3.16

Efficiency and Electrical Devices

Why does one battery-powered radio (**Figure 1**) continue to play long after another's batteries have run down? The answer is that the efficiency of each radio is different. The **efficiency** refers to how well the electrical energy is changed to useful energy by the electrical device. Assuming that the batteries were the same, we can infer that one radio is more efficient than the other.

The conversions of electrical energy to useful energy are never 100% efficient. Some of the energy is converted into useful energy but some of it is always converted into other forms, in many cases, heat energy. The total energy that comes out of an electrical device is always equal to the energy that goes in. It's just that what comes out may be in more than one form. For example, if we say that an electric motor has an efficiency of 80%, we mean that 80% of the input energy of the energy is converted into useful mechanical energy. The other 20% is probably lost as heat energy. A light bulb has an efficiency of only about 5%. That mean that 5% of the electrical energy that goes into the bulb is converted into useful light energy and 95% of the energy is released as heat energy (**Figure 2**).

The efficiency of an electrical device may be affected by the following factors:

- resistance to current flow
- distance the current flows
- friction
- materials used in the circuit

Figure 1

Not all electrical devices are equally efficient.

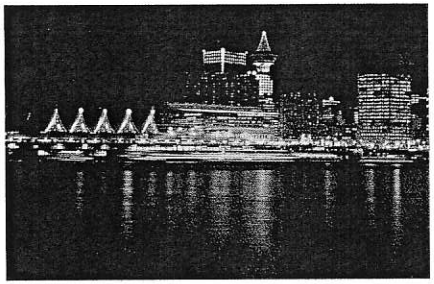

Figure 2

A small percentage of the energy put into lighting this boat is actually converted into light. Most is lost as heat.

Determining the Efficiency of an Electrical Device

The energy that goes into an electrical circuit is called the **energy input**. The energy that is produced by the electrical device, as light, sound, heat, or mechanical energy, is called the **useful energy output**. The efficiency of any energy conversion is calculated by using the formula in **Figure 3**. Efficiency is often expressed as a percentage, which is simply the efficiency multiplied by 100%.

$$\text{Efficiency} = \frac{\text{Useful energy output}}{\text{Energy input}}$$

$$\text{Percent efficiency} = \frac{\text{Useful energy output}}{\text{Energy input}} \times 100\%$$

Figure 3

Calculating the percent efficiency of a device

Sample Problem

Determine the percent efficiency of a 60-W fluorescent light bulb that uses 2000 J of electrical energy to produce 400 J of light energy. (A **joule** is the SI unit for measuring energy, and its symbol is **J**.)

Data:

Energy input = 2000 J
Useful energy output = 400 J
Percent efficiency = ?

Equation:

$$\text{Percent efficiency} = \frac{\text{Useful energy output}}{\text{Energy input}} \times 100\%$$

Solution:

$$\text{Percent efficiency} = \frac{400\ \text{J}}{2000\ \text{J}} \times 100\%$$

Percent efficiency = 20%

Statement:

The percent efficiency of a 60-W fluorescent light bulb is 20%.

Understanding Concepts

1. Explain why energy conversions can never be 100% efficient.
2. What is the difference between input energy and useful output energy?
3. Calculate the percent efficiency of an electric motor that uses 15 000 J of energy to produce 11 500 J of useful energy.
4. Calculate the percent efficiency of an incandescent light bulb that produces 2500 J of light energy from 50 000 J of electrical energy.

Making Connections

5. Why do you think it is important to be able to calculate percent efficiency?
6. Provide one example each of useful output energy using **Table 1** as a guide.

Table 1

Useful output energy	Example
sound	
light	
mechanical energy	

Improving Efficiency

Getting the most from the electrical energy that we use is a priority. In Canada, federal law now requires special "EnerGuide" information to be attached to all appliances (**Figure 4**). This label states the amount of electrical energy the appliance uses per year. Consumers can compare the EnerGuide numbers for similar appliances of the same capacity and make an informed decision about which one is the most efficient model.

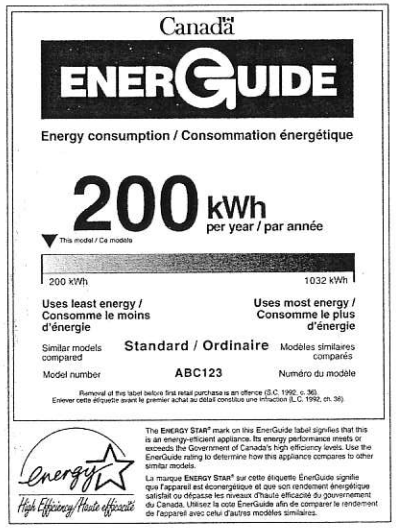

Figure 4

Challenge

1 Is percent efficiency an issue in your circuit? Why or why not?

3 Develop questions on the percent efficiency of electrical devices for your electric game show. Research factors that produce greater efficiency in electrical devices.