for large-scale energy production are high-tech devices specially designed to translate the wind's energy into energy that people can use for electricity. Figure 4.4 shows the kind of windmill used in large "wind farms." A wind farm consists of dozens—sometimes hundreds—of windmills constructed in particularly windy areas to capture the immense energy of the wind. Wind mills are not practical in areas that are not windy.

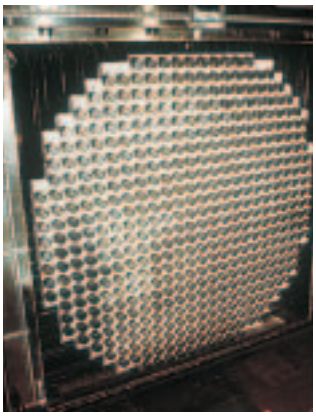


Figure 4.5 Inside a CANDU reactor

Nuclear Energy

Most of our electrical energy in Canada is generated from fossil fuel or hydro-electric sources. However, in central Canada, some electricity comes from nuclear energy. Nuclear fission is a process that uses small amounts of radioactive uranium to produce vast amounts of heat. Uranium is a non-renewable natural resource mined in Canada and other countries. Canadian scientists developed the CANDU (Canada Deuterium-Uranium) reactor to provide nuclear energy in parts of Canada and to sell to other countries. These reactors have one of the best safety records in the world.

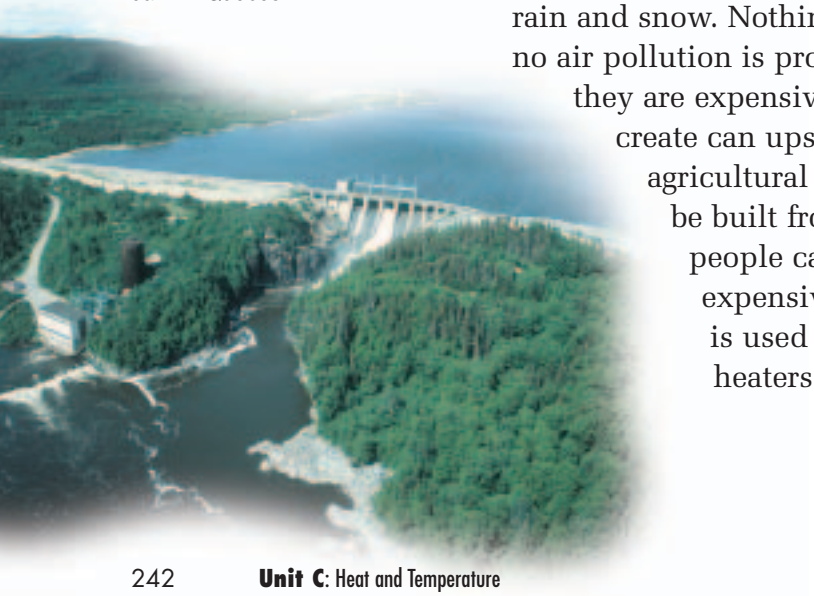
Nuclear power plants can produce large quantities of electricity. However, the fuel source requires special care in handling because it is harmful to living things. This harmful aspect remains after the fuel has been used. A major problem with nuclear energy is the long-term storage of dangerous waste materials.

Hydro-Electric Power

Energy generated by water moving through a dam is called hydro-electric power. Dams are built across rivers to create large artificial lakes called *reservoirs*. The water from the reservoir flows through the dam where it turns large devices called turbines to generate electricity.

Hydro-electricity is very clean energy, and it's renewable. The reservoir is constantly being refilled by the river, which is fed by rain and snow. Nothing is burned in hydro-electric generation, so no air pollution is produced. Dams are not expensive to operate, but they are expensive to build. Dams and the reservoirs they create can upset or destroy local ecosystems and flood agricultural land. Long-distance transmission lines must be built from dams in remote areas to places where people can use the electricity. These lines are expensive to build. However, the electricity produced is used to produce heat in ovens, toasters, room heaters, and many other appliances.

Figure 4.6 A hydro-electric dam in Quebec



Problem Solving Activity

What's the Best Choice?

Recognize a Need

Boiling water is an everyday activity. We do it for cooking, for making hot drinks, and for sterilizing objects. Which heat source will boil 1 L of water the fastest?

Materials & Equipment

- oven mitts
- stopwatch
- large beaker or graduated cylinder
- water
- heatproof container for water
- a variety of sources of thermal energy chosen by you

The Problem

Design and carry out a test to compare the time it takes for different heat sources to boil 1 L of water.

Criteria for Success

For your test to be successful, you must meet the following criteria:

- You must safely bring the water to a full boil.
- You must measure the time it takes for the water to come to a boil.

