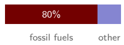
Energy Resources and Consumption

AP Environmental Science ▪ Unit 6

AP Environmental Science

What we will cover

1 Renewable vs nonrenewable
2 Fossil fuels
3 Nuclear power
4 Solar and wind
5 Hydro and geothermal
6 Biomass and conservation



1 Resource types

Renewable vs nonrenewable

The split is a race of two rates – use vs **replenishment** 补充:

- **renewable** 可再生: refills as fast as we use it (sun, wind)
- **nonrenewable** 不可再生: forms far slower (fossil fuels)

> **Fossil fuels** 化石燃料 still supply $\sim 80\%$ of world energy – cheap and energy-dense.

Renewable nonrenewable

Renewable, nonrenewable, and the energy it costs to get energy

Renewable resource	A **renewable resource** replenishes on a human timescale – sunlight, wind, sustainably harvested wood.
Nonrenewable resource	A **nonrenewable resource** does not: coal, oil, gas and uranium exist in a fixed stock.
EROEI	**Energy return on energy investment (EROEI)**: energy delivered divided by energy spent getting it. Conventional oil was once 100:1; tar sands are near 3:1.
Why it matters	A source with an EROEI near 1 cannot power a society, whatever its reserves.

> **Volatile organic compounds** are among the pollutants released in extraction and combustion – a cost that never appears in the fuel price.

Who uses the energy, and who has it

consumption	global use is rising, fastest in developing nations, and most of it is still **fossil fuels** 化石燃料; wealthy nations use the most *per person*
distribution	resources are spread unevenly – oil here, coal there, and renewables wherever the sun, wind or rivers happen to be

> Those two facts together drive trade, dependence and conflict: the countries that use the most are rarely the ones that have the most.

2 Fossil fuels

Fossil fuels

Buried life, pressed for *millions* of years into coal, oil, gas.

- **extraction** 开采: mine coal, pump oil & gas
- burn → steam → turbine → electricity

> Burning releases **carbon dioxide** 二氧化碳 plus **pollutants** 污染物.

Fossil fuels: energy-dense but nonrenewable

Reaching the oil and gas that are hard to reach

hydraulic fracturing 水力压裂	"fracking": high-pressure fluid is pumped into shale to crack it and release oil and gas. Risks: groundwater contamination, **methane** 甲烷 leaks, induced earthquakes, heavy water use
tar sands 油砂	clay, sand, water and thick **bitumen** 沥青. Separating the oil is energy- and water-intensive, so the net energy gain is low
lignite 褐煤	brown coal, dug from open pits and burned at the power station beside them

> **EROEI** 能量投资回报, energy return on energy investment, is the measure: an unconventional source can still be a net *loss* once you count the energy spent extracting it.

Coal comes in ranks

peat 泥炭	**lignite** 褐煤	**bituminous** 烟煤	**anthracite** 无烟煤
partly decomposed plant matter	brown coal: soft, wet, low energy	the common power-station coal	hardest, driest, hottest-burning

more heat, pressure and burial time →

> Rank climbs with what the coal has been through: each step is drier, denser and burns hotter – and takes longer to have formed.

3 Nuclear

Nuclear power

Nuclear power 核能 uses **fission** 核裂变: a neutron splits a uranium nucleus, releasing huge heat.

- almost no **greenhouse gas** 温室气体
- but **radioactive waste** 放射性废物 lasts $10{,}000+$ years

> Low-carbon and steady, but waste storage and accidents are the risks.

Nuclear: steady low-carbon power, long-lived waste

Worked example – radioactive waste and half-life

An isotope has a half-life of 30 years. After 90 years, what fraction of the original waste is left?

- $90/30 = 3$ half-lives
- each halves what remains: $1 \to \frac{1}{2} \to \frac{1}{4} \to \frac{1}{8}$
- $= 1/8$, i.e. 12.5% still radioactive

Three half-lives is not 'nearly gone'. This is why waste storage is planned in thousands of years, not decades.

4 Solar and wind

Solar and wind

Solar PV: clean but intermittent

Photovoltaic cells 光伏电池 turn light to electricity; need storage at night.

Wind: kinetic energy on coasts & ridges

No fuel once built – but both need backup for calm, dark hours.

