# 6-12 Energy Sparks Table of Contents

# The Laws of Thermodynamics

## First Law of Thermodynamics

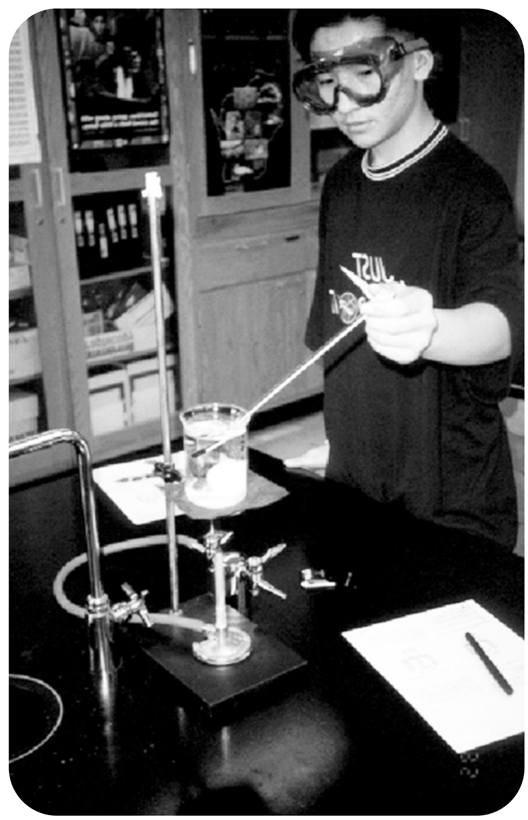
The following set of statements are various ways of expressing the first law of thermodynamics:

- Energy is conserved.
- The amount of energy in the universe is constant.
- Energy can be neither created nor destroyed.
- There is no free lunch.
- It is impossible to build a machine that produces more energy than it uses. (This type of machine is called a perpetual motion machine of the first kind; see **Second Law of Thermodynamics** for a description of a perpetual motion machine of the second kind.)

Find examples that illustrate these statements and explain how they express the first law.

**Temperature, Heat Transfer, and the First Law of Thermodynamics**

Compare how eggs cook in different volumes of water and relate your findings to the process of heat transfer and the first law of thermodynamics (energy is conserved). Get two raw eggs. Carefully put the first in a container such as a beaker or small sauce pan and add enough water to just cover the egg. Record the initial temperature of the water. Turn on a heat source. **Caution: Use tongs to handle materials and always wear protective gloves and eyeglasses.** Make sure the amount of heat is consistent throughout this experiment; for example, if you are using a Bunsen burner, make sure the flame height does not change. Put the container over the heat source for 15 minutes. Record the final temperature of the water. Check to see how cooked the egg is. Cool the container by pouring in cold water, letting it stand a few minutes, and discarding the water. Repeat the experiment with the second egg, but this time fill the container with water to within one-half inch (1 cm) of the rim (you should have more water in the container this time than in the first experiment). How does the second egg look after being heated for the same amount of time (15 minutes)? How does the temperature of the water in the second experiment compare to the first? Write a paragraph describing how heat is transferred from the heat source to the water and the eggs for both experiments. How might you describe the rate of molecular movement of the water for each experiment? Point out how this experiment illustrates the first law of thermodynamics.



### Second Law of Thermodynamics

The following set of statements are various ways of expressing the second law of thermodynamics:

- With each energy conversion from one form to another, some of the energy becomes unavailable for further use.
- Heat cannot flow from a cold object to a hot object on its own.
- It is impossible to convert heat energy into work with 100 percent efficiency.
- You cannot break even.
- It is impossible to build a machine that produces as much energy as it uses. (This type of machine is called a perpetual motion machine of the second kind; see **First Law of Thermodynamics** for a description of a perpetual motion machine of the first kind.)
- The entropy of the universe tends to a maximum. (Rudolf Clausius, 1865)

Find examples that illustrate these statements and explain how they express the second law. Show how the statements above relate to the concept of efficiency.

Explain how the following nursery rhyme is related to the second law of thermodynamics:

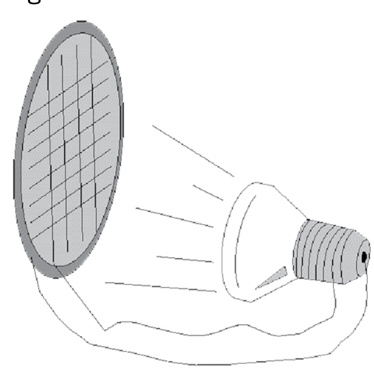
*Humpty Dumpty sat on a wall*
*Humpty Dumpty had a great fall*
*All the kings' horses and all the kings' men*
*Couldn't put Humpty back together again.*

# Perpetual Motion Machines

The following describes an example of a perpetual motion machine:

Since a motor converts electrical energy into mechanical energy and a generator converts mechanical energy into electrical energy, it should be possible to connect a motor to an equally sized generator so that they would supply energy to each other and run forever.

Ask students if this is possible. Have them give reasons for their answers. When they have finished, point out that this arrangement is an example of a perpetual motion machine and that such machines are not possible according to the laws of thermodynamics. (The motor-generator arrangement described above violates the second law of thermodynamics.)



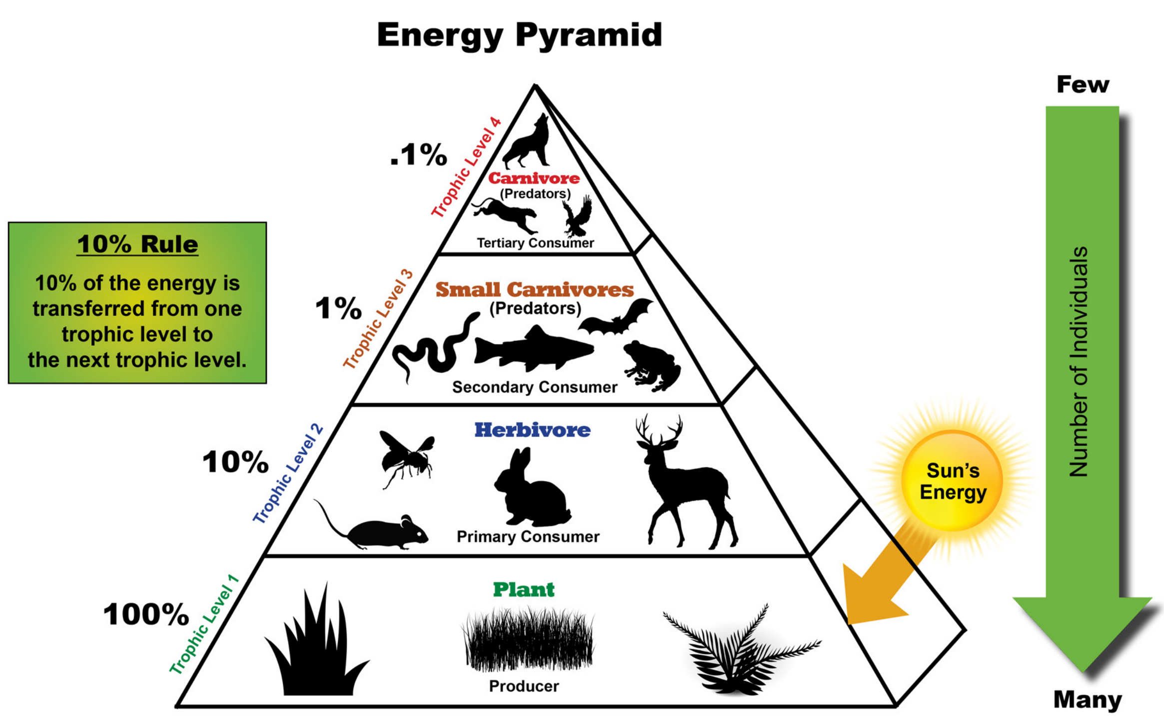
Draw the solar cell and light bulb diagram shown on the board. All the light from the light bulb shines on the solar cell, which makes electricity that goes into the light bulb, which lights the light bulb, and the light shines on the solar cell, which . . . and so on. Will this work? Will the light bulb keep shining? If not, why not? (Answer: No, the light will not keep shining. Reasons: Some of the electricity is converted to heat, not light. The solar cell probably doesn't convert all the light to electricity. Some of the electricity is lost in heating the wires between the cell and the bulb.)

