworks.com.

Activity 4) Time vs. Energy: Comparing Efficiencies in Food Systems

Formative Assessment

Directions

1. Choose to focus on “traditional” or “modern” agriculture. Write your choice here: ____________

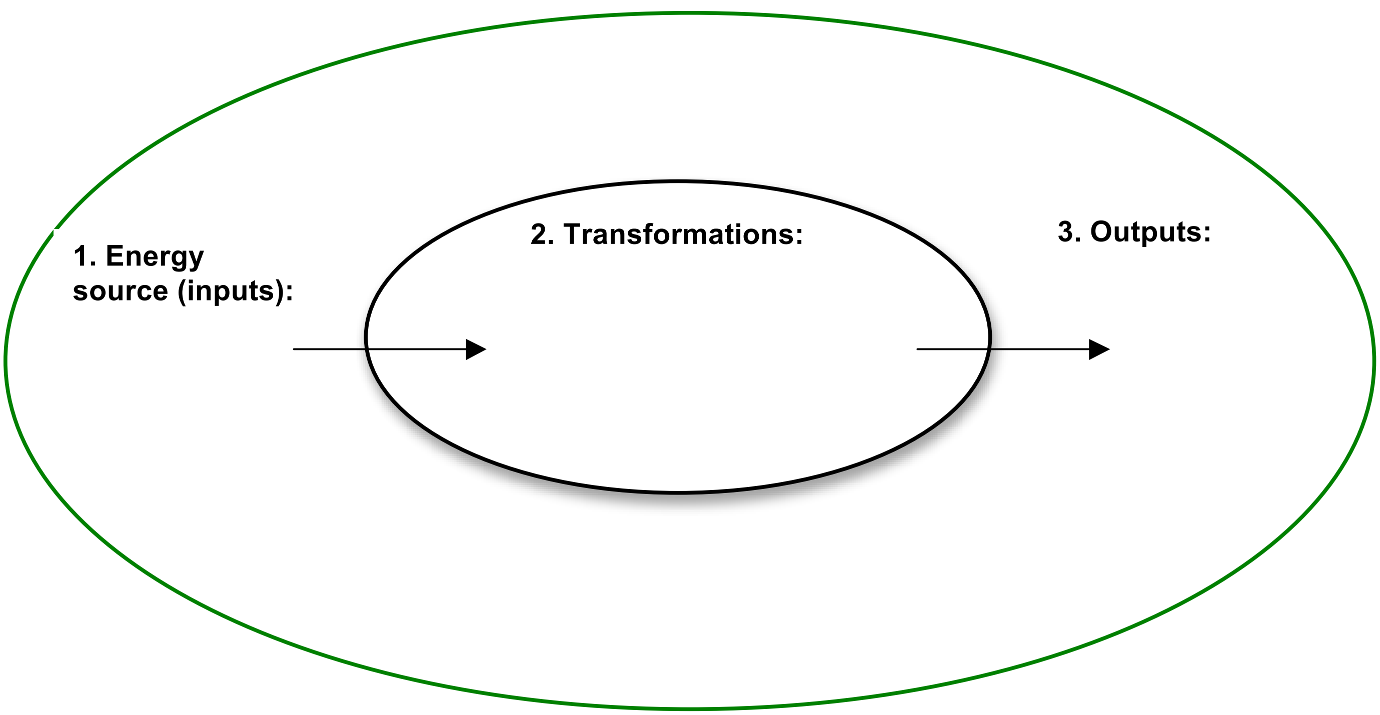
2. Review the reading selection about your system on the prior page. What are the source(s) of energy for the food system? Write in the energy sources in the diagram below.

