CHAPTER

9 Heat Sources in the Environment

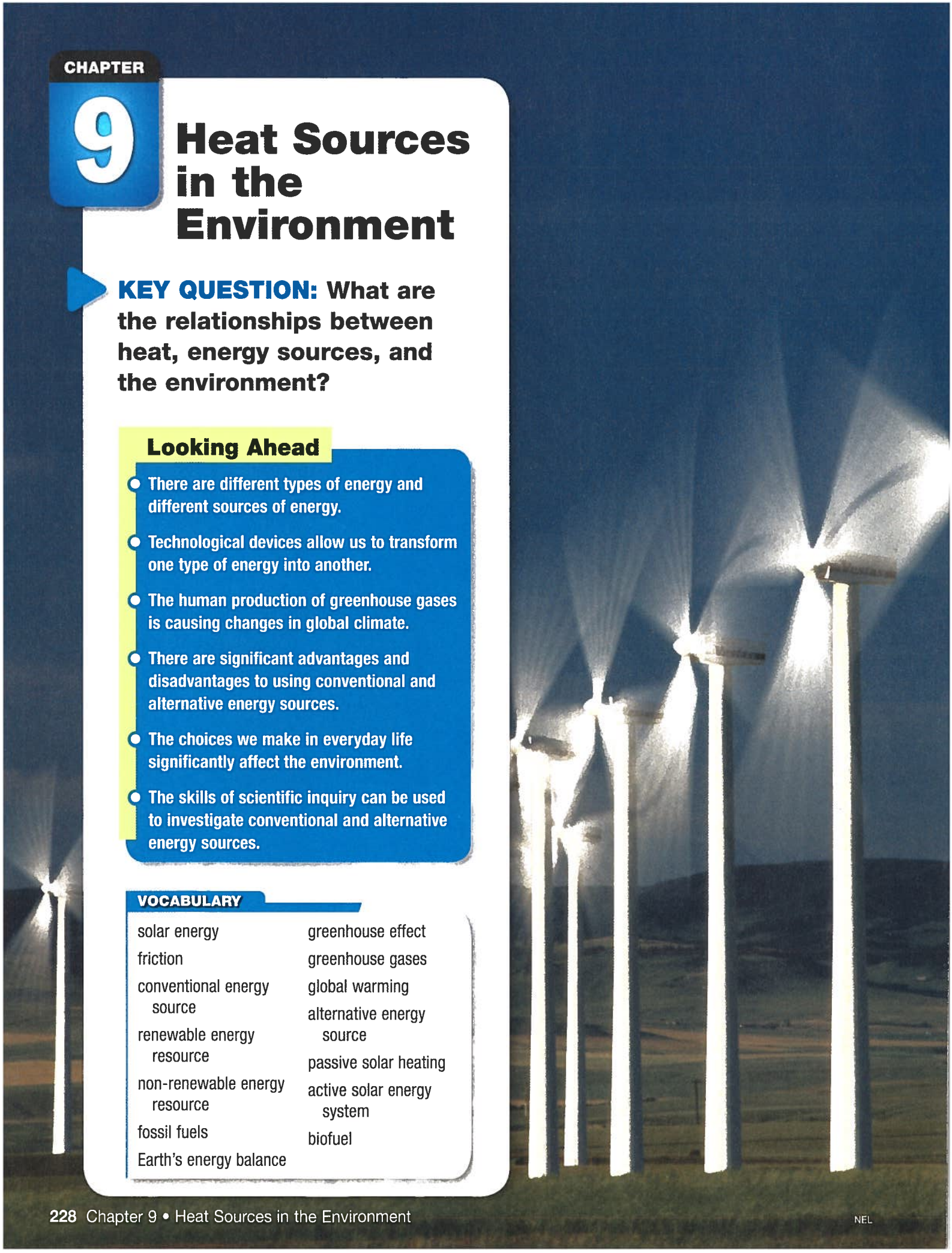
KEY QUESTION: What are the relationships between heat, energy sources, and the environment?

Looking Ahead

- There are different types of energy and different sources of energy.
- Technological devices allow us to transform one type of energy into another.
- The human production of greenhouse gases is causing changes in global climate.
- There are significant advantages and disadvantages to using conventional and alternative energy sources.
- The choices we make in everyday life significantly affect the environment.
- The skills of scientific inquiry can be used to investigate conventional and alternative energy sources.

VOCABULARY

- solar energy
- friction
- conventional energy source
- renewable energy resource
- non-renewable energy resource
- fossil fuels
- Earth's energy balance
- greenhouse effect
- greenhouse gases
- global warming
- alternative energy source
- passive solar heating
- active solar energy system
- biofuel



The Energy Blues

Energy...
Sometimes I think I'm runnin' out
Seems like we use an awful lot
For heatin' and lightin' and drivin'
Readin' and writin' and jivin'
Energy... You'd think we'd be savin' it up.

Energy... You can get it by dammin' up a river
Energy... A windmill can make the breeze deliver
But even with millin' and dammin'
Our needs are so much more demanding
For energy... We have to use some kind of fuel.

Chop, chop, chop, the cavemen used wood to start their fires.
Chop, chop, chop, they made all the tools that they required.
Chop, chop, chop, inventions got more and more inspired.
The fires got higher and higher,
And clearings got wider and wider.
Energy... They were burnin' 'bout all their wood up.

Then one day men discovered that coal would do it better
Miners dug, and it looked like it might just last forever.
It seemed like the final solution.
It started the Industrial Revolution.
Energy... We could just keep on diggin' it up.

Now in 1859— way out in western Pennsylvania—
A man had built a rig that got some laughs from folks who came there
But suddenly, a mighty roar came up from under the ground.
And soon a gusher, gushin' oil, soaked all who stood around.
Now no one knew, when that gusher blew,
The petroleum years were on us,
Or that so many cars and trucks would come to cause a crisis.

Energy... We're looking to try and find some new kinds.
Energy... Exploring to try and make a new find.
Nuclear and thermal and solar,
If we miss we'll get colder and colder.
Energy... We've gotta stop usin' you up.

So don't be cross when momma says turn that extra light out.
Just turn it off 'til we find us a fuel that never runs out.
If everyone tries a bit harder,
Our fuel will go farther and farther.
Energy... We're gonna be stretchin' you out.

LINKING TO LITERACY

Synthesizing

Effective readers collect pieces of information as they read. They combine new information with what they already know, and what they are learning, to gain deeper understanding.

1. Read the title. What do you predict the song will be about? As you read the song, identify new information or phrases that express the key ideas. Reflect on the new ideas presented and how they fit with the other ideas you have gathered.
2. After reading, summarize the text. You may consider questions like: What does the songwriter mean by: "Energy… A windmill can make the breeze deliver"? How does the title convey the meaning of the song?

9.1 Energy Sources

Heat is very important in our daily lives. We heat our homes and wear insulating clothes to keep warm in the winter. We heat water for showering and for cooking. Each of these processes involves the transfer of thermal energy. What are the sources of thermal energy?

Solar Energy and Geothermal Energy

The most obvious direct source of energy on Earth is the Sun (Figure 1). The Sun provides over 90 % of the energy that warms Earth's surface and atmosphere. The Sun's energy comes from deep within its core. This is where nuclear reactions release huge amounts of energy. Most of this energy, called **solar energy** or radiant energy, moves away from the Sun in all directions as visible light and infrared radiation.

solar energy: radiant energy (mostly visible light and infrared radiation) produced at the Sun's outer surface and radiated out into space

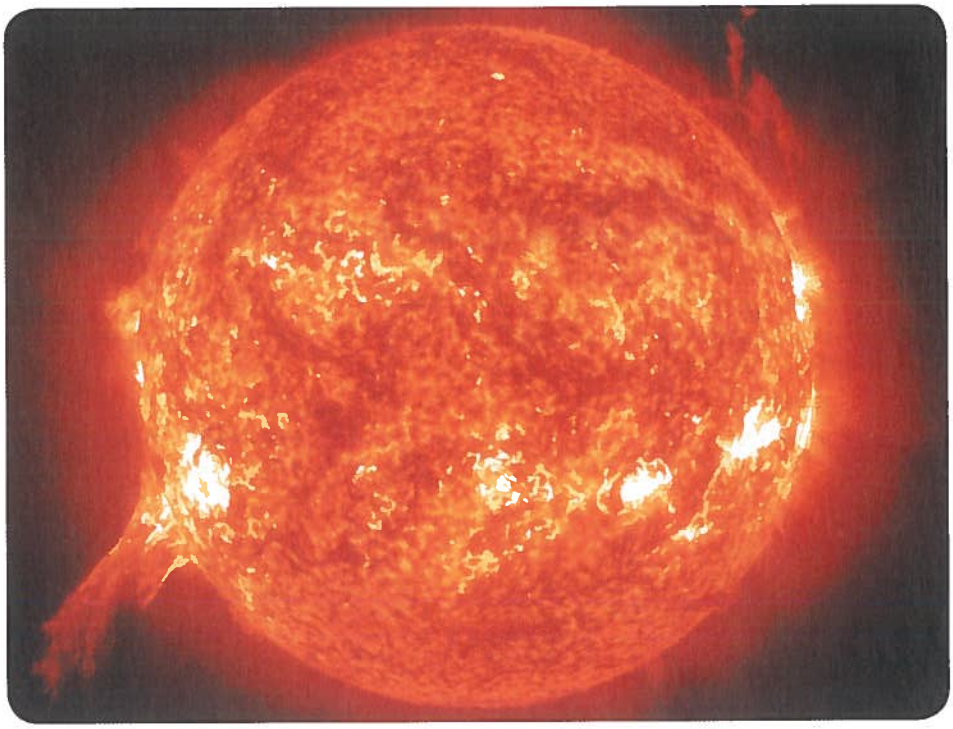


Figure 1 The Sun is the source of most of our energy, even though Earth only captures a tiny portion of the energy emitted by the Sun.

LINKING TO LITERACY

Summarizing

Informational text often asks a question (main idea) that will be answered in the text that follows (supporting details). Use sticky notes to keep a record of the information that answers the question, "What are the sources of energy?" What textbook features help you identify the sources of energy?

A tiny fraction of solar energy eventually reaches Earth. Here, some of it is absorbed and transformed into thermal energy. It is this energy that heats the land and air, evaporates water, and produces winds, clouds, and precipitation. Earth would quickly become a lifeless deep freezer without the continuous supply of energy from the Sun!

Earth also possesses a large store of geothermal energy. Recall that geothermal energy is the thermal energy contained in the hot core and mantle of Earth. Engineers have developed ways of harnessing this thermal energy for our use.

Solar energy and geothermal energy are large continuous sources of thermal energy. However, they are not the only sources.

Energy Transformations

Many forms of energy, such as chemical energy, can be transformed into thermal energy. Wood and other fuels, such as oil and natural gas, contain large quantities of chemical energy. The chemical energy in wood is transformed into thermal energy when wood is burned (Figure 2). Natural fires, such as forest fires, can be harmful for wildlife. Controlled fires, such as the burning of fuels in furnaces, car engines, and thermal-electric power stations, are useful for humans (Figure 3).

Figure 2 The chemical energy stored in wood is sometimes released in forest fires. Huge quantities of thermal energy are released to the atmosphere, along with gases and ash.

