Assess Your Learning

1. Create a mini poster that shows your understanding of conduction, convection, and radiation.
2. You try, unsuccessfully, to open a brand new jar of pickles. You find that the lid is too tightly sealed. After running the lid under the hot water tap for a short time, you are able to open the lid. Explain what happened.
3. It is a hot day and your family decides to have ice cream with dinner. You walk the 30 min to the store to get 1 L of ice cream. Knowing that it will melt before you get back, you need to make a plan to get the ice cream home in its solid state. What would you do? Why?
4. Teeth are examples of solid matter. When you eat hot food or drink cold water, your teeth will expand or contract depending on the temperature inside of your mouth. What would a dentist need to consider when filling a cavity?
5. Summarize your new learning on the mind map that you started on page 189.

Focus On — SOCIAL AND ENVIRONMENTAL CONTEXT

Understanding the science of heat helps us to appreciate how it affects our lives. In this section, you read about examples of how we use heat technology to meet our needs. Think about the information you learned and the activities you did in this section.

1. You have studied how heat moves in three different ways: conduction, convection, and radiation. For each one, describe an example of a technology that uses that method of heat transfer to meet our needs.
2. Describe two examples of heat technology that you use in your daily life. Identify if the device uses conduction, convection, or radiation.

3.0 Understanding heat and temperature helps explain natural phenomena and technological devices.

Key Concepts

In this section, you will learn about the following key concepts:

- heat energy needs and technologies
- thermal energy
- thermal energy sources
- insulation and thermal conductivity
- energy conservation

Learning Outcomes

When you have completed this section, you will be able to:

- describe ways in which thermal energy is produced naturally
- describe how solar heating works
- compare and evaluate materials that maximize or limit the transfer of thermal energy
- explain how devices and systems respond to temperature change
- describe how household devices allow us to generate, transfer, control, or remove thermal energy
- explain practical problems in controlling and using thermal energy

The glowing liquid rock, the blasting hot gases, the billowing ash—volcanoes are both frightening and fascinating. Imagine the amount of thermal energy that Earth must contain to melt rock into a flowing liquid. Volcanoes form when heat and pressure force this hot, liquid rock up to Earth's surface. In some volcanoes, like the one shown here, rivers of liquid rock flow from an opening in the ground. Fire and heat from such a river consume everything in its path. A volcano is just one indicator of Earth's thermal energy. Other examples include hot springs and geysers.

For Web links relating to 3.0, visit **www.pearsoned.ca/scienceinaction**

3.1 Natural Sources of Thermal Energy

What natural sources of thermal energy do you think exist? Look at Figures 3.1–3.4 and read the captions.

Figure 3.1 The sun is Earth's natural source of thermal energy. Many people refer to the sun's energy as solar energy. "Solar" comes from the Latin word *sol*, which means sun.

Figure 3.2 Earth is a considerable source of thermal energy. Much of this energy remains deep inside. It is called **geothermal energy**. "Geo" means Earth, and "thermal" means heat. This geothermal energy is being used in Iceland and parts of New Zealand to provide hot water and to grow crops.

Figure 3.3 All fires consume some type of fuel (wood, oil, coal, or natural gas). Fire converts the chemical energy stored inside the fuel into thermal energy, light energy, and often, sound energy.

Figure 3.4 Decay is a source of thermal energy. The breakdown of dead plants and animals releases thermal energy. If you have ever done any composting, you have felt the thermal energy produced by the decaying process.

Give it a **TRY** — ACTIVITY

APPLICATIONS OF THERMAL ENERGY

So far in this unit, you have discussed and investigated many uses of thermal energy. Work with a group. Brainstorm as many of these applications of thermal energy as you can think of. Record your ideas, in words and pictures, on a sheet of paper that will be your "thermal energy placemat." Share your results with other groups. Change or add to your placemat as you work through the rest of this unit.

FOCUS ON SOLAR ENERGY

Solar energy, or energy given off by the sun, is the most important source of thermal energy for life on Earth. This type of thermal energy is produced by the nuclear reactions that happen inside of the star that is our sun. Every 40 min, the level of energy that comes to Earth is equivalent to the energy used by humans over the period of a full year. Imagine being able to store all of that energy!

*info***BIT**

Nanook

Question: What do you get when you combine more than 70 students from the University of Alberta and the Northern Alberta Institute of Technology (NAIT) with an exciting dream for an environmentally friendly car? Answer: *Nanook*, Alberta's first ever solar-powered race car! *Nanook* is the product of 21 months of creative work by the student design team. Its ultra-sleek 5.8-m body is almost completely covered by 560 solar cells and weighs only 500 kg, including the driver. The solar cells capture the sun's energy, which becomes the race car's power source. Onboard batteries can store the sun's energy during daylight hours so that *Nanook* can travel up to 90 km/h—even at night—without burning any gasoline!

USING THE SUN'S ENERGY FOR SOLAR HEATING

Solar heating systems are of two types: **passive** or **active**. A passive system is heated directly by the sun's rays. It is designed to heat a building without fans or pumps to help carry the heat to different parts of the building. An active system will rely on some mechanical device to help transfer that energy.

