

Electrical Energy and Power



Energy in a Circuit

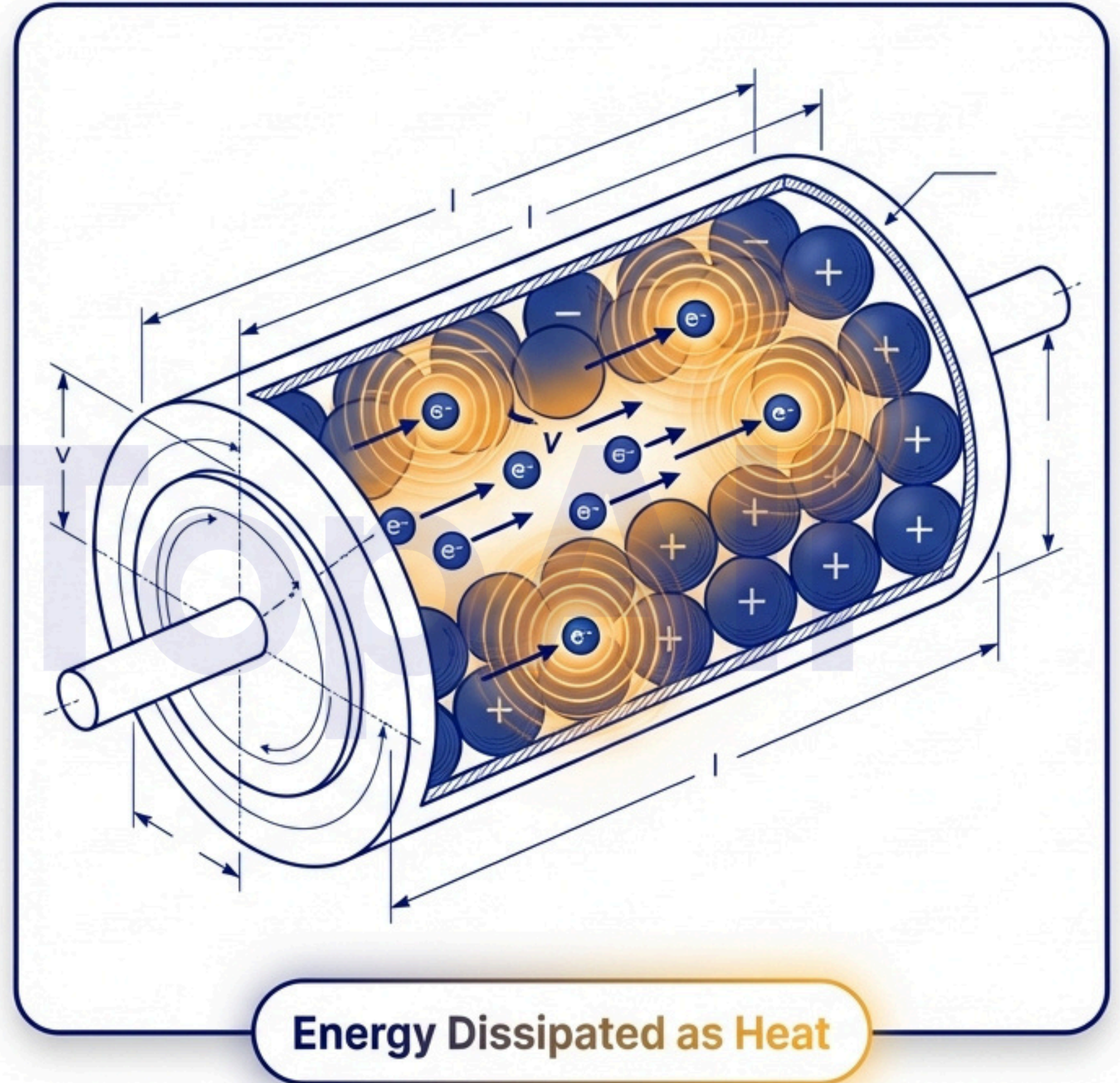
Concept: Charges moving through a potential difference (V) lose potential energy:

$$\Delta U_{\text{pot}} = -IV\Delta t$$

Mechanism: Without collisions, this would infinitely increase kinetic energy. Instead, drifting electrons continuously collide with fixed positive lattice ions.

Result (Ohmic Loss): Energy transfers to the atoms, increasing their thermal vibration. Work done is dissipated as heat:

$$\Delta W = IV\Delta t$$



Electrical Power Definition

Definition: Electrical Power (P) is the rate at which energy is supplied or dissipated.

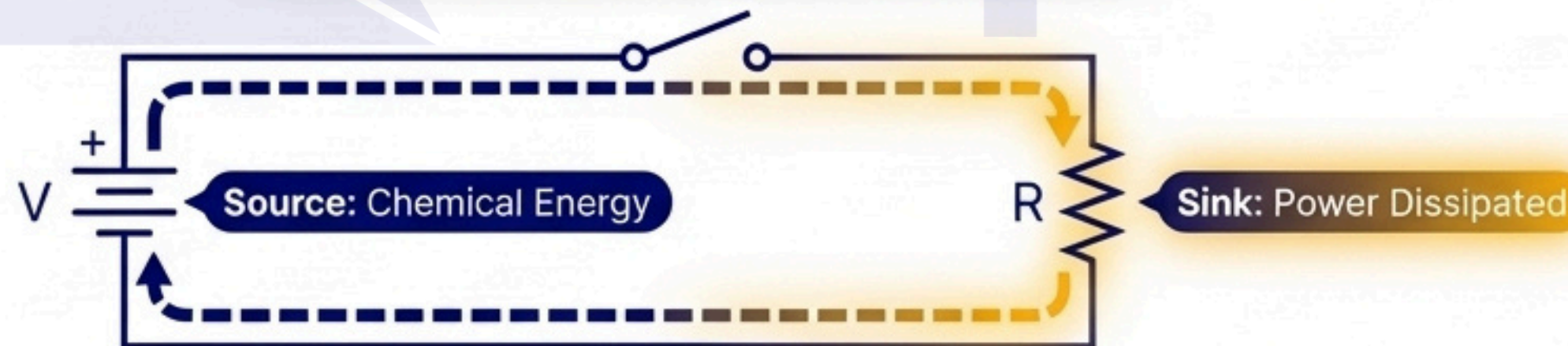
Derivation: $P = \frac{\Delta W}{\Delta t} = \frac{IV\Delta t}{\Delta t}$

$$P = IV$$

[P: Power]

