TOPIC 7 Sources of Thermal Energy

In Topic 1, you thought about common sources of energy in the activity Using Energy. You probably found that much of the energy for cooking and heating was either natural gas or electricity. Gas and electricity have to be transported from where they are found, and they might result from a series of energy transformations. For example, gravity causes the water in a waterfall to fall downward. This energy of the moving water can turn a turbine. The mechanical energy of the spinning generator is changed to electrical energy.

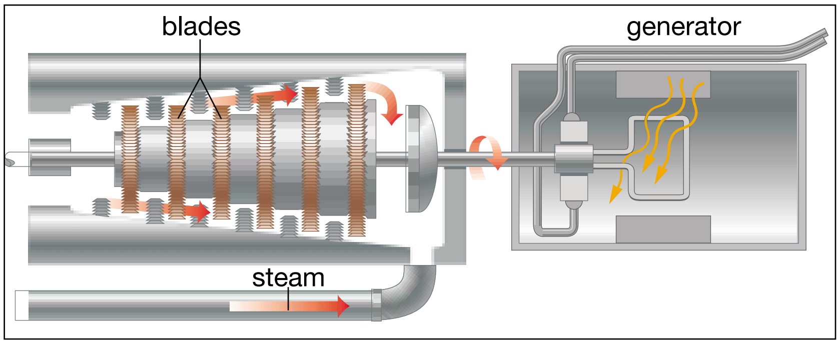


Figure 3.28 Energy of moving water turns a turbine which causes a generator to spin.

If your home uses natural gas for heating and cooking, you are changing energy stored in the gas into thermal energy. Unlike hydro-electric power, natural gas requires few energy conversions before it can be used as a fuel.

Find Out ACTIVITY

Energy Inputs for Energy Outputs

Some energy resources require considerable treatment before they can be used by consumers. When oil is pumped out of the ground, it goes through a process called fractional distillation that turns it into various petroleum products. Natural gas needs less treatment, but it does require the building of pipelines and networks of pipelines to deliver it to homes and industries. How many energy inputs does firewood require?

Procedure

1. With your partner, brainstorm everything that can happen in order for energy to be obtained from firewood.

2. Suppose you were setting up a small business to obtain and sell firewood. Think about how you would obtain the wood, prepare it for sale, get it to its selling point, and find customers. List the steps that you would have to take in order to sell a bundle of firewood.

3. Performing and Recording Beside each step, write any energy input that would be required for this step to be completed.

4. Compare your ideas with those of other students.

What Did You Find Out? Analyzing and Interpreting

1. How many steps did you and your partner think of? How many energy inputs did you find?

2. Wood requires no treatment in order to be burned in a fireplace or wood stove. Why would it be inaccurate to think of it as a "free" energy source?

3. What are some energy inputs that allow us to use natural gas in furnaces and stoves?

Chemical Energy

Humans began using chemical energy long before they understood much about it. Cave dwellers collected wood for their fires, unaware that stored chemical energy was released in the form of thermal energy when the wood burned. Coal also contains stored chemical energy that needs no further treatment to produce thermal energy as it burns.

Electrical Energy

Electricity can be produced in many ways. Hydro-electric dams, like waterfalls, change the energy of falling water to electrical energy. Dams are usually impressive to look at, so they often become attractions and contribute to the tourism industry. Because the river on which a dam is built no longer flows naturally, wildlife in the area is usually affected. Plants that used to grow can no longer do so, and organisms that used to eat them have to move to other areas. The livelihood of people who have fished and hunted in the area for generations is also affected.

Figure 3.29 Dams use the energy of falling water which is transformed into electrical energy.

Electricity can also be produced at generating stations that burn fossil fuels. Where large waterfalls or good locations for dams do not exist, thermo-electric (fuel-burning) generating stations are common. They can provide electrical energy to large populations that have no other means of obtaining it. Heated water is a by-product of thermo-electric plants, however. If it is released into lakes or rivers, many living organisms can be affected by changing temperatures or water levels. Chemicals released by the burning fuel can cause more environmental damage.

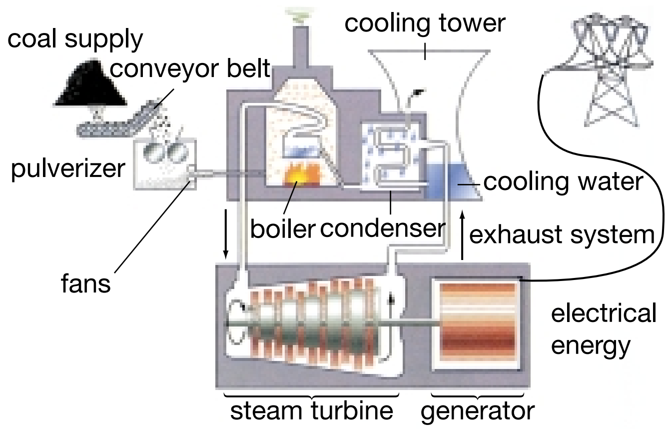


Figure 3.30 Burning fuel converts chemical energy to thermal energy. The thermal energy boils water. Steam from the boiling water spins the turbines. Mechanical energy from the spinning turbines turns a generator. The generator converts mechanical energy into electricity.

Mechanical Forces

Have you ever pounded a nail into a piece of wood and then noticed that the nail felt warm? Thermal energy was released by the impact of the hammer and by the friction of the nail rubbing against the wood as you pounded it into place. Mechanical forces that push or pull objects often release thermal energy. Car brakes, bicycle brakes, skidding tires, and shoes release thermal energy in this way.

Mechanical forces release thermal energy in other ways, as well. You may have noticed that the valve on a bicycle pump becomes warm as you energetically pump up the bicycle's tires. As you compress the air in the pump, it warms up.

DidYouKnow?

In a car engine, oil is used to lubricate the parts, making them slide past each other more easily. In this way, the friction is reduced. This reduces the amount of thermal energy that is released, so the car engine suffers less wear.

Geothermal Energy

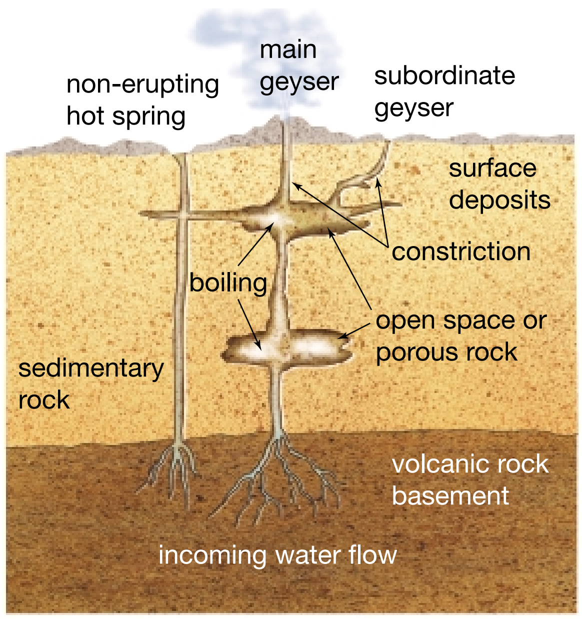
Volcanoes, hot springs, and geysers are indications of extremely hot materials that exist inside Earth's crust. (You will learn more about volcanoes in Unit 5.) The hot material inside Earth that shoots or oozes out during a volcanic eruption can also produce hot water or even steam which moves through cracks in the rock. This boiling water or steam can be piped to a power plant at the surface. There it is channelled through a control system to turbines, and is transformed into electrical energy. Energy that we harness from Earth's interior is called **geothermal energy**.

Another technique for using geothermal energy is called HDR (hot, dry rock). Using this technique, engineers pump water into rock that has been cracked (see Figure 3.31). The heated water returns to Earth's surface as steam, where it is used to generate electricity.

Geothermal energy is clean, and the power plants that convert it to electrical energy are reliable. It is a good alternative to the dwindling supply of fossil fuels. Using more geothermal energy could help reduce wastes resulting from the mining of fossil fuels, as well as pollutants caused by burning fossil fuels.

Looking Ahead

Can geothermal energy be used to heat individual homes? Research this on the Internet. You might want to consider combining geothermal energy with solar heating for your Unit Issue.