# Energy Pyramids

## Typical Energy Pyramids

Build an energy pyramid that diagrams the amount of energy flowing through a biological community. The first level (base) of the pyramid represents the producers. The second level of the pyramid typically represents the first consumers (primary consumers or herbivores). The next level represents the second consumers (secondary consumers or carnivores). In some cases, the pyramid contains a fourth level (the third consumers), which typically represents the consumers that are not killed and eaten by other organisms (top predators). Each level within the pyramid is also referred to as a trophic level. Research the organisms that live in this biological community and put illustrations on the correct pyramid level along with what they eat and other "fun facts."

Why is a pyramid, not a cube or vertical bars, used to illustrate energy flow through a community? Imagine a certain quantity of energy coming from the sun and falling on the plants in your biological community. Would all the sunlight be used by the plants? No, some would fall on the ground, be reflected, or land on animals or other things that can't convert sunlight into food energy (photosynthesis). Herbivores are not able to consume all the plant material (net primary production) that is available to them. Of that which they do consume, their digestive systems are only able to convert a small portion to a form usable for their own life processes. Moreover, the process by which organisms convert food energy to a usable form (respiration) requires energy. Therefore, with each energy conversion, some energy is "lost" as heat. In fact, within a food chain, the amount of energy transferred from one trophic level to the next higher trophic level is roughly reduced by a magnitude of ten. If an average of 1,000 kcal of plant energy is consumed by herbivores, about 100 kcal is converted to herbivore tissue, 10 kcal to first-level carnivore production, and one kcal to second-level carnivores (top predators).



## Unusual Energy Pyramids

Investigate communities that may not have a symmetrical pyramid where one level is one-tenth smaller than the lower one. Create pyramids to reflect these communities. Actually, there are many variations to the “shape” of energy flow pyramids. For terrestrial and shallow-water communities where the producers are large (such as trees), accumulation of organic matter is great, life cycles are long, and the harvest rate is low, gradually sloping pyramids are characteristic. For stream communities where the producers are small (like algae), accumulation of organic matter is low, life cycles are short, and the harvest rate is high, steep-sided pyramids are typical. In some cases the true base of the pyramid is located in a different community! For example, the true base of a stream community is the detrital food chains of forest and field communities. Leaves, twigs, and other organic matter carried into the stream via runoff provide stream organisms with more energy than that supplied by the producers within the stream community.

How would you design an energy pyramid to reflect a human community such as a city or a farm or your own town? In human-built communities, the traditional pyramidal shape may be even more distorted. As humans have gone from living in hunter-gather societies to agricultural and industrial societies, their ability to harness and use various energy resources has expanded. Thus, in modern industrial societies where food is brought to the urban centers from agricultural lands, forests, fields, streams, lakes, rivers, oceans, deserts, and virtually every other biotic community, the true base of the pyramid extends to producers and consumers in virtually every biotic community. Unlike most other organisms, humans have developed the means to alter the energy flow patterns of nearly every biotic community in order to meet their own energy requirements.

# 6-12 Energy Sparks for Theme II

## Energy Flow through Biological Communities

Create a biological community within a bottle. Use plants and small animals such as insects from a specific community. Devise a system to record your observations. Note growth of organisms as well as death and decomposition. Summarize how energy flows through the community and how nutrients, water, and other resources are cycled.

## Energy Costs of Food

**Background**
*Although plants grow just fine using the sun's energy, when we want to a grow a large number of the same type of plant in an organized fashion, we need additional energy. Modern farms use machinery like tractors that usually run on fossil fuels. About 17 percent of the energy we use in the U.S. each year goes into growing, processing, distributing, storing, and preparing food. It takes eight times more energy to produce, process, and transport food than the food energy (in calories) we get from eating the products.*

Design a diagram that outlines the steps needed to grow and eat food from a local garden in contrast to buying food in a grocery store. Each of these steps requires energy. For some ideas, see ***Energy and Our Food System***. What other steps might you add?

### Energy and Our Food System: Food Production Steps and Identification of Energy Costs

**Growing Food**
Growing food on farms requires fossil fuels (oil, gasoline, and natural gas that can be traced back to the sun) and electricity (generated from fossil fuels, nuclear energy, or renewable sources) to run machinery. Also, petroleum products are used to make fertilizers and pesticides.

**Transporting Food**
Trucks, trains, and barges require fossil fuels to transport crops and livestock to industries that process food.

**Processing Food**
Processing involves converting crops and animal products into the food we buy at stores. These processes include heating, freezing, canning, and dehydrating and can also involve cooking, mixing, adding seasonings, colors, preservatives, packaging, etc.

**Transporting Food**
Trucks, trains, and barges require fossil fuels to transport the prepared food to retail stores.

**Selling Food**
Retailers arrange food items in the store so customers will buy them. Stocking items requires energy. Electricity and natural gas are needed to keep buildings warm and the food cold. Lighting is also important so that customers may clearly see the products' labels and prices. We use energy to drive to and from the store.

**Preparing Food**
Once we get the food home, we prepare it for eating. We unpack it, cook it, bake it, freeze it, etc. Energy costs are involved after preparation as well (cleanup, disposing of packaging and waste materials, etc.).

Create a menu at a fictional restaurant with prices based on energy costs. For instance, how would the price of fresh carrots from a local garden compare to dehydrated or canned carrots? Consider the energy required to farm (including the cost of petroleum products to run machinery and to make fertilizers and pesticides), transport, process, and package the food. Share the menu with your family or a friend to see which items they would choose and how energy costs influence their choice.

Write a position paper for or against using corn or some other food source as a fuel. Corn is a food high in carbohydrates; because of its high energy content, it is being considered as an alternative fuel source. Corn can be burned to heat homes and converted to ethanol to fuel automobiles. Research other ways (besides eating) that the energy in food is used.

# Transporting Energy Resources

Research some of the pros and cons of different energy resource transportation methods. Possible topics include the history of energy resource transportation, transportation safety (including accidents, disasters, emergency preparations), and a comparison of the environmental effects, economic costs, and efficiency of different transportation methods.

