

Energy Resources and Consumption

AP Environmental Science

Renewable and Nonrenewable Resources

A **renewable resource** 可再生资源 replenishes on a human timescale (sun, wind, water, biomass); a **nonrenewable resource** 不可再生资源 exists in fixed amounts that take millions of years to form (fossil fuels, nuclear fuel). Nonrenewables will eventually run out and often pollute more.

Global Energy Consumption

Global energy use is rising, especially in developing nations. Most energy still comes from **fossil fuels** 化石燃料. Wealthy nations consume the most per person; access to energy shapes economic development.

Fuel Types and Uses

Different fuels suit different needs: coal and natural gas for **electricity**, oil for **transportation**, and biomass for heating and cooking in many regions. Each has trade-offs in cost, availability, and pollution.

Distribution of Natural Energy Resources

Energy resources are **unevenly** distributed –oil is concentrated in some regions, coal in others, and renewables depend on local sun, wind, or rivers. This uneven distribution drives trade, economics, and geopolitics.

Fossil Fuels

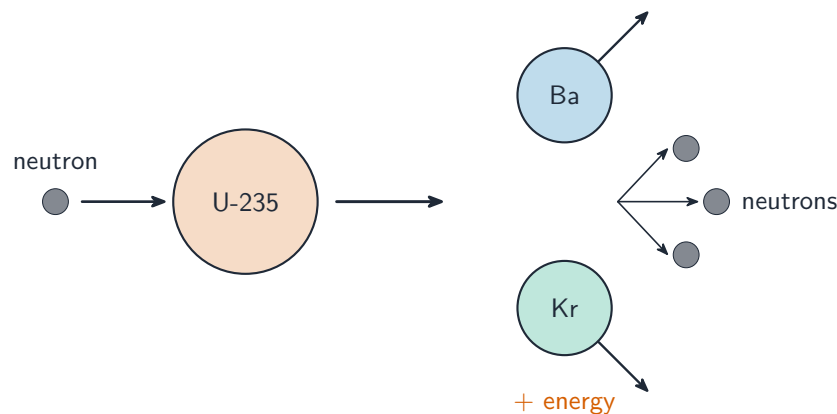
Fossil fuels (coal, oil, natural gas) formed from ancient organisms. They are energy-dense and reliable but **nonrenewable** and the main source of **CO₂** and air pollution. Coal is the dirtiest; natural gas burns cleaner but leaks **methane** 甲烷.

Nuclear Power

Nuclear power 核能 splits uranium (**fission** 裂变) to boil water and drive turbines. It produces **no CO₂** and lots of energy from little fuel, but risks include radioactive **waste** 核废料 (long-lived), the danger of meltdowns, and high cost.

Worked example. Radioactive waste decays by its **half-life** –the time for half of it to decay. Suppose an isotope has a half-life of 30 years and a reactor leaves 100 g of it. After 30 years 50 g remains; after 60 years 25 g; after 90 years (three half-lives)

$100 \times \left(\frac{1}{2}\right)^3 = 12.5$ g. Because the drop is halving, not linear, the waste stays hazardous for many half-lives –the core reason it must be stored safely for centuries.



Nuclear fission of a uranium-235 nucleus releases energy

Energy from Biomass

Biomass 生物质 (wood, crops, waste, biofuels like ethanol) is renewable and can be carbon-neutral if replanted, but burning it causes air pollution, and growing fuel crops competes with food and habitat.

Solar Energy

Solar 太阳能 converts sunlight to electricity (photovoltaic panels) or heat. It is renewable and clean during use, but **intermittent** (no sun at night), needs space, and has manufacturing impacts.

Hydroelectric Power

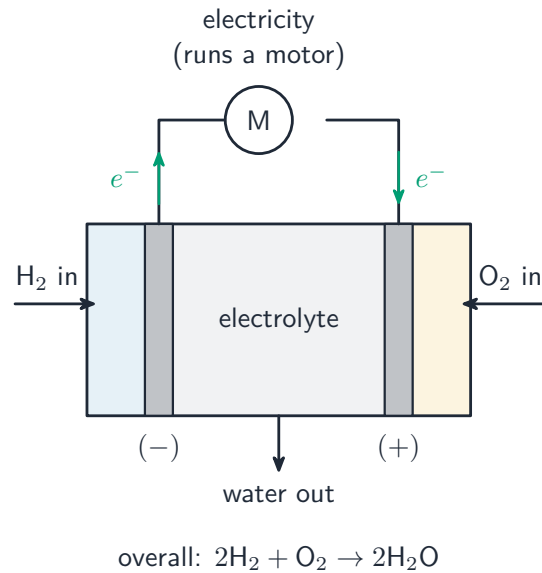
Hydroelectric 水电 power uses flowing water (dams) to spin turbines –renewable and low-emission, but dams flood habitat, block fish migration, trap sediment, and displace people.

Geothermal Energy

Geothermal 地热能 taps Earth's internal heat for electricity and heating. It is renewable and reliable, but only practical where hot rock is near the surface (volcanic regions) and can release underground gases.

Hydrogen Fuel Cell

A **hydrogen fuel cell** 氢燃料电池 combines hydrogen and oxygen to make electricity, with **water** as the only emission at use. But producing hydrogen usually requires energy (often from fossil fuels), and storage is difficult.



A hydrogen-oxygen fuel cell makes electricity, with water as the only product

Wind Energy

Wind 风能 turbines convert moving air to electricity –renewable, clean, and low-operating-cost, but intermittent, land- or sea-intensive, and a hazard to birds and bats. Best where winds are strong and steady.

Energy Conservation

Energy conservation 节能 reduces demand through efficiency (LED lighting, insulation, efficient appliances, public transport) and behavior. Saving energy is often the cheapest and cleanest option –the energy you do not use needs no fuel and makes no pollution.

Worked example. Replacing a 60 W incandescent bulb with a 10 W LED that gives the same light saves 50 W. Running it 5 hours a day saves $50 \text{ W} \times 5 \text{ h} = 250 \text{ Wh} = 0.25 \text{ kWh}$ per day, or about $0.25 \times 365 \approx 91 \text{ kWh}$ per year. Multiply that by every bulb in a city and conservation rivals a new power plant –at far lower cost.

Exam tips

- Separate **renewable** (sun, wind, water) from **non-renewable** (fossil fuels, nuclear) and weigh each source's trade-offs.
- Fossil fuels are energy-dense but emit CO ; **nuclear** emits no CO but leaves long-lived waste.
- Do **half-life** math: after n half-lives a fraction $(\frac{1}{2})^n$ remains.
- Note that solar and wind are **intermittent** and need storage or backup.
- **Conservation** (efficiency) is often the cheapest, cleanest option —the energy not used needs no fuel.