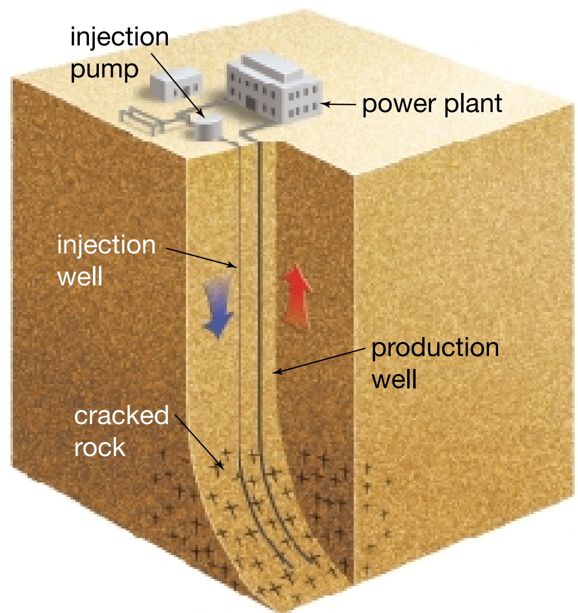


Figure 3.31 The illustration on the left shows a cross-section of a hot spring and a geyser. Both could be harnessed for geothermal power. The illustration on the right shows a geothermal power plant.

Solar Energy

When you hang a shirt out to dry on a sunny, breezy day, you are using **solar energy** (energy from the Sun) to dry your shirt. Solar energy is clean, and it is guaranteed not to run out. Unfortunately, there are periods of time when the Sun does not shine. Solar energy is not available through the night. Less solar energy is available in winter than in summer. How can these problems be overcome?

Passive Solar Heating

There are two basic ways of using solar energy to warm buildings. **Passive solar heating** uses the materials in the structure to absorb, store, and release solar energy. For example, a home that uses passive solar heating might have a wall of windows on the south side of the house. The remaining exterior walls are well insulated and have few windows. Energy from the Sun is absorbed by materials such as concrete in the floor or water in a storage tank. During the night, this stored energy is released and warms the air in the house. **Active solar heating** uses mechanical devices like fans to distribute stored thermal energy.

PROBLEM-SOLVING

INVESTIGATION 3-1

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Passive Paint

Can paint help to keep your home warmer in winter and cooler in summer? Use your knowledge of the transfer of thermal energy to design an investigation to test this claim.

Challenge

Can you change the solar heating of a model room by changing the way its walls are painted?

Safety Precautions

- Use care when working with paint. Avoid inhaling fumes. Use in a well-ventilated area.
- Avoid contact with eyes. If contact occurs, flush eyes immediately and thoroughly with water.
- Wear disposable gloves.
- Dispose of your materials as your teacher directs.

Materials

disposable gloves
two shoe boxes
a source of thermal energy
sheets of heavy, insulating plastic
heavy-duty adhesive tape
2 paint samples (sample A is treated for greater thermal energy efficiency; sample B is untreated)
2 paintbrushes or sponges
2 thermometers
other materials

Specifications

A. Your investigation should investigate how differences in paint affect solar heating in a model room. Your two paint samples will differ in only one way.

B. To test room temperature rather than the temperature of a wall or floor, you will need to avoid or minimize thermal energy conduction. Your design should show the materials and method you will use. Your notes should explain why you think your materials and design will avoid or minimize conduction.

Plan and Construct

1. Write a prediction that relates the likely results of your experiment to the paint property you are investigating. For example, you could complete the following sentence: "We think that painting the model room with Sample A paint will increase the effect of solar heating because …"
2. Decide how you could use the suggested materials to set up an experiment to find out whether differences in paint affect the amount of solar heating in a model of a house room.
3. Write your procedure in point form and list the variables. For example you might write:
The responding variable (the feature we observe) will be …
The manipulated variable (the feature we change) will be …
Controlled variables (features we keep the same) will be …
4. Show the procedure to your teacher. When it has been approved, construct your model.
5. Conduct your experiment, keeping a careful record of your observations. Wash your hands after completing the experiment.
6. Prepare a report, with diagrams, to help explain your findings.

Evaluate

1. Did your findings support your prediction? If not, how might you modify the investigation in order to re-test your hypothesis?
2. How did other groups conduct their experiment? Were their results similar to yours? If not, what explanation might there be for the differences?

Active Solar Heating

Figure 3.32 illustrates an active solar heating system. Active solar heating systems involve fairly complex mechanical systems and devices called **solar collectors**. These collectors, usually on the roof or the south side of a building, contain water or air. The Sun heats the water or air, which is then pumped through the building by the mechanical parts of the system.

Looking Ahead

In your Science Log, list some materials you could use to build a model of an energy-efficient solar home. You could use these ideas for your solar house in the Unit Issue.

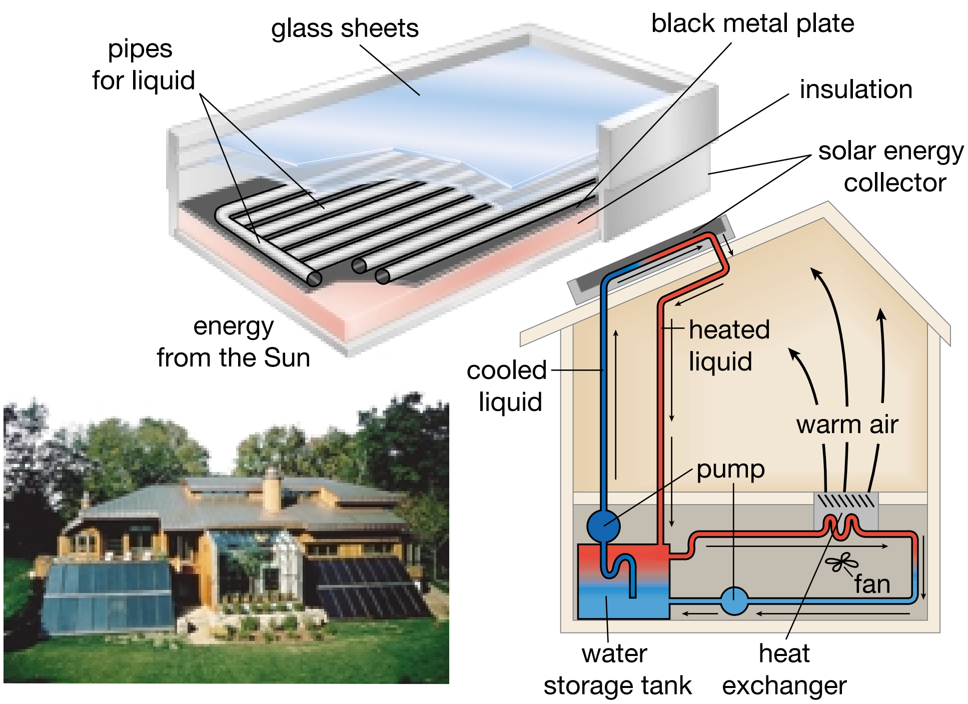


Figure 3.32 Radiant energy from the Sun passes through the glass, which traps the energy in the solar collector. The black metal plate absorbs the radiant energy. The solar energy is converted to thermal energy, warming the metal. This thermal energy is transferred to the water in the pipes just beneath the plate. The water flows through pipes to a basement pump that circulates water to radiators throughout the system. A fan helps the air, heated by the water, to circulate through the rooms. The cooled water is pumped back up to the collector to be reheated. Some active solar heating systems include large, insulated tanks for storing heated water for later use.

Wind Energy

Remember that shirt you hung out to dry? You know that the Sun's radiant energy will cause moisture to continue to evaporate from your shirt until it is dry. The process is speeded up by a breeze.

Wind energy is the energy of moving air. Wind energy is a result of solar energy. As the Sun heats the air, the warmer air rises and cools off. Cooler air falls, creating a convection current. These currents, on a global basis, form our wind systems.

Wind has more uses than simply drying your shirt. Scientists and engineers have been able to harness wind energy to produce electricity. The windmill is a turbine (a wheel with fan blades). When the wind makes it spin, it rotates an electrical generator to produce electricity. Throughout the world there are windmill farms that function in this way.

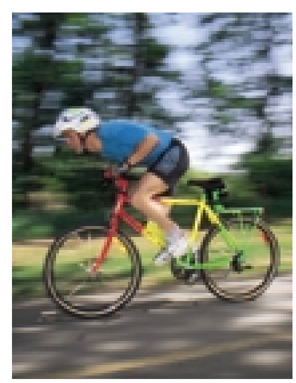


Figure 3.33 If you have ever ridden a bicycle into a strong headwind, you know how much of your energy is required to work against the wind's energy.

Figure 3.34 The use of wind energy is increasing in Alberta. The Cowley Ridge Project in Cowley Ridge in southern Alberta has been producing electricity since 1994. Since then it has averaged 55 million kilowatt hours of electricity annually.

More Sources of Thermal Energy

Figure 3.35 This photograph shows red wrigglers in an indoor composter.