Brainstorm Ideas

1. Brainstorm a list of available heat sources that could be used to boil water.
2. Brainstorm ways that you can make the experiment fair. What would be some of the variables that you would need to control?

Test and Record

3. Measure 1 L of cold tap water.
4. Bring the water to a boil.
5. Record the time needed in minutes and seconds.
6. Record the heat source you used.

Caution!
This experiment should be done with adult supervision. Use oven mitts and use caution around open flames and other heat sources.

Communicate

7. Share and combine your findings with classmates. Construct a chart that will allow you to see everyone's results and to make comparisons.
8. If more than one person worked with a particular source (e.g., an electric stove), compare results. What could account for any differences?
9. Discuss the findings only in terms of the data recorded on the chart. Based on time only, which would be the best choice?

Figure 4.7 What is the fastest way to boil water?

Comparing the Options

In this unit, you have read about different ways of producing heat and thermal energy. Fossil fuels are the most widely used. But hydro-electric dams and nuclear power stations are also important in certain parts of the country for producing electricity that we can use to produce the heat and thermal energy we need. Solar energy offers a clean, renewable alternative but is not yet widely used. Other energy sources include geothermal and wind energy. Neither of these is widely used in Canada as yet either.

Each energy source has advantages and disadvantages. Some are non-renewable sources; some are renewable. Some can be distributed widely, as hydro-electricity can. Others are usable direct from the source, as solar energy is.

When you are analyzing options for selecting thermal energy sources, remember to consider where the energy will be used. For example, active solar heating may be an attractive option for home heating. But if your home is on the third floor of a 10-storey apartment building, active solar heating probably isn't a practical option.

Check and Reflect

1. a) Make a chart summarizing the advantages and disadvantages of fossil fuel use.
   b) Why do you think people continue to use fossil fuels in spite of their disadvantages?

2. For each of the following energy sources, explain why it's a renewable or a non-renewable source.
   a) nuclear
   b) hydro-electric
   c) wind
   d) natural gas

3. Do you think all the sources of energy listed in question 2 will be in use 50 years from now? Explain your answer.

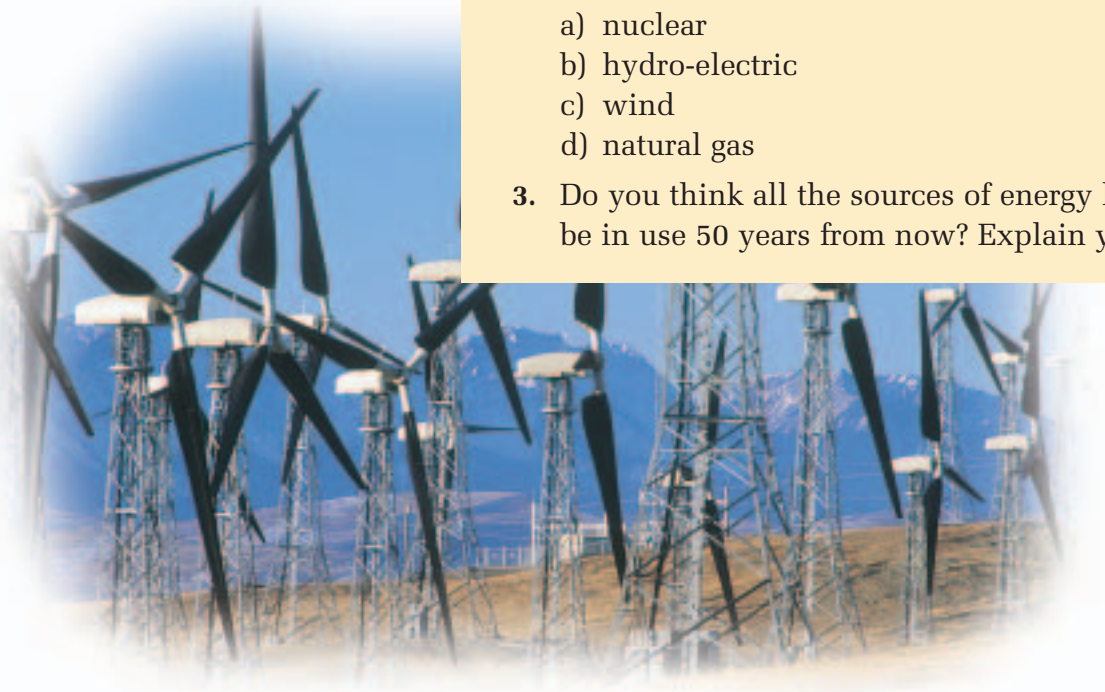


Figure 4.8 Energy in the wind can be converted into electricity with the help of wind turbines.

4.2 Energy Consumption

Figure 4.9 Hanging clothes on a line to dry conserves energy by not using a clothes dryer.