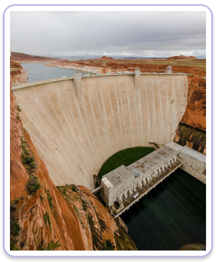
What each renewable costs you

photovoltaic 光伏	clean and falling in price, but needs a large area and produces nothing at night
wind 风能	clean and cheap to run, but intermittent, and siting raises noise and wildlife objections
hydroelectric 水电	reliable and low-emission, but the **reservoir** 水库 floods land and blocks fish migration
geothermal 地热能	renewable and steady, but only where the heat is near the surface
biomass 生物质	carbon-neutral *if* replanted; **ethanol** 乙醇 from corn or cane adds no new carbon but competes with food

Every one of them trades a fossil-fuel problem for a land, timing or siting problem. Naming that trade is the answer.

5 Hydro and geothermal

Hydro and geothermal



Hydro: reliable, but floods valleys A **dam** 大坝 drops water through turbines.

Geothermal: Earth's heat near plates

Only works where hot rock is shallow.

Distribution, and the two big renewables

renewable 可再生资源	replenished on a human timescale – sun, wind, water, biomass, geothermal
nonrenewable 不可再生资源	finite on that timescale – coal, oil, gas, uranium
uneven distribution	oil is concentrated in some regions, coal in others, and renewables depend on local sun, wind or rivers
the consequence	energy is traded and fought over, and no country's mix is freely chosen
hydroelectric 水电	flowing water spins turbines – renewable and low-emission, but dams flood habitat, block fish migration and trap sediment
wind 风能	renewable, clean and cheap to run – but intermittent, land- or sea-intensive, and a hazard to birds

> **EROEI** 能量投资回报 – energy return on energy investment – is what separates a real source from one that costs more energy than it yields.

6 Biomass and conservation

Biomass, hydrogen, conservation

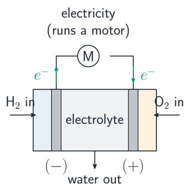
Biomass 生物质 burns stored chemical energy; ferment crops to **ethanol** 乙醇. A **hydrogen fuel cell** 氢燃料电池 makes only water:

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

> The cleanest energy is the energy we never use – **energy conservation** 能源节约.

Conservation + renewables: efficiency first

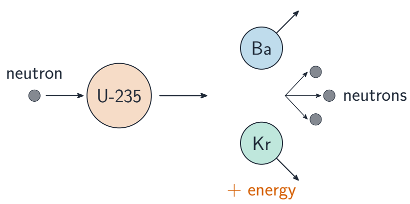
A hydrogen-oxygen fuel cell makes electricity



overall: $2H_2 + O_2 \rightarrow 2H_2O$

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

Nuclear Power, continued



> Nuclear fission of a uranium-235 nucleus releases energy

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.

Exam tips (continued)

- **Conservation** (efficiency) is often the cheapest, cleanest option – the energy not used needs no fuel.
- Know the **coal ranks** (peat → lignite → bituminous → anthracite; more heat/pressure/burial → higher energy) and the unconventional fuels **fracking** (shale oil/gas; groundwater + VOC pollution) and **tar sands** (bitumen, energy-intensive).
- **Ethanol** adds no net CO but has a **low EROEI**; **cogeneration** (combined heat and power) captures waste heat so one fuel gives both electricity and heat.

7 Recap

Worked example – energy and cost

A 100 W bulb runs 10 hours a day. Find its yearly energy use, and the saving from a 15 W LED at \$0.12/kWh.

- Daily: $100\ \mathrm{W} \times 10\ \mathrm{h} = 1000\ \mathrm{Wh} = 1\ \mathrm{kWh}$.
- Yearly: $1 \times 365 = 365\ \mathrm{kWh}$; the LED uses $0.15 \times 365 = 54.75\ \mathrm{kWh}$.
- Energy saved $= 365 - 54.75 = 310.25\ \mathrm{kWh}$
- Cost saved $= 310.25 \times 0.12 = \$37.23$ per year

Watch the units: $\mathrm{W} \times \mathrm{h} = \mathrm{Wh}$, then ÷1000 for kWh. Show every conversion – APES gives marks for the setup, not just the number.

Unit 6 – key takeaways

1 Fossil fuels
~80% of energy; nonrenewable; CO_2 + pollutants

2 Nuclear
fission: low-carbon but long-lived waste

3 Renewables
solar/wind intermittent; hydro/geothermal reliable

4 Cleaner still
hydrogen → water; conservation is cheapest

Check yourself

1. About what share of world energy is fossil fuels?
2. What process powers a nuclear plant?
3. Why do solar and wind need backup?
4. What is the only byproduct of a hydrogen fuel cell?

Answers **1.** about 80% **2.** nuclear fission **3.** they are intermittent **4.** water