Have you thought about your own body as a source of thermal energy? Burning fuels such as natural gas and oil releases thermal energy in a furnace or a car, for example. In a similar way, food you eat is digested and releases energy for your body's growth and activity. Some of that energy maintains your body's internal temperature at about 37°C. Some of your body's thermal energy is tranferred to the air and objects around you. Have you ever been out in the cold watching a sports event? If you huddled together with your friends, you were taking advantage, to some extent, of thermal energy that all of you were releasing. Litters of warm-blooded organisms such as mice, kittens, and puppies huddle together for warmth when they are very young. A composter is another source of thermal energy. In a composter, organisms called decomposers break down food. Chemical changes occur, like burning or digesting food. As these changes occur, they release thermal energy. The thermal energy in turn helps in the process of decomposition.

Off the Wall

How about heating your household water with a composter? It has been done! A large composter (approximately 3 m in diameter and 1.2 m high) has provided hot water to a family on a 24 h basis. A smaller mass would not have provided enough pressure to release the amount of thermal energy required. A plastic coil buried in the compost contained cold water that flowed in at one end. Thermal energy was released by decomposition of the large mass of materials in the composter. It raised the temperature of the water in the pipe. The hot water flowed out of a tap at the other end of the pipe, when needed. Incoming cold water replaced the heated water. Users then had to wait until the water warmed up again.

Fossil Fuels

You have been examining some alternative sources of energy. An **energy resource** is anything that can provide energy in a useful form. Fossil fuels are the main energy resource in Alberta and throughout the world. **Fossil fuels** are chemicals from plants and other organisms that died and decomposed millions of years ago and have been preserved deep underground. Fossil fuels normally form when oceans and silt exert pressure on the cells of dead organisms. Natural gas and petroleum oils are fossil fuels.

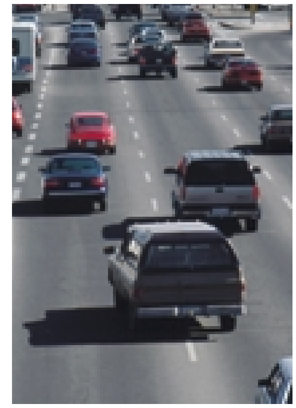


Figure 3.36 Furnaces in buildings use fossil fuels. Airplanes, trucks, and automobiles burn fossil fuels. Thermo-electric generating stations produce electricity by burning fossil fuels.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus7

The cruise ship *Queen Elizabeth II* travels only about 4 cm for each litre of fuel it burns. Go to the web site above for information about how much fuel other forms of transportation require. Click on **Web Links** to find out where to go next. Make a chart to show amount of fuel used and average distance per litre for each form of transportation.

Fossil Fuels: Two Problems

Our society's use of fossil fuels has continued to increase rapidly since the Western world became industrialized in the 1800s. We have been using fossil fuels for only a very short time compared to Earth's age, but we have already used up about half of the known easy-to-obtain fossil fuels (see Figure 3.37). New technology is enabling us to extract the fuel from oil sands and underwater deposits. At our present rate of use, these too will likely be used up in a relatively short time. As a result, fossil fuels will become more difficult and more expensive to obtain. Since fossil fuels take millions of years to form, we refer to them as **non-renewable resources**. Energy resources that can be recycled or replaced by natural processes in less than 100 years are called **renewable resources**. Trees and food crops are renewable resources that can usually grow at about the same rate as they are used up.

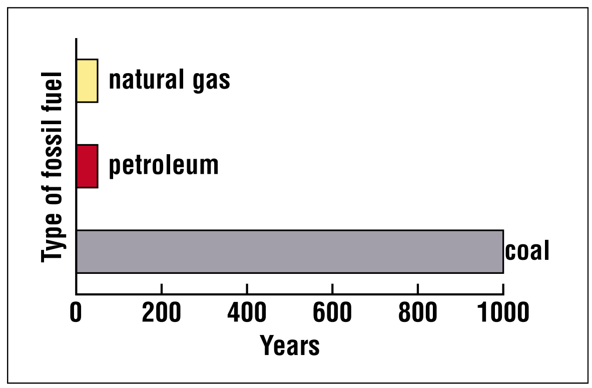


Figure 3.37 This graph shows how long our obtainable supplies of fossil fuels will last if our use of them continues at the current rate.

Another problem occurs when fossil fuels burn and produce carbon dioxide gases. Carbon dioxide is required by green plants, as you saw in Unit 1. It occurs naturally in the atmosphere. You add carbon dioxide to the air every time you breathe out, because as your body uses food, it produces carbon dioxide as a waste product. With ever-increasing numbers of planes, trucks, and automobiles meeting the demands of industry, natural carbon dioxide recycling systems are becoming badly overloaded. What happens then? Heat from Earth is unable to escape into space because it is trapped by greenhouse gases (largely carbon dioxide) in the atmosphere. You can observe the effect of **greenhouse gases** in the next activity.

Looking Ahead

In your Science Log, write some notes about why energy conservation is necessary. Use them as you develop your presentation for the Unit Issue Analysis.

INQUIRY INVESTIGATION 3-J

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Simulating the Greenhouse Effect

In this investigation, you can model the greenhouse effect and make an inference about its impact on life on Earth.

Question

How can you simulate the greenhouse effect?

Prediction

Use what you know about the greenhouse effect to predict what will happen to the temperature in a closed container in a sunny location.

Skill FOCUS

For help with line graphs, turn to Skill Focus 10.

For tips on using models in Science, turn to Skill Focus 12.

Safety Precaution

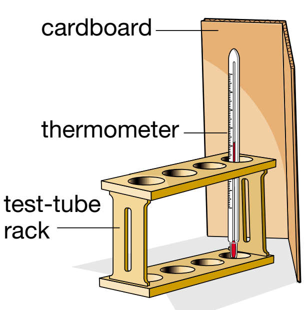
- Always be careful when handling glass thermometers.
- If a thermometer breaks, do not touch it. Have your teacher dispose of the glass.

Apparatus

2 empty aquariums, the same size
glass lid to cover one of the aquariums
3 test-tube racks
3 thermometers

Materials

3 large index cards or other cardboard



Procedure

1. Arrange the aquariums side by side in a sunny window. Leave about 30 cm of space between them.
2. Place a test-tube rack in each aquarium and one rack between the two aquariums. Gently place a thermometer in each rack. Shade each thermometer by making a small wall with the folded cardboard as shown in the diagram.
3. Immediately **record** the temperatures of the three thermometers in your notebook. (The temperature reading on all three should be the same.)
4. Place the glass lid on one aquarium.
5. Record the temperatures of all three thermometers at the end of 5, 10, and 15 min.

Analyze

1. Why did you place a thermometer between the two aquariums? Why is this called a control? Which variable did you change? Which feature did you **observe**? Did your observations support your prediction?
2. Which thermometer indicated the greatest temperature change? Explain why.
3. Assume that this model is truly like Earth. What can you infer about what will happen if Earth's system becomes overloaded with greenhouse gases?

Conclude and Apply

4. How was the glass lid like greenhouse gases in the atmosphere?
5. **Make a line graph** that shows the temperatures of the three thermometers for the 15 min of the experiment.

Global Warming

Normal amounts of carbon dioxide in the atmosphere help to keep Earth warm enough to support life. Many scientists believe that increased amounts of carbon dioxide and other greenhouse gases are trapping thermal energy, warming Earth at a fairly rapid rate. Even a rise in temperature of a few degrees can make a big difference. It can change climatic zones and their plant-growing abilities, dry up rivers and lakes, and even melt the polar ice cap.

Canadians are among the highest producers of greenhouse gases (per person) in the world. Canada's physical size, small population, and fairly cold climate mean that materials have to be transported over large distances. Our energy use produces many economic benefits for ourselves and other countries. It also contributes to global warming.

Figure 3.38 Some companies, such as Canada's Bombardier, are becoming more environmentally conscious. The aircraft shown here was designed to burn less fuel than other aircraft in its class. As a result, it releases less greenhouse gas into the atmosphere and causes less thermal pollution.

Cogeneration

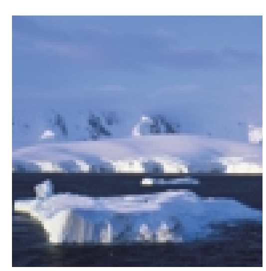
Engines in cars, trucks, trains, and aircraft, and furnaces in buildings, generating stations, and large industries, get hot. They release a lot of thermal energy into the environment. This accidental warming of the environment is called **thermal pollution**. **Cogeneration** uses this waste heat to generate electricity or heat buildings, or do other useful tasks.

For example, waste heat could be transferred from a factory to a downtown area (or to another factory), to heat and power buildings. Waste heat can be collected and transported using hot water running through a heat exchanger (like a huge car radiator). A pipe can run from the place where the heat is collected to where the waste heat is used. All along the pipe, buildings can use smaller exchangers connected to the pipe to obtain the thermal energy they require.

