CAUTION

You pay for energy, which is power × time, not for power

Kilowatt-hour (energy unit used by energy companies)

It is energy, not power, that you pay for on your electric bill. Since power is the *rate* energy is transformed, the total energy used by any device is simply its power consumption multiplied by the time it is on. If the power is in watts and the time is in seconds, the energy will be in joules since $1\ \text{W} = 1\ \text{J/s}$. Electric companies usually specify the energy with a much larger unit, the **kilowatt-hour** (kWh). One $\text{kWh} = (1000\ \text{W})(3600\ \text{s}) = 3.60 \times 10^6\ \text{J}$.

EXAMPLE 18–9 **Electric heater.** An electric heater draws a steady 15.0 A on a 120-V line. How much power does it require and how much does it cost per month (30 days) if it operates 3.0 h per day and the electric company charges 9.2 cents per kWh?

APPROACH Given the current and voltage, we use Eq. 18–5 to find the power. We multiply the power (in kW) by the time (h) used in a month to find the energy transformed in a month, and then multiply by the cost per energy unit, \$0.092 per kWh, to get the cost per month.

SOLUTION The power is

$$P = IV = (15.0\ \text{A})(120\ \text{V}) = 1800\ \text{W}$$

or 1.80 kW. The time (in hours) the heater is used per month is $(3.0\ \text{h/d})(30\ \text{d}) = 90\ \text{h}$, which at 9.2¢/kWh would cost $(1.80\ \text{kW})(90\ \text{h})(\$0.092/\text{kWh}) = \$15$.

NOTE Household current is actually alternating (ac), but our solution is still valid assuming the given values for V and I are the proper averages (rms) as discussed in Section 18–7.

PHYSICS APPLIED

Lightning

FIGURE 18–18 Example 18–10: a lightning bolt.

EXAMPLE 18–10 **ESTIMATE** **Lightning bolt.** Lightning is a spectacular example of electric current in a natural phenomenon (Fig. 18–18). There is much variability to lightning bolts, but a typical event can transfer 10^9 J of energy across a potential difference of perhaps 5×10^7 V during a time interval of about 0.2 s. Use this information to estimate (*a*) the total amount of charge transferred between cloud and ground, (*b*) the current in the lightning bolt, and (*c*) the average power delivered over the 0.2 s.

APPROACH We estimate the charge Q, recalling that potential energy change equals the potential difference V_{ba} times the charge Q, Eq. 17–3. We equate ΔPE with the energy transferred, $\Delta\text{PE} \approx 10^9$ J. Next, the current I is Q/t (Eq. 18–1) and the power P is energy/time.

SOLUTION (*a*) From Eq. 17–3, the energy transformed is $\Delta\text{PE} = QV_{ba}$. We solve for Q:

$$Q = \frac{\Delta\text{PE}}{V_{ba}} \approx \frac{10^9\ \text{J}}{5 \times 10^7\ \text{V}} = 20\ \text{coulombs.}$$

(*b*) The current during the 0.2 s is about

$$I = \frac{Q}{t} \approx \frac{20\ \text{C}}{0.2\ \text{s}} = 100\ \text{A.}$$

(*c*) The average power delivered is

$$P = \frac{\text{energy}}{\text{time}} = \frac{10^9\ \text{J}}{0.2\ \text{s}} = 5 \times 10^9\ \text{W} = 5\ \text{GW.}$$

We can also use Eq. 18–5:

$$P = IV = (100\ \text{A})(5 \times 10^7\ \text{V}) = 5\ \text{GW.}$$

NOTE Since most lightning bolts consist of several stages, it is possible that individual parts could carry currents much higher than the 100 A calculated above.