

Heating and Cooling Systems

Canadians require heating systems to keep homes, schools, and other buildings comfortable during the winter. Many buildings are also equipped with cooling systems for the summer. Conventional heating systems use oil or natural gas as fuels, and air conditioners typically use electricity. In some cases, electric heaters are used for heating. Scientists and engineers are developing more affordable energy-efficient alternatives that Canadians can use for their heating and cooling needs.

Conventional Heating Systems

electrical heating system a system that uses electricity to produce thermal energy for heating

forced-air heating system a system that moves hot air to heat a building

hot water heating system a system that uses hot water to heat a building

All heating systems have a source of thermal energy, a means of transferring the energy from one place to another, and a device that controls the production and distribution of energy. Conventional heating systems use either electricity or fossil fuels as a source of thermal energy. **Electrical heating systems** generate thermal energy by allowing an electric current to pass through metal wires that have a high resistance to the current that passes through them. Similar wires are used in the elements of an electric stove and a toaster. The thermal energy is transferred throughout the building by convection. Fossil fuel systems generate thermal energy by burning fossil fuels such as oil or natural gas.

Some heating systems use the thermal energy to heat air while others use the thermal energy to heat water. A **forced-air heating system** uses a furnace to warm air to heat a building (**Figure 1**). In this system, the warm air passes through ducts that eventually reach vents located in the floor or ceiling. The warm air is transferred throughout the building by convection. As warm air enters a room through the vents, colder air is pushed through another set of ducts called the cold air return, providing more air for the furnace to heat. Fresh air is also brought into the system through an intake pipe out of the building. An exhaust system releases gases such as carbon dioxide. A **hot water heating system** uses a boiler to heat water to heat a building. The boiler uses electricity or burns fossil fuels to heat the water. The hot water is then pumped through pipes that eventually reach radiators located in various rooms of the building.

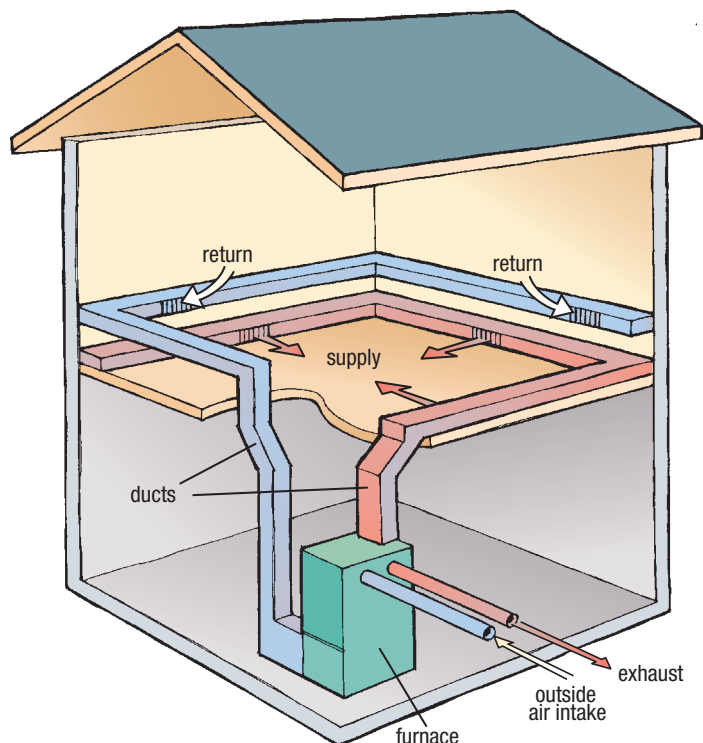


Figure 1 In a typical forced-air system, warm air from the furnace is supplied to each room through a network of ducts. A separate set of ducts returns cooler air to the furnace and brings in fresh air from outside to the furnace for heating.

Conventional Cooling Systems

The physics of conventional air conditioners, refrigerators, and freezers is very similar. All of these appliances use the evaporation of a liquid to absorb thermal energy from air. First, a compressor puts a special type of gas, called a refrigerant, under pressure. Whenever a gas is compressed, its temperature increases. The warm refrigerant gas runs through a coil of tubes, where it starts to release some of its thermal energy. As the refrigerant cools, it changes into a liquid. The liquid refrigerant then passes through an expansion valve, moving from a high-pressure area to a low-pressure area. At this point, the liquid refrigerant absorbs thermal energy from the surrounding air and evaporates back into a gas. The surrounding air cools down as a result. The compressor of an air conditioner gets very warm, so air conditioning units are installed outside the building, where the thermal energy can be released into the external environment.