[I: Current]

[V: Voltage]



A cell's chemical energy continuously supplies this power to maintain steady current.

Alternative Resistor Forms

$$P = IV$$

Apply Ohm's Law: $V = IR$

Substitute $V = IR \rightarrow P = I(IR)$

$$P = I^2 R$$

Best for **SERIES**
(Current I is constant)

Substitute $I = V/R \rightarrow P = (V/R)V$

$$P = V^2 / R$$

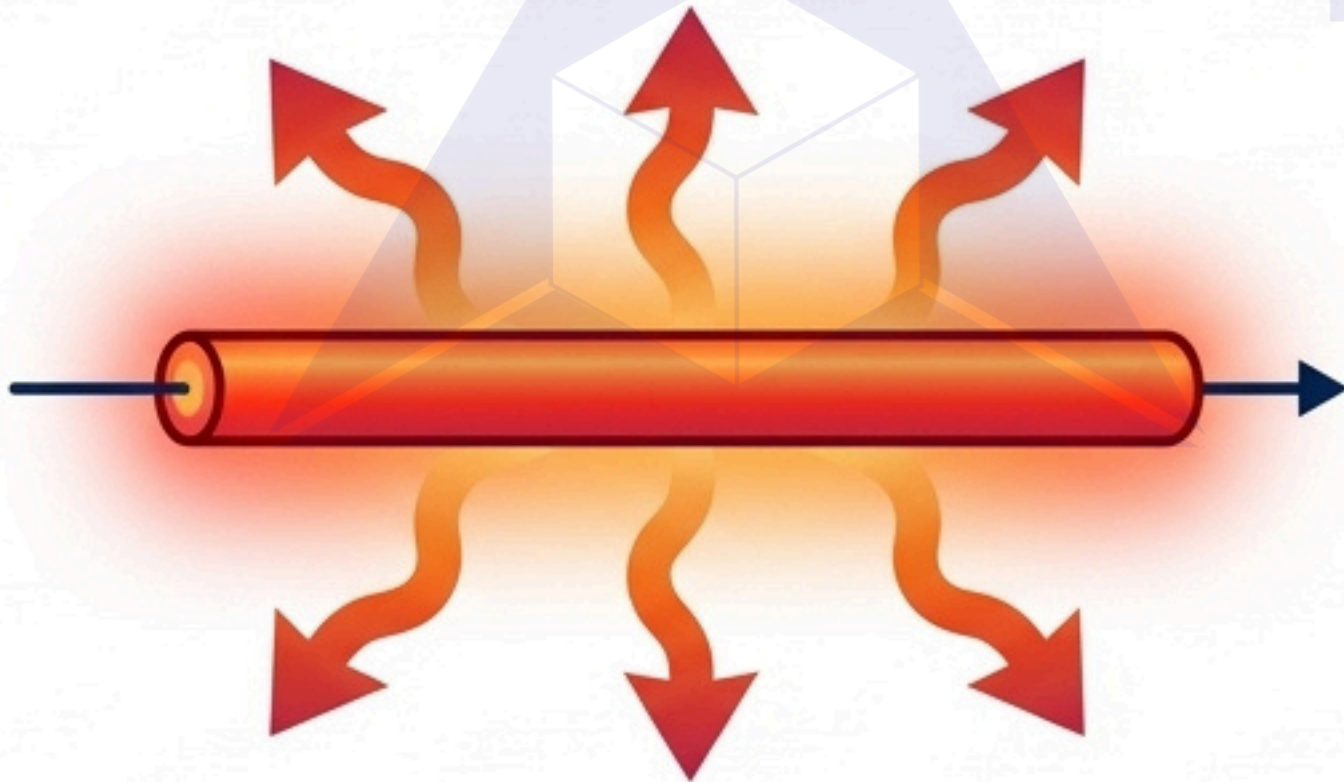
Best for **PARALLEL**
(Voltage V is constant)

Grid Transmission Loss

Context: Delivering power P over long cables with resistance R_c .

Wasted heat: $P_c = I^2 R_c = \frac{P^2 R_c}{V^2}$

Low Voltage (V) $\rightarrow$ High Current (I)



$\uparrow I \rightarrow \uparrow\uparrow I^2 R_c$ (Massive Power Wasted)

High Voltage (V) $\rightarrow$ Low Current (I)



$\downarrow I \rightarrow \downarrow\downarrow I^2 R_c$ (Efficient Transmission)
Transmission loss is inversely proportional to V^2

Key Takeaways

- ✓ **Mechanism:** Collisions between drifting electrons and fixed lattice ions convert electrical potential energy into thermal energy (heat).
- ✓ **Core Equations:** Power dissipated in a resistor is $P = IV = I^2R = V^2/R$.
- ✓ **Energy Source:** A cell's chemical energy maintains the steady current and supplies the continuous electrical power.
- ✓ **Application:** High-voltage grid transmission minimizes current (I), drastically reducing I^2R heat losses in long-distance cables.