Key Terms

base load
hydroelectric power generation
intermediate load
peak load
renewable energy source
non-renewable energy source

12.3 Meeting the Demand for Electricity

A great deal of planning is required to make sure that Ontario has the ability to provide electricity now, and will continue to be able to in the future. About 10 to 20 years are needed to plan and build a generating station. During this time, existing plants need to be upgraded or replaced.

Meeting the Minimum Demand

Ontario must plan carefully to ensure that the daily demand for electricity is matched by the supply. During the early hours of the morning, when most people are asleep and many businesses are not operating, a minimum amount of electrical power is generated **(Figure 12.17)**. In Ontario, this minimum amount is about 12 000 MW. 1 MW = 1 megawatt = 10^6 W. The continuous minimum demand for electrical power is called the **base load**. In this context, the term load refers to the demand for electrical power. To meet the base load demand, large reliable generators are used because their turbines can be run using the least expensive fuel. Off-peak prices are charged when base load generators can meet the demand for electricity. In Ontario, the base load is generated mainly by hydroelectric and nuclear generating stations, but also by some coal-fired generating stations.

base load the continuous minimum demand for electrical power

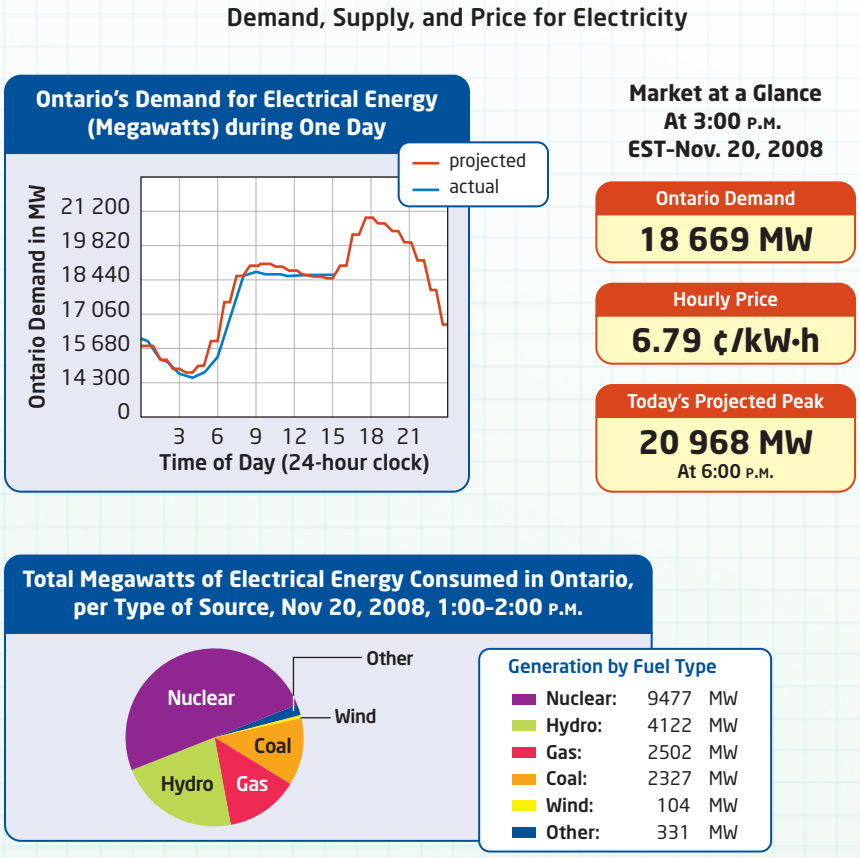


Figure 12.17 In Ontario, the Independent Electricity System Operator (IESO) manages the generation, transmission, and distribution of electricity. The graph shows the demand for electricity at different times on a particular day. The chart shows how much electrical power was supplied by various sources.

Hydroelectric Power Generation

hydroelectric power generation the generation of electrical power using a source of moving water

Hydroelectric power generation relies on a large source of water to provide the energy needed to turn turbines. There are two types of hydroelectric plants: dam stations and run-of-river stations. At a dam station, water that falls between different levels is used to turn turbines. At a run-of-river station, water that is flowing in a river is used. The generating stations at Niagara Falls are run-of-river stations. **Figure 12.18** shows a dam station.

