

King of Dumbs

Level: ♣ Newbie

Joules, watts or calories? Energy and power without fear

Energy is how much; power is how fast. Joules, watts, kcal and kWh explained with a bathtub, why fast means hot and how to compare scales, in three levels.

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Scan to open the interactive lesson

<https://kingofdumbs.com/en/lessons/joules-watts-or-calories>

What you'll learn

- Energy and its units: joule, kilocalorie and kilowatt hour
- Power and the watt
- The difference between energy and power
- Heat versus temperature
- Comparing powers on a log scale

Before this lesson

If something sounds like gibberish, these lessons explain it from scratch:

1. [How much is \$7 \times 10^{27}\$? Huge numbers without fear](#)

Symbols you'll meet

Δ change: how much it moved (♦♠) · E_a subscript: the label underneath (♠) · $\bar{x}$ bar on top: the average (♠) · $\approx$ approximately equal (♦♠) · $\equiv$ is defined as (♠) · $\cdot$ dot: multiply (or dot product) (♠) · 10^{-3} negative exponent: divide (♠) · e the number e (≈ 2.718) (♠) · $\log$ logarithm: how many times do I multiply? (♠) · σ sigma: depends on the lesson (♠) · τ tau: a characteristic time (♠) · ϵ epsilon: something tiny (♠) · dE/dt derivative: the rate of change (♠) · $\int$ integral: adding up slivers (♠)

A kettle's label says **2,000 W**. An electricity bill talks about **kW** and **kWh**. A yoghurt, about **kcal** and **kJ**. And the dumb question of this lesson is: **do all of those measure the same thing?**

Almost. There are two different questions in there: **how much** energy you need, and **how fast** it's delivered. The first is measured in joules (or calories, or kWh); the second, in watts. Mixing them up is so common that education research finds it even among future physics teachers. Pulling them apart clears up more doubts than you'd think, especially the "is that even possible?" kind.

Pick your card: ♠ if you're starting from zero, ♦ if a simple formula doesn't scare you, ♠ if you want the notation. You can switch at any time.



Energy: how much

Same water, three measures

Not to scale



Imagine **energy** is water. To heat something, move it or switch on a light, you have to use up a bit of that water. And, like water, it can be measured with containers of different sizes:

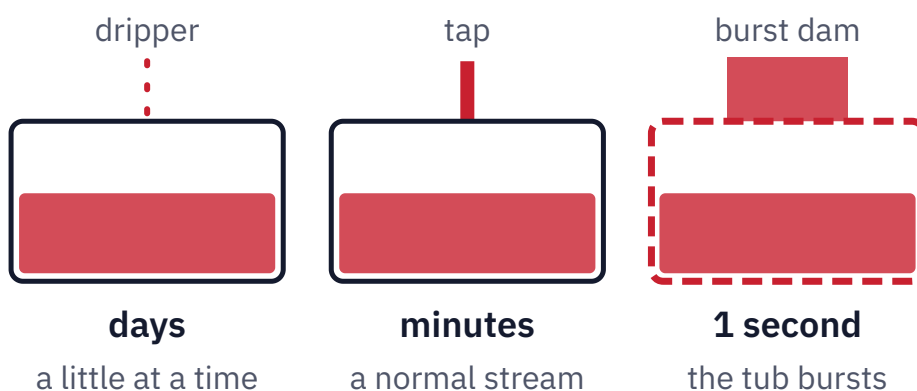
- The **joule** is the teaspoon: roughly what it takes to lift an apple one metre.
- The **kilocalorie**, the one on a yoghurt label, is a glass: 4,184 teaspoons.
- The **kilowatt hour**, the one on your electricity bill, is a bucket: 3.6 million teaspoons.

All three measure the same thing. When a biscuit says “kcal” and the bill says “kWh”, they’re talking about the same stuff with a different glass.

One important detail: water doesn’t vanish when you use it, it spills. Energy isn’t destroyed either. It changes form (from food to your muscles, from electricity to hot water) and almost always ends up as heat that drifts away.



Power: how fast



Now the second question: not how much water, but **how fast it comes out**. That's **power**, and it's measured in **watts**.

Picture three identical bathtubs. The first gets a dripper and takes days to fill. The second, a normal tap: a few minutes. The third gets a burst dam: it fills in one second and bursts. All three receive the same water; the only thing that changes is the rate.

That's why a kettle with 2,000 W on its label doesn't hold 2,000 of anything. That number says how fast it turns electricity into heat. Leave it on longer and it uses more energy; shorter, less. Watts are the tap; joules, the water.