Figure 3.5 Windows in a passive solar house. In summer and at night, these windows are covered by special insulated shades.

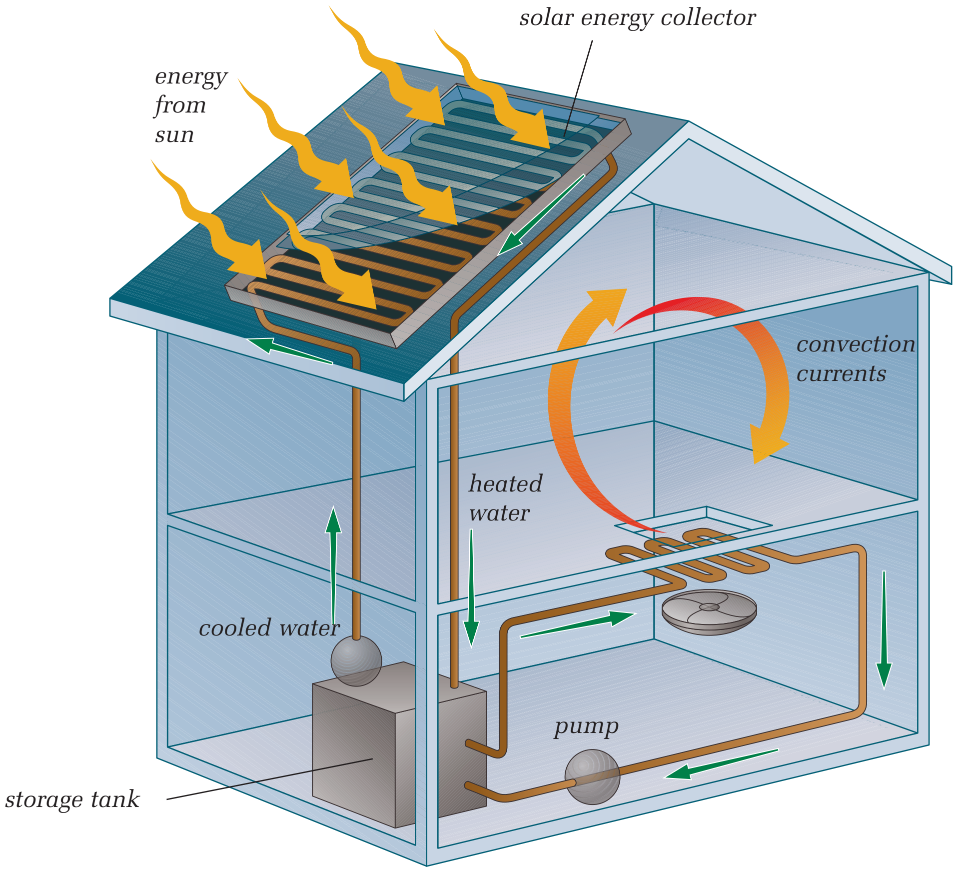
PASSIVE SOLAR HEATING

The basic approach for passive solar heating is simple: reduce heat loss and increase heat gain from the sun. On the most basic level, this means insulating the building as much as possible and placing most of the windows on the south side. A large overhang above the windows shades them from the summer sun, so the building doesn't become too hot. In the winter, the rays of the low sun bring radiant energy into the rooms. The warmth this produces is carried to the other rooms in the building by convection currents.

The thermal efficiency of a building's design can be measured by how well it prevents heat loss. It can also be measured by how well it maintains an even temperature throughout a 24-hour period. Special materials can increase the thermal efficiency of a passive solar home.

Extra panes of glass and special coatings on windows allow windows to let radiant energy from the sun in, but prevent much of it being reflected back out. Special materials in the house can be used to store thermal energy. For example, a stone or brick wall inside the room is placed where the sun shines on it most of the day. Some of the sun's heat transfers to the stone or brick. The stone or brick stores it as thermal energy. Then, at night, when there is no sun and the room begins to get cold, the stone or brick heat transfers into the air and keeps the room a comfortable temperature.

Figure 3.6 An active solar heating system



Active Solar Heating

Active solar heating systems usually have three components: a collector, a heat storage unit, and a heat distribution system. Look at Figure 3.6.

Water is used in the collector to trap solar energy. Copper tubing on a black surface is placed under glass panels. As the sun's rays pass through the glass, the area becomes heated. Insulation helps to keep the thermal energy from escaping. The water running through the copper tubing becomes heated and is pumped to the heat storage and distribution units.

In a prairie climate, a combination of passive and active solar systems can usually meet up to 75% of a family's heating needs. In warmer climates, a greater percentage is possible. Landscaping can also add to the effectiveness of a solar design. Trees can block cold winter winds and help to provide a cooling shade in summer.

Depending on your location and the season, a backup heating system is usually needed for both passive solar and active solar heating systems. The backup system is used when sunlight is not available, or when not enough heat is collected during the day to keep a building warm during the night.

Decision Making Activity

Is Solar Energy a Practical Option?

The Issue

One option for heating our homes is with active or passive solar systems. Is solar heating a practical option for your home?

