

Power, energy and electricity bills

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: Electrical power is the rate at which an appliance transfers energy, measured in watts. You calculate it with $P = V \times I$. The energy used is $E = P \times t$, usually in kilowatt-hours (kWh). An electricity bill is the kilowatt-hours used multiplied by the price of one kWh.

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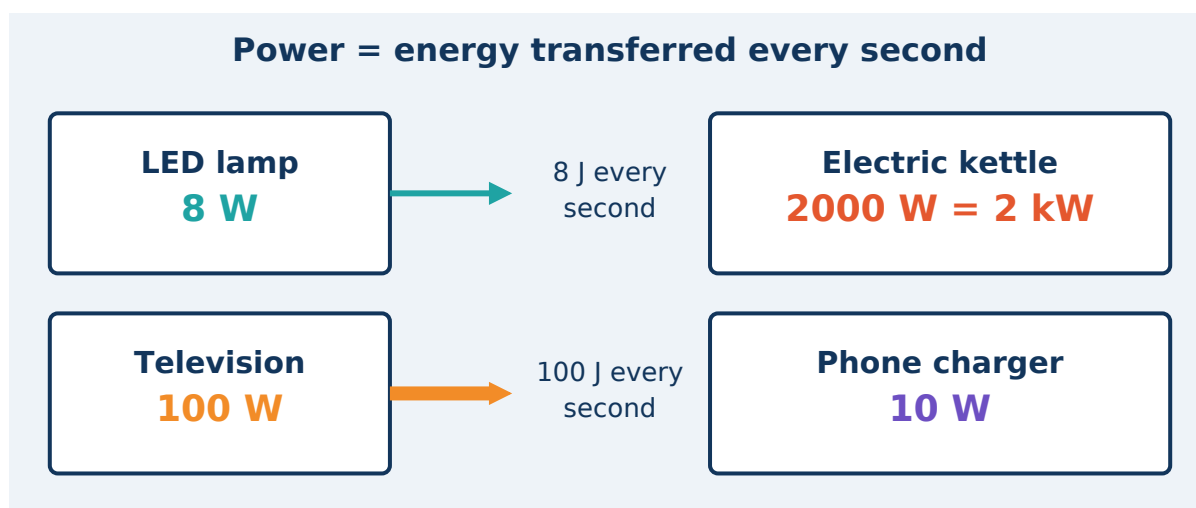
What is electrical power?

Every electrical appliance transfers energy: a kettle heats water, a lamp gives out light, a fan moves air. Some do the job slowly and some do it fast. Power tells us how fast the energy is transferred.

Definition

Electrical power is the rate at which an appliance transfers energy. It is measured in watts (W). A power of 1 W means 1 joule of energy transferred every second.

A 60 W lamp transfers 60 J each second, while a 2000 W kettle transfers 2000 J each second. Large powers are given in kilowatts: 1 kW = 1000 W.



A bigger power rating means more joules transferred every second.

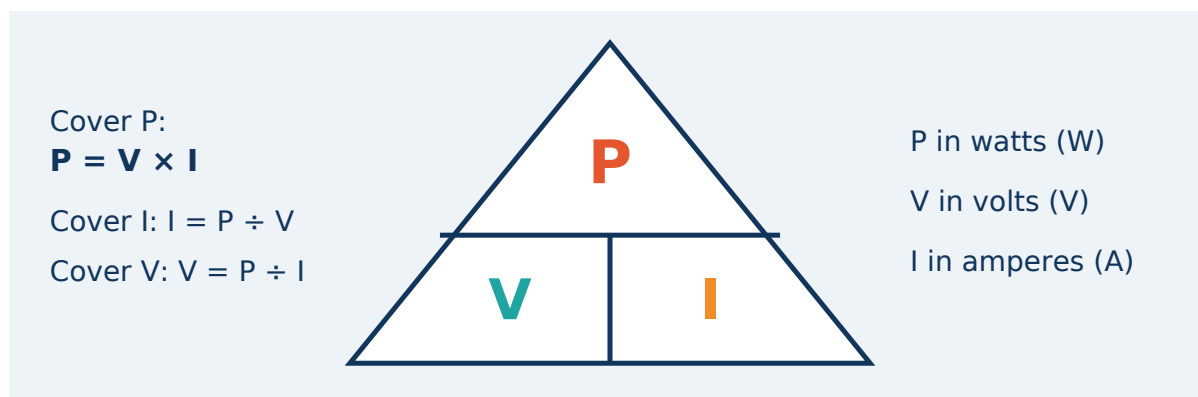
How do you calculate electrical power?

Two things decide an appliance's power: the potential difference (voltage) across it and the current through it. A bigger voltage pushes more energy through each unit of charge, and a bigger current means more charge flows every second.

Formula

$$P = V \times I$$

P = power in watts (W), V = potential difference in volts (V), I = current in amperes (A).



Formula triangle for electrical power. Cover the quantity you want and read the rest.

Worked example 1

A kettle in Leeds works on 230 V and draws 10 A. Find its power.

$$P = V \times I = 230 \text{ V} \times 10 \text{ A} = \mathbf{2300 \text{ W}} \text{ (2.3 kW).}$$

Worked example 2

A fan is labelled 60 W and works on 240 V. Find the current.

$$I = P \div V = 60 \text{ W} \div 240 \text{ V} = \mathbf{0.25 \text{ A}}.$$

How do you calculate the energy an appliance uses?

Power is energy per second, so the energy transferred is the power multiplied by the time.