Advantages and Disadvantages of Hydroelectric Power

renewable energy source a source of energy that can be replaced in a relatively short period of time

non-renewable energy source a source of energy that cannot be replaced as quickly as it is used

Hydroelectric generating stations have a number of advantages. There are no combustion emissions and no fuel costs. Once constructed, a hydroelectric station has very low operating costs. The process is about 90 percent efficient because there are almost no heat transformations, which waste useful energy. In comparison, a generating station that burns fossil fuels (coal, oil, or natural gas) is about 30 percent efficient. In addition, hydroelectric generators can be brought on line quickly, which makes them useful for peak-load generation. Hydroelectric energy is a **renewable energy source**. This is a source of energy that can be renewed in a relatively short period of time. A **non-renewable energy source**, such as fossil fuels, cannot be renewed as quickly as it is used up.

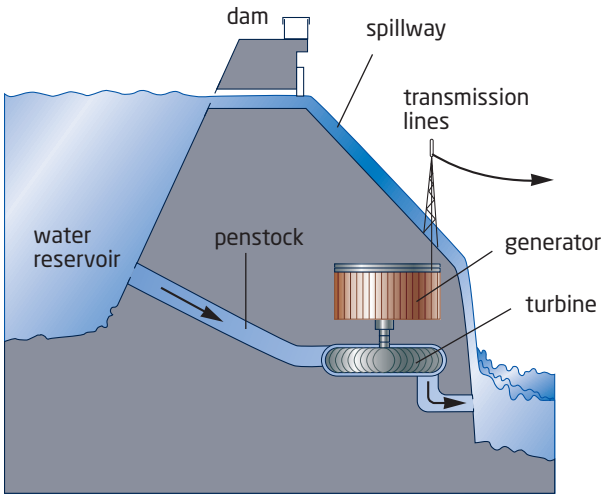


Figure 12.18 The turbine and generator transform the energy of moving water into electrical energy.

Go to **scienceontario** to find out more

Disadvantages of Hydroelectric Power

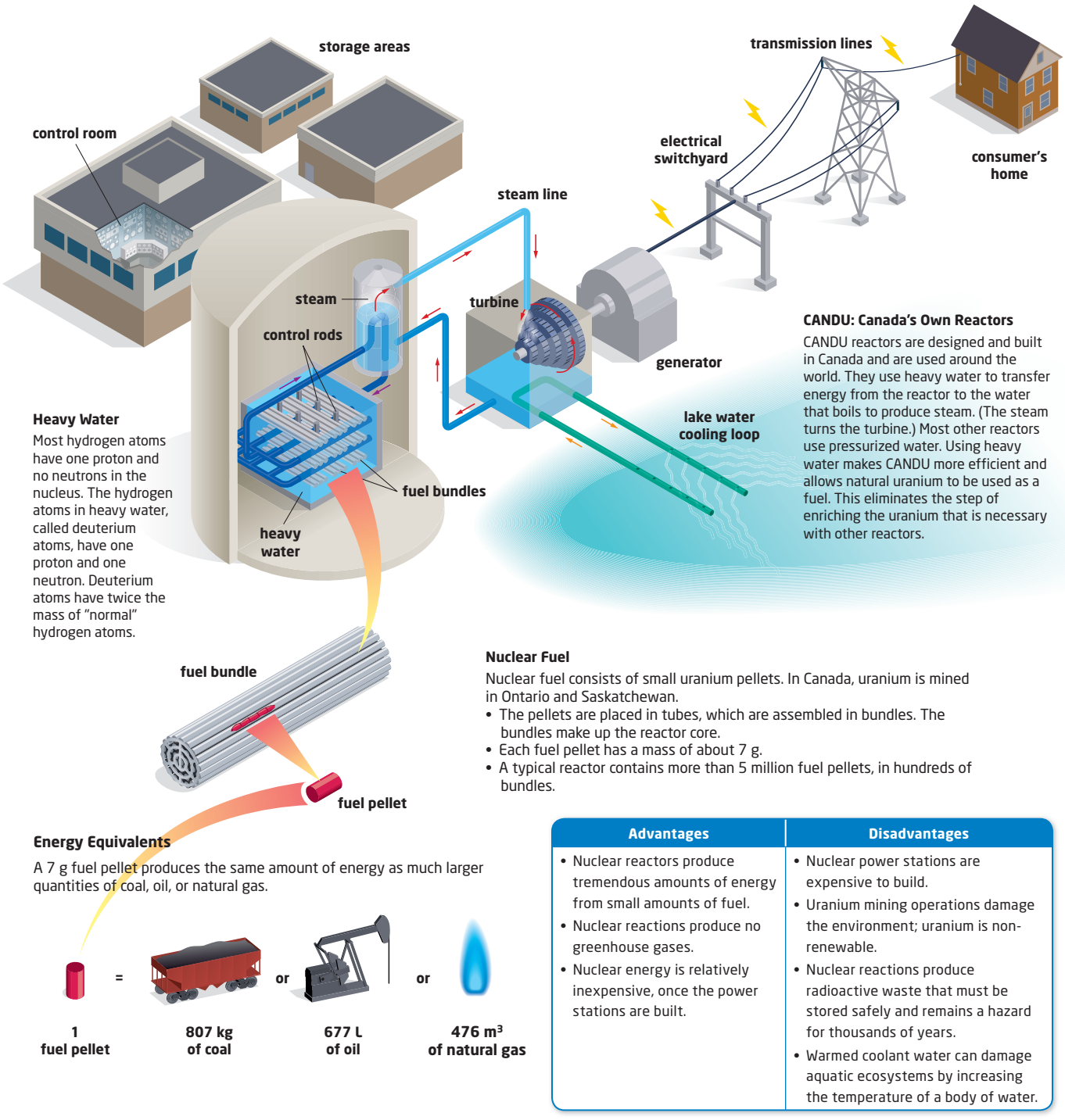
Hydroelectric stations also have disadvantages. When reservoirs are built to store water in dams, large areas of land must be flooded. For example, the La Grande Phase 1 portion of the James Bay hydroelectric project in Québec covers 11 400 km^2, which includes 9700 km^2 of flooded land that had been home to the Cree people. Another disadvantage is that when land is flooded, the submerged vegetation decays. This can lead to the production of methane, a potent greenhouse gas. Mercury, a toxic metal, is released from the soil and vegetation and is taken up by whatever fish manage to survive.