Background Information

Solar energy is not just for new homes. New homes provide an opportunity to design a house in the most effective way to use the sun's energy. These designs include the use of special materials and equipment. But it is possible to change existing homes—including apartment buildings—to make some use of solar energy. For example, placing solar collectors on the roof could provide some hot water. Adding or increasing the size of the windows on the south side of a building could provide some of the space heating. These windows would have to be well insulated at night so they would not allow heat loss from the space.

Many companies that sell solar energy products advertise on the Internet. Do a search for these Web sites and make a list of sources. Use these sources to find information about the cost and efficiency of solar heating products and designs. Make a list of solar options that could be used in your home. For each one, list its approximate cost and its advantages and disadvantages.

Support Your Opinion

Do you think solar energy is a practical option for your home? Write a paragraph summarizing your opinion. Make sure to support your opinion with facts from your research.

Figure 3.7 Solar panels

reSEARCH

Solar Energy Uses

Prepare a report on how solar energy is used in scientific experiments.

Solar Energy and Electricity

In addition to providing heat, solar energy can be converted into electricity. Solar cells are arranged in panels which are connected to form a **solar array**. A series of these solar arrays are then placed so as to capture and store the sun's energy in low voltage batteries. Household appliances needing electricity can use this solar energy during the day. Electricity can also be drawn from the batteries when the sun has gone down. Remote weather stations are often powered in this way because it is both difficult and expensive to deliver regular electricity to these areas.

Figure 3.8 This photo shows a different kind of solar array. Here, an array of hundreds of mirrors reflect solar energy onto a water-filled tower. This heats up the water to produce steam, which is used to generate electricity. Such arrays are set up in desert areas where there is plenty of sunshine and little rain.

Costs and Benefits of Solar Energy

Solar energy has many benefits. Unlike fossil fuels, the sun's energy is not limited, and it is available to everyone. Solar energy does not create pollution in the way burning fossil fuels to provide energy does, nor does it carry the radiation risks that nuclear energy does.

However, the cost of setting up a solar system is usually more expensive than conventional fossil fuel or electrical systems. Generally, in Canada, solar energy cannot provide all the space or water heating needed in a home. A backup system is needed using conventional fuels or electricity. Solar cells for electricity are expensive and cannot provide large amounts of electricity economically. Disposal of solar cells when they are no longer operational may be an environmental concern.

Passive solar energy use continues to be a lower cost option. Maximizing solar energy use this way can be costly—special designs and special materials are needed. But as you read earlier, simple changes can be made to existing buildings to increase the use of solar energy.

Research and development continue into ways of improving the efficiency of solar devices and decreasing their costs.

Check and Reflect

1. Describe four ways in which thermal energy is produced naturally. Give an example of each way not mentioned in this section.
2. What is a passive solar heating system?
3. Predict how important you think solar energy technology will be 100 years from now.
4. Explain how our way of life today affects our thinking about whether or not to use solar heating in our homes.

3.2 Heating System Technologies

Think for a moment about what it is like to be cozy in your bed while there is a snowstorm happening outside. In addition to the blankets that you have wrapped around you, the furnace in your home will help to keep you warm—even if it is –30°C outside. But how does the thermal energy from the furnace that is somewhere else in your home travel to your room? How does it know when to come on and when to go off? How is it that the furnace doesn't come on at all during the summer yet it starts up again on chilly fall mornings?

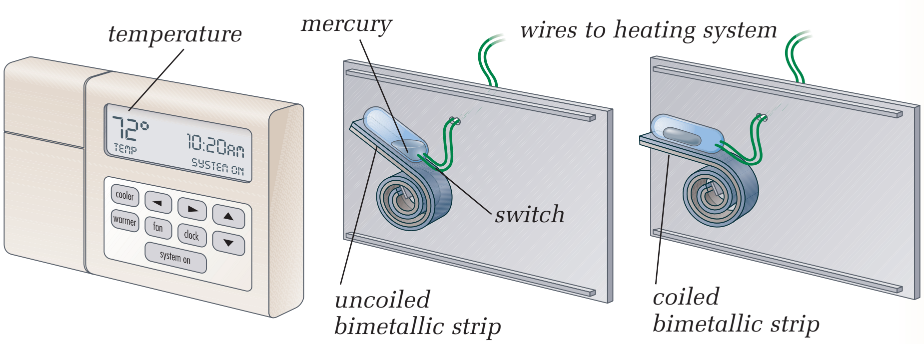
infoBIT

Frosty Fact

The first transatlantic shipment of frozen meat left Argentina in 1877, bound for France. However, all was not "smooth sailing" when the ship collided with another vessel. The accident caused a long delay and the trip took 6 months to complete. But thanks to a special ammonia compression system, the meat stayed frozen the whole way!

Give it a TRY — ACTIVITY

THERMOSTAT: WHAT'S INSIDE?



This diagram shows the inside of a typical thermostat.

Use this diagram to infer and explain how a thermostat works. Here are three tips if you need help.

a) Metals expand when they are heated and contract when they cool.
b) Not all metals expand and contract at the same rate.
c) An electrical conductor allows the passage of an electrical current.

Name five devices in which you would expect to find thermostats.

