



FIGURE 21–25 The transmission of electric power from power plants to homes makes use of transformers at various stages.

Transformers play an important role in the transmission of electricity. Power plants are often situated some distance from metropolitan areas, so electricity must then be transmitted over long distances (Fig. 21–25). There is always some power loss in the transmission lines, and this loss can be minimized if the power is transmitted at high voltage, using transformers, as the following Example shows.

PHYSICS APPLIED
Transformers help power transmission

EXAMPLE 21–12 Transmission lines. An average of 120 kW of electric power is sent to a small town from a power plant 10 km away. The transmission lines have a total resistance of 0.40Ω . Calculate the power loss if the power is transmitted at (a) 240 V and (b) 24,000 V.

APPROACH We cannot use $P = V^2/R$ because if R is the resistance of the transmission lines, we don't know the voltage drop along them; the given voltages are applied across the lines plus the load (the town). But we can determine the current I in the lines ($= P/V$), and then find the power loss from $P_L = I^2R$, for both cases (a) and (b).

SOLUTION (a) If 120 kW is sent at 240 V, the total current will be

$$I = \frac{P}{V} = \frac{1.2 \times 10^5 \text{ W}}{2.4 \times 10^2 \text{ V}} = 500 \text{ A.}$$

The power loss in the lines, P_L , is then

$$P_L = I^2R = (500 \text{ A})^2(0.40 \Omega) = 100 \text{ kW.}$$

Thus, over 80% of all the power would be wasted as heat in the power lines!

(b) If 120 kW is sent at 24,000 V, the total current will be

$$I = \frac{P}{V} = \frac{1.2 \times 10^5 \text{ W}}{2.4 \times 10^4 \text{ V}} = 5.0 \text{ A.}$$

The power loss in the lines is then

$$P_L = I^2R = (5.0 \text{ A})^2(0.40 \Omega) = 10 \text{ W,}$$

which is less than $\frac{1}{100}$ of 1%.

NOTE We see that the higher voltage results in less current, and thus less power is wasted as heat in the transmission lines. It is for this reason that power is usually transmitted at very high voltages, as high as 700 kV.

The great advantage of ac, and a major reason it is in nearly universal use, is that the voltage can easily be stepped up or down by a transformer. The output voltage of an electric generating plant is stepped up prior to transmission. Upon arrival in a city, it is stepped down in stages at electric substations prior to distribution. The voltage in lines along city streets is typically 2400 V and is stepped down to 240 V or 120 V for home use by transformers (Figs. 21–22 and 21–25).