# Energy Resources in Literature

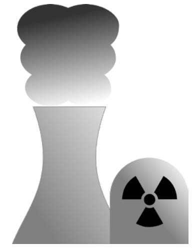
Keep track of references to energy resource development in books, magazines, and newspapers you read or programs that you watch on television.

# Energy Production Timeline

Show how long it takes for solar energy to be converted into various energy resources by constructing an energy production timeline on adding machine tape or long, thin strips of paper taped together. The timeline can range from 6 feet (2 m) to the length of a hallway. The longer the timeline, the easier it is to show the production times accurately. Compare the relationship between the energy resources used today and the time it took for nature to produce these resources. The energy resources and their production times are listed below.

| Energy Resource | Production Time |
|---|---|
| Solar (photovoltaic) electricity | Seconds |
| Direct solar heating | Minutes |
| Wind | Hours |
| Hydropower | Days or weeks |
| Biomass (wood, crops, other plants) | Months to decades, depending on type of plant |
| Coal, oil, and natural gas | Millions to hundreds of millions of years |

# Nuclear Energy



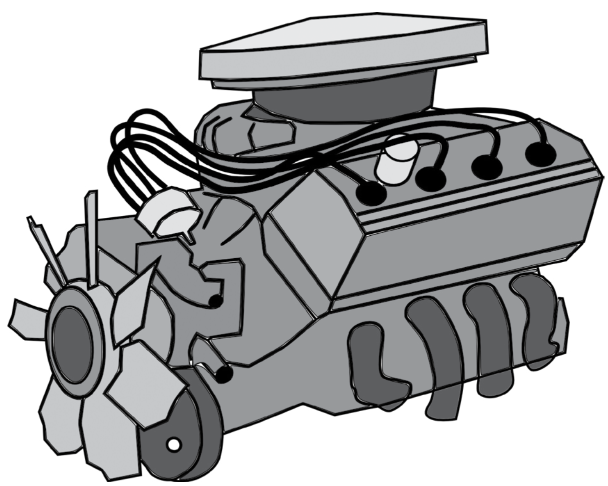
Review how plutonium, a human-made element, is formed during the nuclear fission process. Since plutonium easily undergoes fission, discuss how it can be used in nuclear power plants and weapons.

# Explore Resource Development Technologies

Design models that simulate various stages of oil extraction and refinement or other energy resource development technologies. For example, a model of oil exploration could involve placing various objects, including a strong magnet, in a shallow box. Cover the box with a lid (the lid should touch the tops of the objects, if possible). Guess the location of the objects by tapping the top of the lid and listening for different sounds. Oil exploration also involves looking for magnetic rocks. Using a suspended paper clip that represents a magnetic rock sensor, try to find the magnet in the box. (Hint: Watch the paper clip; it should be drawn toward the concealed magnet.)

# Energy Conversions in an Automobile Engine

Investigate how an automobile engine works and how it converts the energy in gasoline into the motion of the automobile. Also investigate the relationship between (1) the way the engine works and its efficiency, (2) the way the automobile's electrical system works and what purpose it serves, and (3) new engine designs and fuels that may be adapted in the future.



Open the hood of a car and locate the alternator. (It is usually mounted near the battery and is connected to the engine by a rubber belt.) Determine whether the alternator is a motor or a generator, and discuss the purpose it serves as part of the automobile's electrical system.

# Make a Light Bulb

The incandescent light bulb has been used since Thomas Edison introduced the first practical version in 1879. Try to make a light bulb yourself; see ***Making a Light Bulb Instructions*** (next two pages).

# Human Population Growth and Energy Use

Create a timeline that superimposes 500 years of population growth in Wisconsin over the type and amount of energy used. For example, the human population growth would be a line graph that shows exponential growth. A bar graph could illustrate the type of fuel and amount per capita used during different societies over time (hunter-gatherer, non-industrial agricultural, and industrial). What conclusions can you draw from the graphs?

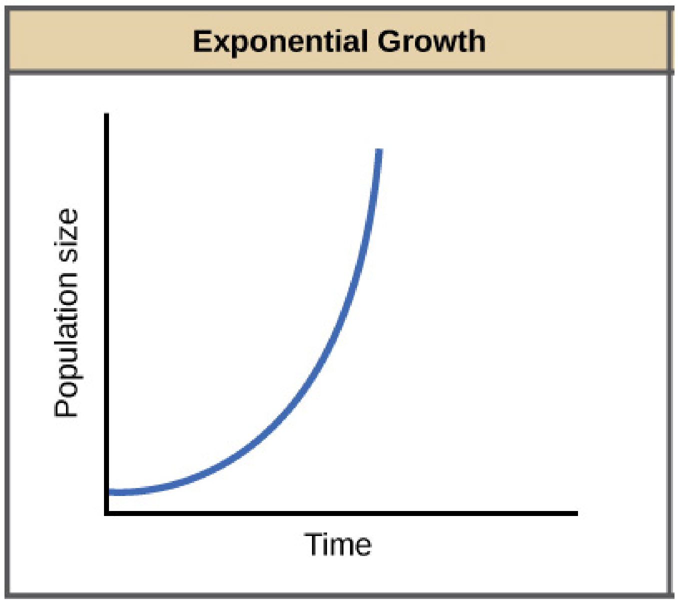



Image credit: "Environmental limits to population growth: Figure 1" by OpenStax College, Biology, CC BY 4.0.

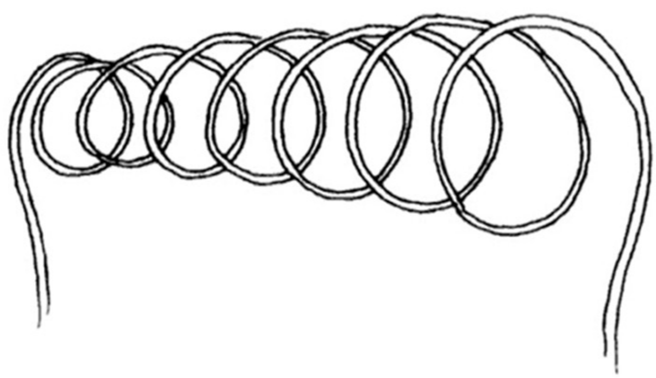
# Making a Light Bulb Instructions

**Try to make a light bulb. You will need:**

- 4 inches (10 cm) long, fine (lightweight), single strand of picture hanging wire (A suitable type is Anchor Wire Corporation Stock #41250, Size No. 1 Braided Picture Wire. Cut the wire into pieces about 4 inches (10 cm) long and unbraid or untwist the wire to obtain single strands. Since it is iron, this wire has a much higher resistance than copper wire.)
- Golf tees, nails, or pencils for forming the filament (Golf tees work best.)
- A silver-dollar-sized chunk of modeling clay
- 2 pieces about 12 inches (30 cm) long of solid copper insulated 18-gauge wire to serve as connecting wire (Available in hardware or electrical supply stores.)
- A wire stripper
- Clear plastic medicine cups, the clear plastic closures that come on some brands of aerosol whipped cream, or very small glass jars, such as baby food jars
- A source of electric power (This activity draws a lot of current.) (NOTE: Although 6-volt batteries will work with some filaments, 9- or 12-volt batteries will give better results. A bank of #6 cells, or "hot-shot" batteries can also be used. There is no danger of shock from such batteries, but they are expensive and will last only one year.)