Have you ever considered how much energy you consume in a day? Do you run the water when you brush your teeth? Do you follow the three Rs—reduce, recycle, and reuse? Do you leave the light on when you are the last to leave a room?

Give it a **TRY** ACTIVITY

Energy Consumption

Make a list of your everyday activities that require energy use. Compare your list with those of your classmates. Make a bar graph of everyone's data. What activity is the most common? the least common? As a class, brainstorm ways you could reduce your energy consumption.

*info***BIT**

Hybrid Power

In the year 2000, Canadians were introduced to the "hybrid" car—a vehicle that combines an electric motor and a small gasoline engine with a lightweight body and special tires. Much less gasoline is burned (3.5 L/100 km), and the level of harmful gases given off is half that of regular cars. Japan's new laws about the issue of harmful emissions from cars was a major factor in the development of hybrid cars in that country. North American car manufacturers will be selling their own hybrid vehicles by 2003. It is expected that, by 2010, one out of every five cars on the road will be a hybrid.

Home

The three main energy users are home, transportation, and industry. Energy use in the home is something that you can control. Look at Figure 4.10. Working with a partner, identify as many ways of conserving energy as you can.

Figure 4.10 What are some ways you can save energy in each scene?

To help people be more energy efficient in their homes, some home renovation stores now carry a line of energy-efficient lighting products and devices that control power consumption by appliances. As well, some stores also stock low-flow shower heads that conserve water.

Transportation

Most of us rely on cars or trucks for at least some of our transportation needs. In many rural or remote areas, there are no buses or other transit services, so people must use cars and trucks to get around. However, cars and trucks are big energy users and major contributors to air pollution.

Road, rail, air, and marine transportation together account for about 66% of the oil used in Canada. Of that amount, more than three-quarters is used to fuel passenger cars and trucks.

The burning of fossil fuels in car and truck engines produces a variety of harmful chemicals that pollute the air. For example, burning fuels causes nitrogen and oxygen in the air to form gases called nitrogen oxides. People with lung problems have trouble breathing air containing high concentrations of nitrogen oxides. If you live in a city, you may have noticed a brown haze, especially at rush hour. The brown haze is caused by nitrogen oxides in the air.

Figure 4.11 Public transportation, such as the LRT in Calgary (shown), uses less energy than people driving cars. And there are many other alternatives to cars that should be taken advantage of.

Actions You Can Take

What can you do to reduce the negative effects of cars? Try walking, riding your bike, roller-blading, or taking public transportation whenever possible. Does a family member drive you to school? Do other students in your neighbourhood go to your school? Maybe you could organize a car pool. Make a list of all the errands that you and your family have to do in a day. See if you can find an efficient way to combine them into one trip.

The size of a car and how it is driven can make a difference to its fuel consumption. Small cars usually consume less fuel, and regular tune-ups can ensure that a car operates more efficiently. Even the way people drive can save energy. Just by driving at 80 km/h instead of 100 km/h, a car owner can increase the number of kilometres travelled per litre by 15%. Reducing the amount of fuel we use conserves a non-renewable resource and reduces pollution.

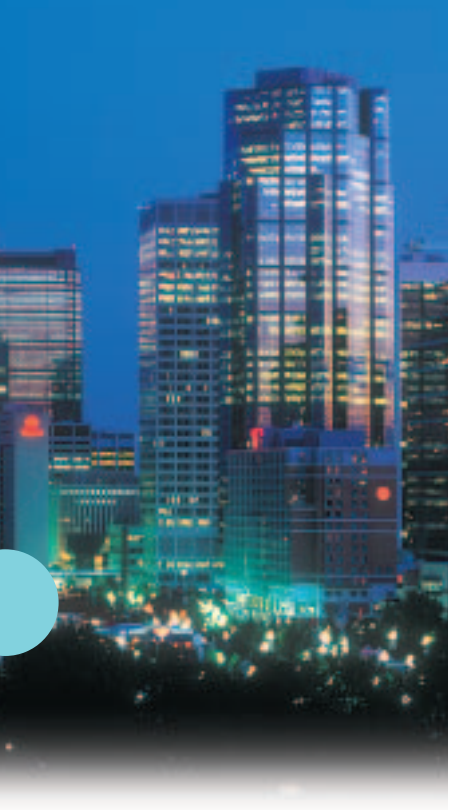


Figure 4.12 Leaving lights on in empty offices overnight wastes electricity.

Industry

Industry is the biggest energy user. Think about just one industry whose products you use: shoe manufacturing. Companies who make shoes have offices and factories that must be lighted and heated. They also have computers, photocopiers, and other office machines that need energy. In their factories, they use energy for preparing materials, such as plastic and leather, and for cutting and shaping shoes. Then, they use fuel for the trucks to distribute their products to stores. This is an example from just one industry. But all industries use energy in some way, even if it's simply for light, heat, and office machines.