2. What energy transformations take place?

3. What are the outputs (the resulting products)?

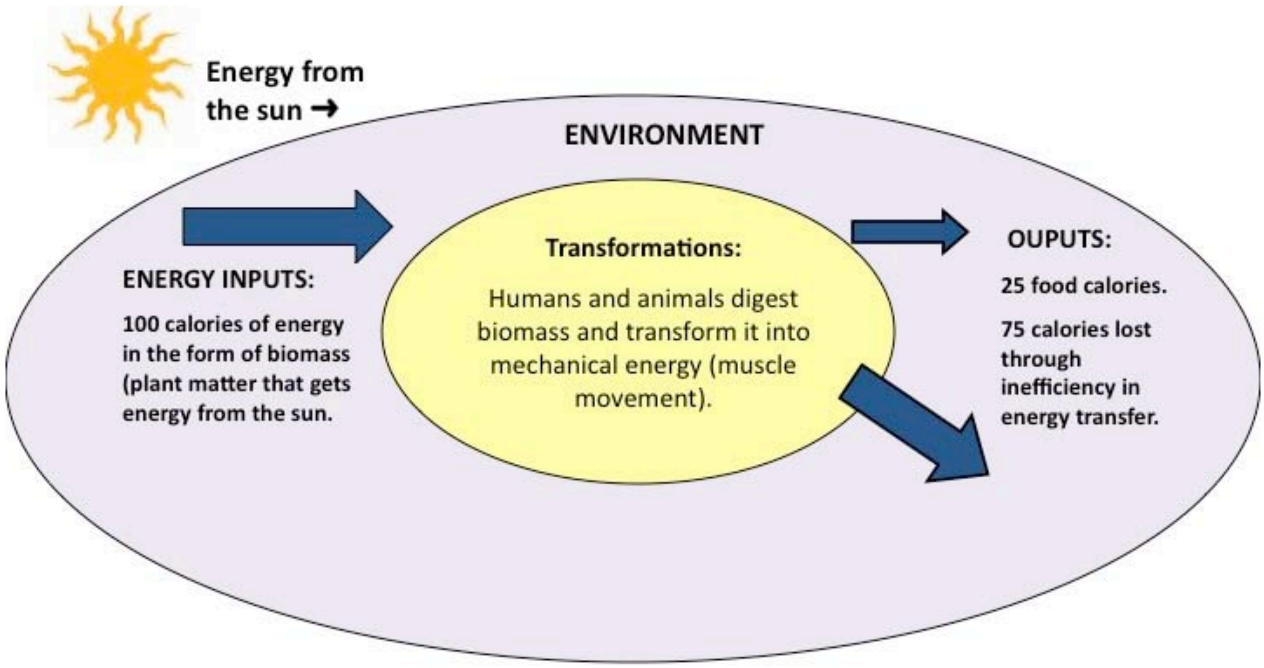
4. What are additional impacts?