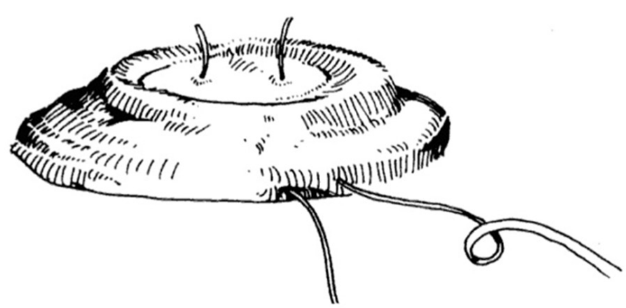
## Step 1: The Filament

Wrap the single strand of picture-hanging wire around a golf tee to form a coiled filament. Leave 0.8 inches (2 cm) of straight wire at each end. After you remove the golf tee from the center, it should look like this:



## Step 2: The Base

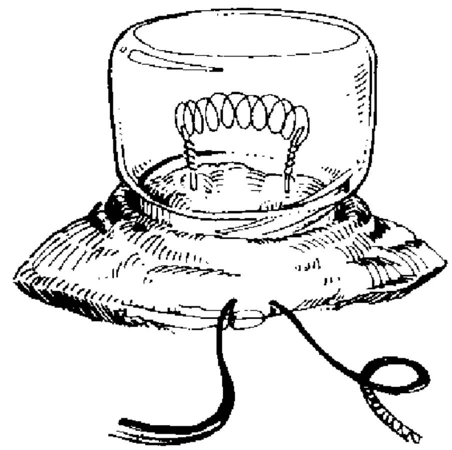
Flatten a piece of modeling clay big enough to cover the mouth of your jar or cup. Use the wire stripper to remove approximately 2 inches (5 cm) of insulation from one end of each of the connecting wires. Stick the two bare ends of your connecting wires through the clay. The wires should be just as far apart as the coiled filament is long. The base should look like this:



# Making a Light Bulb Continued

### Step 3: Finishing the Bulb

Attach the filament to the wires by wrapping the filament wires around the connecting wires. Put the globe (the jar or cup) over the filament and press it to the base. Be sure the filament wire is still touching the connecting wire and that the connecting wires don't touch each other at all.



### Step 4: Connecting Your Bulb to the Battery

Place the exposed ends of your connecting wire on the battery terminals. If the bulb doesn't light by the count of ten, disconnect it and check your connections. Make sure the wires aren't touching under the clay.

### Observations

**1.** Which part of the light bulb gives out light?

**2.** Is there evidence of any other form of energy besides light coming from the light bulb?

**3.** Trace the energy flow from a battery to a flashlight bulb. Four forms of energy should be listed.

____________ → ____________ → ____________ ____________

**4.** About how many years has the incandescent light bulb been in use?

*Adapted from Lord, John, and Glenn Braatten. "Making a Light bulb" pp. 1–16 to 1–17 in Teaching about Energy, Part 1: Energy Fundamentals. Santa Monica: Enterprise for Education, 1991. Used with permission. All rights reserved.*

# Investigation Ideas for Theme III

## Lifestyles

### Consumption Patterns

There are many ways to analyze how we use energy. One way is to conduct a home energy end use survey to find out how much energy you use. Doing a cost analysis on the results of your survey shows you what your energy practices cost. If you think your family is using energy wisely, find out what promotes this behavior. If you find that your home is wasting energy and money, survey family members to determine what they think about their current practices and what changes they would be willing to make.

Research how people in your community try to reduce their waste production. Observe if energy conservation is one reason why they do this.

### Consumer Power

Create a cartoon strip that highlights the adventures of an energy-saving teenager. One of the hero's experiences can involve learning how conscientious shopping contributes to energy conservation. Every product uses energy during its manufacturing process. For example, illustrate how buying a durable product that is more expensive saves more energy than purchasing something that may break easily and has to be replaced.

Rank advertisements based on how well they influence or discourage energy conservation. Develop a chart or scale that shows the results of your ranking and the criteria you used. For example, do the ads promote impulsive shopping? Do they highlight energy-saving efforts such as reduced packaging?

### Consumption Trends

Research consumption trends in the United States for major products like automobiles, televisions, home computers, and appliances. Increased consumption of these products typically leads to increased energy consumption. Compare the consumption trends and energy production and consumption of the United States and another location such as Europe, Russia, China, or a developing nation.

### Energy and Shopping Costs

Energy plays a role in the production, manufacturing, and sale of everything we buy. Below are some topics to investigate to understand the relationship between shopping costs (consumerism) and energy.

- Compare natural raw materials to artificial materials. Which cost more to produce? Which cost more to dispose of or recycle?
- What kinds of product packaging are cost effective and nonpolluting? What is wrong with the packaging of many products today? Describe how the cost of packaging a product affects the cost of the product.
- There are hidden costs involved in many products. Describe all the costs, including energy, used in producing goods. What tips should consumers consider when purchasing products? What kinds of products and packaging should be avoided? How does the consumption of goods relate to economic issues?

### Fueling Our Entertainment

Design a survey related to energy use and entertainment. For example, you can determine the amount of television watched by teenagers in your school. How many of your friends use renewable batteries to power their computer games? What modes of travel do people use when on vacation?

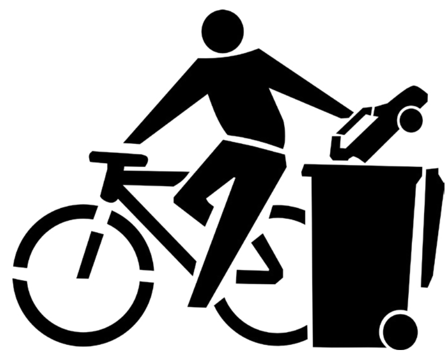
# Energy and Transportation

Transportation has played an important role in the economic development of societies. Following are some topics to investigate to learn more about the relationship between energy and transportation.

- Explain how energy is important in the development of new modes of transportation.
- Describe the history of transportation, focusing on how energy relates to the design of new modes of transportation.
- Compare a variety of modes of transportation.
- Describe and contrast methods of traveling that are energy expensive and energy economical.
- What are the costs of gasoline today? What were the costs in the 1960s, 1970s, 1980s, and 1990s? How and why have the prices changed? What was the energy crisis of the 1970s? What impact did this event have on American society?
- Why do car designers consider energy costs when designing new methods of transportation? Explore the idea of energy efficiency in the auto industry.

### Traveling to and from School

Does your school have a parking problem? What about traffic congestion on streets near your school? Perhaps you want to learn about the potential for carpooling. There are many different investigations related to transportation. Simple tests, such as setting pieces of paper coated with petroleum jelly around your parking lot, provide insight into potential air pollution. Surveying students about how they get to school lets you know who uses cars, buses, and bicycles.