Thermostats

In order to live comfortably, we need to be able to control the temperature of our indoor environment. Most people like to keep their homes, offices, and schools at "room temperature," or about 20°C. While this would have been a problem for people in Alberta 100 years ago, we now have **heating systems** that are controlled by **thermostats**. "Thermo" means heat and "stat" means to maintain or to keep the same.

Thermostats are used to control the air temperature in indoor environments. They are also useful in adjusting the temperature of electric appliances such as an oven or an air conditioner.

The switch in a thermostat is a bimetallic strip, which consists of two different metals joined together. When heated, one of the metals expands faster than the other. This causes the strip to bend.

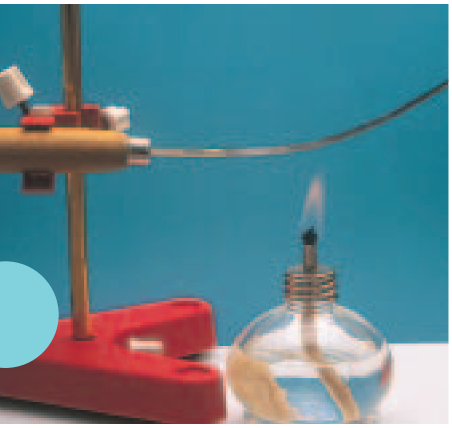


Figure 3.9 A bimetallic strip bends when heated.

The bending effect of the bimetallic strip is used to measure temperature change. As the strip bends and unbends, it opens and closes an electric circuit that controls a heat-regulating device, such as an electric blanket.

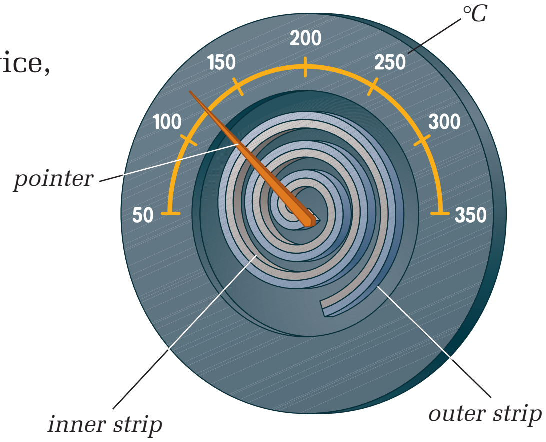


Figure 3.10 When the coil of the oven thermometer is heated, the inner strip expands more than the outer strip. The coil opens. The more the coil is heated, the wider it opens. At the end of the coil is a pointer that moves over the scale.

Heating Systems

There are two types of heating systems: **local heating systems** and **central heating systems**.

- Local heating systems provide heat for only one room or a small part of a building. Fireplaces, wood-burning stoves, and space heaters are common examples of local heating systems. Space heaters are small, portable heating systems that run on fuel or electricity.
- Central heating systems provide heat from a single, central source such as a furnace. The heat transfers through a network of pipes, ducts, and vents or openings in different places around the building. You very likely have a vent in your bedroom. Most newer homes with central heating systems use **forced-air heating**. Some older buildings use **hot-water heating**.

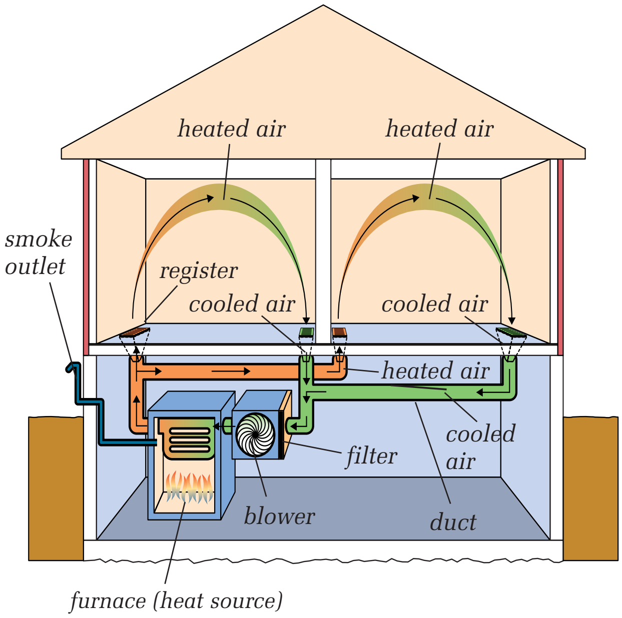


Figure 3.11 Forced-Air Heating

- *Air is heated by burning fuel in a furnace.*
- *The heated air travels through ducts (pipe-like passageways) to registers in different rooms. (Registers are panels or grates in the wall near the floor or in the floor itself.)*
- *A blower helps pull returning air back to the furnace.*
- *The filter helps trap dust, hairs, and other fine particles before the air returns to the furnace.*