Formula

$$E = P \times t$$

E = energy in joules (J), P = power in watts (W), t = time in seconds (s).

A 2000 W kettle running for 3 minutes (180 s) transfers $2000 \times 180 = 360\,000 \text{ J}$. Numbers like this get large quickly, so electricity companies use a bigger unit.

Definition

One kilowatt-hour (kWh) is the energy transferred by a 1 kW appliance running for 1 hour.

$$1 \text{ kWh} = 3\,600\,000 \text{ J}.$$

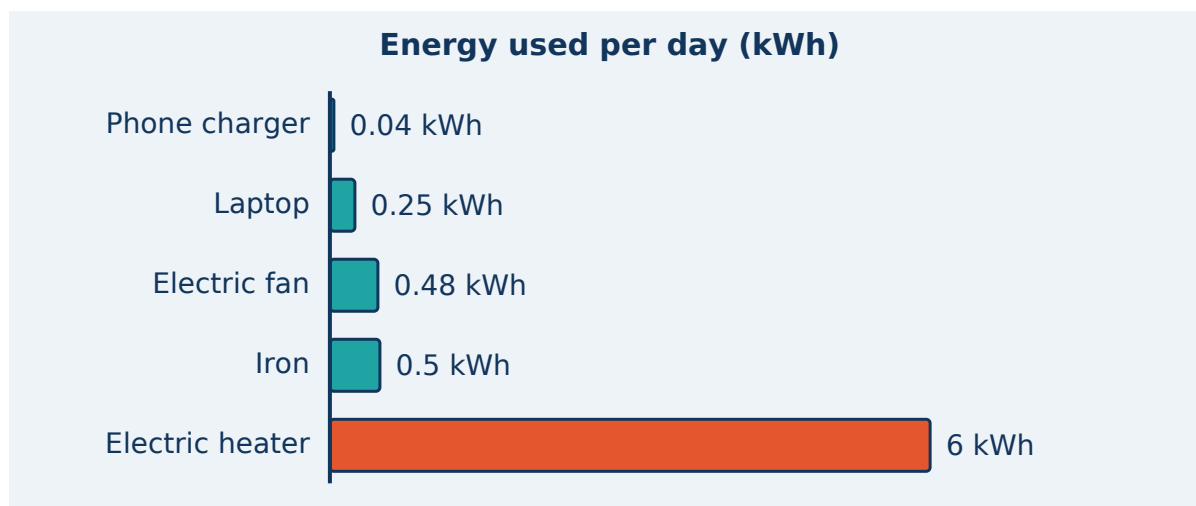
Formula

$E = P \times t$ with P in kilowatts (kW) and t in hours (h) gives E in kilowatt-hours (kWh).

Here is how much energy some everyday appliances use in a day.

Appliance	Power (kW)	Time per day (h)	Energy (kWh)
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Appliance	Power (kW)	Time per day (h)	Energy (kWh)
Phone charger	0.01	4	0.04
Laptop	0.05	5	0.25
Electric fan	0.06	8	0.48
Iron	1.0	0.5	0.5
Electric heater	2.0	3	6.0



A high-power heater used for hours dominates the daily energy.

How is an electricity bill worked out?

The meter in a home counts the kilowatt-hours used. The bill is the number of kWh multiplied by the price of one kWh.

1. Subtract the old meter reading from the new one to get the kWh used.
2. Multiply by the price per kWh.

Worked example 3

Wanjiru's family in Nairobi reads their meter: 3214 kWh at the start of the month and 3262 kWh at the end. One kWh costs 25 shillings.

Energy used = $3262 - 3214 = 48$ kWh.

Cost = $48 \text{ kWh} \times 25 \text{ shillings/kWh} = \mathbf{1200 \text{ shillings}}$.

Common mistake

Do not mix units. A 2000 W heater running for 3 h transfers 6000 Wh, which is 6 kWh, not 6000 kWh. Convert watts to kilowatts before multiplying by hours.

How can you cut the bill?

Energy cost depends on both power and time, so the cheapest saving is to switch off appliances you are not using. Choosing efficient LED lamps, which give the same light with a

much smaller power, also lowers the number of kilowatt-hours bought each month.

Lina's tip

For a bill, change watts to kilowatts first (divide by 1000), keep the time in hours, then multiply by the price. Check that the answer is sensible: a 2 kW heater for 1 hour must be 2 kWh.

Key points to remember

- $P = V \times I$ (watts = volts $\times$ amperes)
- 1 W = 1 joule transferred every second; 1 kW = 1000 W
- $E = P \times t$; with P in kW and t in h the energy is in kWh
- 1 kWh = 3 600 000 J
- Bill = kWh used $\times$ price per kWh

Power, energy and electricity bills: frequently asked questions

What is the difference between power and energy?

Power is how fast energy is transferred, in watts. Energy is the total amount transferred, in joules or kilowatt-hours. Energy equals power multiplied by time.

How do you convert watts to kilowatts?

Divide by 1000. For example, 1500 W is 1.5 kW. Do this before multiplying by hours to get kWh.

What is a kilowatt-hour?

It is the energy used by a 1 kW appliance running for one hour. It equals 3 600 000 joules and is the unit on electricity bills.

How do you find the current from the power of an appliance?

Rearrange $P = V \times I$ to $I = P \div V$. A 920 W toaster on 230 V draws $920 \div 230 = 4.0$ A.

Why does a heater cost more to run than a lamp?

A heater has a much higher power, so it transfers far more joules every second. Over the same time it uses more kilowatt-hours.