# Energy and Health and Safety

Research ways in which energy development and use positively and negatively affect human health and safety. There are some issues:

- Accidents and exposure associated with mining coal and uranium, drilling for oil and natural gas, building dams to harness hydroelectric power, and harvesting wood and biomass fuels
- Food preservation and nutritional health
- Exposure to air emissions from burning fossil fuels, biomass fuels, and wood
- Accidents related to transporting energy resources such as coal, oil, natural gas, and propane
- Benefits of home heating and cooling
- Safety issues associated with electricity and natural gas use
- Exposure to radiation from nuclear sources
- Advances in medicine, such as Xrays, ultrasound, and use of plastics

Compare and discuss the development and use of energy resources in terms of health and safety.

# Energy and the Environment

## Air Pollution

Conduct experiments to investigate various air pollutants or their sources. Some common activities are listed below. If you have an air quality monitoring station nearby, learn what tests they conduct.

- Put a white sock on exhaust pipes of different cars and compare emissions by looking at the gray scale of the socks. **Caution: Make sure the car is cooled down before the sock is put on and removed. This activity should be conducted in an open area, and students should not stand near the car when it is running. When finished, place socks in plastic bags and dispose of properly.**
- Compare the density of particulate matter as it comes out of different smokestacks. (Simple scales that classify the concentration of pollutants emitted from smokestacks can be purchased or designed.)
- Collect and compare particulate matter from different locations (such as a parking lot, windowsill, and kitchen counter) using a thin layer of petroleum jelly smeared onto a piece of white cardboard.
- Buy a carbon monoxide detector and test the air inside the school.

## Warm Water

Power plants use water from lakes and rivers to remove the excess heat produced when the power plants generate electricity. Research how the warmed water released by power plants affects a lake or river. What does it do to fish and other aquatic life? Could power plants be built near small lakes? How many power plants could one river or lake have next to it? Might the distance between power plants along a river be important?

## Oil Spills

Simulate cleaning up an oil spill. First, pour a small amount of oil into a bowl of water. Add rocks to demonstrate oil coating land surfaces. Provide samples of feathers and animal fur to show how oil affects marine life. Then find the most efficient way to contain and remove the oil. Some items that can be used include cotton, eyedroppers, baking soda, kitty litter, and detergent.

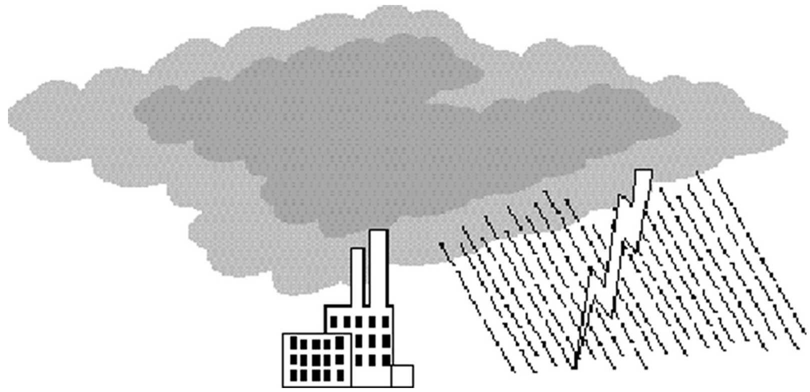
## Ozone Detection through Milkweed Bio-Monitoring

Check the ozone in your area by participating in a bio-monitoring project. This type of study involves growing or locating milkweed plants and collecting data about their health. Through careful planting and placement of ozone-sensitive plants such as milkweed, you can determine if unhealthy levels of ozone are present. Look for milkweed plants that are at least 50 feet from the road, and won't be mowed or walked on. Your study site should have at least 30 milkweed plants. (If you don't know what milkweed looks like, use a plant identification book or ask someone who knows.) It is often found in fields, meadows, and along roadsides. A mature

Ozone damaged milkweed leaf

plant is about a foot and a half tall with hairy leaves that are between two and ten inches long. If you pick a leaf from a milkweed plant, you will see a thick white sap ooze from the stem. Ozone damage can be seen by looking at the leaves. Injured leaves will have small dots or lesions, called stipples, on their upper surface. The amount of damage depends on the quantity of ozone in the air and the age and health of the plant. The Wisconsin Department of Natural Resources sponsors a milkweed bio-monitoring project.

## Acid Rain



Test the pH of water in your area. Obtain some litmus paper or a pH monitor. Collect rainwater at different times of the year and keep a log of the pH. Contact another school from a different part of the state and have students do a similar study. Compare your results.

Investigate the effect of acid water on plants. Make "acid rain" by adding vinegar or lemon juice to distilled water. Prepare solutions with different pH levels (e.g., 6, 5, 4). Sprout some fast-growing plants, such as alfalfa, and then water different plants with acid water. Make careful observations. Compare the condition of the plants to a control that is watered with plain distilled water.

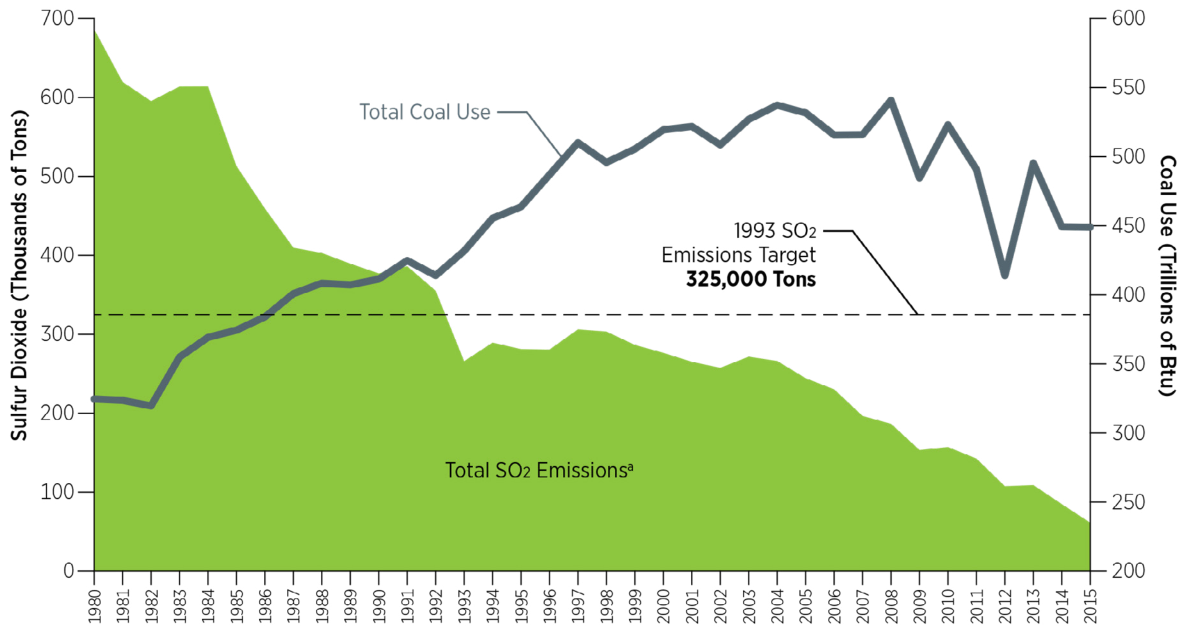
## Pollution Regulations I

Find out what Wisconsin is doing to prevent air pollution. Invite a local government agent to discuss Wisconsin laws and policies about air pollution. Ask a representative from a local utility or industry to discuss the methods they use to monitor and control emissions.

