

Energy Resources and Consumption

AP Environmental Science ■ Unit 6

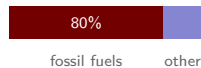
AP Environmental Science



80% fossil

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





Renewable vs nonrenewable

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

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

Fossil fuels 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** ; 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.



Fossil fuels

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

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

Burning releases **carbon dioxide** plus **pollutants** .



Fossil fuels: energy-dense but nonrenewable

Reaching the oil and gas that are hard to reach

hydraulic fracturing

“fracking”: high-pressure fluid is pumped into shale to crack it and release oil and gas. Risks: groundwater contamination, **methane** leaks, induced earthquakes, heavy water use

tar sands

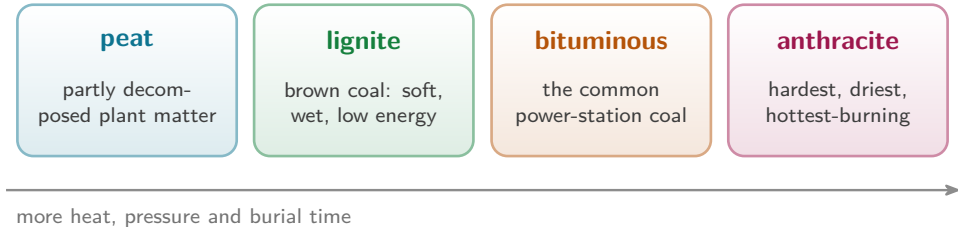
clay, sand, water and thick **bitumen** . Separating the oil is energy- and water-intensive, so the **net energy gain is low**

lignite

brown coal, dug from open pits and burned at the power station beside them

EROEI , 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



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



Nuclear power

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

- almost no **greenhouse gas**
- but **radioactive waste** 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:
 $1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4} \rightarrow \frac{1}{8}$
- = $1/8$, 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.



Solar and wind



Solar PV: clean but intermittent

Photovoltaic cells 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

clean and falling in price, but needs a **large area** and produces nothing at night

wind

clean and cheap to run, but **intermittent**, and siting raises noise and wildlife objections

hydroelectric

reliable and low-emission, but the **reservoir floods land** and blocks fish migration

geothermal

renewable and steady, but only where the heat is near the surface

biomass

carbon-neutral *if* replanted; **ethanol** 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.



Hydro and geothermal



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



Geothermal: Earth's heat near plates

Only works where hot rock is shallow.

Distribution, and the two big renewables

renewable

replenished on a human timescale – sun, wind, water, biomass, geothermal

nonrenewable

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

flowing water spins turbines – renewable and low-emission, but dams flood habitat, block fish migration and trap sediment

wind

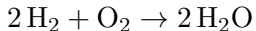
renewable, clean and cheap to run – but **intermittent**, land- or sea-intensive, and a hazard to birds

EROEI – energy return on energy investment – is what separates a real source from one that costs more energy than it yields.



Biomass, hydrogen, conservation

Biomass burns stored chemical energy; ferment crops to **ethanol** .
A **hydrogen fuel cell** makes only water:

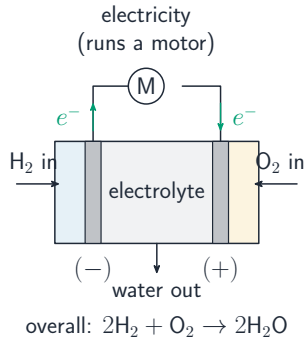


The cleanest energy is the energy we never use – **energy conservation** .



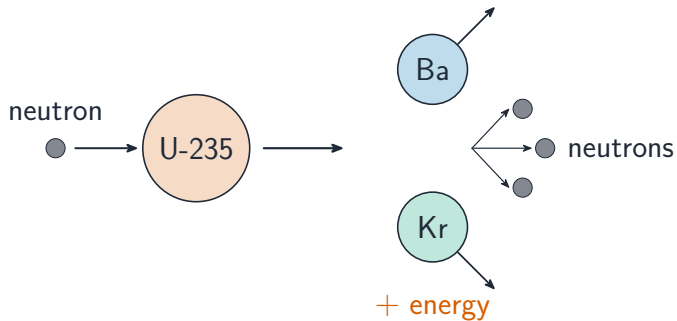
Conservation + renewables: efficiency first

A hydrogen-oxygen fuel cell makes electricity



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_2 ; **nuclear** emits no CO_2 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 CO₂ but has a **low EROEI**; **cogeneration** (combined heat and power) captures waste heat so one fuel gives both electricity and heat.



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

Watch the units: $\text{W} \times \text{h} = \text{Wh}$, then $\div 1000$ 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;
CO₂ + pollutants

2

Nuclear

fission: low-carbon but long-lived
waste

3

Renewables

solar/wind intermittent; hy-
dro/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?



80%

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