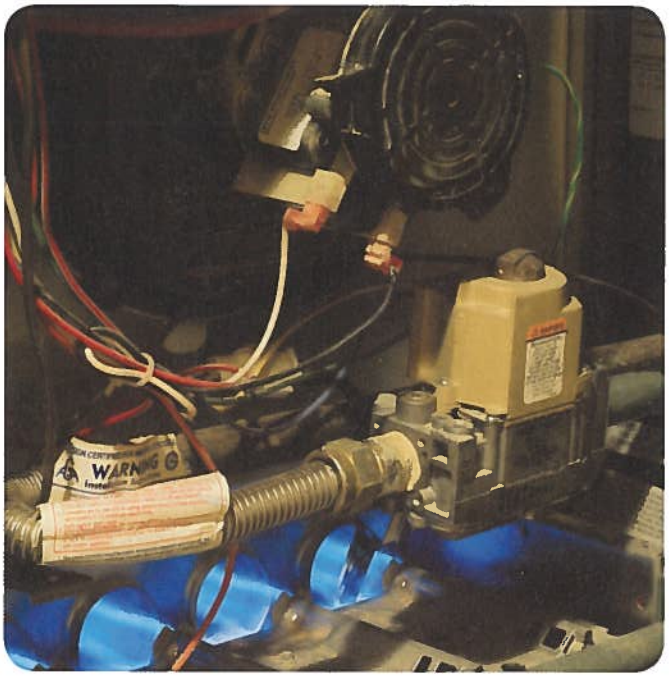


Figure 3 In home furnaces, the chemical energy stored in natural gas is released in a very controlled fashion. This energy is then used to warm your home.

On a smaller scale, you can produce thermal energy by **friction**: the force produced when objects rub together. Just rubbing your hands together produces thermal energy. The motion of your hands (mechanical energy) increases the kinetic energy of the particles in your skin. This results in warmer skin. Friction can transform mechanical energy into thermal energy and radiant energy (light). This occurs when a hard, rough, fast-moving surface rubs against another surface (Figure 4).

friction: a force produced when objects rub against each other

Thermal energy is extremely useful for heating. However, we also need energy for cooling, lighting, communication, transportation, and manufacturing. Our modern lifestyle and high standard of living depend on having energy available to meet our wants and needs.

Figure 4 The sparks tell us that both radiant energy and thermal energy are released when metal is being cut.

Many everyday technological devices use electricity as their direct energy source. The devices transform the electricity into other forms of energy. Where does the electricity come from in the first place?

Sources of Electrical Energy

There is no ready-made usable source of electricity anywhere in the world. Electricity is produced naturally—by lightning in thunderstorms—but not in a form that we can use (Figure 5).

So far, scientists and engineers have not developed an effective method for harnessing the energy in lightning. We need to generate electrical energy from other sources. Scientists and engineers have invented devices that transform almost all other forms of energy into electricity. For example, hydro-electric generating stations transform the mechanical energy of falling water into electrical energy. Nuclear power plants (nuclear reactors) transform nuclear energy into electricity. Thermal-electric power stations transform the chemical energy in certain fuels into electricity. Other forms of energy that can be transformed into electrical energy include radiant energy from the Sun (solar energy), mechanical energy of wind (wind energy), and geothermal energy.

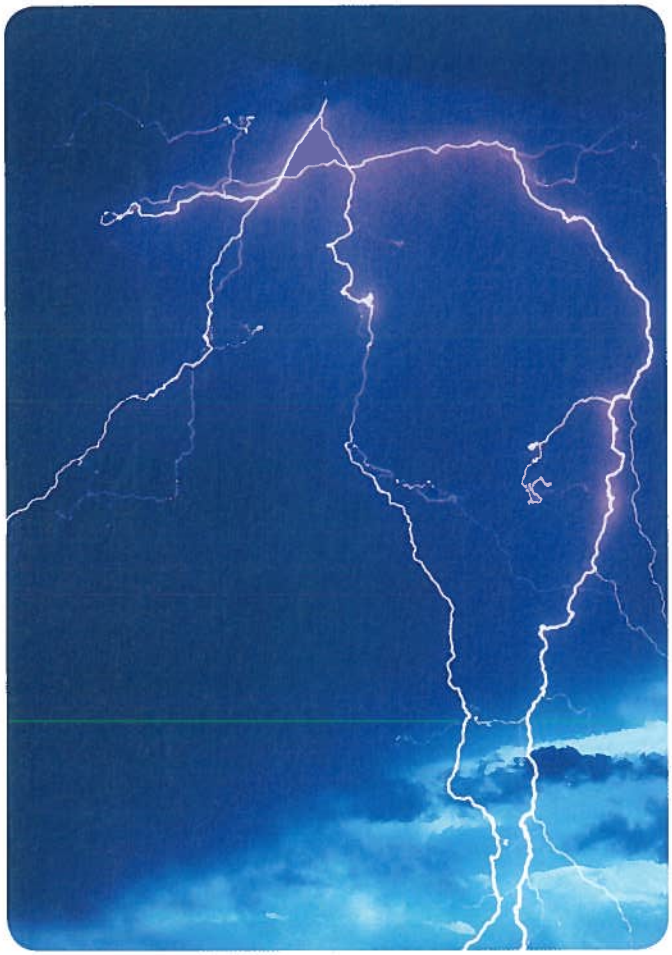


Figure 5 Lightning contains a lot of electrical energy that scientists have not yet been able to harness effectively.

The production and consumption of useful energy have significantly improved our standard of living. This use of energy, however, is also responsible for many serious impacts on the environment, including air and water pollution and climate change. In the remainder of this chapter, we will examine the different ways in which useful energy is produced. We will also consider the advantages and disadvantages of energy production and use, and environmental impacts of energy use and production. We will suggest some ways to minimize the negative impacts.

CHECK YOUR LEARNING

1. Compare the thermal energy of the Sun to geothermal energy in the interior of Earth by answering the following questions:
   (a) How does the Sun's energy reach Earth's surface?
   (b) How does geothermal energy reach Earth's surface?
2. Which naturally occurring source of energy are we not yet able to harness and use? Can you think of any others?
3. Which two forms of energy are most widely used in Canada? Give an example of how each form of energy is used.

AWESOME SCIENCE

Cooling Downtown Toronto with Deep Lake Water

In the middle of the day in summer, temperatures in Toronto (Figure 1) can reach 40 °C. As a result, air conditioners run all day to provide a comfortable environment for people who live and work downtown in tall buildings. Most of these buildings do not have windows that open. Air conditioning systems are expensive and require lots of electricity to operate. The City of Toronto has recently installed a new air conditioning system called Enwave. Enwave is a Deep Lake Water Cooling System that uses cool water from Lake Ontario to remove thermal energy from some buildings in the downtown core.

Figure 1 Downtown Toronto

Cold water is more dense than warm water. During the winter months, cold, dense water on the surface of Lake Ontario sinks. Warmer, less dense water from below the cold water moves toward the surface to take its place. As a result of this, there is a layer of cold water deep in the lake in the spring and summer months, when city temperatures become very warm.

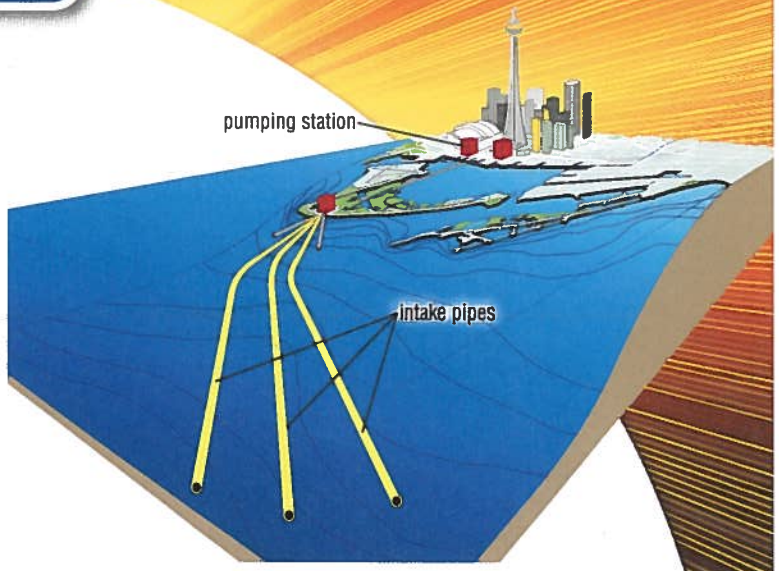


Figure 2 The three intake pipes of Enwave collect water from far and deep in Lake Ontario.

Enwave has three large intake pipes that extend 5 km off the shore of Lake Ontario and 83 m below the surface (Figure 2). Here, the temperature of the lake water is 4 °C all summer long.

The cool water is transported through the pipes to a pumping station that uses some of the cold lake water to cool buildings. The rest of the water is used for normal distribution in the city's water supply.

In 2007, 27 buildings, including the Air Canada Centre, the Metro Toronto Convention Centre, and the TD Centre, were already using the Enwave system. Eventually, Enwave will cool up to 100 large buildings in downtown Toronto.

The Enwave system uses 90 % less electricity than the air conditioning systems that it replaces. This results in millions of dollars in financial savings. The Enwave system also produces far lower greenhouse gas emissions due to reduced electricity consumption.

To learn more about Enwave,
Go to Nelson Science

9.2 Conventional Energy Sources

Thermal-electric power plants, hydro-electric power plants, and nuclear power plants supply most of the electrical energy used in Ontario. These three methods of producing electricity are often referred to as **conventional energy sources**. This means that they are the more traditional or more commonly used sources of electrical energy. Why are these conventional energy sources so widely used? What advantages and disadvantages do they have compared to other energy sources? Think about these questions in this section.

conventional energy source: a source of energy that has been widely used for many years

Hydro-Electric Energy

Electrical energy is produced in hydro-electric power plants from the energy stored in water behind a dam (Figure 1). As this water falls through the penstock, the water's energy of motion spins the turbines. The spinning turbines turn the electrical generator that transforms the water's mechanical energy into electrical energy.

renewable energy resource: a source of energy that can be used indefinitely, without running out

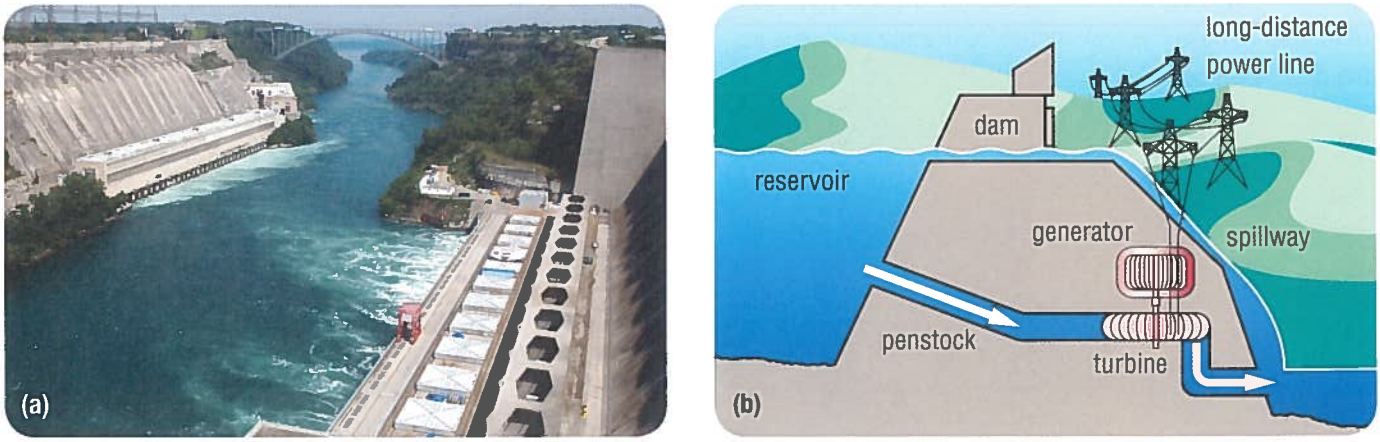


Figure 1 (a) A hydro-electric power plant on the Niagara River (b) Cross-section of a hydro-electric power plant

Figure 2 The top photo shows water flooding the land above the Three Gorges Dam (China).

