

ENERGY EXPLAINED

Get back to basics and find out how energy underpins every process in the universe

On an intuitive level, we all know that energy is what makes things happen, causing the Sun to shine, allowing plants to grow, cooking food on a stove or making a basketball bounce. Whenever something heats up, cools down, moves, grows, makes a sound or changes in any way, it uses energy. And from taming fire to powering smartphones, human civilisation relies on our ability to manipulate energy. But pinning down exactly what energy *is* can be tricky.

Grab a textbook and you'll find energy described as 'the ability to do work'. Work in this context is defined as exerting a force on an object over a distance. Lifting a cardboard box off the ground constitutes work, however continuing to hold it there – although requiring effort on your part – is not work.

When work is done to an object, it gains energy. This energy is called kinetic energy if it's associated with the object's motion, as with a football speeding through the air after you kick it. When you pick up the box it is said to have gained potential energy, stored by virtue of its elevation above the ground. If you let go (mind your toes!), the box will fall, losing potential energy as it loses height, and gaining kinetic energy as it picks up speed.

One of energy's fundamental properties is that it cannot be created nor destroyed, only transformed from one type to another. Potential energy can turn into kinetic energy and vice versa limitless times. Further, mechanical, sound, heat, electromagnetic, light, chemical and nuclear energy can all be converted from one into the other.

But while you can't destroy energy, you can certainly waste it through inefficiency. When you drive a car, for example, chemical energy stored in the fuel is converted into first thermal energy and then kinetic energy which turns the car's wheels. But not all of the chemical energy released from the fuel goes into making the vehicle move. Some is converted to heat and sound, and some is used to displace air around the car – ie air resistance. Once this has occurred it's very hard to turn this wasted energy back into something useful.

5 TOP FACTS ENERGY TRIVIA

Sunlight
1 The solar radiation beaming down on our planet from the Sun over just one hour carries more than enough energy to meet the global population's needs for a whole year.

Nuclear energy
2 Splitting just one kilogram (2.2 pounds) of uranium-235 nuclei in a fission reactor releases as much energy as over 2 million kilograms (4.4 million pounds) of coal.

All in the mind
3 The brain is the body's most energy-greedy organ, taking up 20 per cent of the energy from your food. This energy fuels not only brain function but also its maintenance.

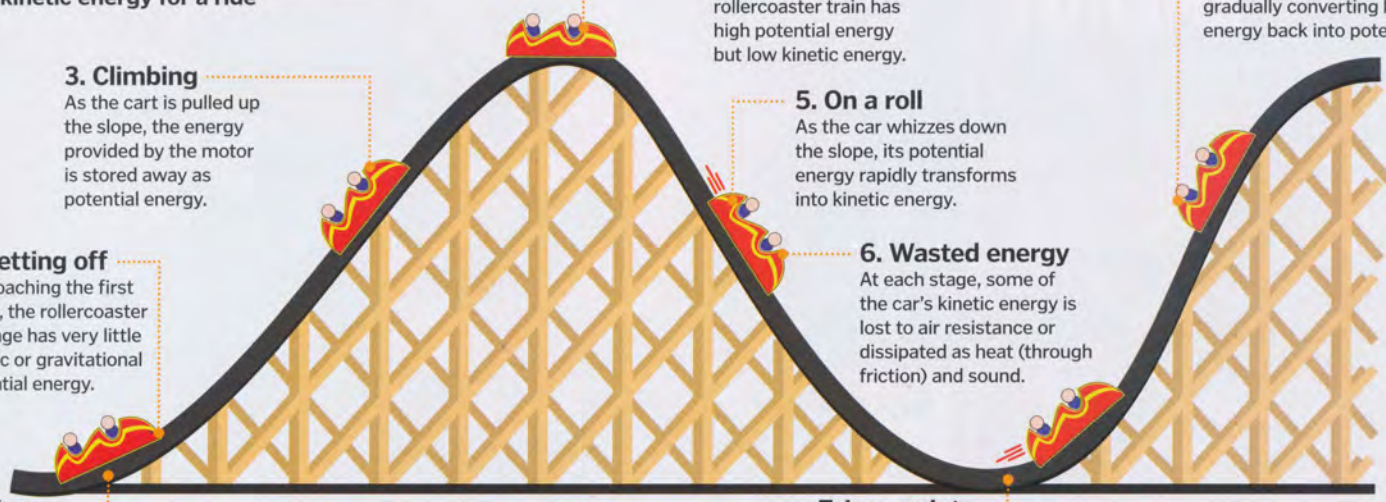
Solar diet
4 Fusion in the Sun's core converts mass into energy, causing it to lose about 4.3 billion kilograms (9.5 billion pounds) every second – still a fraction of its total mass.