When fuel burns in a thermo-electric power plant, only about one third of its energy is usually converted to electricity. Cogeneration is efficient because it uses some of the remaining two thirds of the energy released from the fuel.

DidYouKnow?

In Antarctica, ice shelves are melting at an increasingly rapid rate. Ice shelves are floating extensions of the ice sheets that cover the Antarctic land. Over a few days in 1995, 1300 km^2 of one ice shelf broke up. Average temperatures in the area have risen by 2.5°C in the past few decades. Although it has not yet been proved, researchers suspect the break-ups are related to global warming.



TOPIC 7 Review

1. Describe two ways of producing electricity, and give an advantage and a disadvantage of each.
2. Describe two ways of converting mechanical energy to thermal energy.
3. Define active and passive solar energy.
4. What is the greenhouse effect, and why does it pose a problem?
5. **Thinking Critically** Why have Albertans not taken greater advantage of their geothermal energy sources like the hot springs near Banff?

TOPIC 8

Conserving Our Fossil Fuel Resources

Off the Wall

At the beginning of the last century, horses and wagons were so plentiful in New York City that horse manure caused a serious pollution problem. When it dried, small particles of manure would fly into the air, land on food displayed outside stores, and be inhaled into people's lungs. When the automobile was introduced, people hailed it as a wonderful, pollution-free device.

There are so many disadvantages to burning fossil fuels, but we still use them. Fossil fuels form a key part of Alberta's economy. Coal, for example, is burned in generating stations to produce about 80 percent of the province's electrical energy. That energy is used in homes and in industries that provide employment for people who live here.

Figure 3.39 Has our air become overloaded with gases produced by burning fossil fuels?

Other fossil fuels, like oil and natural gas, are also readily available in Alberta. Fossil fuels have been so plentiful that people have assumed until recently that they would always be available. As well, when people first began to use fossil fuels, they believed that the unwanted gases they produce would simply be absorbed by the atmosphere. Fossil fuels were firmly established as an energy source and as a major part of Canada's and the world's economy before scientists began to observe some of the problems associated with them.

Find Out ACTIVITY

Timing Is Everything!

How long does it take to bring water from room temperature to boiling in a microwave oven? Plan a class project to find out and consider what your findings might mean in terms of energy conservation.

Safety Precaution

Handle hot water with extreme care. The boiling water and the container can cause painful burns. Enlist the help of an adult to do this activity.

Procedure Performing and Recording

1. If you do not have a microwave oven, try to do this test with a friend whose home does have one.
2. Measure 250 mL of water and leave it at room temperature for an hour or so.
3. Place the container of water in the microwave oven. Set it at high power. Start timing as soon as you press the "Start" button. Continue timing until the water is bubbling.

What Did You Find Out? Analyzing and Interpreting

1. Report your findings to the class. Did you find a wide variation in results? What might have caused these variations? How might they be eliminated?
2. If you can, try your test again to see if you can obtain more consistent results. Keep your notes so that you can compare your findings with a variety of cooking methods in the investigation on page 253, How Much Energy?

DECISION-MAKING

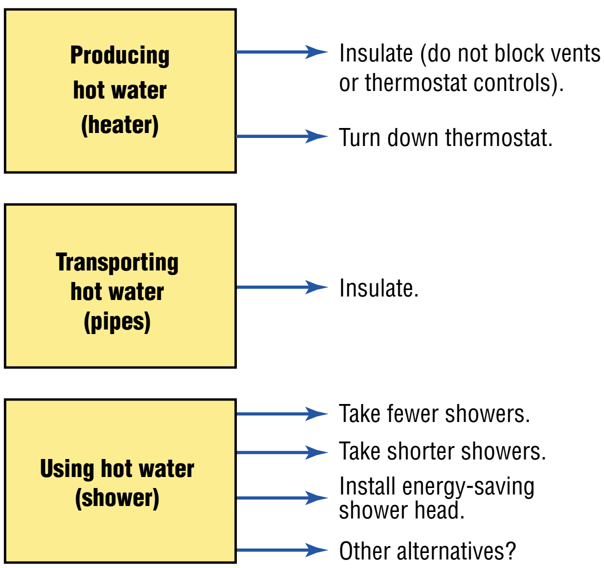
INVESTIGATION 3-K

SKILLCHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

You Choose!

Think About It

Opportunities to be energy-efficient are all around you. For example, the diagram below shows some features of the hot water system in many homes. It also suggests some possible ways to make this system more energy-efficient. This investigation will give you a chance to practise making energy-conserving choices in everyday life.



Procedure

1. In your notebook, write whether you would or would not take each action in the illustration. Give a reason for each choice.
2. Share your ideas and your reasons with the class.
3. **Estimate** how many minutes you spend when you shower.
4. An average shower uses 15 L of water per minute. **Calculate** how much water you use each time you shower.
5. An average bath uses about 220 L of water. Calculate how long you would spend in the shower to use this much water.
6. How many showers would you need to take to use the same amount of water as one bath?

Analyze

1. In your class discussion, which two energy-conserving actions were the most popular? Which two actions were the least popular?
2. Suppose that for one week you showered, and for the next week you took baths. Which method would be more energy-efficient? Give reasons to support your answer.
3. Why might your answers to procedure steps 5 and 6 be inaccurate?
4. What problems could be caused by setting your hot-water heater thermostat to a lower temperature in order to be more energy-efficient? Why might a too-high setting be dangerous?
5. What are the positive effects on your household of taking at least some of these actions? What are the effects on your community?

Extension

1. Next time you take a shower at home, time yourself. How accurate was your estimate in step 3?
2. Consider any hair products you use, such as shampoo or conditioner. In what way do they affect the amount of time you spend in the shower?
3. List other activities in your house that involve hot water use; for example, washing clothes. For each activity, suggest some energy-efficient choices you could make.

INQUIRY

INVESTIGATION 3-L

SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Keep It Warm

Imagine that you are a researcher working for a company that develops products that will keep people warm in the winter. Before you can begin your research, however, you need to answer a basic question about insulating material.

Question

What is the effect of increasing the thickness of an insulating material on the amount of energy transferred through the insulation?

Hypothesis

Write a hypothesis about thickness of insulating material and transfer of thermal energy.

Safety Precautions

Use care when handling the hot water and when working around the heat source.

Materials

tin can (284 mL)

200 mL water

newsprint (One half of one sheet of newsprint will be considered one piece.)

masking tape

Apparatus

heat source

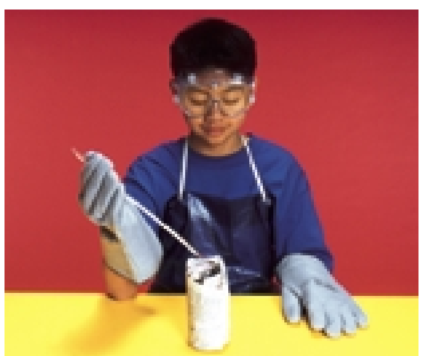
thermometer

retort stand

clamp

beaker (500 mL)

Procedure



1. With your group, heat a 200 mL sample of water to above 80°C. Carefully pour the water into your tin can.

2. Carefully and quickly insulate the tin can by wrapping it in newsprint, as demonstrated by your teacher. The amount of newspaper to be used by each group is shown in the following chart.

3. Insert the thermometer into a small hole, made by your teacher, in the top of the paper. Immediately, start taking the temperature of the water. Continue to **record** the temperature every minute for 15 min (or for as long as your teacher directs). **Make a chart** to record this temperature.

4. Carefully dispose of the hot water down the sink and clean up your work station.

5. **Record** the final temperature of your water in the chart or data base provided by your teacher.

6. **Draw a graph** to compare the results within the class.

Group number	Amount of paper	Temperature After						
		1 min	2 min	3 min	4 min	5 min	6 min	...
1	0 sheet (s)							
2	1							
3	2							
4	3							
5	4							
6	5							
7	6							
8	7							
9	8							
10	9							

Ask an Expert

Turn to page 258 to find out why Mario Patry needs to understand how insulating materials work.

Analyze

1. What scientific name should be given to the first group in the chart? What is the purpose of this group?
2. Which variable (manipulated variable) did you change? Which feature (responding variable) did you observe?
3. If you repeated this activity, do you suppose you would get exactly the same results? What might make the new results different?
4. How was heat lost through each of the following?
   (a) conduction
   (b) convection
   (c) radiation

Conclude and Apply

5. What is the effect of increasing the thickness of an insulating material on the amount of energy transferred? Did your observations support your hypothesis?
6. Would newsprint make a good insulator in your home? Explain your answer.
7. Describe three areas in which you could apply what you have learned about energy conservation.
8. During the winter, house owners often compare the amount of snow on their roof to that of their neighbours to determine if they have enough insulation in their attic. Explain how a homeowner would be able to tell if more insulation were needed.
9. **Design Your Own** With your group, brainstorm other materials that could be used for insulation. Think about different applications: clothing, home insulation, keeping foods warm or cold. What features will each application require? Choose one application, and design an investigation to test at least two insulating materials in that application.