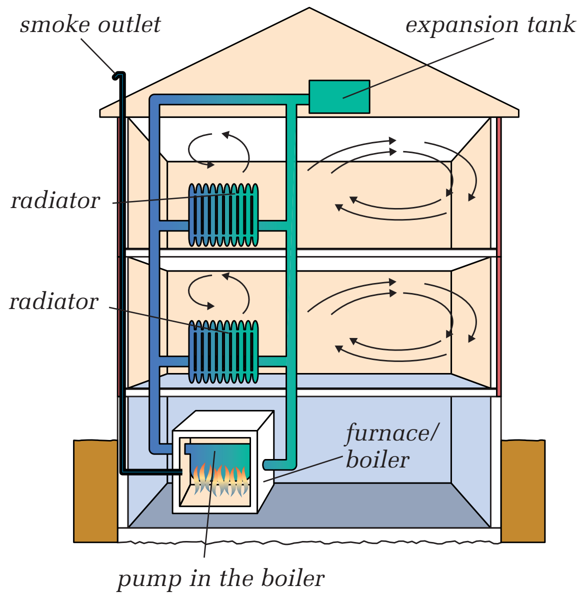


Figure 3.12 Hot-Water Heating

- *Water is heated by burning fuel in a furnace or boiler.*
- *A pump forces the heated water through a network of pipes that lead to metal radiators.*
- *The hot water heats the radiators, which then warm the air in the room.*
- *As the water cools, it is returned to the boiler and heated up again.*

Convection at Work

In each of these types of heating systems, the science of convection is at work. Keep in mind that heat travels in only one direction—from areas of higher kinetic energy to areas of lower kinetic energy. The air particles that have greater kinetic energy, and therefore feel warmer, will move faster about the room. As they come into contact with other air particles with less kinetic energy, the particles of cooler air will begin to move more quickly and the spaces between the particles will expand. This means that the volume of the air will increase. This expansion will cause further movement, and a kind of chain reaction will follow until all of the air in the room becomes warmed. But how does the heating system know when to stop providing thermal energy?

When a fireplace becomes too hot, we can adjust the damper. This device is a movable plate that controls the flow of air to the fire. Some space heaters come with an automatic shut-off, but most need people to turn them off when a room has become warm enough.

Most modern central heating systems are controlled by a thermostat. A thermostat makes automatic adjustments to the air temperature in a room by switching a heating system on or off.

reSEARCH

Jobs, Jobs, Jobs

In 1995, Canada's natural gas production was valued at $6.8 billion. Make a list of 10 different jobs that are connected with this field and describe how each is connected to the energy industry.

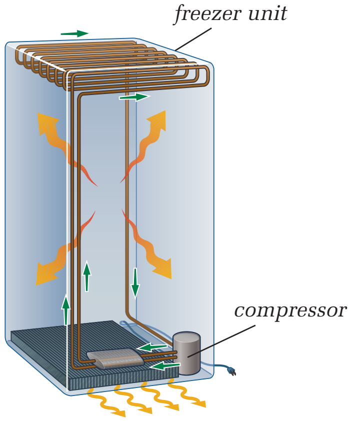


Figure 3.13 A refrigerator's cooling system

Keeping Cool

On a hot summer day, nothing tastes better than a slush drink from the convenience store on the corner. As you have watched the coloured drink swirling around in the machine, have you ever wondered how it keeps from melting?

Did you know that thermal energy is needed to create the cold temperatures we link with such technologies as refrigerators, freezers, and air conditioners?

A motor powered by electricity or natural gas (both sources of thermal energy) is at the heart of all of these cooling systems.

Think about it like this. When you put water on your skin, it feels cool. As the water evaporates, it absorbs heat and creates the cool feeling. A cooling system removes heat from a room or other enclosed space. The basic parts of a cooling system are: a storage tank, a compressor, a freezer unit, condenser coils, and a **refrigerant**. The liquid, or refrigerant, used in a refrigerator evaporates at a very low temperature. This creates freezing temperatures inside the refrigerator.

Figure 3.13 shows how a typical refrigerator works. The refrigerant in the storage tank is pumped to the freezer unit. As it passes through the freezer unit, the liquid refrigerant evaporates. It cools as it evaporates so heat transfers from the warmer air inside the refrigerator to the cooler refrigerant. The refrigerator space becomes cooler, while the refrigerant becomes hotter. Now a vapour, it flows through the compressor to the condenser coils. Heat transfers out of the refrigerant, and it cools down and becomes a liquid. Then the cycle repeats.

Check and Reflect

1. Describe some of the possible safety risks involved in not controlling heat and thermal energy in our homes. Include points about household appliances and other everyday devices that generate heat.
2. Explain how a thermostat works.
3. Describe how thermal energy is used to create cool temperatures.
4. Compare the forced-air heating system with the hot-water heating system. Which system would you choose for a house you designed? Why?

3.3 Heat Loss and Insulation

One of the challenges for Albertans is keeping the temperature of their buildings comfortable. In the winter, that means keeping the warm air inside and the cold air outside. In summer, it is exactly the opposite. The goal is to keep the cool air inside and the warmer air outside. How can this be done in a climate that has such extreme temperature shifts? Insulation!

*info***BIT**

Natural Insulators

Fat is one of nature's most effective insulators. In animals like polar bears and seals, fat forms a protective layer to help keep heat from transferring out of an animal's body.

Figure 3.14
Fibreglass insulation

Insulation

As you learned earlier, an insulator is the opposite of a conductor. It limits the amount of heat that can be transferred by conduction. In the case of buildings, insulation is used to limit heat loss to the colder outside environment or to limit the amount of heat that is able to enter a cooler building on a hot day. Because heat transfers in only one direction (from areas of higher kinetic energy to areas of lower kinetic energy), insulation is useful in both cases.