Some electricity bills, like Spain's, charge for both separately. The **contracted power**, in kW, is the biggest tap you can open at once before the power cuts out. The **energy**, in kWh, is the water you actually used.

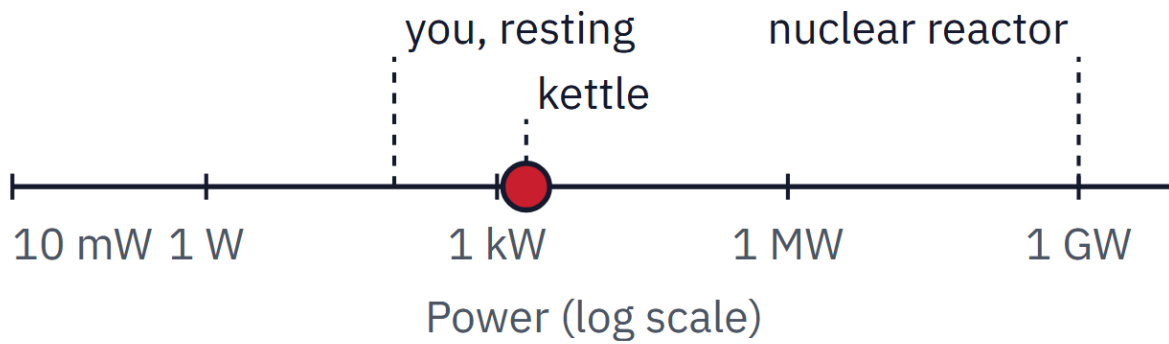
The King of Dumbs says:

Saying a kettle "uses 2,000 watts" is like saying a car "uses 120 km/h". That's how fast it goes, not how much it uses.



Try it: same energy, different pace

Choose what you want to do and how long it takes. The energy of each task doesn't change; watch how the power shoots up as you shorten the time, and what it compares to.



What you want to do

- ☒ Boil 1 litre of water (334 kJ)
- ☐ Burn a day's food (2,000 kcal)
- ☐ Release a typical lightning bolt (950 million joules)

How long it takes



1 s **2.8 min** **1 h** **1 day** In 2.8 min: 2 kW

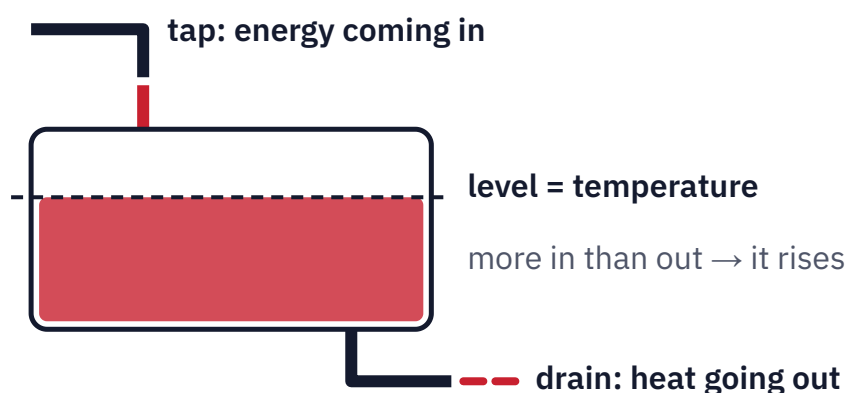
Exactly one kettle.



Interactive widget. Try it on the web: <https://kingofdumbs.com/en/lessons/joules-watts-or-calories>



Heat and temperature: why fast means hot



Almost all the energy we use ends up as heat. And here's a trap: **heat and temperature are not the same thing.**

Back to the bathtub, now with a drain. The tap is the energy coming in. The drain is the **heat** the object gives off to the air. And the water level is the **temperature**: how hot it is. If as much comes in as goes out, the level stays put. If you open the tap more than the drain can swallow, the level rises... until it overflows.

Your body works like this: it produces about 80 watts of heat doing nothing and gives it off through the skin. If you run, the tap opens wider and the body widens the drain: you sweat.

That's why doing something **very fast** tends to burn: you put the energy in faster than it can escape.

Another thing that confuses people: a spark from a bonfire is very hot, and yet you barely feel it if it lands on your hand. A warm bath, on the other hand, heats you all over. The spark is so small that it carries very little energy. Temperature tells you how hot something is, not how much energy it carries.