5. What is the efficiency ratio (the ratio of calories of energy inputs to the calories of food energy outputs)?

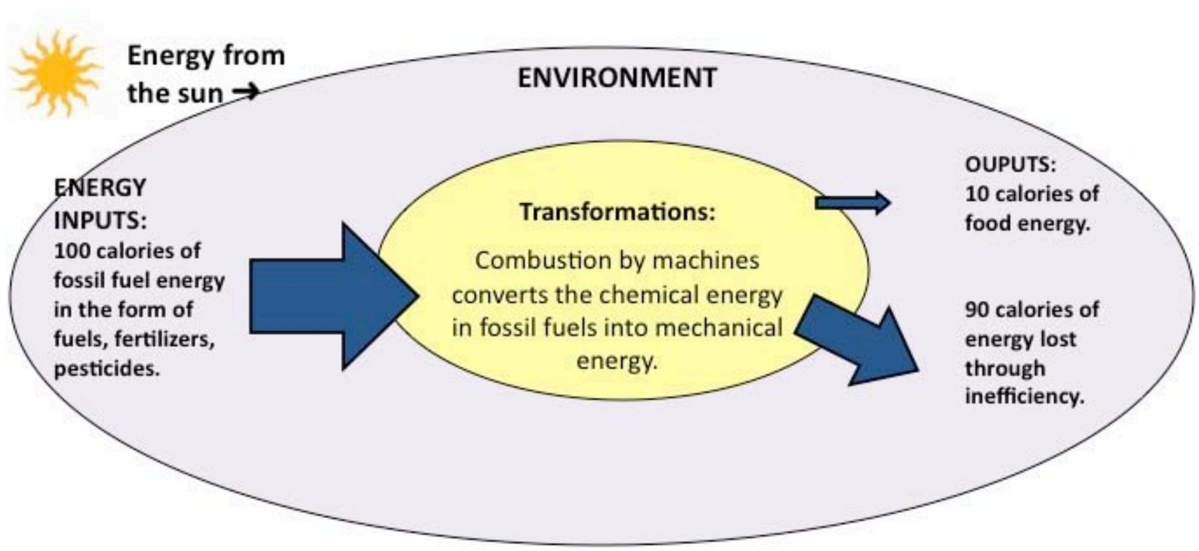


Activity 4) Time vs. Energy: Comparing Efficiencies in Food Systems

Traditional Food System Efficiency Ratio: 4:1



"Modern" Food System Efficiency Ratio: 10:1



Activity 5) Gasoline for Lunch

Introduction

As described in the reading, the current food system requires ten **calories** of energy (in the form of fossil fuels) to produce one calorie of food. Based on this 10:1 ratio, it takes approximately 25,000 calories of external energy per capita (mainly in the form of fossil fuels) to produce a daily diet of 2,500 calories. This calculation assumes an average 2,500 calories per person of food available per day for consumption.

embodied energy is the all energy required to produce an item. It includes energy used in all stages of a life cycle: extraction of raw materials, production, transportation, etc.

These fossil fuels, mainly in the form of gasoline, are used to power machinery for planting, harvesting, and transportation. Fossil fuels are also used to make and distribute fertilizers, pesticides and herbicides for food and feed crops. All of this external energy is contained in, or **embodied**, in the foods you eat. In the United States, the equivalent of 400 gallons of oil are expended annually to feed each American (Pfeiffer, 2004).

Calculating the Embodied Energy in Your Food

So how much fuel does it take to produce, harvest, and/or transport your daily diet of food? How much energy is embodied in your weekly diet? Here's how you can find out:

Step 1: Fill in the table below with the foods you consumed yesterday and the approximate calories of each item. Add up the number of calories at the bottom of each column, then use these figures to complete the rest of the steps.

Food Items	Breakfast	Approx cal.	Lunch	Approx cal.	Dinner	Approx. cal.	Other (snacks)	Approx cal.
Item 1								
Item 2								
Item 3								
Item 4								
Item 5								
Total calories								

Step 2: Calculate your **total calories** for the day. Add up the total amount of calories you consumed for all of your meals. Record your answer below.

Total number of calories for the **day**: ______________________________.

Activity 5) Gasoline for Lunch

Step 3:

Calculate the **number of** calories of embodied energy that was used to produce this amount of food. Remember the ratio of fossil fuel energy to food energy is 10:1. You can calculate this number by multiplying your total calories per day by 10. Record your answer below.

Total number of calories/day *X* 10 =

Number of calories of embodied energy: ______________________________.

Step 4:

Calculate the approximate amount of fuel, primarily in the form of gallons of gasoline, it took to produce the food you consumed yesterday. To complete this calculation, you will need to set up a conversion formula as shown in the following example. Remember that a gallon of gasoline is approximately equivalent to 31,000 calories of energy. Record your answer below.

Conversion formula:

$$\frac{\text{\sout{calories of embodied energy}}}{\text{1 Day}} \times \frac{\text{1 Gallon of Gasoline}}{\text{31,000 \sout{calories}}} = \frac{\text{Gallons of Gasoline}}{\text{Day}}$$

Example: (Based on a daily average of 2,500 calories)

$$\frac{\text{25,000 \sout{calories}}}{\text{1 Day}} \times \frac{\text{1 Gallon of Gasoline}}{\text{31,000 \sout{calories}}} = \frac{\text{.81 Gallons of Gasoline}}{\text{Day}}$$