The materials used in the construction of a building have a major impact on how heat can be transferred both into and out of a structure. The **thermal conductivity** of a material reflects its ability to transfer heat by conduction. When building a house, you want materials that are good insulators, not conductors. Stone and brick walls are good insulators. However, these can be very expensive, and many people choose to have a layer of Styrofoam panelling between the outer walls and the siding of their homes. Fibreglass insulation can also be packed between inner and outer walls and in the attics of buildings. Doors and windows are another important part of a good insulation plan.

Figure 3.15 Styrofoam insulation

HEAT LOSS

Figure 3.16
- white/yellow: the greatest heat loss
- pink/purple: the next greatest heat loss
- green/blue: the least heat loss

Contractors can use infrared photography to "diagnose" the areas of heat loss in a building. This kind of photo is called a *thermogram*. The colour shows the type of heat loss. Look at the thermogram in Figure 3.16. What recommendations would you make to the owners of this home?

The kind of heat loss shown by Figure 3.16 is fairly typical of most homes. Figure 3.17 illustrates this point. Notice that the roof, windows, doors, and walls are all part of the problem of unwanted heat transfer. This means that additional heat will need to be produced in order to keep our homes and other buildings comfortable. This is where the issue of waste comes in. We are wasting electricity and natural gas when the warm air within buildings is transferred to the outside. More resources, particularly the non-renewable resource of natural gas, must be consumed in order to meet our needs and wants for heat.

Average Heat Loss in a House

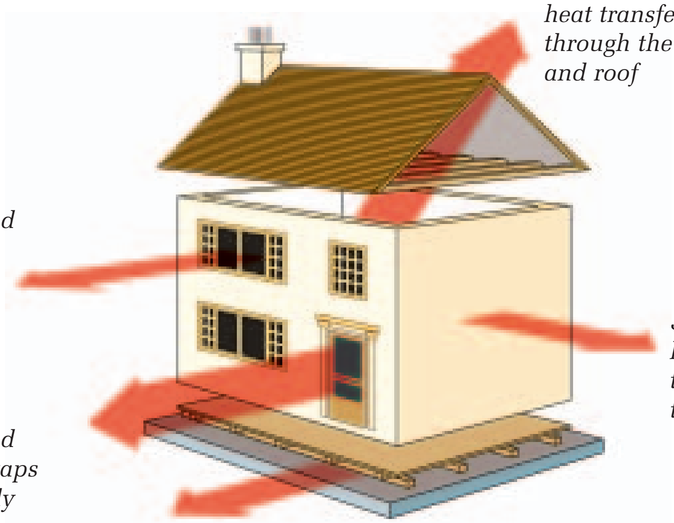


Figure 3.17 Where does wasteful heat transfer happen in this house? Why does it happen in these places? How would you reduce it?

Many people are involved in developing better insulators to help us keep our indoor environments at a comfortable "room temperature." A lot of research has gone into inventing windows, doors, siding, weather stripping, and insulation that are more efficient at reducing unnecessary heat loss. A system of rating the quality of these insulators has been developed to let consumers know how effective different products are. Every insulator is given a number called an **R-value**. The higher the R-value, the better the product is at providing insulation.

Problem Solving Activity

MARS MISSION

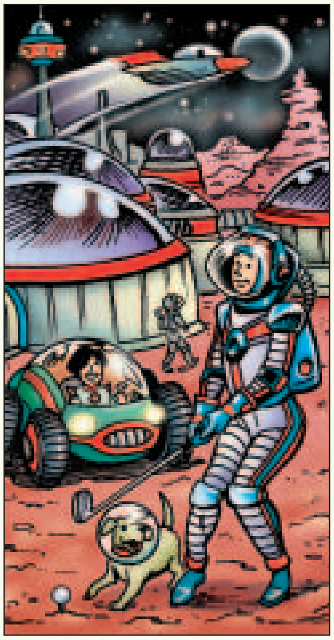


Figure 3.18 Living on Mars

Recognize a Need

It is expected that humans will land on the planet Mars in the first half of this century. The first colonists on Mars will need to deal with temperatures as low as −126°C. As well, they will live through windstorms of up to 300 km/h. How will they stay warm?

The Problem

Use what you have learned so far to design a home for these future colonists. If possible, use a computer-assisted drawing program (CAD) or other graphics program to help give your work a professional finish. Insulation should be a major feature in your design.

Criteria for Success

Your design should reflect what you have learned to this point in the unit. Your ideas for insulation materials should show your understanding of conductors and insulators. Keep in mind that the colonists will need to transport the building materials from Earth, so weight will need to be considered. Your design will not actually be built, but try to make it as workable as possible.

Brainstorm Ideas

1. Work with a partner or in a small group. Brainstorm ideas that would fit the criteria. All serious ideas should be considered.
2. Look for ways to blend the best of the group's ideas.

Design a Model

3. Use the computer to draft your design. If possible, use a three-dimensional design. Include a scale.

Test and Evaluate

4. How effectively would your design protect the colonists? How well is it insulated? How well does it show your understanding of heat and thermal energy? Make adjustments to improve your design.
5. How practical is your design? That is, could it really be workable on Mars?