From a person to the Sun: comparing scales

Not to scale

the Sun: another league



Real-life powers range from the tiny to the enormous. A ladder to get your bearings:

- **You, sitting still:** about 80 watts.
- **A professional cyclist on a half-hour climb:** nearly 400 watts.
- **A kettle:** 2,000 watts.
- **A nuclear reactor:** a billion watts.
- **The Sun:** so many zeros they don't fit on the ladder.

Each rung isn't "a bit more". The reactor equals more than eleven million people at rest. To compare things this different you have to count zeros, which is exactly what the big-numbers lesson teaches.

A fool's trick that works: when someone says something "needs a huge amount of energy", ask **in how long**. Divide, and compare with the ladder.



Final challenge

1. A kettle's label says 2,000 W. What does that number tell you?

- a. How much energy it stores inside
- b. How fast it turns electricity into heat
- c. How much you'll pay each month

2. You boil a litre of water in a 1,000 W kettle and another litre in a 2,000 W one, with no losses. What changes?

- a. The 2,000 W one uses twice the energy
- b. They use the same energy; the 2,000 W one takes half the time
- c. The 1,000 W one can't bring it to the boil

3. A spark from a bonfire is very hot, yet you barely feel it if it lands on your hand. Why?

- a. It's so small it carries very little energy, even though its temperature is high
- b. Sparks are cold inside
- c. Skin can't feel temperature



In three sentences

- 1. Energy is the how much (joules, kcal and kWh are the same thing in a different glass) and power is the rate (watts, joules per second).
- 2. The same energy in less time takes more power, and almost all of it ends up as heat: if it comes in faster than it goes out, the temperature rises.

3. To judge whether something is possible, work out the energy, divide it by the time and compare it with references: a person (about 80 W), a kettle (2,000 W) and a reactor (1 GW).



Sources

- Unit conversions (calorie, kWh, tonne of TNT, horsepower): [NIST SP 811, appendix B.8](#). Electronvolt: [NIST CODATA](#). Joule and watt in the SI: [BIPM, SI Brochure](#).
- Kelvin and the Boltzmann constant: [IUPAC Gold Book](#) and [BIPM, kelvin appendix](#).
- Food labels in kJ and kcal: [Regulation \(EU\) 1169/2011](#), Annex XV. Power and energy terms on the Spanish bill: [IIT Comillas](#) (in Spanish). Automatic cut-off above contracted power: [Royal Decree 1955/2000, art. 92](#) (in Spanish).
- Specific heat of liquid water: [NIST WebBook](#) ($C_p \approx 75.4 \text{ J}/(\text{mol}\cdot\text{K})$ at 25 °C, divided by 18.015 g/mol) and [OpenStax, College Physics 2e, table 14.1](#) (4186 J/(kg·°C)).
- Basal metabolic rate (68 W and 87 W): [Harrison, University of Toronto](#), cross-checked with [OpenStax, College Physics 2e, table 7.4](#) (85 W). Routes of body heat loss: [OpenStax, Anatomy and Physiology 2e, 24.6](#) and [OpenAnesthesia](#).
- Power of Tour de France cyclists: Vogt et al., *Int J Sports Med* 28, 756 (2007), [doi:10.1055/s-2007-964982](#).
- Power of a typical nuclear reactor: [US DOE](#). Energy of a lightning bolt: Cooray, *J. Geophys. Res.* 102 (1997), [doi:10.1029/96JD01917](#), and [EPA AP-42, ch. 14.3](#).
- Nominal solar luminosity and total solar irradiance: IAU 2015, Resolution B3, [arXiv:1510.07674](#).
- Confusion between energy, power and force among future physics teachers: Sağlam-Arslan and Kurnaz, *Asia-Pacific Forum on Science Learning and Teaching* 10(1), 2009, [conclusions](#). Heat versus temperature: [IOP Spark](#).

How this lesson was made: researched and written with help from Claude from the sources above, checked and cross-checked against a second source on 13 October 2026, and translated from Spanish by Claude. Figures without their own link are calculations based on them. The drawings are my own.

Answers

1. **b)** How fast it turns electricity into heat. That's it: watts are a rate. What you use depends on how long you leave it on.
2. **b)** They use the same energy; the 2,000 W one takes half the time. Exactly: same water, twice the tap.
3. **a)** It's so small it carries very little energy, even though its temperature is high. Good. Temperature says how hot; energy, how much. A spark has lots of the first and little of the second.

A King of Dumbs lesson, kingofdumbs.com. Offline version; the original, with widgets you can play with, is at: <https://kingofdumbs.com/en/lessons/joules-watts-or-calories>

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