## Pollution Regulations II

Find out how successfully Wisconsin has reduced air pollution by analyzing changes in sulfur dioxide (SO2) emissions by the state's major electric utilities since 1980. Sulfur dioxide, one of the pollutants associated with the formation of acid rain, is produced by burning fossil fuels, especially coal. In an effort to address the problem of acid rain, the Wisconsin state legislature passed a law (1985 Wisconsin Act 296) in 1985. The law set a goal of 325,000 tons of sulfur dioxide emissions (from major electric utilities and other sources) by 1993. A graph showing Wisconsin coal use and sulfur dioxide emissions from 1980 to 2012 is shown on the next page.

Sulfur Dioxide Emissions and Coal Use 1980-2015 (Thousands of Tons and Trillions of Btu




Source: Wisconsin Office of Energy Innovation. Wisconsin Energy Statistics Book, 2018.

## Questions

1. How many tons of sulfur dioxide were produced in 1980?

2. How many tons of sulfur dioxide were produced in 2015?

3. What is the percent change in sulfur dioxide emissions from 1980 to 2015?

4. Did Wisconsin meet its sulfur dioxide emission goal for 1993? Has it been maintained since then?

5. By how many trillion BtUs did coal use change from 1980 to 1993? Did coal use increase after 1993?

6. Comment on how changes in coal deliveries to Wisconsin power plants from different regions of the United States may be related to the decrease in sulfur dioxide emissions. Below is a table showing where Wisconsin got its coal between 1980 and 2010.

| Coal Deliveries to Wisconsin (Thousands of Tons) | | | | |
|---|---|---|---|---|
| **Region of United States** | **1980** | **1990** | **2000** | **2010** |
| Eastern | 4,056 | 2,151 | 969 | 678 |
| Midwestern | 3,842 | 3,029 | 221 | 186 |
| Western | 6,617 | 12,631 | 20,975 | 22,400 |
| Total | 14,515 | 17,811 | 22,165 | 22,263 |

# Energy and Economics

### State Energy Budgets
Wisconsin imports all the fossil fuels it uses. Find out the yearly cost of importing fossil fuels. Does a significant part of the state budget go toward paying for energy? Where exactly does this money go?

### Externalities
Should the price of energy include the cost of environmental and health effects? Identify possible environmental and health effects of fossil fuel combustion. Who pays to fix or address these problems?

# Sociopolitical Issues

### Environmental Justice
"Energy for Everyone." Is this true? Does everyone in your community get the energy they need? What programs does your community have to help low-income residents? Are these programs effective? Interview government agencies to find out what they're doing to help. Talk to people who use these programs to learn what they think.

### The History of Hydropower in Wisconsin
Write a creative story about issues related to hydropower in Wisconsin's past. For example, you could investigate how hydropower helped industrialize the state. Another option is to dramatize some of the political debates surrounding the ownership and development of various hydropower plants.

### The Energy Crisis
Search for and compare energy-related advertisements that appeared in magazines and newspapers during the energy crisis (1973 to 1980) to those that appear today.

# Energy and Culture

### Energy and the Rise and Fall of Ancient Civilizations
Choose an ancient civilization from the list below and become an expert on that culture's society and their use of energy. Remember to keep a running list of resources you use and create a bibliography.

| | | |
|---|---|---|
| Ancient Sumerians | Ancient Atlantians | Ancient Aztecs |
| Ancient Mesopotamians | Ancient Greeks | Ancient Mayans |
| Ancient Egyptians | Ancient Romans | Ancient Incas |
| | Ancient Celts | |

Following are just a few research topics you can explore to learn the role that energy played in the success or downfall of these civilizations.

- What was the primary energy source of the society? All ancient civilizations used various forms of alternative energy, from biomass to solar energy to wind. List and describe the various forms of alternative energy used.
- What type of heat was most commonly used to keep the members of your civilization warm? Why? Be descriptive!
- What other ways did the civilization use energy (cooking, transportation, agriculture, warfare)? To what extent did energy resources influence the economy of the society?

## Material World

Check your local library for a copy of Material World by Peter Menzel or search for his images online. This book includes photographs of families around the world with their household possessions. Compare the types and amounts of items in their households. Using energy as your focus, write a paper that expresses your impressions of the different photographs.

Create your own version of Material World, using stories, posters, or drawings. Compare energy use in the United States to that in a developing nation. Contact the National Peace Corps Office and ask for the name of a volunteer. Write that volunteer and ask what the energy use practices are like in their location. Better yet, try to make contact with a youth of your own age.

## The Use of Lights During Holiday Festivals

Design a calendar that identifies different cultural holidays that use light in their celebrations. An alternative is to research one event and demonstrate how light is used. For example, candles are important symbols of Christmas (tree lights), Hanukkah (candles in the Menorah), and Kwanzaa (a candle representing different values is lit each day). These celebrations all take place during winter, but light is used in celebrations throughout the year. In November, during a celebration called Loy Krathong, people in Thailand send candles and incense out onto the river on floats made out of banana leaves. Before sending the boats afloat they make a wish. Clay lamps are lit during the Hindu feast of Diwali in October to show the way to Lakshmi, the goddess of propriety. Can you discover other examples?

## Communicating Energy Ideas Using Art and Music

Develop ways to portray energy ideas using drawings, paintings, and music. Energy-related ideas you may want to communicate visually include the following:

- Objects moving fast or slowly
- Hot, warm, and cold
- The energy contained in an energy source (like batteries, the sun, a piece of wood)
- How people use energy

Analyze famous paintings to see the influence of energy. For example, how did Van Gogh paint the sun? How do impressionists use light and dark to create images? Use some of these same techniques in your own artwork.

Compose a musical piece that focuses on the variety of sounds emitted from different instruments. These instruments can be of your own design or from different cultures.

# Energy Efficiency Measures

Below is a list of action ideas that can improve energy efficiency at home, at school, and in the community. Students can perform many of these measures themselves, or they can work with their peers, family, school personnel, and community members to improve energy efficiency.

Energy efficiency measures that correspond to the ***Appliance Survey*** from "At Watt Rate?" (available at keepprogram.org) are listed under each end use category. Teachers may want to have students do these surveys first. If students discover other energy efficiency measures not listed here, they should be encouraged to undertake them if possible.

The cost of implementing energy efficiency measures varies widely. Measures listed under Basic Action Ideas for each end use are free. Many other measures only cost a few dollars. A few require a major investment, such as purchasing a large appliance, buying a new vehicle, or adding insulation as part of a home improvement project. Each energy efficiency measure is ranked from the least costly to the most costly within a specific energy end use category. The rankings are symbolized as follows:

**No cost: Ø**
**Low cost: ¢ - $ (less than $1 to $25)**
**Medium cost: $ - $$ ($25 to $200)**
**High cost: $$$ (Greater than $200)**

Broader cost ranges are shown using two cost symbols separated by a dash. For example, a cost range shown as "Ø - $" means that the cost to implement this measure ranges from no cost to a low cost. All costs are initial investment costs that save energy (and money) over time. Even those that cost little or no money may yield noticeable energy savings. The energy efficiency measures listed here represent only some of the many possible measures that can be taken.