Now add your own calories based on your prior calculation in Step 3, and complete the conversion formula:

$$\frac{\text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}}{\text{1 Day}} \times \frac{\text{1 Gallon of Gasoline}}{\text{31,000 calories}} = \frac{\text{Gallons of Gasoline}}{\text{Day}}$$

The number of gallons of gasoline it took to produce my food:

_______________________ gallons.

Activity 5) Gasoline for Lunch

Step 5: Calculate the approximate amount of fuel, in gallons of gasoline, it took to produce the food you consume in a week. This will be an approximate amount taking into consideration you probably do not consume the same amount of calories every day. To complete this calculation, you will need to multiply your answer from Step 4 by seven days in a week. Follow the example below.

Number of gallons of gasoline	X	7 ~~days~~	=	Number of gallons of gasoline
1 ~~Day~~		week		week

Example:

.81 gallons of gasoline	X	7 ~~days~~	=	5.67 gallons of gasoline
1 ~~Day~~		week		week

Now add your own amount of gasoline based on your prior calculation in Step 4 and complete the conversion:

______________________	X	7 days	=	5.67 gallons of gasoline
1 Day		week		week

Total number of gallons of gasoline embodied in my food for the week:

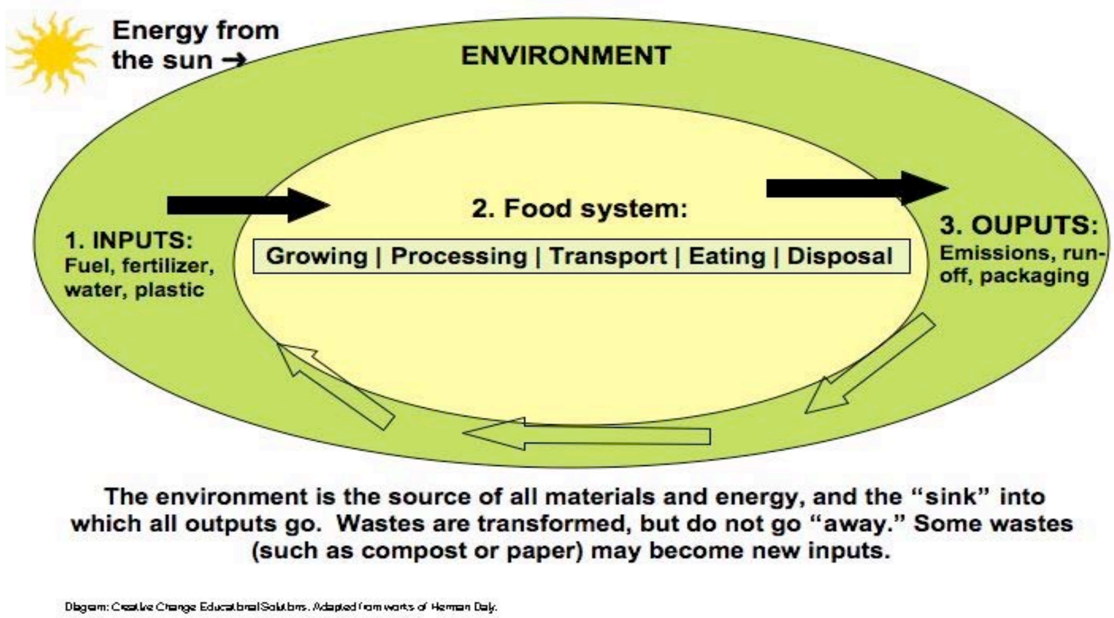
______________________________.

Activity 6) Summary: The Food Footprint

> **the environment:** all living and non-living things that together make up the world. The environment includes plants, people, other animals, minerals, soil, and all things around us. We are in the environment all the time.

The food system requires inputs (materials and energy) and produces outputs (materials, waste, and heat loss). But where do all the inputs come from? Where do all the outputs go? The answer is *the environment*. Here are four key ideas to remember:

1. The environment serves as the ultimate source of all inputs: Everything needed to produce food comes from the living or non-living substances of the environment including soil, water, trees, solar energy, and pastures for animals. The people who provide labor for food production also depend on the environment.