Sometimes, industry's use of energy can harm the environment. Industry is the major contributor of chemicals called sulfur oxides, which turn to sulfuric acid in the air and form acid rain. Companies must meet a wide range of environmental regulations that are designed to reduce their effect on the environment.

For many companies, energy can be a major cost. In an effort to reduce these costs, they look for ways to reduce their energy consumption. An important tool that companies use is the energy audit. An energy audit focusses on finding places where energy is being wasted and identifying ways to fix the problem. For example, a company finds that they are losing a large amount of heat from leaving the huge doors in the loading area open all the time. By installing an efficient opening and closing system, they can keep the doors closed most of the time. They are only opened when a shipment is being sent out.

Cogeneration

Some companies use such large amounts of electricity that they have their own small generating plants. However, electricity generation from fuel is not very efficient. Only about one-third of the energy produced from burning fuel such as natural gas, oil, or coal is transformed into electricity. The rest becomes heat that is usually just released to the environment as waste energy. To improve their energy efficiency, many large companies that produce electricity now use a process called **cogeneration**.

Cogeneration is the production of two forms of energy (usually electricity and heat) at the same time from one energy source. Not only large companies but other large organizations use cogeneration. The University of Alberta has its own electricity plant, so it now uses what would have been waste heat to heat the university buildings.

Decision Making Activity

Conserving Energy in Your Community: Cogeneration

The Issue

Your community is looking for a way to use energy more efficiently and reduce pollution. You already have an electricity generating station in your area. Some people have suggested that it could be converted to a type of energy production called cogeneration.

Your task is to determine the costs and benefits of cogeneration so that you can make a recommendation on whether cogeneration is a practical choice for your community.

Background Information

Electricity generation from burning fossil fuels or other fuels, such as wood waste, is an inefficient process. Only about one-third of the energy produced is converted to electricity. The rest is heat, which is usually wasted by being released into the environment. In a cogeneration system, this heat is used to heat hot water, which is then pumped through pipes to heat buildings in the area. A cogeneration system uses one energy source to produce two forms of usable energy. Usually, these are electricity and heat.

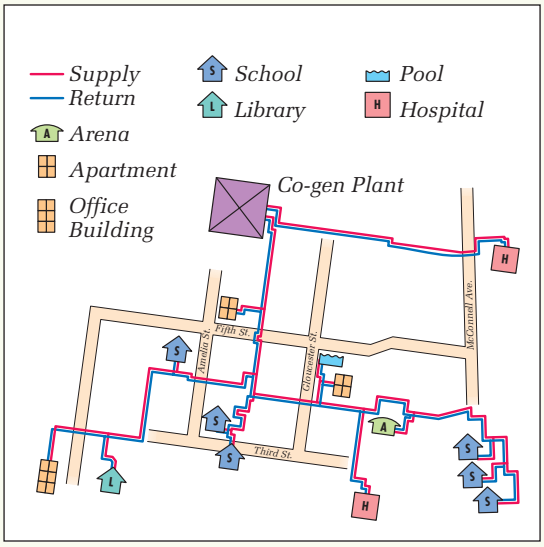


Figure 4.13 The electricity generating plant in Cornwall, Ontario, uses its waste heat to heat part of the local community. Hot water is pumped through 10 km of underground pipes.

Cogeneration makes sense because:

- it makes good use of heat that would otherwise be wasted
- it reduces air pollution because two forms of energy are generated at the same time
- it reduces thermal pollution of rivers and lakes

Constraints to cogeneration in communities include:

- a large investment in equipment and in setting up the distribution systems, especially in areas that are already built up
- the need for cooperation among many groups: municipal government, the utility that owns the electricity generating plants, developers, and building owners
- problems with municipal and provincial regulations controlling placement of large plants and systems

Support Your Opinion

Find out how your community meets its electrical and heating needs. Research the costs and benefits of cogeneration. Using the information from your research, explain in your own words why cogeneration would or would not make sense for your community. You may wish to illustrate your written work with a poster, diagram, or chart. In your report, suggest one or more scientific questions that would need to be answered before a final decision on cogeneration could be made.

Being a Responsible Citizen

When people purchase products that promote a cleaner environment, they are making a responsible decision. As well, they can voice their ideas to government about supporting research that will help to develop new environmentally friendly technologies that use energy wisely.