In a refrigerator or freezer, the same type of compressor and coil system is used (**Figure 2**). The only difference is that the cooled air is produced in the refrigerator or freezer and the warm air is released into the external environment. 🌍

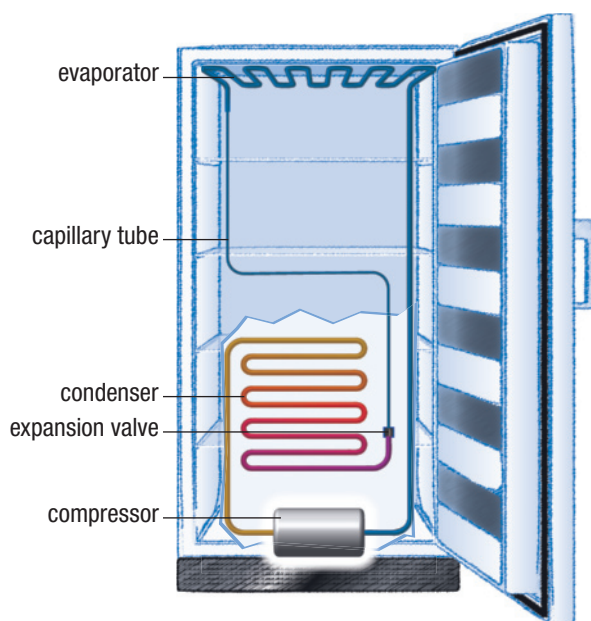


Figure 2 The compressor in a refrigerator puts the refrigerant under pressure to change it into a liquid. When the refrigerant moves through the expansion valve, the pressure decreases and the liquid evaporates as it passes through the evaporator, removing thermal energy from the air.

Controlling Heating and Cooling Systems

Both heating and cooling systems contain a thermostat to sense the temperature of the environment and turn the furnace or air conditioner on or off accordingly. Conventional thermostats contain a coiled bimetallic strip and a mercury switch (**Figure 3**). A bimetallic strip consists of two types of metal bonded together back to back. Due to the different types of metals, the two sides of the strip expand and contract at different rates when heated or cooled. Expansion and contraction make the coil tighten and loosen as the temperature of the house fluctuates. On top of the bimetallic strip is the mercury switch. Mercury is a liquid metal that flows like water and also conducts electricity. When the bimetallic strip coil changes shape again, the mercury switch tilts and the mercury moves inside. When the temperature in the building is above or below the temperature that an operator has set on the thermostat, the switch tilts in one direction and causes the mercury to touch two bare wires. This creates a closed circuit and turns the furnace or air conditioner on. As the environment warms up or cools down, the bimetallic coil changes shape again. This causes the switch to tilt in the opposite direction, moving the mercury away from the circuit wires. This opens the circuit and turns the furnace or air conditioner off.

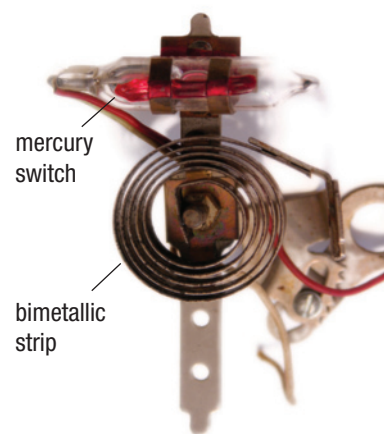


Figure 3 A bimetallic strip is curled into a coil so it winds up or unwinds as the temperature changes, resulting in the tilting of the mercury switch on the top.

CAREER LINK

HVAC (heating, ventilation, air conditioning) engineers and technicians design and maintain the heating and cooling systems of buildings. To learn more,



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Geothermal Systems: An Alternative Method of Heating and Cooling

The most popular methods of heating involve the burning of fossil fuels. This burning results in the release of greenhouse gases, such as carbon dioxide, into the atmosphere, contributing to global warming. The refrigerants used in cooling systems are also greenhouse gases and contribute to global warming when they leak into the environment. Some refrigerants also damage the ozone layer, a layer of ozone gas in the upper atmosphere that helps reduce the amount of ultraviolet radiation from the Sun that reaches Earth's surface. Damage to the ozone layer contributes to increases in skin cancer caused by excess ultraviolet radiation. To reduce production of greenhouse gases and protect the ozone layer, alternative forms of heating and cooling are being developed. Several alternatives were introduced in Chapter 5. One of the newest heating and cooling technologies makes use of the thermal energy contained within Earth's crust. **Geothermal systems** use heat pumps to transfer Earth's natural thermal energy for heating and cooling.

geothermal system a system that transfers thermal energy from under Earth's surface into a building to heat it, and transfers thermal energy from the building into the ground to cool the building

Temperatures at a depth of 3 m below the ground remain fairly steady throughout the year. Depending on the latitude, the actual ground temperature can vary. In Ottawa, the temperature remains at about 9 °C, which might seem cold, but it can still be used to heat a building in the winter.

During the winter, the temperature below the ground is higher than the temperature above the ground. In a geothermal system, a liquid antifreeze–water mixture is pumped through a network of plastic pipe that is placed a few metres underground. As the antifreeze–water mixture is pumped through the pipes, the thermal energy from the ground is transferred to the walls of the pipe by conduction and then transferred from the pipe to the liquid by convection. The liquid is then pumped into a heat pump located inside the building, which then transfers the thermal energy from the liquid to the air inside the building (**Figure 4(a)**).