Sense of Value

Ontario currently has over 60 hydroelectric generating stations, which have the capacity to supply 21 percent of the province's demand for electricity. There are very few remaining sites, where new hydroelectric stations could be built.

Generation from Nuclear Fuel

About 51 percent of Ontario's capacity to generate electricity comes from three nuclear stations. The heat from nuclear reactions generates steam, which turns turbines that are connected to generators. **Figure 12.19** shows the components of a nuclear generating station. Because nuclear energy is relatively inexpensive, it is suitable for meeting base load demand.



Heavy Water

Most hydrogen atoms have one proton and no neutrons in the nucleus. The hydrogen atoms in heavy water, called deuterium atoms, have one proton and one neutron. Deuterium atoms have twice the mass of "normal" hydrogen atoms.

CANDU: Canada's Own Reactors

CANDU reactors are designed and built in Canada and are used around the world. They use heavy water to transfer energy from the reactor to the water that boils to produce steam. (The steam turns the turbine.) Most other reactors use pressurized water. Using heavy water makes CANDU more efficient and allows natural uranium to be used as a fuel. This eliminates the step of enriching the uranium that is necessary with other reactors.

Nuclear Fuel

Nuclear fuel consists of small uranium pellets. In Canada, uranium is mined in Ontario and Saskatchewan.

- The pellets are placed in tubes, which are assembled in bundles. The bundles make up the reactor core.
- Each fuel pellet has a mass of about 7 g.
- A typical reactor contains more than 5 million fuel pellets, in hundreds of bundles.

Energy Equivalents

A 7 g fuel pellet produces the same amount of energy as much larger quantities of coal, oil, or natural gas.

Advantages	Disadvantages
• Nuclear reactors produce tremendous amounts of energy from small amounts of fuel. • Nuclear reactions produce no greenhouse gases. • Nuclear energy is relatively inexpensive, once the power stations are built.	• Nuclear power stations are expensive to build. • Uranium mining operations damage the environment; uranium is non-renewable. • Nuclear reactions produce radioactive waste that must be stored safely and remains a hazard for thousands of years. • Warmed coolant water can damage aquatic ecosystems by increasing the temperature of a body of water.

Figure 12.19 In Canada, all active nuclear reactors are CANDU (Canada Deuterium Uranium) reactors. They are located in Ontario, Québec, and New Brunswick. The ones in Ontario are in Tiverton, Newcastle Township, and Pickering.

Meeting Intermediate and Peak Demand

Although nuclear energy is very useful for supplying base load, nuclear reactors cannot be turned on and off quickly. How is power generated as thousands of people wake up, turn on lights, and prepare breakfast?

Generators are designed to provide an alternating current that goes through 60 cycles every second. As electrical demand increases, the generators slow down. To keep the alternating current close to 60 cycles per second, more generators are brought on line. The reverse process happens when the demand for electricity begins to fall. Thus, to meet intermediate and peak loads, smaller generators that are capable of coming on line quickly are used. **Intermediate load**, between roughly 15 000 MW and 20 000 MW, is met by generating stations that burn fossil fuels. The increased fuel costs are passed along to consumers as mid-peak rates. **Peak load**, above 20 000 MW, is met by using hydroelectric and gas turbines, which can be turned on and off quickly. Again, the cost of providing electricity increases, especially if the electricity must be purchased from outside Ontario. Thus, the higher on-peak rates apply.

intermediate load a demand for electricity that is greater than the base load and is met by burning coal and natural gas

peak load the greatest demand for electricity, which is met by using hydroelectric power and natural gas

Power Generation from Coal

In a coal-burning generating station, as shown in **Figure 12.20**, the heat from the burning coal is used to boil water, which circulates in tubing in a boiler. The steam turns the blades of turbines, which are connected to generators. Most of the energy of the fossil fuel is converted to heat rather than to the turbine motion as the fuel burns and the water boils.