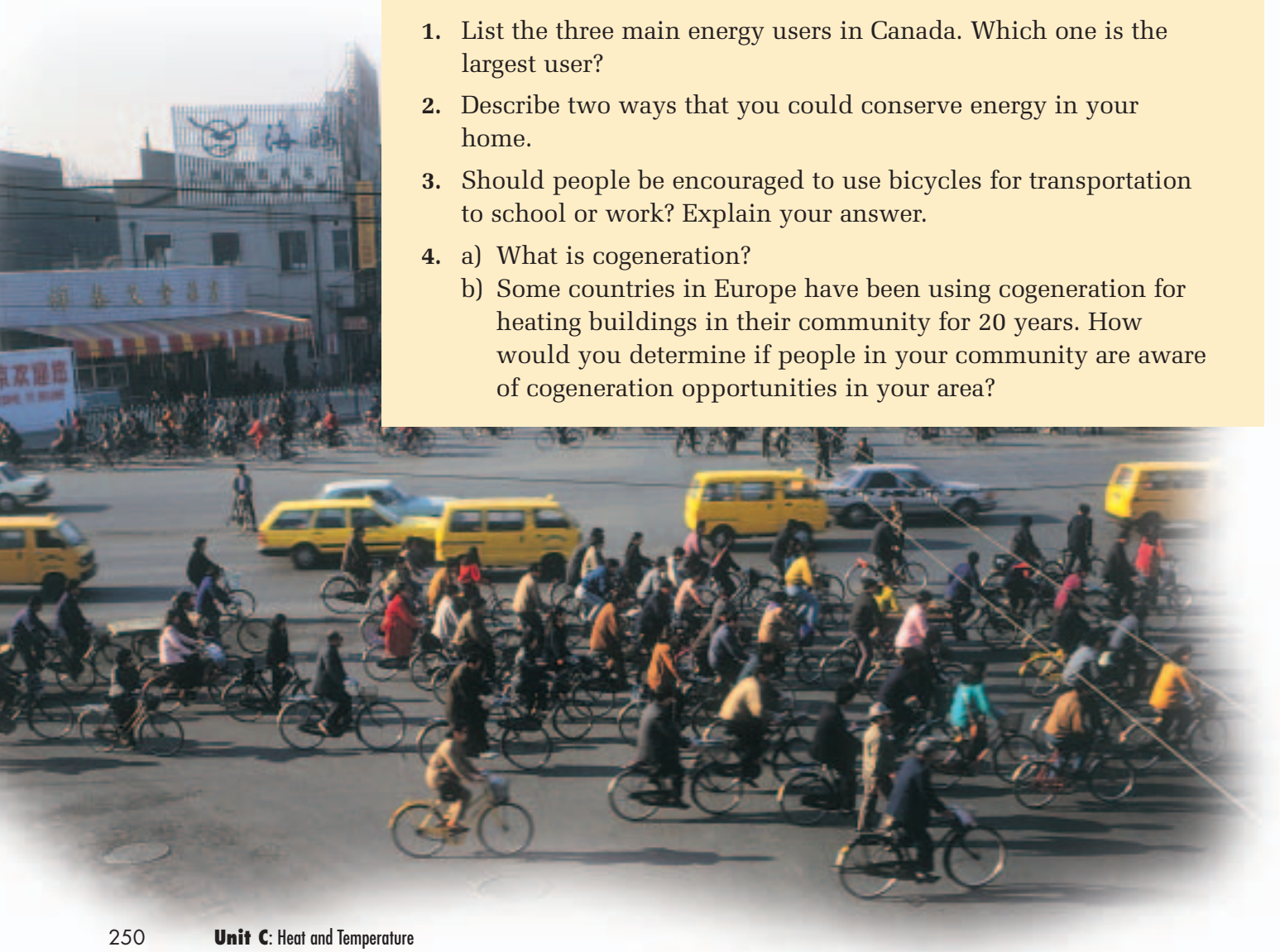
*re*SEARCH

Recycling

Recycling is a good way to conserve energy and natural resources. Work with a group to prepare a radio announcement encouraging people to recycle. Find information about how much energy and money can be saved by recycling.

Check and Reflect

1. List the three main energy users in Canada. Which one is the largest user?
2. Describe two ways that you could conserve energy in your home.
3. Should people be encouraged to use bicycles for transportation to school or work? Explain your answer.
4. a) What is cogeneration?
   b) Some countries in Europe have been using cogeneration for heating buildings in their community for 20 years. How would you determine if people in your community are aware of cogeneration opportunities in your area?



Assess Your Learning

1. a) Make a chart comparing the economic and environmental costs of wind energy, nuclear energy, and hydro-electricity.
   b) Which one do you think would be the best choice for your part of the province? Why?
2. Do you agree or disagree with the following statement? Explain your answer. *We need to look at other sources besides fossil fuels for meeting our thermal energy needs.*
3. Most of British Columbia's electrical energy needs are provided by hydro-electricity. Most of Alberta's are provided by generating stations burning fossil fuels. Why do you think these two neighbouring provinces use such different technology?
4. You have been asked to design an action plan to help conserve energy at your school.
   a) What data would you need to collect before you could prepare your plan?
   b) Make an outline for your plan.
5. Complete the mind map that you started at the beginning of this unit.