## Lighting

### Implement Basic Action Ideas Ø

- Remember to turn off lights that are not in use.
- Do not turn on more lights than you need for specific tasks such as reading or writing.
- Clean light bulbs and fixtures by removing dust and dirt that have accumulated on them. **Caution: Never use water to clean light bulbs while they are turned on. The water's cooling effect could shatter hot bulbs.**

### Delamp and Relamp Fixtures

- Reduce light levels that are too bright by removing unnecessary bulbs from fixtures (delamping). Ø
- Replace high wattage bulbs with lower wattage bulbs of the same type (relamping). ¢ - $
- Combine delamping and relamping to get the desired amount of light from a fixture. For example, replacing two 60-watt incandescent bulbs (120 watts and 1,730 lumens total) with one 100-watt, 1,710 lumen incandescent bulb will save 20 watts and provide the same amount of light. NOTE: Be sure to delamp and relamp first those fixtures that are used most often (4 hours or more per day).

### Replace Incandescent Light Bulbs with More Efficient Bulbs

- Replace incandescent bulbs with light emitting diodes (LEDs) or compact fluorescent lamps (CFLs). Be sure to install LEDs/CFLs first in fixtures that are used most often (4 hours or more per day). $ - $$ (depending on the number of bulbs being replaced)

### Use Daylight

- Rearrange living and work spaces to take advantage of daylight. Ø
- Open curtains and blinds during the day to reduce the use of indoor lighting. Ø
- Consider repainting walls and ceilings with light colors to reflect more light. $ - $$
- Consider investing in skylights or extra windows to allow more daylight to enter the room. $$$

### Use Other Lighting Energy Efficiency Measures

- Connect a timer or a light sensor to outdoor lights so that they automatically turn off during the daytime and turn on at night. $ - $$

# Insulation and Air Infiltration

### Implement Basic Action Ideas—Air Infiltration Ø

- Close drapes and window shades during the winter and the summer.
- Close doors when going in and out.
- Make sure that all interior windows and storm windows are closed during the heating season.
- If your home has a fireplace, make sure that the damper is tightly closed when you don't have a fire burning.

### Add Insulation

- Add insulation to the attic, walls, and basement as needed. Contact a building supply dealer, a home builder, an energy professional, the Wisconsin Energy Bureau, or the Wisconsin Department of Industry, Labor, and Human Relations (the state agency that oversees building codes) to find out recommended R-values for the areas where insulation is to be added. $$ - $$$

### Reduce Air Infiltration in Windows

- Place clear plastic barriers over windows during the heating season to prevent drafts. Many department and hardware stores sell window plastic kits for this purpose. ¢ - $
- Replace cracked and broken windowpanes. ¢ - $
- Caulk and weatherstrip air leaks around the exterior and interior of window frames. ¢ - $
- Install new storm windows or repair old ones. $ - $$

### Add Window Coverings

- Install drapes, shades, or insulating coverings that can be rolled down and closed into place. $ - $$$ (depending on the type of window coverings installed and the number of windows covered)

### Reduce Air Infiltration in Doors

- Install door sweeps or make fabric "snakes" and place them at the bottom of doors to prevent drafts. ¢ - $
- Caulk and weatherstrip air leaks around doors. ¢ - $

- Repair door closing mechanisms so that doors close automatically. ¢ - $
- Install storm doors on exterior doors if none are present. $ - $$

### Reduce Air Infiltration in Walls, Foundations, and Other Openings

- Install foam rubber gaskets behind electrical outlet cover plates. ¢ - $
  **Caution: Make sure that the electricity to the outlet is turned off before removing a cover plate.**
- Caulk or seal cracks in the foundation and gaps or openings where wires and vents enter exterior walls of homes and buildings. ¢ - $$
- If your fireplace damper doesn't work, either have it repaired, install a chimney-top damper, or install a door on the fireplace. $ - $$

# Space Heating, Water Heating, and Air Conditioning

### Implement Basic Action Ideas—Space Heating Ø

- During the heating season, set your thermostat to 68 degrees F (20°C) during the day (or when you are home) and to 58-60 degrees F (13 °C) when you go to bed (or when you are away).
- Close heating vents, radiators, etc. in rooms and other interior spaces that do not need to be heated. Also, clean the dust and cobwebs from heating vents (registers).
- Bleed the air out of hot water radiators.
- Close off rooms that do not need to be heated.

### Implement Basic Action Ideas—Water Heating Ø

- Turn down the water heater thermostat to 120 degrees F (49 °C). Turn it down even further when your family goes on vacation. Some water heaters have a vacation setting specifically for this purpose.
- Do not let the water run while washing your hands, brushing your teeth, shaving, or washing dishes.
- Do not let the shower run for more than a few seconds before stepping into it.

### Implement Basic Action Ideas—Air Conditioning Ø

- During the cooling season, set the air conditioner at 78 degrees F (26 °C). Set it higher if your home has ceiling fans.
- Turn off the air conditioner if you leave your home for more than an hour.
- Close off rooms that do not need to be cooled.

### Implement Space Heating Energy Efficiency Measures

- Clean or change the air filter of your furnace monthly. ¢ - $
- Build reflectors out of aluminum foil and place them between the radiator and the wall. This will help reflect heat from the radiators into a room. ¢ - $
- Install a programmable thermostat. $ - $$
- Have your boiler or furnace serviced every one or two years. $ - $$
- Seal and insulate warm-air heating ducts that come out of your furnace. $ - $$
- Consider installing a high-efficiency furnace or boiler if replacing an old furnace or boiler. $$$

### Implement Water Heating Energy Efficiency Measures

- Install a low-flow shower head in your shower. ¢ - $
- Install water-efficient faucet aerators (faucet heads) in your kitchen and bathroom sinks. ¢ - $
- Fix leaky faucets. ¢ - $
- Install an insulating blanket around your water heater. ¢ - $
  **Caution: Do not cover thermostats, burners, water heater controls, or air inlets of water heaters with insulating blankets. Do not cover the tops of natural gas water heaters. Make sure that blankets are taped securely to water heaters to prevent them from slipping down. Ask an adult for help when adding blankets to water heaters. Note that installing insulating blankets on certain high-efficiency water heaters may reduce efficiency. Follow directions and manufacturer's recommendations.**
- Insulate the first three feet (90 cm) of the hot water pipe coming out of the water heater. ¢ - $
- Insulate all hot water pipes in unheated basements and crawlspaces. $ - $$
  **Caution: Do not replace or cover older pipe insulation on your own. It may contain asbestos and should not be touched or disturbed except by a professional.**
- Consider installing a high-efficiency water heater, if replacing an old water heater. $$$

### Implement Air Conditioning Energy Efficiency Measures

- Place window air conditioners on the shaded sides of the house. Ø - $, depending on whether you have to buy mounting brackets
- Clean or change your air conditioner is air filter every one or two months. ¢ - $
- Build an awning over the air conditioner so that it is not exposed to the sun. $$ - $$$
- Consider installing a high-efficiency air conditioner, if replacing an old air conditioner. $$$.