Advantages and Disadvantages of Power Generation from Coal

On the plus side, there are large known reserves of coal. In addition, the economic costs of generating electrical energy from coal are very low. However, the conversion of energy from coal to electricity is very inefficient. Burning coal produces gases that contribute to acid rain, particulates, and other emissions, including carbon dioxide, a greenhouse gas. And coal is non-renewable, meaning that eventually, supplies will run out. Reliance on coal can be decreased if people shift more of their use of electricity to off-peak hours, when most power generation does not require fossil fuels.

Sense of place

Nanticoke generating station, located on the north shore of Lake Erie in Haldimand County, is the largest coal-burning generating station in North America. This station has a generating capacity of 4000 MW and burns crushed coal. It is the single largest source of carbon dioxide in North America.

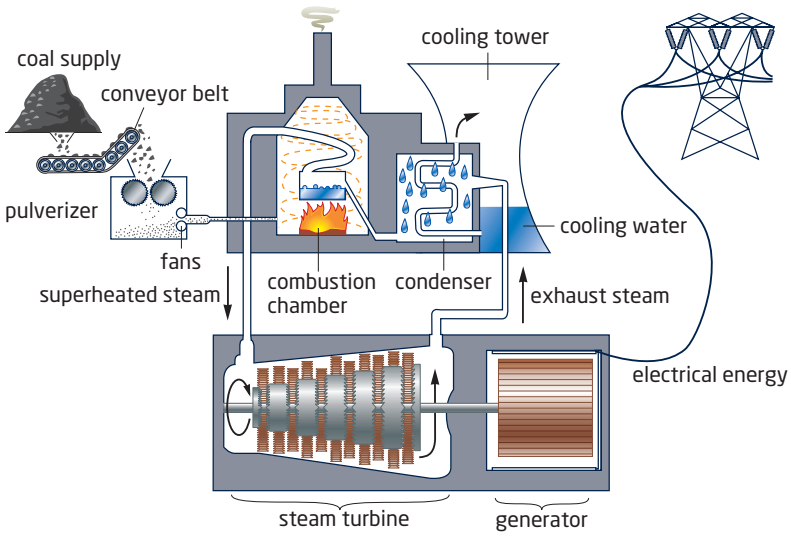


Figure 12.20 Ontario has five generating stations that burn fossil fuels. These stations use coal or natural gas to heat water into steam.

Section 12.3 Review

Section Summary

- Base load is the continuous minimum demand for electrical power. It is met by using large generators that run on the least expensive fuels.
- Intermediate load and peak load are met by using smaller generators that can be turned on and off quickly.
- Ontario obtains most of its electrical energy from nuclear, hydroelectric, and fossil fuel-burning stations.
- The rate that is charged for electricity changes when the cost of the fuel that is used to generate the electricity changes.

Review Questions

K/U **1.** The demand for electricity varies at different times.

a. What is base load?

b. Why does only base load need to be supplied on holidays and weekends?

K/U **2.** Explain why hydroelectric generating stations can be used to supply both base load and peak load.

T/I **3.** Uranium is mined at the Elliot Lake mine in Ontario, which is shown on the right. It is also mined in Saskatchewan, but there are no nuclear power stations there. Suggest a possible reason for this.

About one quarter of the world's supply of uranium comes from Ontario mines. The operation shown here is in Elliot Lake.

K/U **4.** Examine the data in **Figure 12.17**. Calculate the contribution of each fuel type as a percentage of the total.

A **5.** In general, electricity must be used as it is generated. Hydroelectric stations can pump water into a dam reservoir when the demand is off-peak. Suggest a reason for doing this.

T/I **6.** The sources of electricity that are used have an effect on the overall environmental impact.

a. Once constructed, which type of generating station has the least effect on the environment? Explain.

b. Which type has the greatest effect on the environment, after it is constructed? Explain.

A **7.** If hybrid and electric cars become more popular, which type of load demand is likely to increase the most? Explain your answer.

T/I **8.** Use the data given in **Figures 12.13** and **12.17** to estimate the mid-peak demand for electricity.