Focus On Social and Environmental Context

Every day we use heat-related technologies, but we may not be aware of the effects of our using these technologies. For example, we know that when we turn on the shower, we'll get water the temperature we want. But the water is hot because technology was developed to heat that water using either electricity or fossil fuel. The use of these energy sources can affect the environment. Think back to the information learned and the activities you did in this section.

1. Brainstorm a list of at least five ways that you used heat or thermal energy in the past week. For example, you heated water for drink or you made ice cubes. What effect do you think your actions had on the environment?
2. Think about each action in question 1. Suggest a way that you could have done it differently.
3. What recommendations would you make for yourself and your family members in the future when making decisions about using heat technologies?

SCIENCE WORLD

Case Study

The Ostrowskis: Clean, Green Living

The Ostrowskis' house

The Issue

Sustainable living. How realistic is the idea? Imagine living in an Alberta home that had no natural gas line, no furnace, did not use city water or sewage systems, and used no city electricity. What century do you think you would be living in? The past? The future? How about today?

Meet Jorg and Helen Ostrowski, a twenty-first-century couple living in suburban Calgary. Their 170-m^2 environmentally friendly home reflects their commitment to a way of life that focusses on a minimal use of natural resources. In one year, they save an average of:

- $1800.00 on utilities (gas, water, electricity)
- $500.00 for space and water heating
- 10 000 kWh of electricity
- 5000 kg of coal for generating electricity
- 238 200 L of treated drinking water

Their home has such high-tech features as:

- solar power for electricity
- system for collecting and storing rainwater
- non-flush toilets that compost human waste
- super-efficient wood-burning fireplace for heating and cooking (uses one cord of wood per year—2.4 m long by 1.2 m wide by 1.2 m high. Scrap wood is collected from local companies rather than cutting down trees.)
- solar cookers for cooking and baking food

Making informed and responsible choices that protect the environment is at the heart of the Ostrowskis' lifestyle. They read labels and carefully consider how buying products will impact the environment. "In Alberta, we have an overabundance of natural resources and so we have lost our sense of appreciation. We need to reflect for a moment, to ask ourselves, 'What can we give back to society, to make the world better?' This kind of thinking makes us realize that what you put into the system comes back out," notes Jorg.

Go Further

Now it's your turn. Follow the Ostrowskis' lead. Look into the following resources to help you form your own opinion about sustainable living.

- Look on the Web: Check out sustainable living or sustainable development on the Internet.
- Ask the Experts: Try to find an expert on sustainable living. Experts can be found in many places: environmental groups, universities, government agencies.
- Look It Up in Newspapers and Magazines: Look for articles about sustainable living.

In Your Opinion

Create a 3–5-min video, write an article for your school newspaper, or make a poster to share your views on sustainable living. Be sure to highlight key information from your research so that your opinion is backed by facts.

Unit Summary: Heat and Temperature

Key Concepts	Section Summaries
1.0 • heat energy needs and technologies • energy conservation	**1.0 Human needs have led to technologies for obtaining and controlling heat.** • Heat technologies have changed and developed over time as people work to meet their needs for heat. • Culture (way of life) includes how people meet their basic needs, and technology is linked to culture. • As people have evolved, so has the development of heat-related materials and technologies. • Choices about the environment are made by individuals and by society.
2.0 • change of state • particle model • thermal energy • heat transfer • thermal expansion • temperature • insulation and thermal conductivity	**2.0 Heat affects matter in different ways.** • Transferring heat to or from matter can cause a change of state. • The particle model of matter explains why matter changes state and changes volume. • Conduction transfers heat between two substances in contact with each other; only the energy is transferred from particle to particle; convection transfers heat by the movement of particles; radiation transfers heat by invisible waves. • Thermal energy is the total kinetic energy of the particles in a substance; heat is the energy transferred between two substances; heat transfers from substances whose particles have a higher kinetic energy to substances whose particles have lower kinetic energy. • Temperature is a measurement of the average kinetic energy of the particles in a substance.
3.0 • heat energy needs and technologies • thermal energy • thermal energy sources • insulation and thermal conductivity • energy conservation	**3.0 Understanding heat and temperature helps explain natural phenomena and technological devices.** • Thermal energy is produced naturally by the sun, decay, fire, and geothermal sources. • Passive and active solar heating systems use the sun's energy and are environmentally friendly. • Thermostats help control temperature in heating systems. • Insulation helps block unwanted heat transfer.
4.0 • heat energy needs and technologies • thermal energy sources • energy conservation	**4.0 Technologies that use heat have benefits and costs to society and to the environment.** • Non-renewable resources such as fossil fuels have a limited supply. • Fossil fuels such as oil, natural gas, and coal are major heat sources but burning them is harmful to the environment. • Three types of costs are involved in using natural resources: economic, environmental, and societal. • Five alternatives for producing thermal energy include solar energy, wind energy, geothermal energy, nuclear energy, and hydro-electric power; each has different costs and benefits.