Communicate

6. Share and compare your design with others in the class. You may wish to use a computer and/or a projector to enlarge your work. In your explanation, use your knowledge and the heat-related terms that you have learned to this point in the unit.

Check and Reflect

1. Describe the role of insulation in keeping the temperature of a building comfortable.
2. Explain the difference between insulators and conductors.
3. Update your mind map. Be sure that you understand the major ideas and the details of this section. Make a list of any questions that you have and share them with a partner. Work together to find the answers.
4. Your neighbour has been complaining about cold drafts coming in under his doors in winter. He wants you to help him minimize his heat loss. What materials do you think might make good insulators? Make a list. Use your list to create a chart comparing which insulator(s) would be best in this situation. What questions would you like to ask your neighbour before you give him your recommendation?

Experiment on Your Own

Design Challenge: Insulate It!

Before You Start ...

Review what you've learned about heat, conductors, and insulators. Now is an opportunity for you to apply that knowledge to stop or slow down an ice cube from melting.

Think about the strategies you would use.

The Question

How can you design and build a device to prevent an ice cube from melting?

Design and Conduct Your Experiment

1 Work by yourself or in a small group. What ideas do you have to solve the problem? Brainstorm a list of possibilities and then choose the best idea.

2 Create a plan for how you will build your device. Make sure to include a detailed sketch of your device and a list of the materials and equipment you will need. Have your teacher approve your plan before you start to build it.

3 Build your device. Test it. Do you need to make any changes to your device? Do so now. Retest your device if necessary.

4 Compare your device with those of your classmates. How successful were their devices?

Assess Your Learning

1. Describe three ways in which thermal energy is found in nature.
2. In your own words, explain how solar energy works. Why do you suppose that it is becoming a more popular choice for consumers?
3. How does a bimetallic strip work? How does it respond to temperature change?
4. Describe the heating system used in your home. Draw a diagram to illustrate your explanation. Identify which natural resources are used to make the heating system work.
5. Explain why we need to control heat and thermal energy in the everyday devices that we use. How do these devices control that heat and thermal energy? What are the dangers of not controlling them ?

Focus On SOCIAL AND ENVIRONMENTAL CONTEXT

In this section, we looked at how our needs as a society help shape the development of heat-related technology. Think back to the activities you did and what you learned in this section.

1. How have the science of heat and heat-related technologies contributed to our well-being?
2. At the end of this unit, you will work on a project to determine the best options for improving the energy efficiency of an old house. What did you learn in this section that you think could help you with your project?

Figure 3.19 What direction do you think the windows most likely face?

4.0 Technologies that use heat have benefits and costs to society and to the environment.

Key Concepts

In this section, you will learn about the following key concepts:

- heat energy needs and technologies
- thermal energy sources
- energy conservation

Learning Outcomes

When you have completed this section, you will be able to:

- identify different sources of heat and evaluate their possible impacts on the environment
- compare how much energy is used by different devices
- identify positive and negative consequences of energy uses
- describe examples of energy conservation

Earth Day is a day for celebrating nature and focussing attention on environmental issues.

Right now Canadians are using non-renewable resources at an increasing rate. In fact, 72% of our energy needs are met by using fossil fuels such as coal, oil, and natural gas. But what will happen when the supply runs out? Should we continue to rely on fossil fuels as such a major source of energy?

Deciding what heat technologies to use is a complicated decision. There are environmental, societal, and economic costs to consider. Achieving a balance among all three costs is not always easy. That's why choosing resources that are renewable is so important. Being able to sustain our energy resources is crucial to the future of the planet.

For Web links relating to 4.0, visit **www.pearsoned.ca/scienceinaction**

4.1 Looking at Different Sources of Heat

Natural resources come from the environment and are not human-made. There are two types of natural resources: renewable and non-renewable.

Renewable natural resources are those that can be replaced. The sun's energy is an example of a renewable resource. Even though we use it, it is constantly being replaced. Another example is wind energy.

Non-renewable natural resources cannot be replaced. They are limited. For example, minerals such as gold are non-renewable resources. Once they have been used up, no more is available. Fossil fuels—oil, natural gas, and coal—are also non-renewable resources. We rely on them for our heat and thermal energy needs and wants, but once they have been used, no more are available.

*info***BIT**

Nuclear Power

The energy stored in 1 kg of nuclear fuel contains nearly 3 000 000 times the energy that is in 1 kg of coal.

Figure 4.1 Burning fossil fuels pollutes the environment by releasing soot and ashes and gases such as carbon dioxide, carbon monoxide, sulfur dioxide, and nitrogen oxides.

Give it a **TRY** ACTIVITY

LOST!

Imagine being lost while hiking in the woods. You have only one sandwich, two cookies, and an apple to eat. Your only source of water is the juice in your water bottle. Knowing that you will probably be found by this time tomorrow, you sit down to make a plan. How will your food and water last until then? Should you just eat it all now and hope for the best? Or should you try to ration it? Sketch a quick cartoon to show how you would solve this problem. How do you think this story could be linked to the way we use our natural resources? How do you think your solution would change if you had another person lost with you who had no food?