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Note: The diagram shows human activities in the center; this reflects the fact that humans exist within the larger biosphere. This is not meant to suggest that humans are the most important species or that the natural world exists for their needs only.

2. Natural materials are transformed throughout the food system. For example, crude oil is refined into gas; coal is burned to make electricity; trees are made into paper for packaging. These activities require energy, typically fossil fuels.

3. The environment serves as the final "sink" into which all outputs go. The outputs created in the food system stay in the environment. Discarded packages go into landfills, run-off goes into rivers, and fuel emissions go into the atmosphere. Wastes may transform (through burning or decomposition) but the laws of physics tell us that they do not go away. In reality, it is impossible to throw something "away" since all wastes go into some other part of the environment. *The more polluting wastes produced, the bigger the environmental impact and the larger the footprint.*

What is sustainable? "Sustainability" is a complex concept with many aspects. One element focuses on environmental impacts that utilize materials and produce wastes at a rate that the environment can renew. Examples: Catching fish at a rate that ensures replacement; adding fertilizers at a rate that does not overload the ability of wetland and waterways to filter them; using energy in a way that reduces emissions.

Activity 6) Summary: The Food Footprint

These diagrams show the difference between large and small footprints in food systems:

Larger food system footprint:

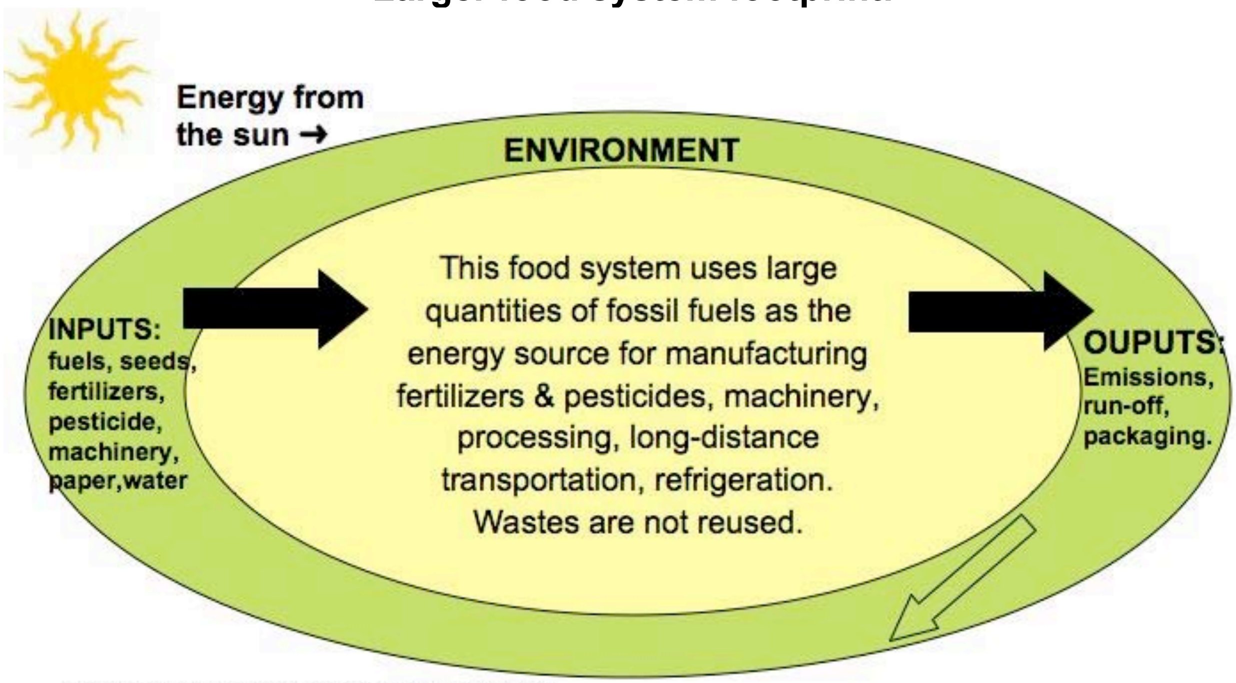

Diagram: Creative Change Educational Solutions. Adapted from works of Herman Daly.