PROJECT

USING THERMAL ENERGY MORE EFFICIENTLY

Getting Started

Canadians of this century live fast-paced lives. Change is part of our culture. As technology quickly advances, we often seem to model the saying, "Out with the old, in with the new!" But is that always the best decision?

In this unit, you have learned about making decisions that consider possibilities, facts, values, and priorities. You have a new understanding about the science of thermal energy and how we use that energy to meet our needs and wants for heat. How and why we have developed different heat-related technologies has been explored. You have also learned about different costs linked to the use of natural resources. This project will help you apply your learning to the renovation of a historical building in your community.

Your Goal

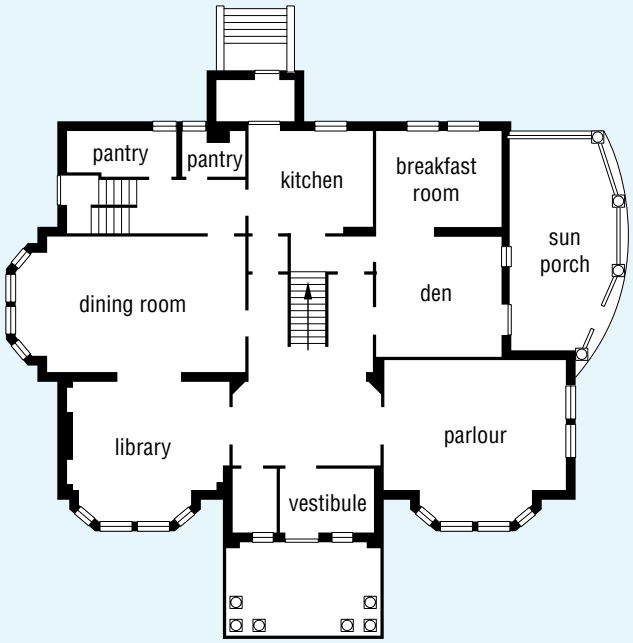
Use the background information to determine the most likely sources of thermal energy loss in this old house. Figure out how thermal energy could be used more efficiently and in a more environmentally friendly way. Develop a plan within a budget of $50 000.

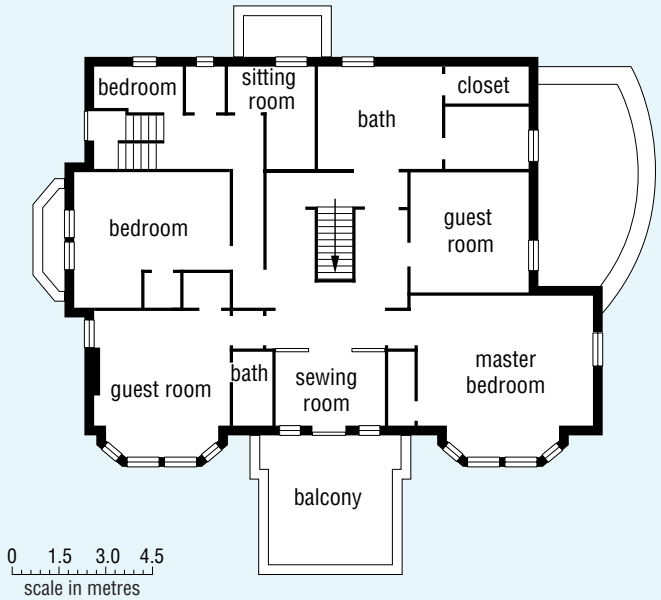
What You Need to Know

In 1911, the Michaels family, founding members of your community, built a very grand brick mansion in the centre of town. The family's history of generous community service and financial donations made them well loved. The Michaels home became a unique community landmark.

This past summer, the last surviving member of the Michaels family died, and in the will, left the mansion to your community. Some developers would like to tear it down to make a shopping complex because of its prime location. Another group would like to bulldoze the house to put up condominiums. However, a third group wants to preserve the house and turn it into a museum that would celebrate the community's history. They feel that the house's historical value is as important as its economic value. They also believe that it is very worthwhile to conserve the high-quality materials that were used in constructing the house.

At a town hall meeting, it is decided that the third group should have a chance to make the house into a museum. School programs and other activities could be run from such a place, giving the people of the community and visitors a chance to learn more about local history. Most people feel that it is important to save the building if some of the operating costs can be lowered. The outside of the building is still in very good shape, needing only some minor repairs to the brickwork. However, there is a major concern about the large monthly heating bill.