Hydro-electricity is a **renewable energy resource**. The water above the dam is replaced continually by natural processes (rain). We can obtain energy from a hydro-electric power plant almost indefinitely.

Hydro-electricity is often thought of as a "clean energy" source because hydro-electric power plants produce little to no pollution. This does not mean that they have no impact on the environment. The construction of a major hydro dam often results in the flooding of a large area of land (Figure 2). The dam also stops fish and other animals from moving up and down the river. Water in reservoirs above hydro-electric power plants may also get warmer and become lower in oxygen content than free-flowing river water. This also negatively affects the water's ecosystem.

Another disadvantage of hydro-electricity is that the dams can only be built on certain sites. For example, although Ontario has many rivers and streams, there are few suitable sites for more large hydro-electric power plants.

Nuclear Energy

Nuclear energy is produced from the nucleus of the tiny particles that make up matter. The nucleus of a particle stores large quantities of nuclear energy. Canadian nuclear power plants use the nucleus of a substance called uranium as fuel. The nuclear energy in the uranium nucleus is transformed into thermal energy. This thermal energy is used to boil water to produce very hot, high-pressure steam. Then, the steam is used to turn the turbines of an electricity generator (Figure 3).

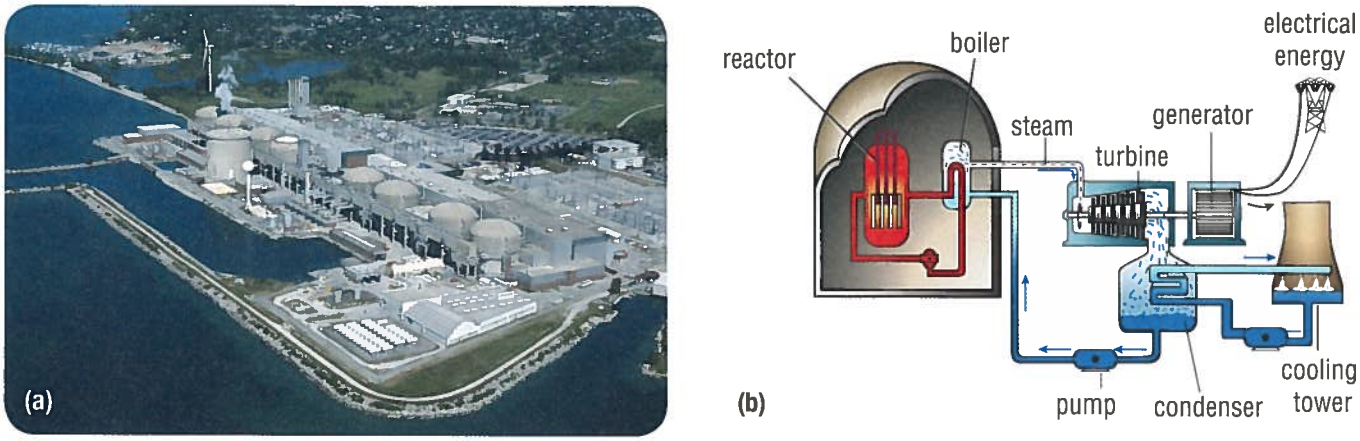


Figure 3 Nuclear power accounts for approximately 52 % of Ontario's electrical energy supply. (a) A nuclear power plant in Pickering, Ontario (b) Cross-section of a nuclear power plant

Like other sources of energy, nuclear energy has significant advantages and disadvantages. Nuclear energy is the most highly concentrated form of energy. Just 1 kg of uranium has more energy than 2000 kg of coal!

Nuclear power plants have some major disadvantages. They are complex and expensive to build and maintain. Nuclear fuel is highly radioactive. The radiation that it gives off can damage or kill living cells. Some forms of nuclear fuel are used in atomic weapons. This means that uranium mines and nuclear power plants must be designed and monitored to ensure safety. A number of serious accidents have occurred at nuclear power plants around the world. These accidents released large amounts of radioactive materials into the atmosphere and into nearby bodies of water. Unlike hydro-electricity, uranium is a **non-renewable energy resource**. This means that it is a resource that is in limited supply and could eventually be completely used up.

non-renewable energy resource: a source of energy that could eventually be used up

Another important disadvantage of nuclear power is that uranium remains dangerous for a very long time. Used nuclear fuel (called spent or depleted fuel) must be safely stored, and not allowed to escape into the environment. Radioactive substances break down into less harmful materials, but this process can take hundreds or thousands of years. We have to be willing to safely store nuclear waste. This is a very long and expensive commitment. The advantages and disadvantages of nuclear power are quite dramatic. Nuclear energy is one of the most controversial of all energy sources.

Thermal-Electric Energy and Fossil Fuels

In thermal-electric power plants, electrical energy is produced by burning coal, oil, or natural gas. In this process, the thermal energy released when these fuels are burned is used to boil water. This produces steam. The steam is used to spin the turbines of generators that produce the electricity (Figure 4).

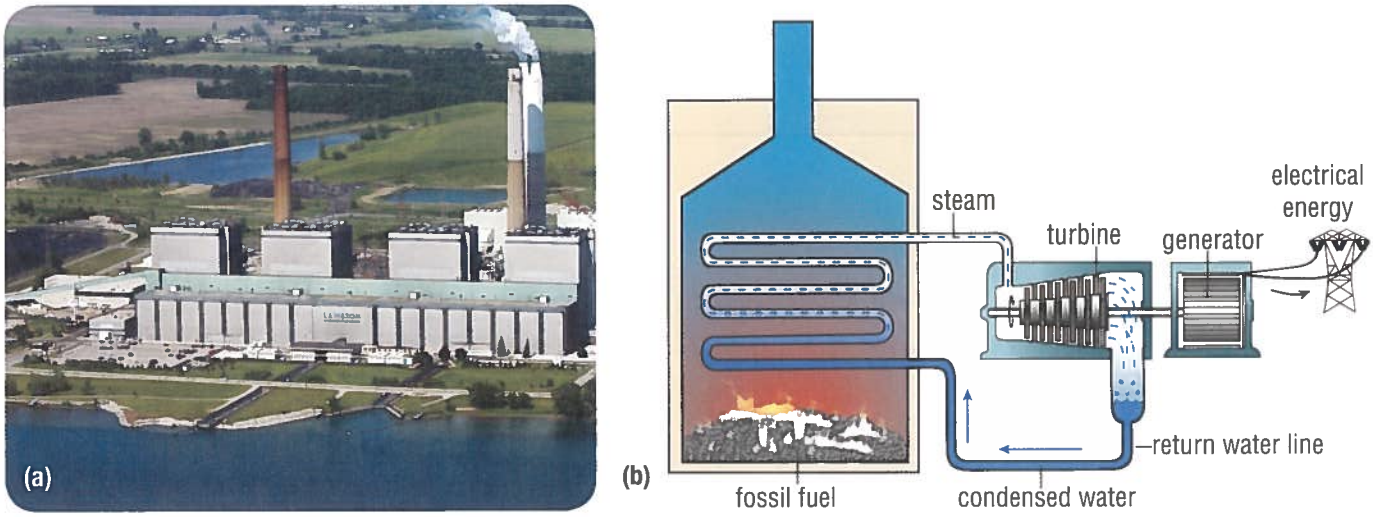


Figure 4 (a) The Lambton coal-fired thermal-electric generating station near Sarnia, Ontario (b) Cross-section of a coal-fired thermal-electric generating station

fossil fuels: concentrated sources of chemical energy such as coal, oil (petroleum), and natural gas that were formed deep in Earth's structure over millions of years from decayed and compressed plant and animal material

Coal, oil, and natural gas are concentrated sources of chemical energy called **fossil fuels**. Fossil fuels are formed from decayed and compressed plant and animal material from millions of years ago. Fossil fuels are extremely valuable in modern society. They are easy to transport and can be obtained at a relatively low cost. However, although fossil fuels are used around the world, they are only mined in certain areas, including parts of Canada. Because fossil fuels are so valuable and they are not found everywhere, international politics is very much involved in producing and distributing fossil fuels.

To learn more about fossil fuels,
Go to Nelson Science

Fossil fuels are used to generate electricity. They are also used for heating. Natural gas and oil are burned in furnaces to heat many homes, schools, and commercial buildings. Fossil fuels also provide the energy for virtually all of our transportation needs. Without gasoline, diesel, and jet fuels, our economy would come to a grinding halt (Figure 5).

In Ontario, fossil fuels provide almost all of the energy used for transportation. Fossil fuels also provide one-quarter of the energy used to produce electricity, and about two-thirds of the energy used to heat residential and commercial buildings.

Figure 5 Oil refineries use crude oil as a raw material to produce gasoline, motor oil, diesel fuel, and jet fuel.

The Fossil Fuel Dilemma

At present, fossil fuels account for more than 80 % of global energy production. Fossil fuels are extremely valuable, but they have two major disadvantages.

First, fossil fuels are non-renewable. We are consuming them far faster than they can be replaced. This poses a big problem for society and the economy. Some scientists think that we will run out of oil and natural gas within the next few decades. We will need to find other sources of energy to take their place as our fossil fuel supplies run out. Alternative forms of energy are available, but not without problems.

Second, burning fossil fuels produces air pollution. This pollution contributes to acid rain and smog. Burning fossil fuels also causes an increase in the concentration of carbon dioxide. This results in climate change and global warming.

CHECK YOUR LEARNING

1. Describe an idea in this section that is new to you. How does this idea add to your understanding of heat in the environment?
2. List three conventional sources of energy.
3. Briefly describe the difference between renewable and non-renewable energy sources, with examples.
4. Construct a chart to compare the advantages and disadvantages of fossil fuels, hydro-electricity, and nuclear power.
5. How might concern for the environment affect your choice of the best energy source to use?
6. Some conventional energy sources are non-renewable. Why is this important?

9.3 Global Warming

Recent studies show that Earth's average temperature is increasing. This increase in temperature will likely have a serious effect on Earth's climate (Figure 1). What are these effects? Why is the temperature increase happening now?