Extension

10. Use library and Internet resources to research survival and other clothing that helps protect people from very cold weather and from the danger of hypothermia (dangerously low body temperatures). Find out what kinds of materials and fillings are used in cold-weather clothing. What design specifications do these articles need to meet? What criteria are used to rate them? How do clothing manufacturers reduce fossil fuel use and pollution at their factories? Prepare a report for presentation to the class. Use informative visuals and, if you can, obtain samples of each material for display. Evaluate the usefulness of these products.

It's Hot in Here!

Figure 3.40 Programmable thermostats can be set to adjust the temperature so that a home is cooler when its occupants are away or sleeping.

Programmable thermostats and other technologies have provided many ways to save energy (and money) at home. If you turn on a hot water tap at school, is the water hot right away, or do you have to wait for it to warm? If it is instantly hot, it is probably produced by a recirculating hot water system. Examine Figure 3.41 to see how a recirculating water system works. The system saves energy and provides instant hot water at all times.

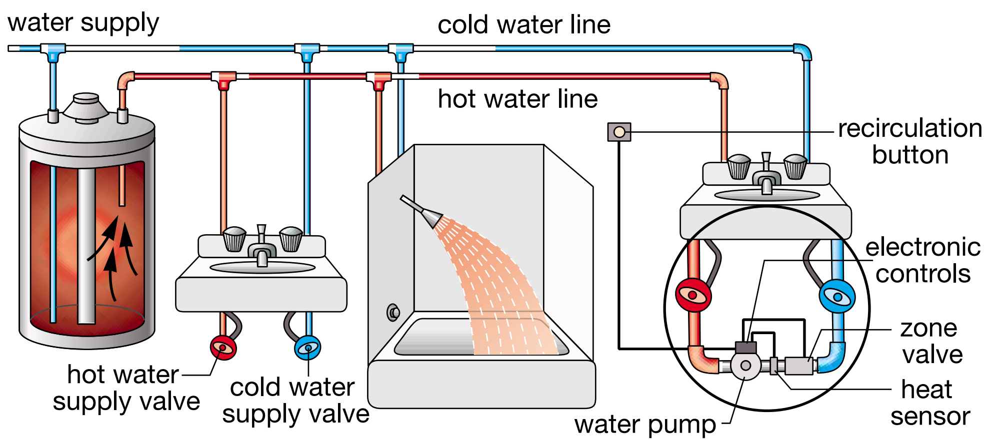


Figure 3.41 This recirculating system pumps hot water to a zone valve. When the system is filled with hot water, the zone valve shuts off the pump.

It's Cold in Here!

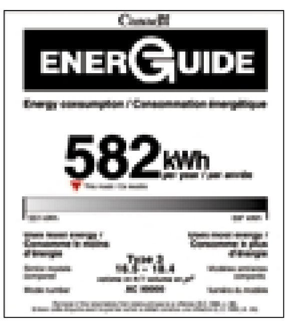


Figure 3.42 The EnerGuide label, found on most household electrical appliances, tells the consumer how much electricity, in kwh/year an appliance uses in one year under normal use. Check the energy ratings of large appliances in your home.

What do a refrigerator and an air conditioner have in common? Both are thermal energy movers. A thermal energy mover is a device that transfers thermal energy from one location to another location at a different temperature. How does it do this?

The operation of a refrigerator or an air conditioner depends on the processes of evaporation and condensation. Examine Figure 3.43. Refrigerators use **refrigerants** (liquids that evaporate easily at low temperatures) to remove thermal energy from food. The refrigerant is pumped through coils inside the refrigerator. As the refrigerant evaporates, it absorbs thermal energy from the items inside the refrigerator, so they cool down. The warmed gas is pumped to a compressor at the back or bottom of the refrigerator. When the gas is compressed, its temperature rises until it is above room temperature. Then it loses thermal energy to the air in the room and condenses again into a liquid.

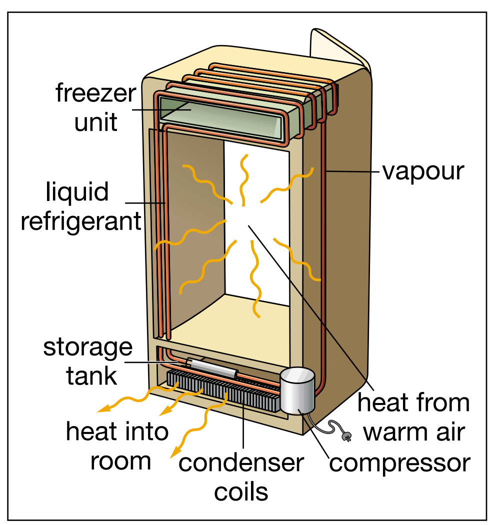


Figure 3.43 A refrigerator is a thermal energy mover.

How Much Energy?

Think About It

What is the effect of the choice of cooking method on energy use?

How Can Science Help?

Your knowledge of thermal energy transfer and your science skills in conducting fair tests will help you in this investigation.

Procedure

1. With your group, examine the graphs. They tell you how long it took to bring 900 mL of water from room temperature (20°C) to boiling and the cost of the energy it required.

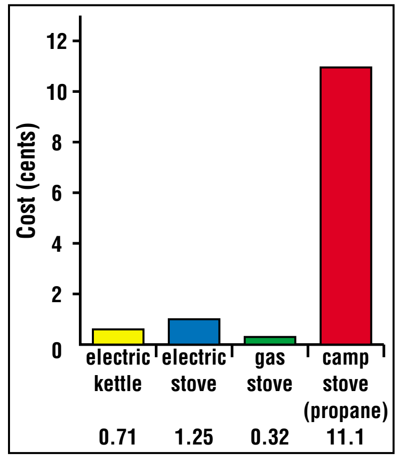
2. Discuss the variations in times with your group. Think about why such variations would occur, and make some notes about your ideas.

3. Trace and record as many energy inputs as you can for each method.

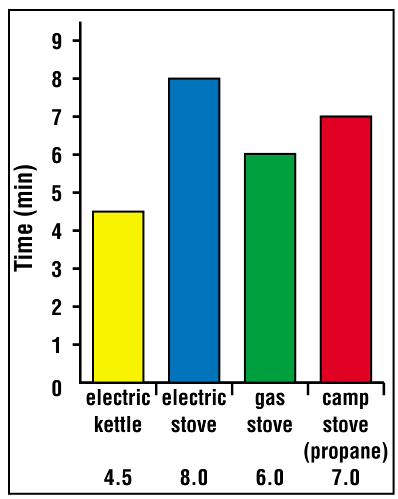
4. Examine the photograph of the solar cooking device shown below. Although such devices cost nothing to operate, they are complicated to construct. The cooker has to point directly at the Sun, so it must be turned as the Sun's position changes. A solar cooker can get hot, but, depending on the weather, it may take considerably longer than the other methods you have investigated.

5. Share the ideas you recorded in step 2 and the inputs you recorded in step 3 with the rest of the class.

Boiling Water (Cost)



Boiling Water (Time)



Analyze

1. What does it mean to say that some heating methods are more energy-efficient than others?

2. If you look only at the graphs of experimental results, which method of heating required the smallest energy input?

3. If you look at the "total" energy inputs required for the different heating methods, which method appears to be the most energy-efficient? If you cannot decide, what additional information would help you to answer the question?

Find Out ACTIVITY

Turn It Down!

You have been examining ways to conserve energy. One idea is to turn down the thermostat on your home hot water heater. Would others in the household notice any change if you did?

Safety Precautions

Hot water heaters are dangerous if not handled carefully. Have an adult turn down the thermostat while you observe. Use care when testing the hot water temperature.

Procedure — Performing and Recording

1. Fill the kitchen sink with hot water, and use a thermometer to measure the temperature. Record the temperature. Ask an adult to change the setting on the water heater.
2. A day or so later, fill the same sink with hot water and check the temperature. How does it compare to the first measure you took? After turning down the thermostat, what difference (if any) do you notice?
3. Check to see if members of the household find that the water is not hot enough or if they ever run out of hot water.

What Did You Find Out? — Analyzing and Interpreting

1. How did your results compare with the results of other class members?
2. What scientific knowledge have you learned in this unit that you could use to explain to someone how turning down the water heater thermostat saves energy?
3. If you live in an apartment building, get the permission of an adult to speak to the superintendent about the temperature setting on the building's hot water heater. Compare it with the temperature of hot water heaters in houses.

