

Photographs of large cities, such as Seattle, Washington, are visible reminders of how much people rely on electrical energy.



## Generating Electric Current



**How is voltage induced in a conductor?**



**According to Faraday's law, a voltage is induced in a conductor by a changing magnetic field.**

## Generating Electric Current

A magnetic field can be used to produce an electric current.

- **Electromagnetic induction** is the process of generating a current by moving an electrical conductor relative to a magnetic field.
- Changing the magnetic field through a coil of wire induces a voltage in the coil.
- A current results if the coil is part of a complete circuit.

## Generating Electric Current

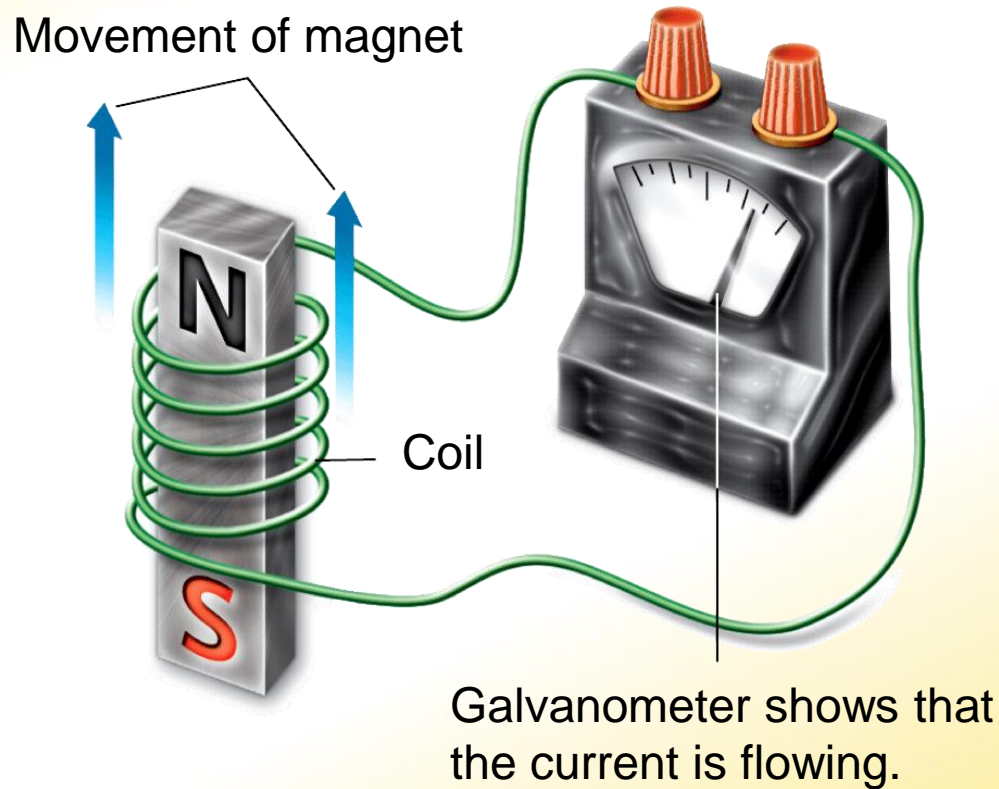
When a magnet is placed inside a coil of wire attached to a galvanometer, the galvanometer will detect no current if the magnet is not moving.

If the magnet is quickly moved out of the coil, the current flows briefly and then immediately drops back to zero.

Moving the magnet in and out of the coil causes an electric current first in one direction and then in the other.

## Generating Electric Current

According to Faraday's law, the moving magnetic field induces a current in the coil.



## Generators



**Name two types of generators.**



**The two types of generators are AC generators and DC generators.**

## Generators

Most of the electrical energy used in homes and businesses is produced at large power plants using generators.

- A **generator** is a device that converts mechanical energy into electrical energy by rotating a coil of wire in a magnetic field.
- Electric current is generated by the relative motion of a conducting coil in a magnetic field.