Figure 1 Scientists have evidence that global warming is causing environmental changes around the world.

The Greenhouse Effect

Earth's atmosphere has been warmed mainly by radiant energy from the Sun for millions of years. Earth's temperature depends on how much energy is absorbed by the atmosphere, and on how much energy radiates into space. This is known as **Earth's energy balance**. This energy balance is influenced by the amount of incoming solar radiation as well as by the amount of energy that radiates from Earth back into space. If Earth's atmosphere is altered, this energy balance may tip in either direction.

The **greenhouse effect** is a process in which the Sun's radiant energy becomes temporarily trapped by Earth's atmosphere. Much of the Sun's high-energy visible light passes easily through the atmosphere to reach Earth's surface. The waves of light are absorbed by rocks, soil, plants, and oceans. Most of this absorbed energy is then radiated back into the atmosphere as low-energy infrared (IR) radiation. However, some of this IR radiation is absorbed by certain gases. These gases are called **greenhouse gases** because they trap thermal energy near the surface of Earth (Figure 2). This effect is like the glass of a greenhouse causing the temperature inside to rise. The most important greenhouse gases are water vapour, carbon dioxide, methane, and nitrous oxides.

Earth's energy balance: the balance between the energy lost by Earth into space and the energy gained by solar radiation trapped by Earth's atmosphere

greenhouse effect: a rise in temperature resulting from certain gases in the lower atmosphere trapping radiant energy and warming Earth's surface

greenhouse gases: gases such as water vapour, carbon dioxide, methane, and nitrous oxides that trap energy in Earth's atmosphere

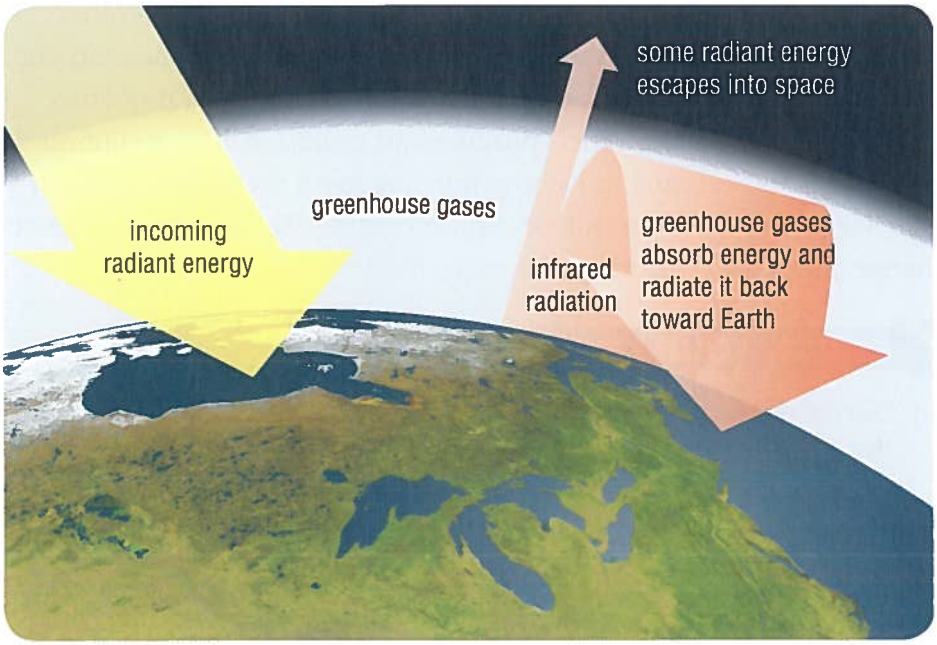


Figure 2 Certain gases create a greenhouse effect in Earth's atmosphere.

Sources of Greenhouse Gases

Greenhouse gases occur naturally and are a necessary part of our atmosphere. Without these gases, much more energy would be released into space. Earth would be too cold to support life. However, human activity is causing increases to the levels of some greenhouse gases in the atmosphere.

In the last two centuries, humans have burned large quantities of fossil fuels for power, transportation, and heating. Burning these fuels always produces carbon dioxide. Carbon dioxide is also released when humans burn forests to clear land for farming.

Mining fossil fuels causes methane (natural gas) to leak into the atmosphere from deep inside Earth. Cattle produce methane gas in their intestines and release it when they breathe. Worldwide, more than 1 billion cattle are raised by humans. This huge number of cattle means that methane is produced in large enough amounts to be a problem. Large garbage dumps (landfills) and some agricultural crops (such as rice) also produce and release methane gas.

Most nitrous oxides are produced during the breakdown of artificial fertilizers and animal manure, and by the burning of fossil fuels.

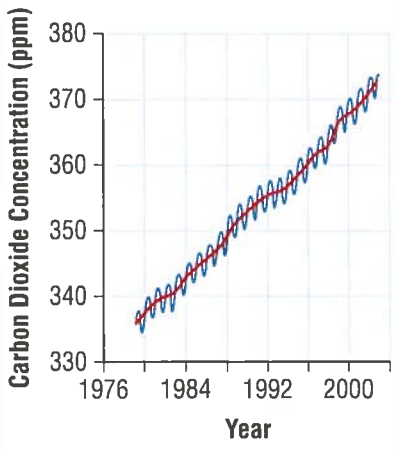
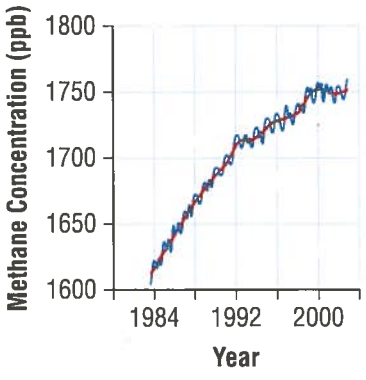
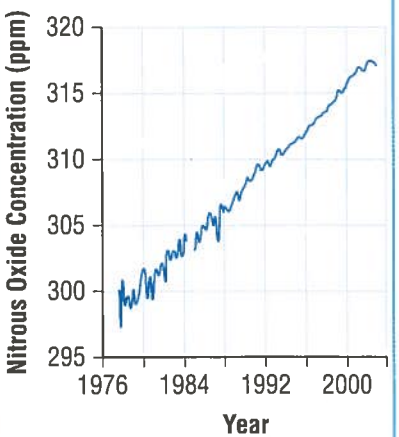
Table 1 summarizes the major greenhouse gases, their sources, and how their production is increasing. What do you think the effect of increasing levels of greenhouse gases might be on the environment?

LINKING TO LITERACY

Summarizing

Table 1 summarizes the information presented in the text. Read the table to review key information. Ask yourself, "How has the production of each gas changed over time? What is its contribution to global warming?"

Table 1 Major Greenhouse Gases Associated with Human Activity

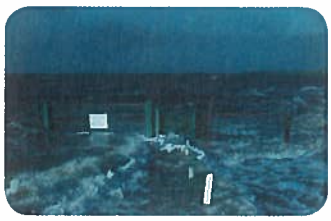
	Carbon dioxide	Methane (natural gas)	Nitrous oxides
major sources related to human activity	• burning of fossil fuels for power generation, transportation, and heating • intentional burning of forest to clear land for farming	• agricultural practice—livestock emissions • fossil fuel processing and natural gas leaks • landfills	• agricultural practice—fertilizers • burning of fossil fuels
global trend in production			

The Link to Global Warming and Its Effects on Society and the Environment

global warming: an increase in Earth's global temperature due to changes in the atmosphere that enhance the greenhouse effect

Recent measurements show that the average temperature of Earth's oceans is increasing. The temperature of the air near Earth's surface is also increasing. This trend of increasing average global temperature is called **global warming**. Scientists believe that our increased production of greenhouse gases has affected Earth's energy balance and is causing a bigger greenhouse effect. This appears to be causing global warming. Scientists predict that during the 21st century, the average global surface temperature may increase by several degrees Celsius. This increase will almost certainly have many effects on Earth (Table 2).

Table 2 Effects of Global Warming

Effect	Details	
ecological disturbances	The world's habitats depend on the balance of rainfall and temperature. Less rainfall in some forests increases the chance of forest fires. Fires disrupt all of the organisms in that habitat. Changes to many habitats are expected to cause the extinction of many plants and animals. Some diseases and pests, once common only in the south, are moving north as the climate warms.	
rising sea levels	The melting of glaciers and polar ice and an increase in the volume of ocean water due to thermal expansion are causing ocean levels to rise. These factors will result in flooding of coastal areas, as seen in the photo on the right. This will impact shoreline ecosystems and disrupt many human populations. The economic cost of damage to buildings will be huge.	
crops and food supply	Some areas may become warmer and allow new crops to grow, while some areas where we now grow crops could experience drought. Overall, global warming is expected to reduce our ability to grow food.	

Taking Action on Climate Change

We choose to do many things that result in greenhouse gases being produced. Burning fuels to warm our homes or drive our cars is an obvious source of greenhouse gases. Less obvious is the use of electricity to light rooms and buildings, and to run computers. Some electricity is produced by burning fossil fuels in thermal-electric power plants. Even the choice of foods you eat for lunch can affect greenhouse gas production and global warming.

To learn more about how our food choices affect global warming, Go to Nelson Science

We all need to make lifestyle changes that reduce our production of greenhouse gases. One way to do this is to consume less of Earth's resources, especially non-renewable energy resources. Switching to renewable energy sources will reduce our greenhouse gas emissions.

You can reduce your energy consumption every day. You can walk to school or take public transit instead of asking your parents for a ride in a car (Figure 3). You can use less hot water and turn off electrical devices when you are not using them. You can choose to eat foods that are grown locally rather than transported great distances by airplanes or trucks.

Figure 3 What steps can you take to reduce your energy consumption?

TRY THIS: The Green Team Action Challenge

SKILLS MENU: questioning, planning, observing, analyzing, evaluating, communicating

The Green Team Action Challenge gets you to track your daily actions to reduce greenhouse gas emissions. At the end of the week, you will tally your individual and team scores and see which Green Team has been most successful in reducing its environmental impact.

1. In your class Green Team, list as many Green Actions as you can think of. Focus on actions that you could take to reduce the production of greenhouse gases. Ask your teacher to approve the actions.
2. In the following week, take as many of the Green Actions as you can. At the end of each day, place a check mark for that day next to each Green Action that you have taken.
3. At the end of the week, add up the total number of check marks that you have entered for the seven days. Add up your team's total score.

A. Which Green Actions were the easiest to perform, and which were the most difficult? Explain.

B. Which Green Actions do you think had the biggest impact on reducing greenhouse gas emissions?

C. Why do you think more people are not already doing these actions every day?

D. Which of the Green Actions will you continue doing and why?

Scientists, researchers, and concerned citizens think that global warming and climate change are the most serious issues facing us today. There are problems associated with climate change and the looming shortage of fossil fuels. It makes sense for us to find ways to reduce our reliance on fossil fuels and to obtain the energy we need in other ways.