# Major Home Appliances

### Implement Basic Action Ideas—Refrigerators and Freezers Ø

- Set your refrigerator's temperature between 38 and 42 degrees F (3 and 6°C), and your freezer between 10 and 15 degrees F (-12 and -9 °C). Use a thermometer to check these temperatures, since refrigerator or freezer dials usually do not show temperatures.
- Do not open the refrigerator or freezer door longer than necessary.
- Decide what you want to get from the refrigerator or freezer before you open the door.
- Stock your refrigerator with food and fill any remaining large spaces with jugs of water. However, do not overfill your refrigerator to the point where you reduce air circulation and cooling effectiveness.
- Clean the coils behind your refrigerator and freezer at least once a year.
- Make sure the refrigerator door seal is tight when closed.
- Move refrigerators and freezers away from direct sunlight, stoves, dishwashers, and other heat sources.
- Make sure that the refrigerator is not pushed tightly against the wall; air must circulate through the coils.
- Use energy-saving settings on your refrigerator and freezer if they have them.

### Implement Basic Action Ideas—Clothes Washers, Clothes Dryers, and Dishwashers Ø

- Use energy-saving settings on your clothes washer, clothes dryer, and dishwasher if they have them.
- Run clothes washers, clothes dryers, and dishwashers with full loads when possible.

- Wash clothes in cold or warm water when possible.
- Hang washed clothes on a clothesline to dry.
- Wash dishes by hand, especially if there aren't enough to fill a dishwasher. Use water-conserving habits (for example, don't let the water run unnecessarily) when washing.
- If your dishwasher doesn't have a no-heat air dry feature, turn off the dishwasher after the final rinse cycle and open its door to let dishes air dry.

### Implement Basic Action Ideas—Stoves (Ranges) Ø

- Use microwave ovens and toaster ovens in place of electric ranges and ovens when possible.
- Cover pots when cooking food or boiling water, except when cooking food that may boil over (like pasta).
- Place small pots or pans on small burners when cooking.
- Make sure that the metal reflectors under burners are kept clean so they can reflect heat to pots and pans during cooking.
- Avoid opening the oven to look at food while it is cooking. Turn on the oven light and look through the window instead.
- Reduce cooking time by defrosting foods in the refrigerator before cooking.

### Implement Refrigerator and Freezer Energy Efficiency Measures

- Consider purchasing a high-efficiency refrigerator if replacing an old refrigerator. $$$

# Small- and Medium-Sized Electrical Appliances & Equipment

### Implement Basic Action Ideas Ø

- Turn off appliances and equipment if they are not being used.
- Substitute manual effort (labor) for using an appliance when possible. Think of it as a way of getting exercise.

### Implement Electrical Appliance and Equipment Energy Efficiency Measures

- Buy energy-efficient appliances and equipment whenever possible. ¢ - $$$

# Transportation

### Use Transportation Alternatives

- Walk or bike to destinations whenever possible. Ø
- Start or join a carpool to commute to school or work. Ø - $ (depending on how the cost of carpooling compares to the cost of using your own vehicle)
- Use mass transit (buses, trains) for commuting purposes, when possible. Ø - $$ (depending on how the cost of using mass transit compares to the cost of using your own vehicle)

## Maintain Vehicles for Greater Fuel Efficiency

- Keep the tires of your vehicle inflated to the manufacturer's recommended maximum pressure. Ø
- Change engine oil and the oil filter according to the manufacturer's recommended schedule. ¢ - $
- Have your vehicle's engine tuned up regularly. $ - $$
- Have the wheels of your vehicle aligned regularly. $ - $$

## Practice Driving Habits That Increase Fuel Efficiency Ø

- Combine several errands into one trip.
- Reduce any unnecessary weight carried by the vehicle. Extra weight reduces fuel efficiency.
- If you stop for more than one minute, it is more efficient to turn off the engine than to let it idle.
- Avoid revving up the engine.
- Avoid rapid acceleration and braking. Drive smoothly and anticipate traffic stops.
- Obey speed limits. Most vehicles reach their optimum fuel efficiency at speeds between 40 and 55 miles per hour (mph) (64.4 and 88.5 km/hr). As speed increases over 55 mph (88.5 km/hr), fuel efficiency drops quickly. Speeds of 65 mph (104.6 km/hr) use from 10 to 15 percent more fuel than 55 mph (88.5 km/hr). Losses at 75 mph (120.7 km/hr) compared to 65 mph (104.6 km/hr) are even greater.
- Use cruise control when driving on level highway roads.

## Consider Buying a More Fuel Efficient Vehicle $$$

- If you or a member of your family plans to buy a new or used vehicle, consider choosing one with the highest possible fuel efficiency (miles per gallon, or mpg) rating. Small vehicles with four-cylinder engines and manual transmissions generally have the highest fuel efficiency ratings. However, fuel efficiency ratings also vary for different classes of vehicles (cars, minivans, station wagons, light trucks, etc.), so make sure to consider the most efficient vehicle within a certain class.

## Trip Planning

- Design a travel brochure of Wisconsin that identifies energy-efficient ways of getting to various destinations and points of interest within the state.

# Energy Efficient Landscaping

## Plant Trees

- It's much cooler to sit under a densely leafed, spreading tree that blocks the sun's rays than under one that only filters rays. The Arbor Day Foundation suggests planting trees with round or horizontal-oval crowns. Trees rated highest for shade are maple, horse chestnut, beech, green ash, walnut, poplar, and sycamore.
- Consider the plant's adaptability and hardiness. For the north side of a building, choose a shade-tolerant plant that's extremely winter hardy. For the south and west sides, use plants that are adaptable to drought, excessive sun, and hot winds.
- To prevent foundation damage, a tree planted within 10 feet (300 cm) of a building should be selected from those species that have a taproot instead of a lateral root system.
- Plant trees with strong wood. However, for quick shade, interplant fast-growing weaker trees such as willows. When the slower, stronger trees reach a desirable height, remove the weaker ones.

- When deciding where to plant your trees, observe summer shadows on your property and plant trees where they will shade hot spots during the hottest days of summer. Locate large deciduous shade trees on the south, southwest, and west sides of the building about 15 to 25 feet (45-75 m) apart and 10 to 15 feet (30-45 m) from the building. Deciduous trees block the summer sun but let winter's warming rays filter through after the leaves fall. Plant trees with strong wood, such as oaks, lindens, or ashes. (Weaker trees can cause damage if branches break off during high winds.)

## Plant Dwarf Shrubs near Building Foundations

- Dwarf shrubs are suitable for energy-efficient landscaping because they remain small at maturity (2 to 3 feet high [60-90 cm]) and can be planted near buildings. Also, since they stay small, they require little maintenance. Small plantings near your building can save energy year-round. In the winter, dwarf shrubs, especially evergreens, can block the force of cold winter winds against the foundation. This reduces both heat loss through the walls and cold air leaks. In the summer, dwarf shrubs can cool the air near your building by a process called transpiration. As plants give off moisture to the air, the air cools, similar to the way perspiring cools humans. The air temperature can be as much as 10 degrees cooler by shrubs. Evergreen dwarf shrubs are especially effective for cutting heat loss in the winter. Many of the conifers (needle types) are very hardy and form an effective foundation wind barrier year-round. Locate these shrubs on the north and northwest sides of your building.



The Wisconsin K-12 Energy Education Program is supported through funding from

Wisconsin K-12 Energy Education Program (KEEP)
College of Natural Resources
University of Wisconsin-Stevens Point