Smaller food system footprint:

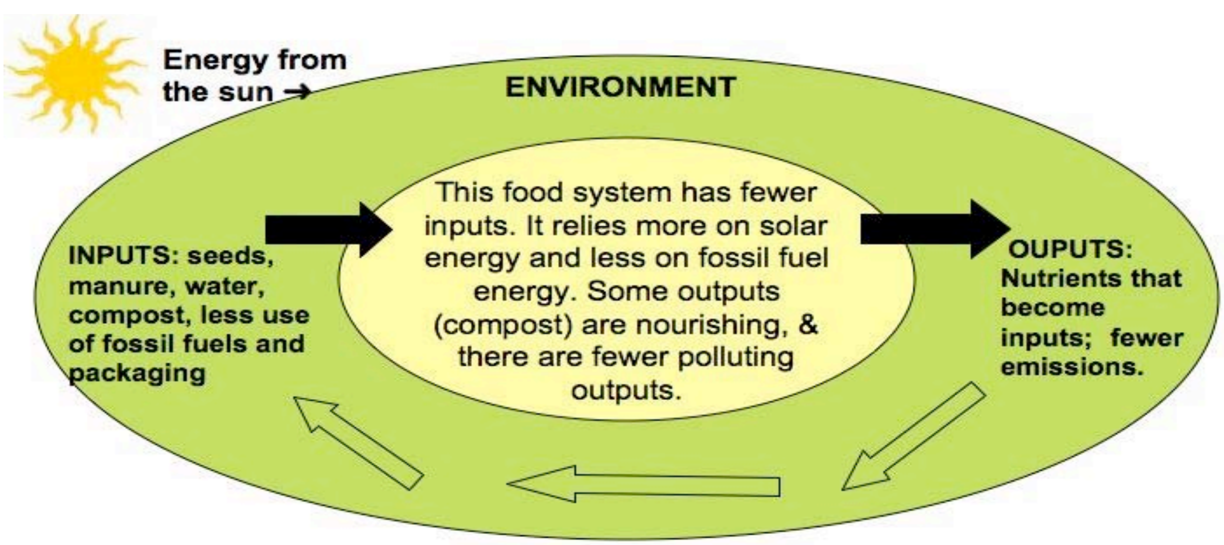

Diagram: Creative Change Educational Solutions. Adapted from works of Herman Daly.

Activity 7) Strategies to Reduce Energy Use

Directions

1. Review the table below. It provides an overview of fossil fuel use in U.S. good production. The percentages represent the fossil fuels used in each stage of the food system. For example, 6.6% of the total fossil fuels used in the food system are used in packaging materials.
2. In the blank column, brainstorm food choices you can make that would reduce the amount of fossil fuels used.
3. Compare your choices with a classmate and review the suggestions on the next page.

A) Food system stage	B) % of fossil fuels used in the this stage	C) Examples of energy used and impacts	D) What choices and actions can reduce the use of energy at this stage?
Agricultural Production	24%	Researchers estimate that 40% of energy used at this stage is for producing synthetic fertilizers and pesticides; 25% is for diesel fuel; 35% is for other uses such as irrigation. Excessive fertilizer can run off into waterways; too much creates algae blooms and can kill other aquatic life forms.	
Transportation	13.5%	Gas and diesel fuel are used to transport foods from manufacturers to store and from stores to your home.	
Processing Industry	16.4%	Electricity (often powered by coal) is used for processing steps such as baking, drying, slicing, and freezing.	
Packaging Material	6.6%	Making packaging requires energy as well as raw materials to make glass, plastics, aluminum, and paper products. Disposing of wastes requires fuel for trucks and other modes of transportation.	
Food Retail	3.7%	Among other uses, stores use electricity for refrigeration and freezing.	
Commercial Food Service	6.6%	Cooking and preparing food for restaurants, schools and other institutions consumes natural gas and electricity.	
Household Storage & Preparation	31.7%	Operating refrigerators, freezers, stoves, ovens, and dishwashers uses electricity and natural gas.	