To learn more about global warming and climate change, Go to Nelson Science

CHECK YOUR LEARNING

1. Draw a simple diagram to explain how the atmosphere and incoming solar radiation create a greenhouse effect.
2. **(a)** What is the main factor that affects Earth's average temperature?
   (b) What do scientists believe is causing the temperature of Earth's atmosphere to increase?
3. List at least three possible effects of an increase in the global temperature.
4. How might thermal expansion affect future sea levels?
5. **(a)** List at least three activities you perform that contribute to global warming by producing greenhouse gases.
   (b) List at least three changes that you could make in your behaviour to reduce your contribution to global warming.

9.4 Alternative Energy Sources: Wind and Wave Energy

Conventional sources of energy have been used because they have been relatively inexpensive and easy to obtain until now. It would be difficult to imagine a cheaper fuel than coal. In many parts of the world, coal can simply be scooped out of Earth's surface and burned!

alternative energy source: a source of energy that is not as common as conventional sources; alternative energy sources tend to be renewable and have few negative impacts on the environment

Alternative energy sources include wind, waves, solar energy, geothermal energy, and biofuel. These sources are not always as common or cheap as conventional sources of energy. Many alternative energy sources are renewable and have very few negative impacts on the environment.

Wind energy and wave energy are very promising alternative energy sources. Both are non-polluting and renewable. Winds are produced by convection currents. The currents are formed by the uneven heating of the land and water by the Sun. Water waves are often produced by the action of strong winds on the surfaces of lakes and oceans. Therefore, wind energy and wave energy are really products of solar energy.

Wind is a very old source of energy. Winds have pushed sailing ships all over the world for thousands of years. Windmills have ground grain for centuries. Today, engineers have developed devices called wind turbines that can transform the mechanical energy of wind into electrical energy (Figure 1).

LINKING TO LITERACY

Reading Persuasive Text

Persuasive writing tries to convince you to think in a certain way. Read critically by asking yourself, "What argument is being presented? What support is provided? What are some of the objections?" After considering the viewpoints, how do you feel about alternative energy sources?

Figure 1 Wind turbines can be set up on land or in shallow water—wherever they will get strong wind.

Modern wind turbines are efficient, economical, and environmentally friendly. They are initially expensive to install, but they require little upkeep and produce electricity at very low cost. Wind power is the fastest growing alternative energy source.

There are some drawbacks to wind power. Some people do not like the appearance of large wind turbines. Also, wind turbines can produce some noise pollution. Concerns have also been raised about the number of birds that may be killed by the moving blades. Recent studies suggest that this is not a significant problem as long as the turbines are not placed near bird migration flight paths.

Of course, to be useful, wind turbines must be installed where it is windy! In Ontario, the best places for wind energy are over and along the Great Lakes. In June 2006, Canada-based Trillium Power Energy Corporation announced plans for a wind power project called *Trillium Power Wind 1*. This project is to be located in shallow water approximately 15 km off the shores of Lake Ontario (Figure 2).

Moving water, in the form of waves and tides, is another source of energy. Engineers are working on harnessing this energy. They plan to use underwater turbines to transform mechanical energy into electrical energy (Figure 3). Capturing the energy from large waves and tidal flows is difficult. There are a few coastal locations around the world, including some Canadian locations, that are collecting energy from waves and tides.

Figure 2 The *Trillium Power Wind I* project will have over 140 wind turbines in Lake Ontario. When completed, the turbines will look similar to these turbines off the coast of Denmark.

To learn more about wind and water energy,
Go to Nelson Science

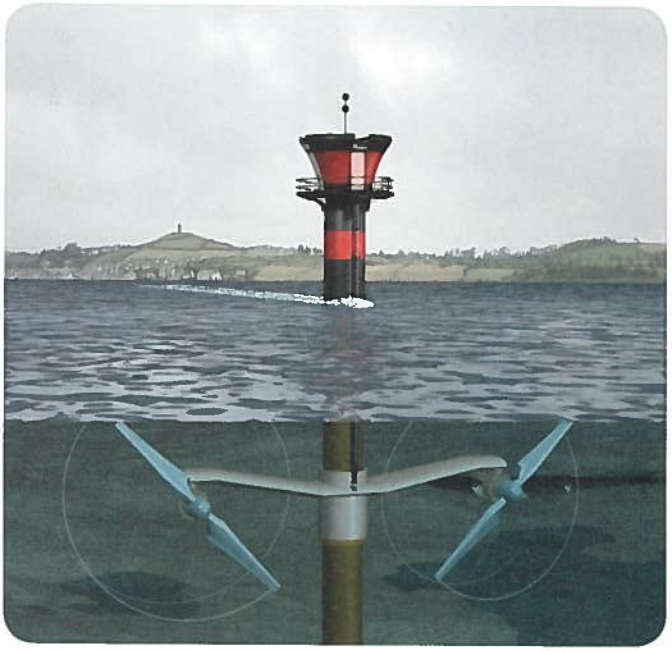


Figure 3 Underwater turbines may capture both tidal and flowing river energy and convert it into electricity.

CHECK YOUR LEARNING

1. Describe an idea in this section that is new to you. What connections have you made between this idea and your understanding of heat in the environment?
2. Wind and water energy are renewable energy sources. Why is this so important?
3. Wind and wave energy may be used to generate electrical energy. What is the ultimate source of energy for both wind and water waves?
4. **(a)** What is the best geographic location for wind turbines?
   (b) What is the best geographic location for water turbines?

9.5 Alternative Energy Sources: Solar Energy

passive solar heating: heating caused by the passage of radiant energy through the windows of a building

Solar energy is used as a source of energy in a number of ways. Buildings may use **passive solar heating** if there are large windows on the south-facing side (Figure 1). (Of course, homes in the southern hemisphere would need their large windows on the north side!) These windows allow sunlight to enter the building. Once inside, the radiant energy is absorbed by the floor and walls, where it is transformed into thermal energy. Passive solar heating helps reduce the need for other sources of thermal energy.

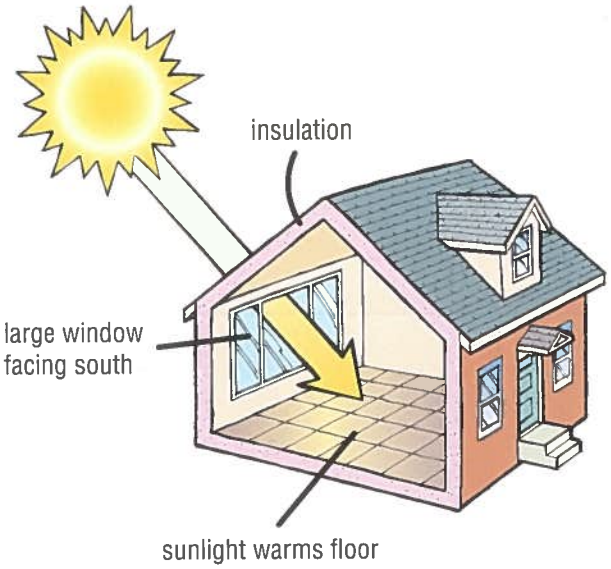


Figure 1 Buildings with large south-facing windows benefit from passive solar heating.

active solar energy system: a device that harnesses radiant energy from the Sun and converts it into a more useful form of energy

Active solar energy systems need equipment to trap the Sun's energy. There are two main types of active solar energy systems. In the first type, solar energy heats water running through panels placed on roofs. (Figure 2(a)). In the second type, photovoltaic panels or "solar cells" convert radiant energy directly into electrical energy (Figure 2(b)). Photovoltaic panels are an alternative form of electricity generation.

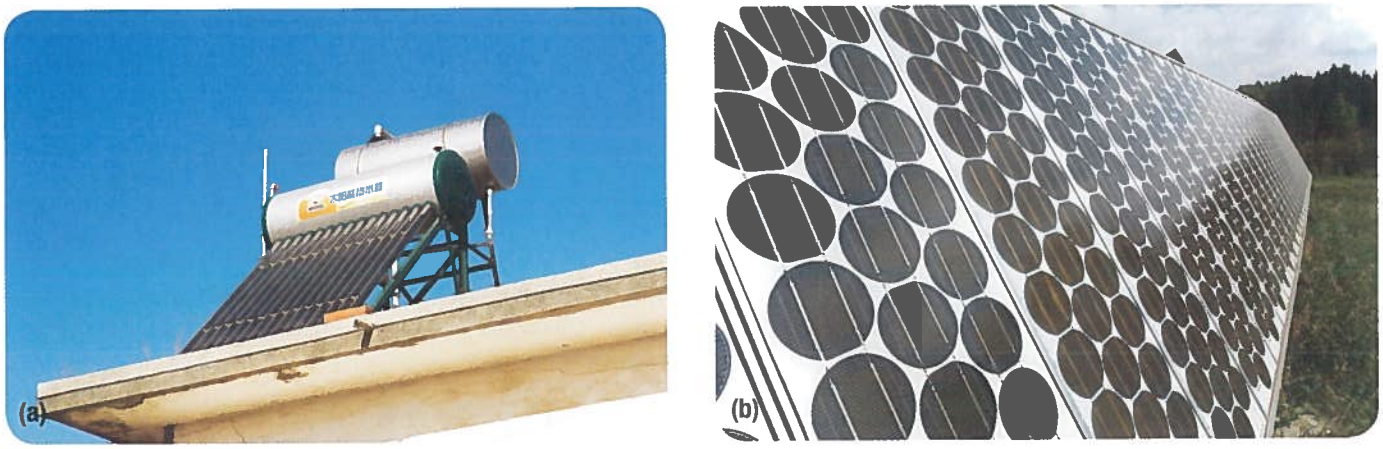


Figure 2 (a) A solar hot water system (b) A solar photovoltaic panel

There are a number of reasons why people are interested in solar energy. Conventional energy sources are getting more expensive. People are also getting more involved in conserving resources. Recent advances in technology have made large-scale solar energy projects cheaper. Some projects use large arrays of photovoltaic panels to generate electricity. In other cases, mirrors can be arranged to concentrate sunlight on a central tower. The tower produces steam for electricity generation. The Ontario government has recently approved a plan by OptiSolar Farms Canada Inc. to build what would be the largest solar photovoltaic plant in North America (Figure 3).

Solar energy has many advantages over other energy sources. It is renewable, there is a lot of it, and it is non-polluting. Compared with conventional energy sources, solar power is expensive. However, recent advances in the design and production of photovoltaic panels are reducing the cost of this very environmentally friendly source of energy.

Figure 3 OptiSolar Farms Canada Inc. plans to install more than 1 million solar panels at four farms near Sarnia, Ontario, by 2010. The project will produce enough electrical energy to power 6000 homes.

TRY THIS: Make a Solar Oven

SKILLS MENU: planning, observing, analyzing, evaluating, communicating

SKILLS HANDBOOK 4.C., 7.C.

In this activity, you will design and build a miniature "solar oven" to test how well sunlight heats a confined space. The solar oven is a box with a clear window to allow sunlight to enter (Figure 4). Large reflectors are often added to direct the sunlight into the cooking chamber. Painting the inside of the chamber black increases its ability to absorb energy.