Danger: Thermal Energy

Figure 3.44 Care must be taken with the use and storage of fossil fuel products in order to avoid situations like this.

Many of the harmful effects of thermal energy are obvious. A burn caused by touching a hot metal pot is painful. The effects of a forest fire are devastating. Thermal energy does indeed have the power to hurt and destroy us, our belongings, and our environment.

Look again at the photograph on page 186. It is just one example of a problem with the storage of petroleum products. Storage of fossil fuels presents a fire hazard, but there are other risks, as well. Industries are sometimes charged with unsafe storage of materials that pollute the environment. Large storage tanks buried underground may leak harmful chemicals into the soil. Industries that produce petroleum products use chemicals in their manufacturing processes. These chemicals end up in the soil and water. Many millions of dollars are spent in reclamation programs — programs that attempt to restore the soil to its original state. Until the soil is restored, it cannot be used for other purposes.

Individuals, as well as industries, need to take proper care with the storage and use of fossil fuel products, even when those products are used in small quantities.

Find Out ACTIVITY

Store it Safely

People sometimes mix paint and clean paint-brushes in their basements because they do not need to worry about staining the floor with any spilled paint. For certain types of paints, though, this can be a real danger. Fumes from the paint or paintbrush cleaner can be ignited by the flame of a furnace or hot water heater.

What to Do

1. Find out how to use and store paint safely. Read the labels on paint tins. With your group, decide if those labels present the dangers clearly enough for consumers.
2. **Performing and Recording** Contact paint store employees to find out what they can tell you about these dangers and if there is anything consumers can do to reduce them. Find out what the store does in order to handle large quantities of paint safely.
3. **Performing and Recording** Find out what the difference is between water-based (latex) paint and solvent-based (oil) paint. Identify which type presents a greater fire hazard.
4. **Performing and Recording** Contact your fire department to find out other dangers of burning paint. Ask the firefighters to describe how they would put out a fire in a paint store.
5. **Communication and Teamwork** Design your own visual safety label for a paint tin and use it in a poster in which you include your recommendations for the safe use and storage of paint products.

DidYouKnow?

It is possible that the largest fire on Earth occurred about 66 million years ago. There is evidence that at that time an asteroid smashed into the Gulf of Mexico close to the Yucatan peninsula. White-hot and molten rock from the impact sprayed across North America. This may have set most of the forests on fire and killed almost all of the living creatures on the continent. Many scientists believe that this type of catastrophe caused the extinction of the dinosaurs.

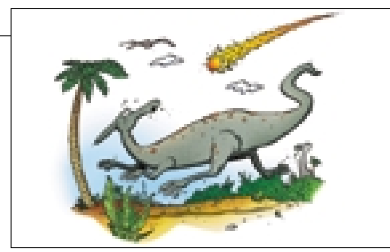


Figure 3.45 In Canada, many thousands of square kilometres of forest burn each year. Most forest fires are set off by lightning. However, some are caused by careless use of fire in the wilderness.

Figure 3.46 Copper is a good heat conductor, so the coating on this pan cooks the food evenly and prevents burning and scorching. The material in the oven mitt is a poor conductor, so thermal energy cannot be transferred from a hot pan to your hand.

Cool Tools

Technological advances now use thermal energy to help drivers avoid danger. An infrared beam senses thermal energy in an object in front of a car at night time. The infrared beam reaches up to five times beyond the headlights. It translates the thermal energy into a black and white image that is projected onto the lower part of the windshield, enabling the driver to take action and avoid a collision.

By-Products of Thermal Energy Use

Not all the dangers of using thermal energy are as obvious as house or forest fires. One problem comes from the products released during burning. You may recall that carbon dioxide, which all fossil fuels give off as they burn, is a greenhouse gas. This means that it helps to trap heat energy in our atmosphere and so leads to global warming. But many fuels, like coal and sulfur-containing natural gas or oil also release other gases while they burn. One of these is sulfur dioxide. This gas is extremely irritating to the eyes, nose, and throat. People with asthma suffer greatly from this pollutant. Hydro-electric companies invest large amounts of money into researching and developing technology that will remove or reduce emissions of sulfur dioxide.

When a fire burns without enough oxygen, a gas called carbon monoxide is produced. It is colourless, odourless, and lethal. The symptoms of carbon monoxide poisoning begin with dizziness and confusion. Because it hinders the brain's reasoning ability, people often do not notice when they are being affected by carbon monoxide. Many people have died in houses or in stranded cars from inhaling this gas. That is why governments in Canada recommend that every house contain carbon monoxide detectors, as well as smoke detectors.

Large-scale use of any type of energy has both benefits and problems. Thermal energy is no exception. Your knowledge of thermal energy and how it is released and transferred will help you to make choices that will preserve both our resources and our environment.

Figure 3.47 Carbon monoxide detectors should be installed in all homes for the safety of the occupants.

TOPIC 8 Review

1. In what ways are fossil fuels important to Alberta?
2. Describe some of the dangers involved when thermal energy is used.
3. Why is it necessary to remove sulfur dioxide gas from the gases given off by a coal-burning hydro generating plant?
4. (a) When is carbon monoxide produced?
   (b) Why is carbon monoxide so dangerous?
5. **Apply** A fire produces hot gases. Using what you know about the behaviour of gas when it is heated, answer the following:
   (a) Where should you place fire detectors and carbon monoxide detectors in the house?
   (b) Where is the air safest to breathe in the corridors of a burning building?

Wrap-up TOPICS 7-8

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

geothermal energy
solar energy
passive solar heating
active solar heating
solar collectors
wind energy
energy resource
fossil fuels
non-renewable resources
renewable resources
greenhouse gases
thermal pollution
cogeneration
refrigerant

Reviewing Key Terms

1. Copy the following list of terms into your notebook. Match each with the correct definition. Write a definition of terms that are not defined.

(a) active solar heating	energy that will never run out (7)
(b) non-renewable resources	energy that depends on the Sun (7)
(c) thermal pollution	an important resource in Alberta (7)
(d) refrigerant	prevent heat from escaping into outer space (7)
(e) solar energy	undesirable effect of thermal energy (7)
(f) fossil fuels	solar heating without fans or motor (7)
(g) resource	technique for using unwanted thermal energy (7)
(h) cogeneration	a means of trapping the Sun's energy (7)
(i) wind energy	liquid that easily evaporates at cold temperatures (8)
(j) greenhouse gases	fossil fuels are this kind of resource (7)
(k) solar collectors	energy inside Earth (7)
(l) renewable resources	
(m) passive solar heating	
(n) geothermal energy	

Understanding Key Concepts

2. Classify the sources of energy you have studied in these Topics as renewable or non-renewable. Explain what it means to say an energy resource is non-renewable. (7)

3. What is another name for a windmill? How does it produce electricity? (7)

4. In your notebook, draw a diagram showing how cogeneration works. (7)

5. Explain why you should never leave a pet inside a closed car in warm weather. (7)

6. List several advantages and disadvantages of a solar cooker. (7)

7. Is any energy resource "free"? Explain. (7, 8)

8. Why is a refrigerator called a thermal energy mover? On what scientific principles does it work? (8)

9. Look up the word "combustible" in the dictionary and explain how it applies to fossil fuels. (8)

10. Is it possible to change people's attitudes so that they will make wise environmental choices? How can you do it? (8)

UNIT 3



Ask an Expert

Planning a camping trip? Talk to someone like Mario Patry. Mario, who works at a camping equipment store, knows a lot about outdoor equipment. He can help you figure out which of the store's 30 different sleeping bags you will need to keep you warm. Mario knows a lot about insulation and energy transfer—the same topics you studied in Investigation 3-L (page 250).

Q How do you help a customer choose a sleeping bag?

A The first question I ask is where and when they intend to use the bag. If you are back-packing in southern Canada in July, you will want a very different bag than if you are backpacking in Yellowknife in April.

Q Can a sleeping bag really keep you warm in Yellowknife in April?

A The right kind of sleeping bag can. Not all of the bags we sell would be warm enough in that situation, especially those designed for summer camping. Our warmest bag, though, has a tem-perature rating of –40°C. It can keep you warm on very cold nights, if you use it in a tent for protection from the wind and on top of a sleeping pad for insulation from the cold ground.

Q What makes these bags so much warmer than the summer ones?

A Many factors affect how well a sleeping bag can keep the sleeper warm. Probably the biggest factor is what kind of insulation it uses. By that I mean what the bag is filled with. There are two main types of sleeping bags: those that are filled with down (the fluffy layer under the feathers of water birds) and those that have synthetic fills (fibres made by machine).