A real estate report provides clues to solving the problem:

- inside of house in excellent condition—has many special features including hardwood flooring, oak panelling, variety of ceiling mouldings, sliding doors, carved staircase, south-facing sun porch (glass enclosed), stained-glass windows, four large fireplaces, 3-m-high ceilings
- original heating system (hot-water heating)
- original single-pane windows
- original insulation in attic
- has new electrical wiring
- landscaping consists of large lawn area, small shrubs, and flowering plants

Steps to Success

1. Work in teams of 3 to 5. Brainstorm what you would do to reduce the heating bill. Make a list of all possible options. Then collect information about the costs of making changes to the house. Writing letters, making phone inquiries, reading catalogues, visiting home improvement stores, using e-mail, and checking Web sites on the Internet are some ways to gather the needed information.
2. Prepare a written proposal that clearly explains what changes you would make and why. Remember that you need to stick to your $50,000 budget. Using diagrams, CAD drawings, three-dimensional models, or other visual aids will add to your written work.
3. Present your team's plan to the class.

How Did It Go?

4. Describe how you decided on the changes to make to the house.
5. Describe your research process. How was it similar or different from other teams' research?
6. How well did your team work together? How effectively did you make your decisions?
7. What would you do differently another time?

Unit Review: Heat and Temperature

Unit Vocabulary

1. Write a short story about heat and temperature using the following terms.

thermometer
particle model of matter
expand
contract
conduction
convection
radiation
insulator
conductor
convection current
radiant energy
temperature
kinetic energy
thermal energy
fossil fuels
solar energy
sustainable use of resources

Check Your Knowledge

1.0

2. Is heat a substance or a form of energy? Explain your answer.
3. Describe one example of heat technology from the past and one example from the present day.
4. a) Give one example of a personal choice related to the use of heat as an energy source or technology.
   b) Give one example of a societal choice related to the use of heat as an energy source or technology.
5. Identify one technological device that produces heat and explain how it does that.

2.0

6. List the four main ideas of the particle model of matter.
7. How does the particle model explain a change of state of matter?
8. A metal bolt heated to a high temperature will be slightly larger than if it was in a freezer. Why?
9. Define *conduction*, *convection*, and *radiation*.
10. Define *temperature*. Include the words "kinetic energy" and "particle model of matter" in your definition.
11. Explain how heat and temperature are related yet different concepts.

3.0

12. Give three examples of natural thermal energy.
13. Describe how passive and active solar heating systems differ.
14. Explain how a thermostat works and why it is important for safety.
15. Describe and give examples of local and central heating systems.
16. Explain how insulation works in a building and why we use it.

4.0

17. Describe three alternative forms of energy that can be used to produce thermal energy.
18. Describe three non-renewable resources.
19. Describe two examples of energy conservation in your home or community.

Connect Your Understanding

20. Create a chart or picture that illustrates the three ways heat can be transferred. Your chart should include a description of the method of heat transfer and an example of a device that uses it.

21. Humans have gone from burning wood as their main heat source to using alternative energy sources such as solar energy. Describe how and why this has happened. Include illustrations in your answer.

22. List some of the costs and benefits to using fossil fuels. For each point in your list, describe the consequences to the environment and society.

Practise Your Skills

23. A student poured hot water into a plastic cup, a Styrofoam cup, and a Styrofoam cup with newspaper wrapped around it. Each had a thermometer in it. The student recorded the water temperature for each cup for 10 min (see table below). Graph the results for each cup, and determine which results go with which cup. Briefly explain your choices.

Time (Minutes)	Container 1 (Temp °C)	Container 2 (Temp °C)	Container 3 (Temp °C)
1	75	75	75
2	73	72	73
3	70	66	69
4	68	63	67
5	67	59	63
6	65	55	60
7	64	53	58
8	63	50	55
9	61	46	53
10	60	44	49

24. Sketch a diagram of your home. In that same diagram, show how passive and active solar heating could be used where you live.

Self Assessment

25. Describe the fact or concept that you found most interesting or most surprising in this unit.

26. What unanswered questions do you still have about heat and temperature?

27. Has your thinking about sustainable living changed now that you have finished this unit? Why or why not?

28. What do you now see as your own personal responsibility to the environment?

Focus On — Social and Environmental Context

In this unit, you have learned about the social and environmental context of heat and temperature. Think about what you learned as you answer the following questions.

29. In a paragraph, describe the relationship between these terms: human needs, thermal energy technologies, fossil fuels, and conservation.

30. What are three major issues related to how we generate and use heat?

31. Reread the three questions on page 179 about the social and environmental context of heat and temperature. Use a creative way to demonstrate your understanding of one of the questions.