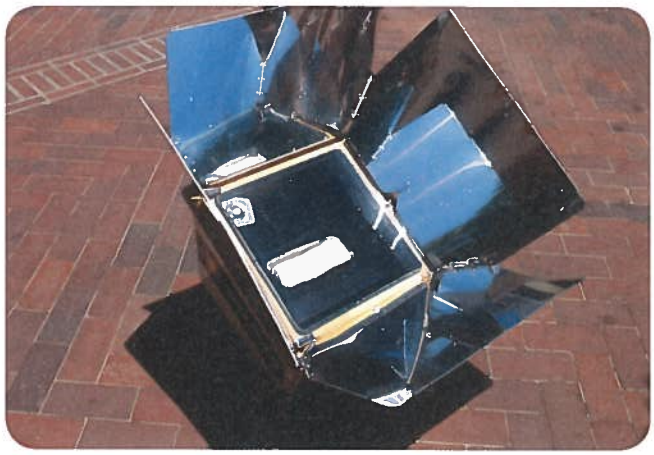


Figure 4 A solar oven

1. Working with a partner or a small group, choose a simple solar oven design that you have found on the Internet. Or, you could design your own solar oven! It should use only materials that are easy to find and to work with.

Go to Nelson Science

2. Gather the materials you will need, and work as a team to build your solar oven. When it is done, have it checked by your teacher.
3. When all student groups have made their solar ovens, organize a class competition. On a sunny day, see how quickly each oven can melt an ice cube or heat a container of water to a specific temperature.

A. Submit a drawing or photograph of your solar oven.

B. Explain how each part of the oven helps to increase the temperature of the cooking chamber.

C. What are some of the advantages and disadvantages of using a solar oven to cook food? Use the knowledge you gained about conduction, convection, and radiation in the last chapter in your explanation.

CHECK YOUR LEARNING

1. Describe two differences between passive solar heating and active solar heating systems.
2. In Canada, which side of a building receives the most radiant energy from the Sun?
3. What type of energy is produced from radiant energy in photovoltaic panels?

9.6 Alternative Energy Sources: Geothermal Energy

Geothermal energy is the energy contained deep within Earth. Although the quantity of geothermal energy is virtually unlimited, it is not easily accessible everywhere. Few places on Earth are located near highly concentrated sources of geothermal energy. Volcanoes, geysers, and hot springs are sources of geothermal energy.

Figure 1 Iceland gets a lot of its electricity from geothermal energy.

Geothermal energy is a non-polluting renewable energy source. Over 20 countries in the world use geothermal energy to generate electricity. These include the United States, Iceland, and New Zealand (Figure 1). In Canada, we have an experimental geothermal-electrical site in British Columbia, in the Meager Mountain–Pebble Creek area.

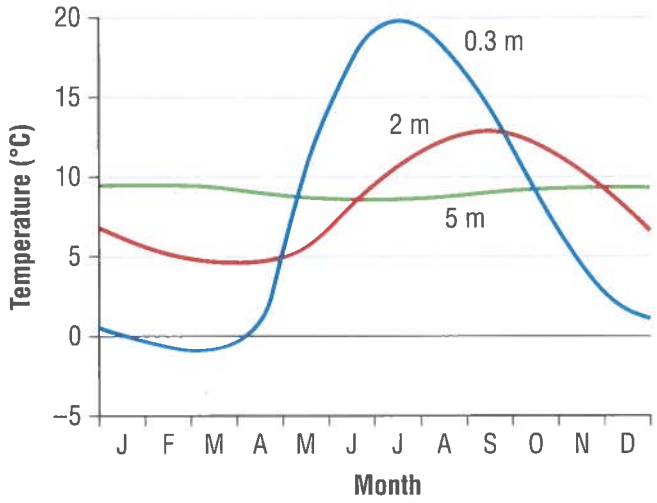


Figure 2 The ground temperature at different depths throughout the year in Ottawa, Ontario

Geothermal Energy and Heat Pumps

You do not need a power plant to take advantage of geothermal energy. The ground outside and around your house contains a huge amount of thermal energy. Around most of Ontario, the temperature of the ground several metres below the surface remains relatively constant throughout the year. It never freezes, even in the coldest winter months. For example, in the Ottawa area, the ground temperature at a depth of 5 m remains close to 9 °C throughout the year (Figure 2).

There is a relatively easy way to transfer thermal energy from the ground below a house into the house. You are already very familiar with this technology. It is the same device used in refrigerators, freezers, and air conditioners—a heat pump. A heat pump is a device that moves thermal energy from one location to another. Look at the functions performed by the different heat pumps listed in Table 1.

Table 1 Uses of Heat Pumps

Type of heat pump	Function
air conditioner	transfers, or removes, thermal energy from the air inside a building (or car) to the air outside the building (or car)
refrigerator or freezer	transfers, or removes, thermal energy from the air inside a refrigerator or freezer to the air outside the refrigerator or freezer
geothermal heat pump	transfers thermal energy from deep in the ground to the air inside a building

Many houses are now being built with geothermal heat pumps, rather than natural gas furnaces, for heating. A geothermal heat pump system consists of water-filled pipes that are buried underground near a building (Figure 3). A pump circulates the water through the pipes. In the winter, the water removes thermal energy from the ground and brings it into the building. Here, it is concentrated by the heat pump, and then circulated by an air delivery system. In the summer, the heat pump can be operated in reverse, so the water transfers thermal energy from the building back into the ground.

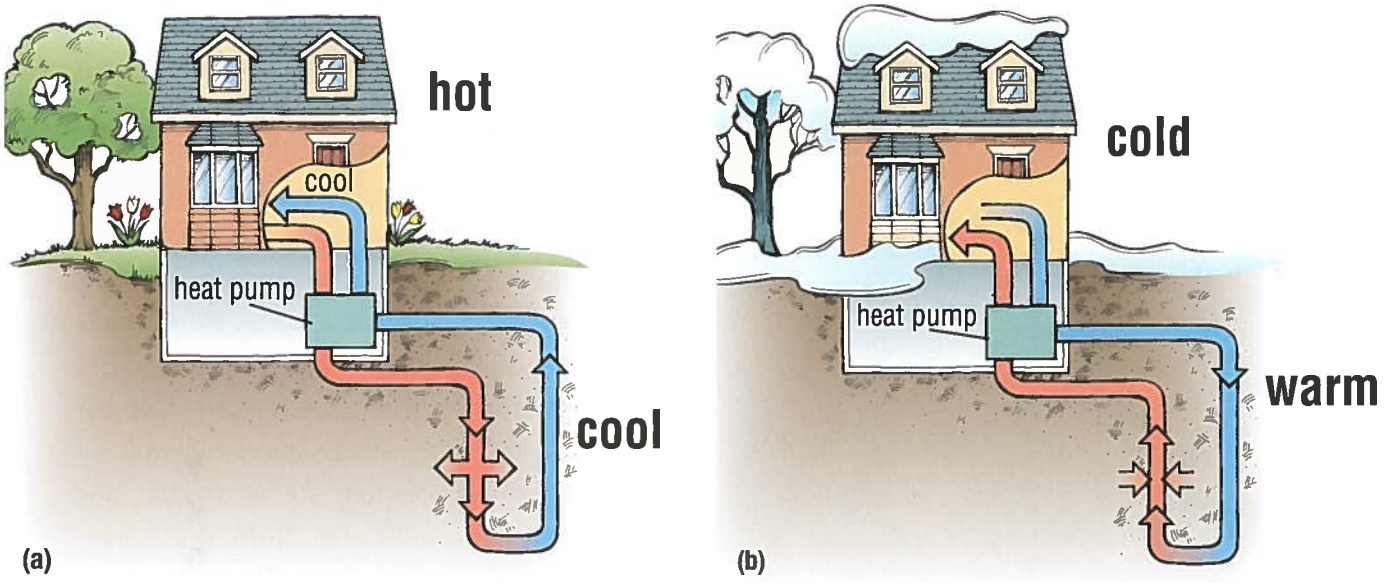


Figure 3 A geothermal heat pump transfers energy to and from the ground to keep a house (a) cool in summer and (b) warm in winter.

Geothermal heat pumps are very efficient. They only use a small amount of electrical energy to transfer a very large amount of thermal energy. Heat pumps are better for the environment than the more common furnaces. They also cost much less to operate. Using a geothermal heat pump to heat a home can cost 80 % less than using a natural gas–fired furnace. The disadvantage is that installing heat pumps can be very expensive.

To learn more about geothermal energy and geothermal heat pumps,
Go to Nelson Science

CHECK YOUR LEARNING

1. Describe an idea in this section that has added to your understanding of heat and the environment. Share your new ideas with a classmate.
2. What are two technologies that use geothermal energy?
3. Describe three different uses for a heat pump.
4. Describe the relationship between soil temperature and depth.
5. Describe two advantages and two disadvantages of using a geothermal heat pump to heat and cool a home.

9.7 Alternative Energy Sources: Biofuels

biofuel: a liquid fuel, such as ethanol, produced from plant or animal material

There is growing interest in producing fuels that can replace fossil fuels like gasoline. One possible option is the production of biofuels. **Biofuels** are fuels produced from virtually any kind of plant or animal material. Grain crops, such as corn, can be grown and then processed to make ethanol (Figure 1). When ethanol is burned, it releases carbon dioxide into the air. Carbon dioxide contributes to global warming. However, this release of carbon dioxide is partially balanced by the carbon dioxide that is removed from the air when the corn plants are growing. (All plants absorb carbon dioxide from the air during the process of photosynthesis.) Plants can be grown and harvested year after year. Therefore, biofuels are a renewable source of energy. Biofuels can even be made from waste plant or animal materials, such as wood chips or used frying oil from fast-food restaurants.

Figure 1 Ethanol is a biofuel that can be used in vehicles powered by a fossil fuel.

Biofuels offer several advantages over many other energy sources. Plants can be grown wherever there is adequate soil and water, and suitable weather conditions. Biofuels are also fairly inexpensive to produce. The technology that converts the plant material to clean, purified fuels is not as expensive as other energy sources (for equivalent energy production).

Unfortunately, crops such as corn often require large quantities of pesticides, chemical fertilizers, and fuel for farm equipment. It can actually take more fossil fuel energy to grow, harvest, and process the crops than is obtained when the biofuels are burned! Biofuel crops also require agricultural land. A large demand for biofuels could take up farmland needed to grow food crops. The price of food could rise because fewer food crops are grown.

CHECK YOUR LEARNING

1. What raw materials can be used to produce biofuels?
2. Why are biofuels becoming a popular alternative source of energy?
3. List two possible disadvantages of using biofuels.

More Nuclear Power?

The demand for electricity in Ontario is increasing much faster than the supply. The Government of Ontario has pledged to provide Ontario with "a safe, clean, reliable, secure, and affordable supply of electricity."

SKILLS MENU

- ☐ Defining the Issue
- ☐ Researching
- ☐ Identifying Alternatives
- ☐ Analyzing the Issue
- ☐ Defending a Decision
- ☐ Communicating
- ☐ Evaluating

The Issue

To meet Ontario's growing demand for electricity, the provincial government plans to spend about $45 billion to build several new nuclear power generating stations (Figure 1).

Figure 1 Darlington Nuclear Generating Station is located in Durham Region, 70 km east of Toronto.

Goal

Review and evaluate the Ontario government's plans for providing energy to the people of Ontario, including its plans for taking advantage of conventional and alternative forms of energy production.

Gather Information

SKILLS HANDBOOK 3., 7.C.