## Generators

### AC Generators

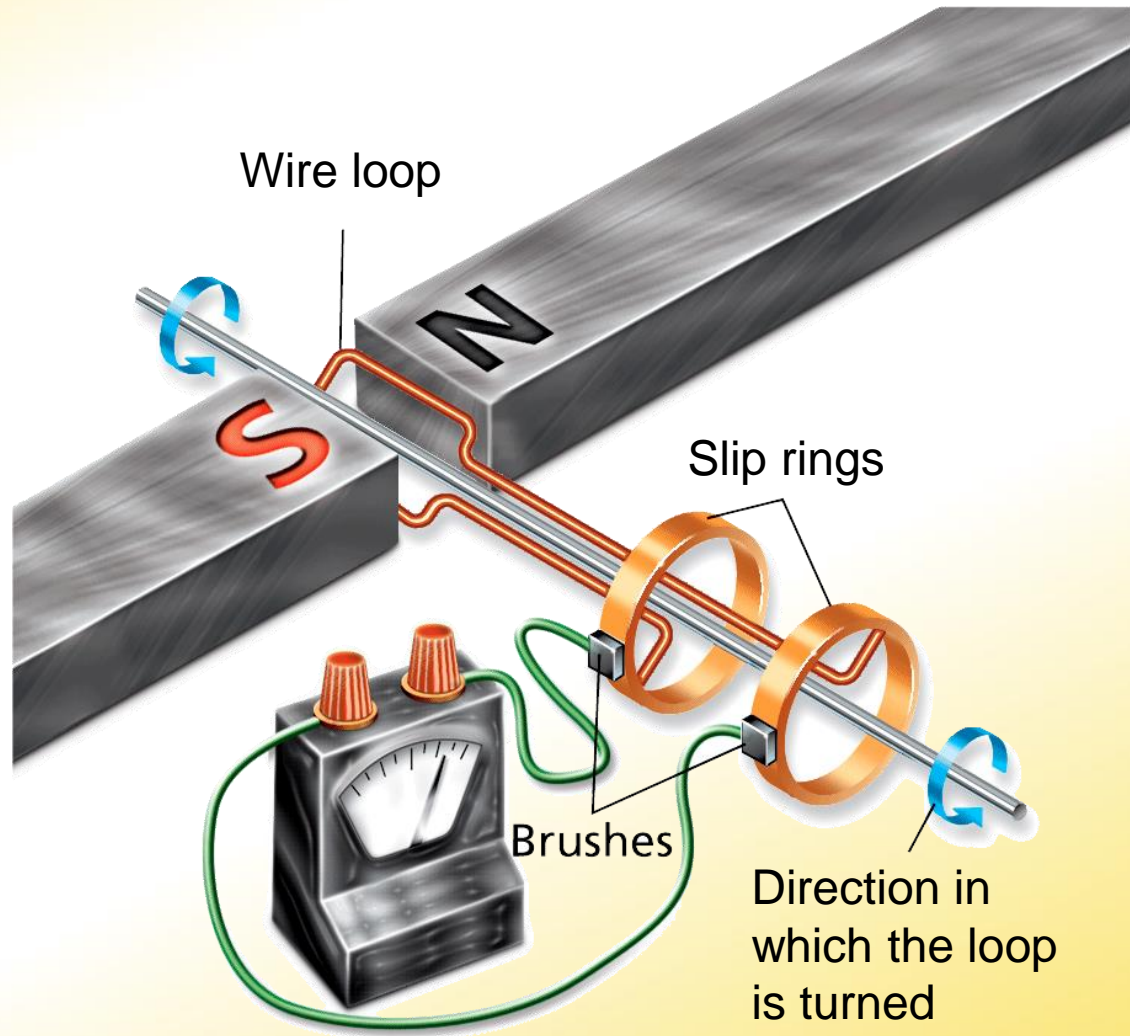
An AC generator produces alternating current, in which charges flow first in one direction and then in the other direction.

The generator looks very similar to an electric motor. While a motor converts electrical energy into mechanical energy, a generator does the opposite.



## Generators

In a simple AC generator, an external force rotates the loop of wire in the magnetic field. This induces a current in the wire.