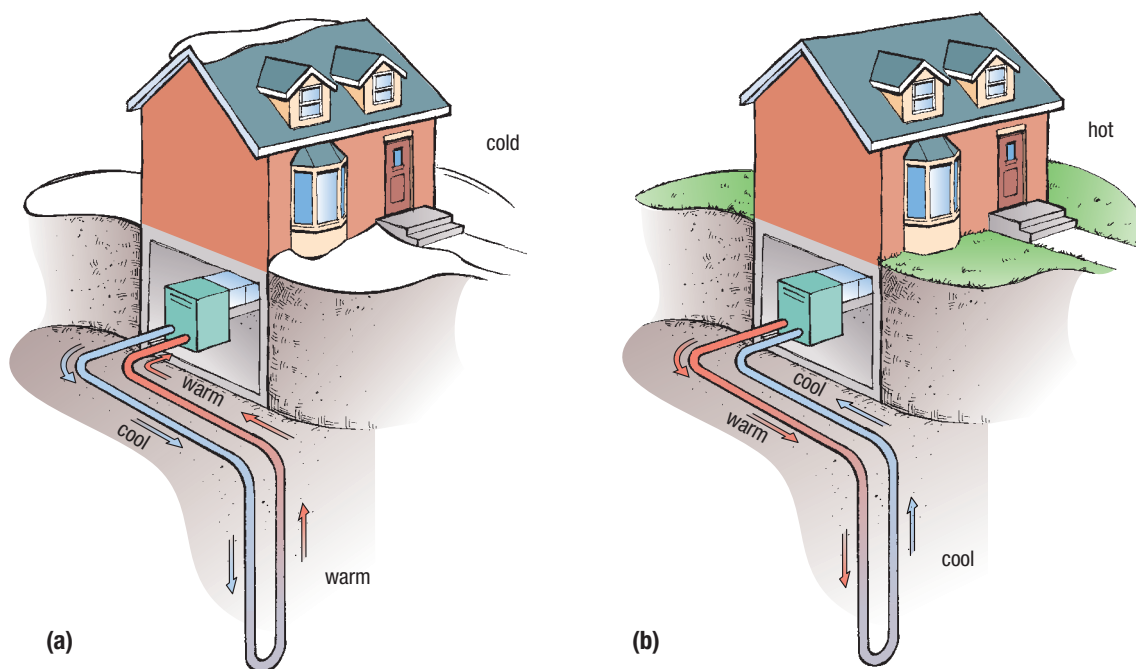


Figure 4 (a) In a geothermal system, thermal energy from below the ground is transferred to a heating system inside a building during the winter, heating the building. (b) During the summer, thermal energy is transferred from the building to the ground outside, cooling the building.

Inside the heat pump, a liquid refrigerant is pumped through a series of coils. Thermal energy is transferred from the antifreeze–water mixture to the refrigerant, changing the refrigerant into a gas. The gas moves through another set of coils where the pressure is increased. As the pressure of the gas increases, its temperature also increases. Air blows over the coils containing the hot refrigerant gas, and the hot air is distributed through ducts to warm the building.

During the summer, the heat pump process is reversed. Hot air from the house is pumped over the refrigerant, causing it to warm up. The refrigerant then transfers its thermal energy to the antifreeze–water mixture so that the mixture warms up. Since it is cooler underground than above ground during the summer, the thermal energy is transferred from the antifreeze–water mixture to the ground by conduction (**Figure 4(b)**).

6.5 Summary

- All heating systems have a source of thermal energy, a means of transferring the energy, and a thermostat to control the production and distribution of energy. Conventional heating systems use either electricity or fossil fuels as a source of thermal energy.
- Conventional cooling systems use the evaporation of pressurized refrigerants to absorb thermal energy from the air, resulting in cool air that can then be blown through a duct system.
- A typical thermostat uses a bimetallic strip and a mercury switch to turn a heating or cooling system on or off as temperatures change.
- Conventional heating and cooling systems produce greenhouse gases such as carbon dioxide, so they are not considered environmentally friendly.
- Geothermal systems use Earth’s natural thermal energy for heating and cooling purposes. In the winter thermal energy is transferred from below Earth’s surface into a building to heat it. In the summer, thermal energy is transferred from a building into Earth’s surface to cool it.

UNIT TASK BOOKMARK

You can apply what you have learned about heating and cooling systems to the Unit Task on page 360.

6.5 Questions

1. Forced-air heating systems are found in most homes. Brainstorm reasons why they are so popular. **K/U A**
2. Refrigerants used in air conditioners and refrigerators can be a type of chlorofluorocarbon, or CFC. Research other uses for CFCs. **A**
3. Research programmable thermostats and smart thermostats. How do these thermostats work? Why are these thermostats environmentally friendly? **A**
4. Why can a geothermal system be used as both a heating system and a cooling system? **K/U**
5. Create a flow chart or other graphic organizer summarizing the process of heating and cooling using geothermal energy. **K/U A**
6. The specific heat capacity of water is much greater than that for air. **T/I C A**
 - (a) Research the specific heat capacity value for air. **A**
 - (b) Perform research to compare the efficiency of a typical new forced-air furnace for a home with that of a new hot water boiler. **A**
 - (c) Based on your research, comment on which heating system would be more effective, a forced-air system or a hot water system.



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