Q Which type of fill keeps you warmer?

A If you compare a down sleeping bag with a synthetic sleeping bag of the same thickness, the down bag is warmer.

Q Why is that?

A Down puffs up very high — we call this effect "loft" — because of the many, many tiny air pockets in-between the bits of down. These air pockets are excellent insulators. They warm up with heat from your body and hold on to this warmth instead of letting it seep out of the sleeping bag. If you unroll your sleep-ing bag when you first set up camp, it has a chance to puff up with as many air pockets as possible before you sleep in it.

Q What about synthetic bags?

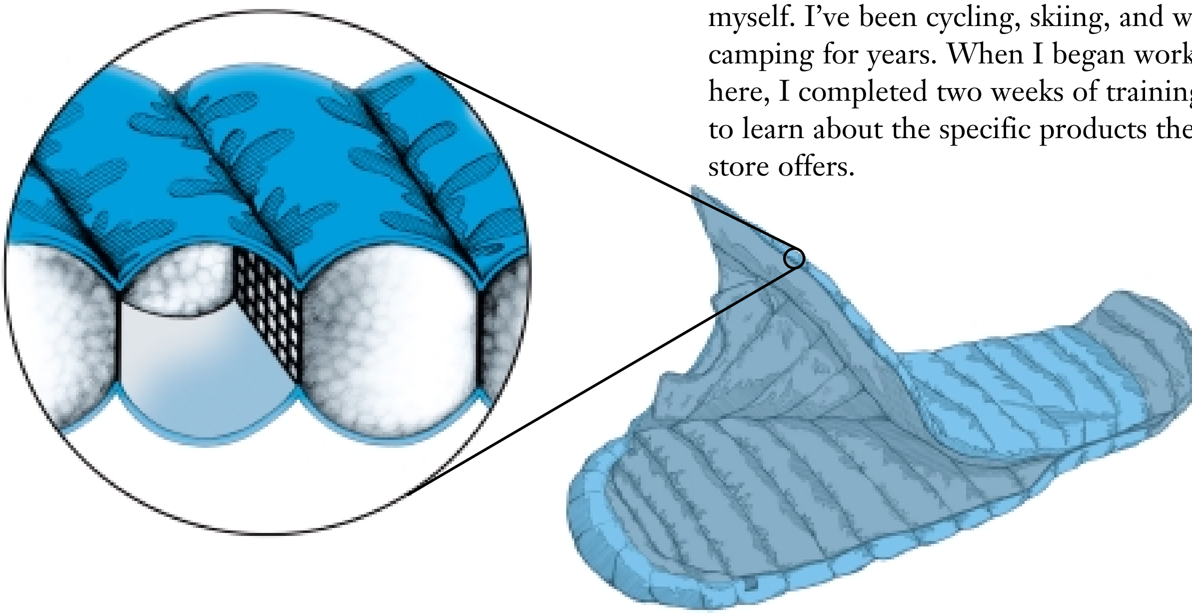
A Synthetic fill doesn't have as much puffiness, or loft, as down because synthetics have fewer air pockets. Fewer air pockets mean less trapped heat.

Q Why would a customer choose a synthetic bag, then?

A For any of several good reasons. Down is very expensive, sometimes twice the price of a comparable synthetic bag. Also, synthetic is a better choice if there's a chance your sleeping bag will get wet. A down bag takes much longer to dry out than a synthetic bag. While it's wet, the feathers are stuck together. That means fewer air pockets and not as much warmth. And, of course, people who are allergic to down need to buy synthetic bags.

Q How did you learn so much about sleeping bags?

A A lot of what I know about equipment I've learned from reading backpacking books and magazines and from trying out the equipment myself. I've been cycling, skiing, and winter camping for years. When I began working here, I completed two weeks of training to learn about the specific products the store offers.



Cross section of synthetic sleeping bag insulation

EXPLORING Further

Who Is Warmer?

Imagine this situation. Sydney and Yasmine arrive with their school group at a camp site cold and damp from a day of canoeing. Luckily their equipment is dry. Yasmine unpacks her synthetic sleeping bag, pad, and one-person tent, and quickly sets up camp. Sydney ignores her down sleeping bag and gets the stew cooking. As the Sun sets, they feel the temperature dropping. After supper is cleared away, Sydney unrolls her sleeping bag on the ground. Then both campers climb into their sleeping bags and go to sleep.

If Yasmine's and Sydney's sleeping bags are both rated to –10°C, who do you think will be warmer during the night? Why?

An *Issue* to Analyze

A SIMULATION

Using Thermal Energy Efficiently

Background Information

Imagine that you and your team are a planning committee. Your task is to suggest alternative energy-efficient home heating systems for city council to examine. You believe that passive solar energy should be part of the system you recommend. Because you know that it will not be possible to use passive solar heating all year, you plan to combine it with another heating method. Some people on city council see no need to make home heating more energy-efficient and are not convinced that passive solar heating works. How can you persuade them to your point of view?

Think About It

How will you and your group effectively do the following?

(a) identify features of a solar heating system that increase its efficiency

(b) research alternative heating methods to combine with passive solar heating

(c) decide which is the best combination of heating methods and recommend it in a presentation.

How Can Science Help?

In order to prepare for your presentation, you need to understand the particle model and its relationship to thermal energy. You need to understand how thermal energy is transferred and how to prevent its transfer. If you recommend a fossil fuel resource, you must be able to explain why you are recommending one resource over another.

Skill FOCUS

For tips on scientific decision-making, turn to Skill Focus 8.

Materials

- paper
- Internet access/ library research materials
- coloured markers
- notebooks

Procedure

Identifying Features

1. Think about what you already know about solar heating and how it works. Think about features that might make a house more efficient. You could consider features such as;
   - the size and location of windows
   - insulation
   - colour of the outer walls
   - types of interior fabrics
   - any other relevant features, based on what you have learned in this unit

2. Examine the material you have been collecting in your Solar Centre and your Internet bookmarked sites. You might look for other features that you haven't yet considered. You might also look for new information that will improve on features you have considered. (For example, you might not have considered the overall layout of the house. You might not have thought about how landscaping can help with the house's efficiency.) Think about the cost and availability of materials as you consider various features. You might want to make a table for each feature with headings such as the following:

Feature
How/Why It Works
Cost/Availability
Pros/Cons

3. Conduct a careful discussion of the features you have been examining. Obtain agreement about the ones you want to include. They should be features that each person thinks will make the house more efficient. Make sure that everyone understands why each feature has been chosen, and that each person sees the reason for the choice, even if he or she disagrees.

4. Prepare a labelled diagram of your model house design. With your diagram, include a reference list of books, magazines, periodical, and web sites that you consulted during the research stage.

Researching Alternatives

5. With your group, research possible heat sources that could be combined with passive solar heating. Earlier, you investigated the cost of different energy sources. Find out about the cost of wood so that you can be prepared to consider the alternative of heating a house without natural gas or fuel oil. Find out about geothermal energy possibilities.

6. Discuss your findings with your group. Think about what else, besides cost, you need to consider in choosing a heating system. Develop a way to compare the systems under consideration. Through discussion decide which you prefer, stating your reasons.

Suggesting Alternatives

7. Prepare a presentation for city council. Make your presentation as effective and interesting as you can. You should consider:
   - **(a)** what understanding of science you will need in order to persuade city council that more energy efficient methods are necessary
   - **(b)** what understanding of science you will need to explain how passive solar heating works
   - **(c)** how and why the supplementary heating method you recommend will work
   - **(d)** why you feel the supplementary method is the best choice.

8. Your report on your model house should include solar energy features, landscaping material, and a description of the heating system. Use specific data to make it very clear to city council how your system could cut costs and save non-renewable resources.

9. You and your teacher will act as city council members as you listen to and observe the presentations made by other groups.

Analyze

1. As a class, discuss each system and select the one you think is most efficient. Think about it from an energy-saving viewpoint. Think about it from the consumer's point of view: its cost, its convenience, its comfort. Explain why you consider that system the most efficient and how you reached your decision.

2. If the class disagrees about which is the most efficient system, those of you who have voted for that system should meet and discuss how you can persuade the rest to your point of view.

3. If you were to do this Issue Analysis again, how might you do it differently? What parts of it could you improve upon? In what way?