## Generators

A wire coil in the generator is attached to metal bands called slip rings.

- The slip rings are in contact with metal brushes that are in turn attached to a circuit.
- As the loop of wire is rotated, the magnetic field induces a current in the wire, which reverses direction every half rotation.

## Generators

Small generators provide power in areas that are not served by power companies or provide electrical energy during a power outage.



## Generators

### DC Generators

A DC generator produces a direct current.

- Its design is very much like the design of an AC generator except that a commutator replaces the slip rings.
- As opposite sides of the commutator touch the brush, the current that leaves the generator flows in only one direction.

## Transformers



**How can a transformer change voltage and current?**

A **transformer** is a device that increases or decreases the voltage and current of two linked AC circuits.



**A transformer changes voltage and current by inducing a changing magnetic field in one coil. This changing field then induces an alternating current in a nearby coil with a different number of turns.**

## Transformers

Electrical energy from power plants is transmitted through power lines at voltages too high to be used safely in homes.

The voltage must be changed, or transformed. A series of transformers changes high-voltage current in power lines into 240-volt current.

## Transformers

### Why Transformers Are Needed

- Early power plants used DC generators because the power plants were close to the customers.
- Over long distances, the resistance of transmission wires causes large losses of power, which can be reduced by using lower current and higher voltage.
- Only AC voltage and current can be transformed.

## Transformers

### Changing Voltage and Current

A transformer has two sets of coils wrapped around a ring-shaped iron core.

- When there is an alternating current in the primary coil, the current creates a changing magnetic field in the iron core.
- Because the iron core is also inside the secondary coil, the changing field induces an alternating current in the secondary coil.



## Transformers

The number of turns in the primary and secondary coils determines the voltage and current.

- To calculate the voltage, divide the number of turns in the secondary coil by the number of turns in the primary coil.
- The result is the ratio of the output voltage to the input voltage.

## Transformers

Transformers are very efficient because very little energy is lost as heat.

- Assuming 100% efficiency, the power ( $I \times V$ ) must be the same in the primary and secondary coils.
- If voltage increases in the secondary coil, the current must decrease in the same ratio.

## Transformers

### Types of Transformers

A step-down transformer decreases voltage and increases current.

If the primary coil has 400 turns, the secondary coil has 100 turns, and the input voltage in the primary coil is 120 volts, then the output voltage is reduced to 30 volts.

## Transformers

A step-up transformer increases voltage and decreases current.

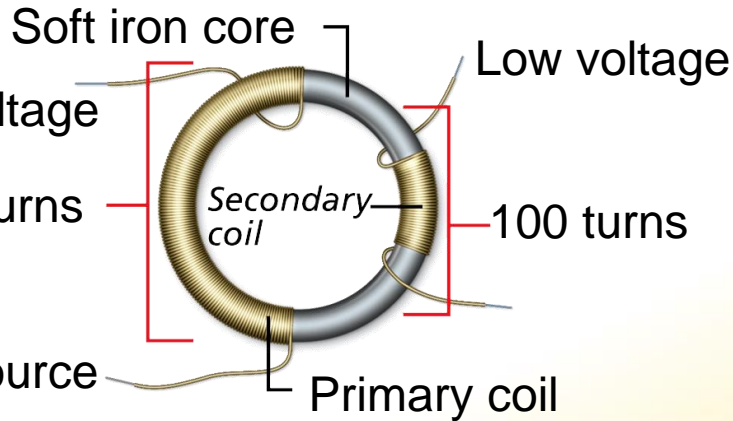
If the primary coil has 100 turns, the secondary coil has 400 turns, and the input voltage is 20 volts, the output voltage is 80 volts.