Focus on Fossil Fuels

Fossil fuels formed from the remains of plants and animals that lived on Earth millions of years ago. Petroleum (oil) and natural gas are usually extracted from the ground by pumping. Coal is mined. All three are non-renewable resources.

Fossil fuels are used all over the world because they are fairly easy to obtain and transport. They have been available in large quantities and can be used for a variety of purposes. Most of our technology for transportation, heating, and electricity production is designed to use fossil fuels. Because of their widespread availability and technology, fossil fuels are generally cheaper to use than other energy sources.

In 1995, almost 60% of the world's energy needs were met by burning oil and natural gas. Coal provided another 30%. Alberta is rich in all three of these natural resources. Figure 4.2 shows how Canada's use of fossil fuels has increased over time and continues to increase.

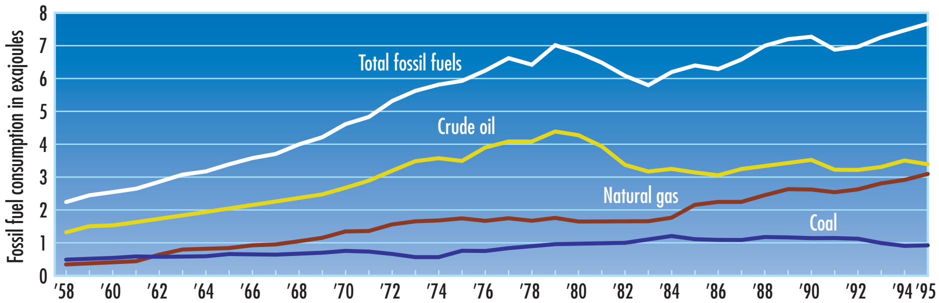


Figure 4.2 Canadian consumption of fossil fuel

Although fossil fuels are widely available today, they are non-renewable resources, so eventually they will be used up. As well, there are costs associated with their use today that should be considered when we compare them with other sources of energy.

Figure 4.3 Special technology is needed to drill below the ocean floor and to transport the oil and natural gas to shore.

Economic Costs

The costs in dollars of using fossil fuels are what we call the economic costs. The most obvious economic cost for you and your family is the cost of buying gasoline to put in your car or natural gas to heat your home. There are other economic costs that you don't see when you pay for your fuel. For example, the companies developing fossil fuel resources must pay the cost of drilling wells for oil and natural gas or mining coal. There are the costs of processing the fuels and transporting them to market (pipelines, trucks).

Some economic costs, such as anti-pollution technology in cars, are associated with the environmental costs you'll learn about below. Economic costs such as these are considered when the costs of developing and using fossil fuels are being analyzed. But there are other costs as well.

Environmental Costs

The negative effects on the environment of our using these fuels are called the *environmental costs* of fossil fuels. Most of these costs are the result of burning fossil fuels—in cars, trucks, and buses; in furnaces; and in electrical generating plants. When we burn these fuels, chemicals form that pollute the environment and contribute to global warming.

Air pollution caused by the burning of fossil fuels is a major problem in many cities. Gases such as sulfur dioxide and nitrogen oxides in the air are harmful to people's lungs. In earlier studies, you may have learned about acid rain. Rain falling through polluted air dissolves the sulfur dioxide in the air. Acid rain harms lakes and vegetation, as well as stone buildings and statues.

The environmental costs of fossil fuels can be reduced by improving technology. For example, car engines today are much less polluting than those of 20 years ago. Environmental costs can also be reduced by using less fossil fuel.

Societal Costs

The negative effects on people all together are the *societal costs* of using fossil fuels. Most of these costs are closely linked to environmental costs. For example, pollution in cities causes increased breathing problems for people. The cost to our health care system of treating these problems is a societal cost of using fossil fuels. Similarly, the cost of treating lakes that have been harmed by acid rain is a societal cost because we all have to pay for it. These are societal costs that we deal with right now.

A major concern in the longer term is how we deal with the effects of using up these non-renewable resources. Because fossil fuels are non-renewable, it makes sense to consider other sources of energy that can help us meet our thermal energy demands.

ALTERNATIVES FOR THERMAL ENERGY

In subsection 3.1, you learned about solar and geothermal energy. These natural sources of thermal energy can provide some of our thermal energy. Other technologies to provide thermal energy are also being used or could be used.

Wind Energy

Wind energy is the energy of moving air. It can be captured by windmills. In the past, windmills were used mainly to grind flour and pump water. You can still see small windmills on farms being used to pump water out of sloughs or dugouts. These simple windmills are inexpensive and practical. But the windmills used

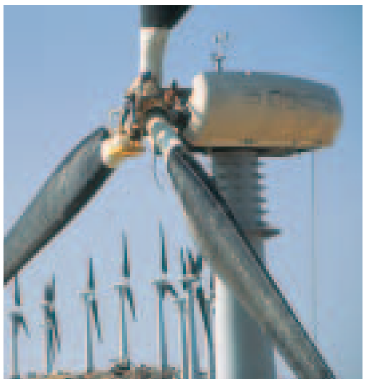


Figure 4.4 A windmill