Work in a small group to learn more about the provincial government's plans for supplying electrical energy. Learn more about the reactions of a variety of stakeholders to the government's proposals.

Go to Nelson Science

Identify Solutions

SKILLS HANDBOOK 3.J.6., 3.K.

Consider the following strategies to help you identify solutions:

- Conduct a cost-benefit analysis to assess the social, environmental, and economic costs and benefits of the Ontario government's plans.
- Conduct library or Internet research to compare Ontario's energy supply plans with the plans of other provinces.
- Survey your classmates and family to determine their opinions on these issues.

Make a Decision

Review and evaluate the provincial government's energy plans. Which programs should it continue with? Which should it abandon? Which new strategies should it adopt? What criteria will you use to decide on your recommendations?

Communicate

Write an article to send to a school or community newspaper. Your article should summarize the information and opinions that you have researched, evaluate the government's current energy program plans, and recommend the best solution for Ontario's energy future.

CHAPTER 9

SUMMARY

Heat Sources in the Environment

BIG Ideas

- ☐ Heat is a form of energy that can be transformed and transferred. These processes can be explained using the particle theory of matter.
- ☑ **There are many sources of heat.**
- ☑ **Heat has both positive and negative effects on the environment.**

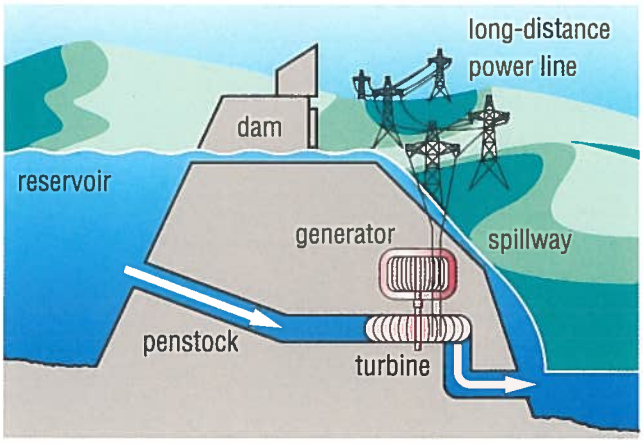
Looking Back

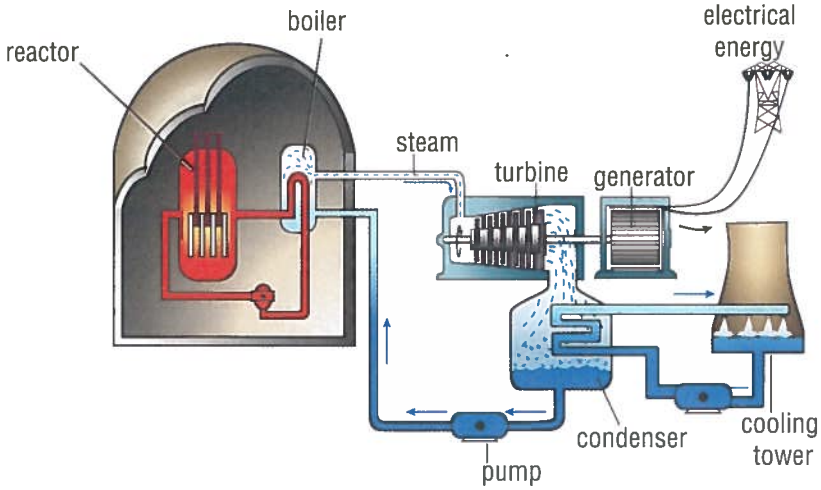
There are different types of energy and different sources of energy.

- We classify energy sources as conventional or alternative, and as renewable or non-renewable.
- Energy sources include the Sun (solar energy); Earth's interior (geothermal energy); fossil fuels and biofuels (chemical energy); particles (nuclear energy); and wind energy, wave energy, and waterfalls (mechanical energy).

Technological devices allow us to transform one type of energy into another.

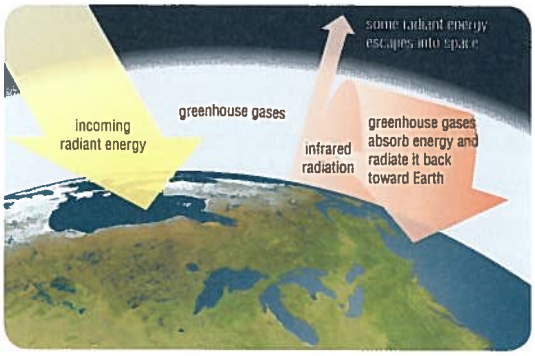
- Energy from a variety of sources is transformed into electricity in electricity generators.
- Electricity can be transformed into many useful forms of energy, including radiant energy, thermal energy, and mechanical energy.





The human production of greenhouse gases is causing changes in global climate.

- The major greenhouse gases are water vapour, carbon dioxide, methane, and nitrous oxides.
- Greenhouse gases are produced by mining and burning fossil fuels, raising cattle, and growing certain crops (for example, rice).
- The increase in greenhouse gases in the atmosphere is altering Earth's energy balance, leading to global warming.
- Global warming has significant impacts on society and the environment.



There are significant advantages and disadvantages to using conventional and alternative energy sources.

- Advantages of conventional energy sources are that they are well established and relatively inexpensive, and there are well-developed technologies for their production and use. Disadvantages include pollution (greenhouse gases from fossil fuels), lack of suitable rivers (for hydro-electricity), and long-term storage (for nuclear energy).
- Advantages of alternative energy sources are that many of them are non-polluting, produce no dangerous products that need special storage, and are renewable. Disadvantages include a lack of established technologies for production and use, and high initial costs.

The choices we make in everyday life significantly affect the environment.

- Our everyday activities affect the quantity of greenhouse gases that enter the atmosphere. This affects global warming, which in turn affects society and the environment.
- We can choose activities that reduce our impact on the environment.

The skills of scientific inquiry can be used to investigate conventional and alternative energy sources.

- Analysis skills can be used to determine the impacts of using conventional and alternative sources of energy

VOCABULARY

solar energy, p. 230
friction, p. 231
conventional energy source, p. 234
renewable energy resource, p. 234
non-renewable energy resource, p. 235
fossil fuels, p. 236
Earth's energy balance, p. 238
greenhouse effect, p. 238
greenhouse gases, p. 238
global warming, p. 240
alternative energy source, p. 242
passive solar heating, p. 244
active solar energy system, p. 244
biofuel, p. 248

CHAPTER 9 REVIEW

The following icons indicate the Achievement Chart categories: K/U Knowledge/Understanding; T/I Thinking/Investigation; C Communication; A Application

What Do You Remember?

1. (a) List four fossil fuels.
   (b) Why are these fuels called fossil fuels?
   (c) What form of energy do fossil fuels contain?
   (d) What forms of energy are produced when fossil fuels burn? K/U
2. (a) Why is hydro-electric power considered a "clean" source of energy (Figure 1)?
   (b) Why is hydro-electric power considered a renewable source of energy?
   (c) Why do hydro-electric power plants produce only about 3 % of the electrical energy in the world today? K/U

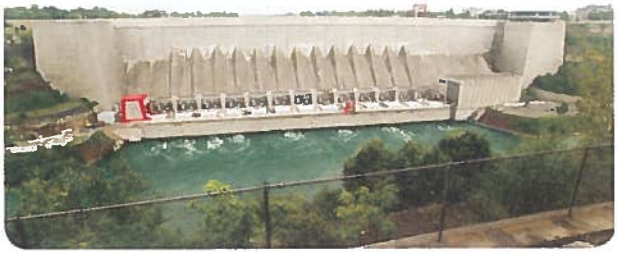


Figure 1

3. Describe how the energy in uranium is used to produce electrical energy in a nuclear power plant. K/U
4. How is the greenhouse effect affecting Earth's energy balance? Explain. K/U
5. Identify four greenhouse gases and one common source for each gas. K/U
6. How may global warming lead to the flooding of coastal areas around the world? K/U T/I
7. Describe two ways in which home builders may take advantage of passive solar heating. T/I
8. (a) Name a heat pump that you use every day at home.
   (b) What is a geothermal heat pump, and how does it work? K/U T/I A

What Do You Understand?

9. Why are fossil fuels the most common source of energy for heating and transportation today? K/U A
10. What are some possible effects of an increase in the global temperature? Can you think of other effects not mentioned in the chapter? If so, what are they? K/U T/I
11. How might your choice of the best energy source depend on your geographic location? K/U T/I
12. A family is deciding whether to install a geothermal heat pump to warm and cool their home. State and explain two financial considerations that they need to take into account when making this decision. T/I A
13. Describe the role of radiant energy in heating and cooling Earth. Explain how greenhouse gases affect the transmission of radiated heat through the atmosphere. K/U
14. Imagine that you are planning to plant a row of tall trees alongside your house to help keep your house warmer in winter.
   (a) Would you plant deciduous trees or evergreens? Why?
   (b) Would you plant the trees on the north or south side of the building? Why? K/U T/I A
15. You are planning to install solar hot water panels on the roof of your home.
   (a) Would you install the panels on the side of the roof that faces south or on the side of the roof that faces north? Explain.
   (b) What type of energy transformation will occur in the panels?
   (c) How will this help reduce the greenhouse effect and global warming? K/U T/I A

16. Large solar energy or wind energy projects may involve hundreds of photovoltaic panels or wind turbines in one area. Currently, both options are relatively expensive methods for generating electrical energy. Describe two benefits and one additional drawback for each of these methods of producing electrical energy. K/U T/I A

17. (a) What is a biofuel? Provide one example.
    (b) State one similarity and one difference between biofuels and fossil fuels.
    (c) State one advantage and one disadvantage of using biofuels as an energy source. T/I

18. (a) In what ways does your choice of foods contribute to global warming?
    (b) What can you do to reduce your contribution to global warming, yet still get enough to eat? T/I A

Solve a Problem!

19. Research the types of plants that are good candidates for biofuel production in Canada. T/I

Go to Nelson Science

Create and Evaluate!

20. We use incandescent light bulbs as a source of radiant energy (light), but they primarily produce thermal energy instead. Describe an alternative to incandescent light bulbs and explain why it is a better or worse alternative. K/U A

21. Your family is building a new home. Present a case for installing a geothermal heat pump. In your discussion, be sure to include the benefits and costs from both an environmental perspective and an economic perspective. K/U A

22. Make a case for (or against) using rural land or marginal land-use areas for wind turbine farms. K/U A

23. (a) Some people feel quite strongly about nuclear energy. Why do you think the people in Figure 2 are protesting?
    (b) Do you promote this type of action? Why or why not? A

Figure 2

Reflect on Your Learning

24. (a) How do you feel about the issue of climate change? Discuss your feelings about climate change with a classmate. Identify similarities and differences in your feelings.
    (b) How do your feelings about climate change affect your ability to learn about climate change?
    (c) How do you think climate change will affect your future? How concerned are you? Discuss your concerns with a classmate or teacher.

25. Think back to the Key Question on the first page of this chapter.
    (a) In a brief paragraph, answer the Key Question. You may use diagrams.
    (b) Write one or two more questions about the topic of this unit that you would like to explore.