(Heller and Keoleian, 2000)

Activity 7) Strategies to Reduce Energy Use

Production:

- Eat seasonally and locally. Choose foods available by season to insure they have not been transported long distances. For example, when food from Europe is imported to the USA by plane, it takes 127 calories of energy (aviation fuel) to transport 1 calorie of food energy across the Atlantic (Cormack, 2000). "Locavore" is a new term for someone who tries to eat locally; a "100 mile diet" is a particular type of local eating that focuses on foods grown within that range.
- Plant a garden or take part in a community garden. Home-grown food travels only yards to your plate.
- If you eat meat and dairy, choose pasture-fed products. Non pasture-fed meat is from animals that are typically fed corn and soy. Producing these grains is very energy-intensive, both in terms of the fertilizer usage and the transportation and processing. By some estimates, it takes about seven pounds of corn to produce one pound of beef (Leibtag, 2008). In contrast, pasture-fed animals rely more on grass; this reduces energy use while providing benefits for grasslands, assuming there is no over-grazing.
- Choose foods grown with methods that reduce the use of fossil fuels.
    - Choose certified organic foods, which eliminate the use of fossil fuel-based fertilizers and pesticides made with fossil fuels. Organic foods can still have a high carbon footprint if they travel a long distance or are grown using a lot of machinery. For this reason consider a food's overall life cycle, not just production methods.
    - "No-till" farming reduces the use of machinery and keeps organic matter in the soil, adding fertility. Soil that is not tilled also stores carbon, acting as a "sink" for carbon dioxide (Elstein, 2004). As of this writing (Jan. 2011), foods are not identified in stores with a "no-till" label the way organic foods are.
    - Eat lower on the food chain. Choosing to eat just one meal per week without meat can make a difference.

Processing and transportation:

- Choose whole/unprocessed foods: Grinding, milling, cooking, freezing, and other steps of food production are energy-intensive. For example, the grinding, milling, wetting, drying, and baking of a breakfast cereal requires about four calories of energy for every calorie of food energy it produces. Producing a two-pound bag of breakfast cereal burns the energy of a half-gallon of gasoline; this does not include fuel for transportation (Manning, 2004).
- Choose foods with less packaging to reduce waste.

Purchasing, consumption, and disposal:

- Shop at your local farmer's market, natural foods store, coop or other venue that is committed to supporting local and organic agriculture.
- Conserve energy in food preparation and storage. Put lids on pots when boiling water. Keep your refrigerator and freezer tuned and running at an appropriate temperature. When possible, choose energy efficient appliances.
- Consider traditional methods of food storage and preparation often rely on naturally-occurring heating and cooling, such as solar ovens and driers or root cellars.
- Compost food scraps in an outdoor bin or worm bin.

Questions:

- Which actions do you already take?

Glossary

- **biomass:** plant matter that gets energy from the sun
- **embodied energy:** all the energy required to produce an item. It includes energy used in all stages of a life cycle: extraction of raw materials, production, transportation, etc.
- **calorie:** A unit of measurement for heat and the energy stored in food. It is the amount of heat required to raise the temperature of one gram of water by 1°C. It equals 4.18 joules or about 0.004 British thermal units (Btu). Also called gram calorie or small calorie. When applied to food, the term "calorie" actually means a kilocalorie ("kilo" means 1000). A kilocalorie (or food calorie) is equal to 1,000 small calories; this amount of heat required to raise the temperature of one kilogram of water by 1°C. (One kilogram is 1,000 grams). It equals 4.18 kilojoules or about 4 British thermal units (Btus). Food calories are commonly shown on the nutrition labels of food packaging.
- **monocropping:** Farming just one type of crop. "Mono" means "one" and comes from the Greek *monos* meaning "alone."

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