# Transformers

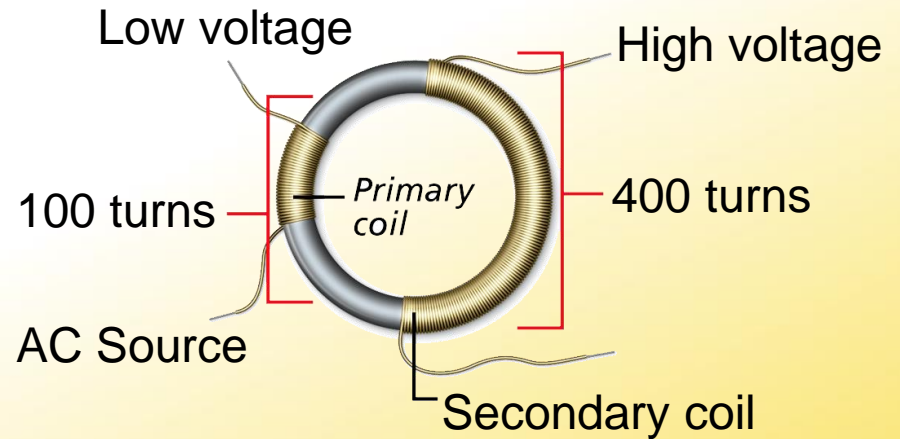
Transformers, such as those at substations of power plants, change voltage.



**A** Step-down Transformer



**B** Step-up Transformer



## Electrical Energy for Your Home



**What are some sources of electrical energy in the United States?**



**Most of the electrical energy generated in the United States is produced using coal as an energy source. Some other sources are water (hydroelectric), nuclear energy, wind, natural gas, and petroleum.**

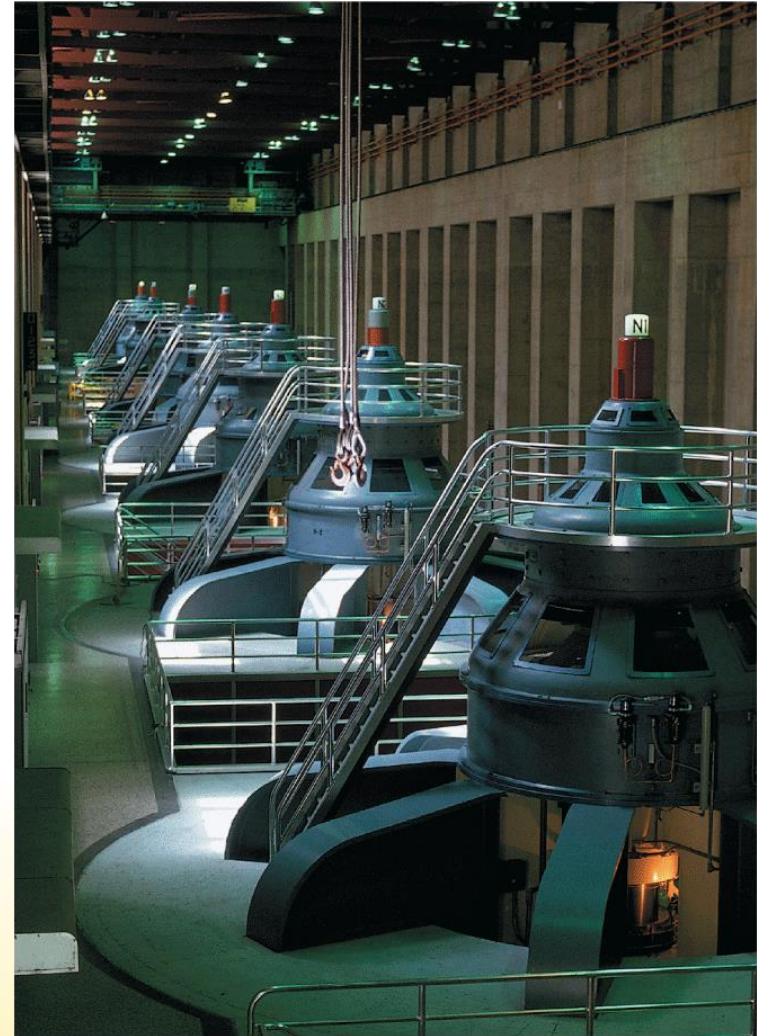
## Electrical Energy for Your Home

A **turbine** is a device with fanlike blades that turn when pushed, for example, by water or steam.