UNIT 3 Review

Unit at a Glance

- Humans use thermal energy to meet increasing needs. In order to monitor thermal energy, we need to know how to measure temperature. We make use of a variety of technological devices and systems that help us in our use of thermal energy.
- The particle model of matter helps to explain:
  - why gases are compressible, while solids and liquids are nearly incompressible
  - why solids are rigid, while liquids and gases can flow
  - the relationship between thermal energy, heat, and temperature
  - how heat is involved in melting, freezing, vaporization, condensation, and sublimation
  - thermal expansion and contraction
- Thermal expansion and contraction is the basis for many devices such as thermometers and thermostats. An energy transfer system consists of an energy source; direction of energy transfer; control systems; and waste heat.
- Some sources of thermal energy are: chemical energy, electrical energy, mechanical forces, nuclear energy, geothermal energy, solar energy, wind energy, and fossil fuel resources.
- Fossil fuels are advantageous because they are plentiful. However, over-use has led to dwindling supplies. Fossil fuels have also created problems due to thermal pollution and the production of greenhouse gases.
- New technologies and new strategies are now being developed to help us to conserve our fossil fuel resources and to use them safely.

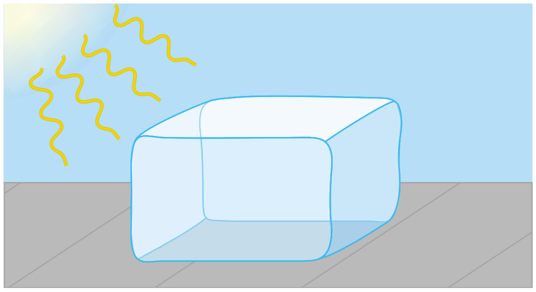
Understanding Key Concepts

1. A block of ice is placed on the pavement of a parking lot on a sunny day. Make some inferences based on your observations. What do you think would happen after one hour? What would happen after two hours?

(a) List the thermal effects that occurred in this story.

(b) The thermal effects in (a) involved adding energy. Explain where the energy came from in each case.

(c) For each thermal effect in (a) explain where the energy went.



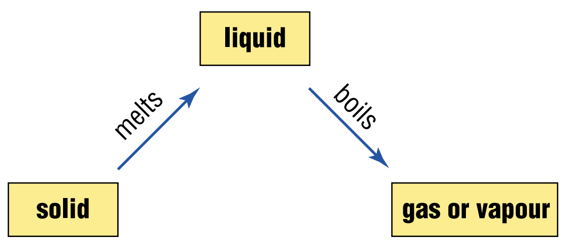
2. A new "super insulation" is made from plastic foam with a shiny, metal foil covering. All the air is pumped out of the holes in the plastic foam, so it is a vacuum. The foil prevents air from entering the foam again. This insulation could be used to insulate houses, refrigerators, vending machines, and refrigerator trucks and train cars. Experts estimate that it could save as much as $1 billion worth of fuel each year.

(a) Explain how the super insulation prevents heat transfer by
convection   conduction   radiation

(b) Suggest one problem that might occur with the new insulation.

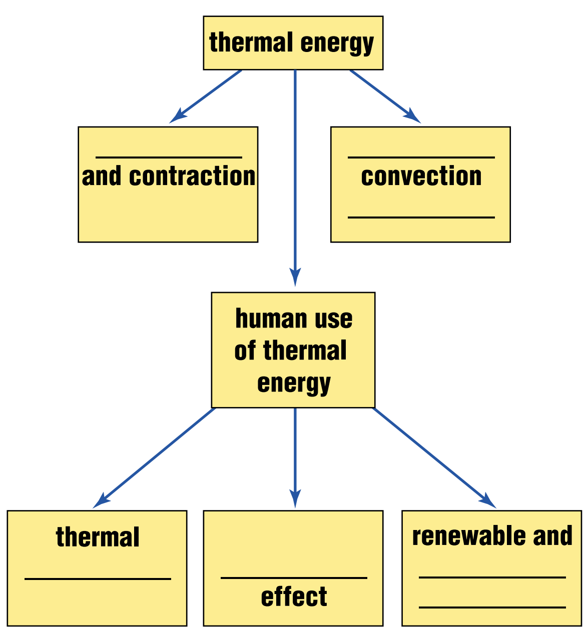
Developing Key Skills

3. The diagram below describes what happens to a large ice cube as it falls into a saucepan of hot soup boiling on a stove. Copy the diagram onto a full sheet of paper. Add information to each section about particle motion, temperature, and thermal energy.



4. Imagine hitching a ride on a particle of candle wax as it melts and then evaporates in the candle flame. Describe what the ride would be like. Include as many details as you can about the changes in position and motion of the particle.

5. In your notebook, copy and complete the following concept map.



6. Draw a diagram that traces the path of energy through one of these systems: a person riding a bicycle, the hot water system that supplies your shower, a pet. Start with the source of almost all energy on Earth — the Sun. Remember to include waste heat. Label different energy transformations and transfers using the vocabulary you have learned in this unit.

Problem Solving/Applying

7. What type of thermometer would be appropriate for measuring temperature in each situation below? Give a reason for your answer.

(a) measuring very low temperatures in the Arctic

(b) regulating the temperature in a hot oven

(c) finding if the temperature of a flame is high enough to melt the metal parts above it

8. Write a short story in which you imagine that you are a particle of water living with many friends in a pitcher in a refrigerator. Describe how you and your friends are behaving and how your behaviour changes in the following situations. You are taken out of the refrigerator, heated in a microwave oven, and left to cool on the kitchen counter.

9. One way to preserve fruit is to "can" it. Fruit and syrup are placed in a clean glass jar and then heated in boiling water to kill harmful bacteria. An airtight lid is fastened onto the jar, which is then left to cool.

(a) Should the jar be filled completely to the brim before it is heated? Explain your answer.

(b) After the jar cools, there is always some empty "head space" at the top. Does this mean that the contents leaked out during the canning process? Explain your answer.

10. Fruit farmers sometimes spray water over their orchards on cold, frosty evenings. As the water freezes, it protects the fruit from frost.
   (a) When the water freezes, does the energy of the water particles increase or decrease?
   (b) Explain how a change in the energy of the water particles can protect the fruit that the water is covering.

11. Identify the signals that your body's temperature control system would probably receive and send out while you spent an afternoon
   (a) playing beach volleyball
   (b) ice fishing

12. **Design Your Own** Use what you have learned about solar energy to design a solar cooker. You might want to try two designs and then test them to find out which is more efficient.

13. Look at the picture of the girl by the campfire. Describe all the energy transformations you can see in this picture.

14. A solar heating system for a home is designed with dark-coloured roof panels containing liquid-filled pipes to absorb solar energy. The heated liquid then transfers energy to the interior of the house.
   (a) What liquid would be best for the system: water, alcohol, or a mixture of water and antifreeze? Explain your choice.
   (b) Extra thermal energy can be used to warm an underground water tank, an underground bin of gravel, or a big brick wall in the middle of the house. Which energy storage method do you think would be best? Why?

Critical Thinking

15. The particle model of matter tries to explain everyday happenings by describing the behaviour of things that are too small to see clearly.
   (a) Why are scientists convinced that the particle model is correct?
   (b) Which parts of the particle model seem reasonable to you? Which parts do you find hard to accept?

16. To loosen a very tight lid on a glass jar, people often hold the jar and lid under hot running water. After a minute, the lid twists off easily.
   (a) What must be different about the behaviour of the metal and the glass to explain why the lid loosens?
   (b) What would probably happen if a jar with a loose-fitting lid were placed in a freezer? Explain why.

17. A large body of cool water can easily have higher total thermal energy than a small amount of hot water (for example, the amount of water in a hot water bottle). Explain how this is possible.

18. (a) How does the game of bowling model energy transfer by conduction?
(b) How does swimming model energy transfer by radiation?
(c) How does dancing model energy transfer by convection?

19. Birch bark and paper both burn well. Yet water in a paper bag or a birch bark container can be warmed and even boiled over an open flame without catching fire. How is this possible?

20. Plants and trees need carbon dioxide, and use it to produce oxygen, which people and animals need. Why might this fact make many people object to destroying a park to build a housing development?

21. Which type of temperature-measuring device is shown in the photograph below? Describe how this device works, and suggest a situation in which it could be used. Do you know any other scientific device that has similar features, and what it is used for?

22. You pour 100 mL of hot water at 50°C into 200 mL of cold water at 10°C.
(a) In which direction is thermal energy transferred?
(b) Which methods of energy transfer take place?
(c) What happens to the temperature of the hot water and the temperature of the cold water?
(d) If you leave the water mixture in a glass beaker for 24 h in a room with a temperature of 20°C, what will happen? What general feature of energy transfer does this illustrate?

23. Barbecues produce carbon monoxide when they are in use. Should they be banned? Write a list of pros and cons and be prepared to debate the issue.

24. Why is energy a useful characteristic to measure or calculate when you are preparing a scientific description of an object or a system?

Pause & Reflect

Go back to page 186 at the beginning of this Unit, and check your original answers to the Focussing Questions. How has your thinking changed? How would you answer those questions now that you have investigated the Topics in this Unit?