Designing an Energy-Efficient Doghouse

Background

Choosing the best materials is important when you are planning a building project. Insulation can slow down the transfer of thermal energy through the walls of a building. If the designer wants to keep the building cool, she or he might choose to paint the building a light colour, or use a material on the outside walls that is shiny. The designer must consider form and function.

Scenario

The K-9 Doghouse Company is holding a design competition to develop a new doghouse. The company is looking for a doghouse that will keep a dog comfortably warm during the winter months and cool during the summer.

Design Brief

Designers must build a prototype of a doghouse that is designed to keep a dog warm during the winter and cool during the summer. The prototype must not exceed 15 cm × 15 cm in floor area, and 15 cm in height, inside. There must be a doorway. Designers are encouraged to use materials efficiently, to keep the doghouse affordable, and to minimize negative effects on the environment (Figure 1). All materials must be safe for use in the classroom and home.

Research and Consider

SKILLS HANDBOOK 4.B.3., 4.C.

Before designing your doghouse, research different types of materials. Remember that energy can be transferred by conduction, convection, and radiation.

Figure 1 Your doghouse must be affordable, with minimal effects on the environment.

Draw sketches of designs for your doghouse. Your sketches should show the structure, dimensions, and types of materials to be used. Keep in mind the comfort and safety of the dog when designing and choosing materials.

Plan and Construct

SKILLS HANDBOOK 4.B.4.

Choose one of your designs and build a prototype doghouse for the design competition. Before building, you should do the following:

- Complete a scale drawing of the doghouse.
- Produce a list of equipment and materials to be used during construction.
- Create a step-by-step plan for building the prototype.

- Produce a list of job responsibilities for each team member (if you are working in a team).
- Ask your teacher to approve the list of materials and the building plan before you begin.

Test and Modify

Test the doghouse prototypes using the procedures in Table 1:

Table 1 Cold Weather and Warm Weather Tests

Cold weather test	Warm weather test
1. Measure the temperature inside the doghouse at room temperature and record it as the initial (comfortable) temperature. Leave a thermometer inside the doghouse. 2. Put the doghouse prototype into a freezer for 10 min. 3. Remove the doghouse prototype from the freezer and quickly read the thermometer inside the doghouse. Record this temperature as the final doghouse temperature. 4. If the temperature of your doghouse changed to an uncomfortable temperature during the trial, work with your team to make modifications to the design. 5. Build your redesigned prototype and retest it.	Repeat the procedure for the cold weather test, except put the doghouse in direct sunlight for 10 min.

Evaluate

Answer the following questions:

1. Which elements of the doghouse design prevented the inside temperature from dropping too quickly when the prototype was placed in the freezer?
2. Which elements of the doghouse design kept the inside temperature comfortable when the prototype was placed in direct sunlight?
3. Compare the test results from your doghouse with those of other prototypes. Give reasons for the outcome.

Communicate

Make an oral presentation to the "Board of Directors" of K-9 Doghouse Company that points out the pros and cons of your design. You need to convince the Board that the prototype deserves to be mass-produced. Create a poster that features a scale drawing of your doghouse design, highlights the ways in which the doghouse prevents heat loss and overheating, and displays the results of the cold weather and warm weather tests.

Assessment

You will be assessed on how well you

- state the design problem or challenge
- identify several possible design solutions
- make sketches of several possible designs
- develop a plan for building a prototype, based on one of your possible designs
- build a prototype based on one of your designs
- test your prototype and record observations, make modifications, or identify modifications that could be made to improve the effectiveness and efficiency of the prototype
- evaluate your prototype according to your observations and the criteria
- use the concepts and terminology of the unit to communicate the development and testing of your prototype

Heat in the Environment

Make a Summary

During this unit, you have learned many new concepts about heat and its effects on the environment. The Chapter Review for each chapter lists the new words and terms that you learned. In this activity, you will use those words to complete a series of activities.

Equipment and Materials

- markers
- sticky tape or glue
- sticky notes or small pieces of paper
- chart paper

Procedure

1. Form a team of three or four people.
2. Work together to write each of the vocabulary words on the sticky notes. Write one word (or one term) only on each note.
3. Place a piece of chart paper in the centre of your team. Share the vocabulary words equally among team members.
4. Organize the words into two to five logical groupings on the chart paper. You can use any criteria you like to put the words into groups.
5. Once your team agrees on how the words are grouped, stick the words in place on the chart paper.
6. Write a title above each group that describes why the words are in that particular group.
7. Below each list of words, write one sentence that describes an important idea from the unit that is associated with that group of words.
8. Use these sentences as the basis of a paragraph or two, summarizing your learning in this unit.

Unit C Review Questions

The following icons indicate the Achievement Chart categories: K/U Knowledge/Understanding; T/I Thinking/Investigation; C Communication; A Application

What Do You Remember?

1. Which of the following types of energy is most commonly used for home heating?
   (a) chemical energy
   (b) mechanical energy
   (c) friction
   (d) solar energy K/U
2. Which form of energy transfer is primarily responsible for thunderstorms?
   (a) convection
   (b) conduction
   (c) friction
   (d) radiation K/U
3. Which type of rock is formed as molten lava cools?
   (a) metamorphic
   (b) sedimentary
   (c) igneous
   (d) all of the above K/U
4. The radiant energy of the Sun is directly transformed into electrical energy in a
   (a) wind turbine
   (b) photovoltaic panel
   (c) geothermal heat pump
   (d) nuclear reactor K/U

5. Decide whether each of the following statements is true or false. If the statement is false, rewrite the statement to make it true.
   (a) Heat is energy that is transferred from a cooler object to a warmer object.
   (b) Heated liquids expand much more than heated solids.
   (c) Visible light is a form of chemical energy.
   (d) Wind is caused by the transfer of energy through conduction. K/U

6. When a substance's particles absorb energy, what happens to the motion of the particles? K/U

7. A cup of hot chocolate is set on a table before you drink it (Figure 1). Suggest two different ways in which energy is transferred away from the hot chocolate, allowing it to cool. K/U

Figure 1

8. What invisible form of electromagnetic radiation is emitted by low-temperature objects like the human body? K/U

9. Matter can exist as a solid, a liquid, or a gas. Which state(s) of matter
   (a) has particles that are free to move long distances in all directions?
   (b) has the most effective forces of attraction between the particles?
   (c) efficiently transfers energy by conduction?
   (d) has a fixed volume, but takes the shape of its container? K/U

10. What causes lightning to form in a thunderstorm? K/U

11. Rearrange the following phrases into an order that describes the production of energy by a hydro-electric power plant:
   (a) Water flows into a river.
   (b) A generator turns.
   (c) Water is held in a reservoir.
   (d) Electricity is produced.
   (e) Water flows through a penstock.
   (f) A turbine turns. K/U C

12. Radiant energy from the Sun can pass through the atmosphere to reach the surface of Earth, and some of the radiant energy from Earth passes back through the atmosphere toward space. How is some of the radiant energy from Earth prevented from escaping through the atmosphere? K/U

What Do You Understand?

13. Explain how thermal energy is involved in each of the following situations:
   (a) A cool breeze blows from a lake onto a beach on a sunny summer day.
   (b) You clutch a cup of hot chocolate with your hands on a cold winter night.
   (c) A large thundercloud rolls with thunder on a springtime afternoon. K/U A

14. The thermal expansion of materials can be an advantage or a drawback. Provide an example of each. K/U A

15. How can you prevent the unwanted transfer of thermal energy in your home by
   (a) radiation?
   (b) convection?
   (c) conduction? K/U A

16. Scientists studying glaciers have found that the snow is contaminated with tiny specks of black soot released from factory smoke stacks.
    (a) How could this observation help explain why glaciers are melting faster than predicted?
    (b) Is the melting of glaciers an environmental concern? Explain. K/U A

17. When engineers design a device or structure composed of different materials, they consider how materials expand and contract. Why is this an important consideration? Provide an example. K/U A

18. On a particularly cold winter day, you hear a neighbour exclaim, "So much for global warming!"
    (a) What does your neighbour mean by this statement?
    (b) Is your neighbour's exclamation reasonable? Explain. K/U A

Solve a Problem!

19. You have just been selected to join a field trip to the Arctic in January. What type of clothing will you pack? Describe the properties of the clothing that you will choose. Explain your choices. T/I A

20. An adventure company wants to design a new camp stove to be used by backpackers to boil water while out on the trail. Using a small candle as a source of thermal energy, suggest a design that will transfer the greatest amount of energy from the burning candle into the water in a kettle. Draw a detailed sketch of your camp stove design. T/I A

21. To help keep pizza hot during delivery, restaurants put the pizza boxes in a delivery bag (Figure 2).
    (a) How does the design of the pizza bag help to keep the pizza hot? K/U
    (b) How could the delivery bag in Figure 2 be improved? A

Figure 2

22. The Space Shuttle has a "Thermal Protection System" mainly consisting of thick dark tiles that line the bottom surface. These tiles protect the Shuttle and its occupants when it re-enters Earth's atmosphere prior to landing.
    (a) Why would the bottom surface of the Space Shuttle warm up as it descends through Earth's atmosphere? K/U
    (b) What form of energy transfer do you think the tiles are designed to prevent? K/U
    (c) If you were a NASA engineer assigned the task of designing these tiles, what material would you use? What would influence your choice? T/I A

23. Methane is one of the greenhouse gases you read about in Section 9.3. Methane has a much higher global warming potential than carbon dioxide. One kilogram of methane warms Earth 25 times as much as 1 kg of carbon dioxide. Research the main sources of methane. How can you reduce the amount of methane released into the atmosphere as a result of your actions? T/I A

Create and Evaluate!

24. Most scientists believe that global warming is mainly caused by an increase of greenhouse gases, like carbon dioxide, in the atmosphere. Create a plan to make one change in your life that will reduce your greenhouse gas emissions. Evaluate your plan, and explain why it will have the desired effect. T/I A

25. Which devices in your home use the most energy? What can you do to reduce the amount of energy they use? Research more about the energy consumption of home devices by using the Internet or going to the library. Based on your research, evaluate which devices in your home would be best to replace or upgrade so that you can reduce your family's energy consumption. T/I A

Go to Nelson Science

26. A scientist claims that "it takes more energy to make ethanol biofuel than you get out of it." Evaluate this claim by researching and comparing the amount of energy needed to make a litre of ethanol from corn and the energy we can get from the litre of ethanol. T/I

Go to Nelson Science

Reflect on Your Learning

27. Thermal energy has both positive and negative effects on the environment. Draw a table similar to Table 1 in your notebook. Complete the table by listing the positive and negative effects of thermal energy that you have learned. In the third column, list facts that you may have found particularly interesting or meaningful.

Table 1 Effects of Thermal Energy on the Environment

Positive	Negative	Interesting/ meaningful

28. Reread Section 9.3. Think about the issues presented in this section. Write a brief expository paragraph, a poem, or a lyric that expresses your feelings about these issues. If you prefer, you may draw a cartoon, compose a poster, or write a slogan. Share your composition with a classmate and discuss common interests and concerns.

29. The particle theory is a model that helps us visualize an idea.
    (a) How did using a model (the particle theory) help you as you learned about how energy affects matter?
    (b) What are the disadvantages of using a model like the particle theory?
    (c) How have you used this model to help make sense of the things you see in the world around you?