- Burning fossil fuels or nuclear reactions can heat water to produce steam that spins a turbine.
- Water from a reservoir behind a dam can also turn a turbine.
- To produce electrical energy, the turbine may turn the coils of a generator, or it may spin magnets around the coils of wire.

## Electrical Energy for Your Home

A turbine turns the magnet inside the coil of a generator.





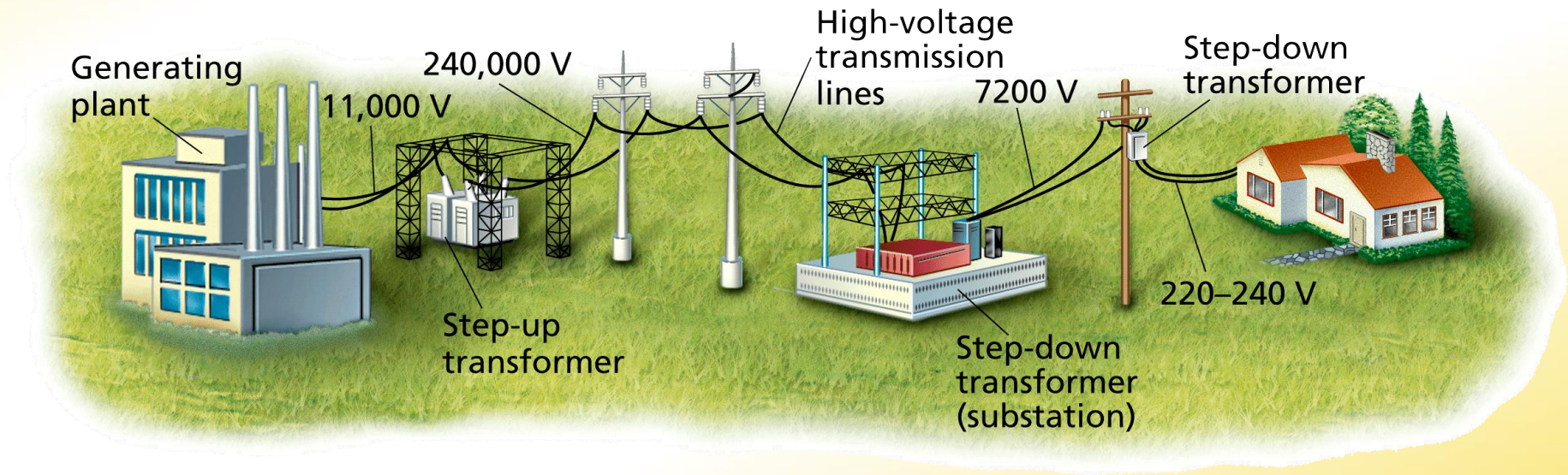
## Electrical Energy for Your Home

A power plant transmits electrical energy at hundreds of thousands of volts.

- After the current passes travels through high-voltage transmission lines, the voltage is stepped down at a substation, to a few thousand volts.
- The electrical energy is then distributed and stepped down to between 220 and 240 volts.
- Appliances like an electric stove use 240-volt circuits. Most other appliances in the home use 120 volts.

## Electrical Energy for Your Home

Voltage is increased for long-distance transmission and then decreased near homes, schools, and businesses.



## Assessment Questions

1. In a DC generator, the commutator
  - a. generates an electric current.
  - b. converts an alternating current to a direct current.
  - c. reduces the voltage.
  - d. reverses the direction of the direct current.

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  - a. generates an electric current.
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ANS: B

## Assessment Questions

2. A transformer has 400 turns on the primary coil and 1600 turns on the secondary coil. What is the output voltage if the input is 1,000 volts?
- a. 250 V
  - b. 500 V
  - c. 2,000 V
  - d. 4,000 V

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ANS: D

## Assessment Questions

3. Which property would you want to increase in transmitting electrical energy as efficiently as possible over long distances?
- a. current
  - b. voltage
  - c. resistance
  - d. insulation

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ANS: B



## Assessment Questions

1. In electromagnetic induction, an electric current is induced by the motion of a magnet relative to a magnetic field.

True

False

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True

False

ANS: F, conductor