High-energy physics
5 A proton whizzing around the Large Hadron Collider has a comparable amount of kinetic energy to a mosquito – but it is concentrated in a much, much tinier body.

DID YOU KNOW? *A lightning bolt contains 5 billion joules of energy – enough to cook 100,000 slices of toast*

Energy in a rollercoaster

Find out how a rollercoaster takes potential and kinetic energy for a ride



1. Mass
The rollercoaster cart's mass determines how much energy is required to move it, as well as how much potential energy it can store.

2. Setting off
Approaching the first slope, the rollercoaster carriage has very little kinetic or gravitational potential energy.

3. Climbing
As the cart is pulled up the slope, the energy provided by the motor is stored away as potential energy.

4. At the top
Edging slowly past the highest point, the rollercoaster train has high potential energy but low kinetic energy.

5. On a roll
As the car whizzes down the slope, its potential energy rapidly transforms into kinetic energy.

6. Wasted energy
At each stage, some of the car's kinetic energy is lost to air resistance or dissipated as heat (through friction) and sound.

7. Low point
At the bottom of the slope, the car's potential energy is at its minimum while its kinetic energy peaks.

8. Back up
The rollercoaster carriage slows as it climbs the next peak, gradually converting kinetic energy back into potential.

Einstein's big idea

In 1905, Einstein revolutionised physics with a jaw-dropping revelation: matter and energy are one and the same. This fact is immortalised in the world's most famous equation: $E=mc^2$. Under the right conditions, energy can be converted into matter and vice versa. This energy comes from the ultra-strong bonds holding protons and neutrons together in atomic nuclei. The c in the equation represents the speed of light – about 1.13 billion kilometres (700 million miles) per hour – so even an object with tiny mass contains a huge amount of energy. If you could turn every atom of a paperclip into energy, you would release as much energy as the atomic bomb that obliterated Hiroshima in 1945. Doing so would, however, require extreme temperature and pressure conditions that are impossible on Earth.

c
The speed of light in a vacuum: ie around 300,000,000m/s (983,600,000ft/s).

$$E = mc^2$$

E
E is energy, which is measured in joules.

m
m represents mass, measured in kilograms.

Throughout history we have relied on different means to get hold of usable energy, from early windmills to coal-burning steam engines. Today, we consume energy mainly as petroleum, natural gas and electricity. We tap into the energy stored in the chemical bonds of petrol or natural gas by burning these fuels, whether inside a boiler or an engine, etc.

Electricity, on the other hand, is a handy way of transporting energy converted from various more cumbersome sources into our homes or workplaces. A wind turbine, for instance, converts kinetic energy, while a nuclear reactor exploits the energy locked in atomic nuclei, generating first thermal and then electrical energy. Once inside our home, electricity can be used for heating, cooking, lighting and running all of our appliances and gadgets.

Energy is measured in joules (J), with one joule being the energy needed to apply a force of one newton (N) over one metre (3.2 feet).

In practice, a variety of different units are commonly used to measure energy in its multitude of different forms. The chemical energy in food is measured in calories – the amount it takes to raise the temperature of one gram of water by one degree Celsius. Your electricity bill, in comparison, measures the electrical energy you have used in kilowatt-hours (kWh). For some context, one kilowatt-hour is enough to run one washing machine cycle or watch seven hours of TV.

Conservation of energy

One of our universe's most basic principles, the law of conservation of energy states that energy can be neither created nor destroyed. That is, the amount of energy in a closed system is fixed. It can, however, be transferred from one object into another, and converted from one form to another.

Although we discuss energy production, you can't create new energy – only convert existing energy to a different usable form. A photovoltaic panel, for instance, taps into the Sun's radiant energy, converting it to usable electrical energy.

Likewise, the energy that we use doesn't disappear – it just changes into other forms. Switch on your television and the heat, sound and light energy emanating from the set gradually leak back into the environment.

Throughout history, numerous inventors have attempted to design and build perpetual motion machines that would give out more energy than was put in, but conservation of energy has made such inventions impossible – at least thus far!

