

Unit 6: Energy Resources and Consumption

Unit 6 covers where energy comes from and what each source costs. It starts with renewable and nonrenewable resources and global consumption patterns, moves through fossil fuels and nuclear power, then works through biomass, solar, hydroelectric, geothermal, hydrogen, and wind, and closes with energy conservation.

AP Environmental Science

Energy Resources and Consumption

About 14 minutes to read

How to use this guide

Read it in order the first time. The unit moves from the big categories, renewable versus nonrenewable, to specific sources, and the same tradeoff pattern repeats throughout. Every source has a benefit and a cost, and exam questions ask you to name both. The comparison table near the end collects them in one place.

After the first read, use the trap boxes and the table to review the distinctions that exam questions test most often. Finish with the practice questions, then complete the recall check on the last page out loud and note any items you cannot explain yet.

What this unit is worth. Energy Resources and Consumption is about 10 to 15 percent of the AP Environmental Science exam. It also feeds directly into Unit 9, because the environmental effects of each source become part of the global change story.

6.1 Renewable and Nonrenewable Resources

Nonrenewable energy sources exist in a fixed amount. Once they are converted into usable power, they cannot be replaced on any timescale that matters to us. Fossil fuels and uranium are the unit's examples.

Renewable energy sources replenish naturally at or near the rate we consume them, and they can be used again. Sunlight, wind, flowing water, geothermal heat, and biomass all qualify.

Trap. Renewable does not mean unlimited or impact-free. Biomass can be overharvested into deforestation, and large solar farms can damage desert ecosystems. The word describes the supply, not the footprint. When a question asks for the environmental cost of a renewable source, reach for its specific impact, not the label.

6.2 Global Energy Consumption

Fossil fuels dominate energy use. They are the most widely used sources of energy in the world, which is why their combustion products drive so much of the course.

Consumption is **uneven**. Developed countries use far more energy per person than developing countries. As developing countries industrialize, their energy demand rises, and that new demand is mostly met with fossil fuels, so total global consumption keeps growing.

Three factors shape which sources people actually use: **availability, price, and governmental regulations**. A fuel that is cheap and nearby wins unless a regulation changes the math.

Trap. A country choosing the cheapest available fuel is not behaving irrationally. Price and availability drive real energy choices, and regulations shift them. Questions that ask why a region has not switched to a cleaner source are usually testing these three factors, not asking you to judge the decision.

6.3 Fuel Types and Uses

Wood, as firewood and charcoal, is a common fuel in developing countries because it is easily accessible. **Peat** is partially decomposed organic material that can be burned for fuel.

Coal comes in three ranks: lignite, bituminous, and anthracite. Rank reflects how much heat and pressure the buried plant matter experienced, which depends on depth of burial. Higher rank means more carbon and more energy per unit, so anthracite burns hottest and cleanest of the three, and lignite is the lowest grade.

Natural gas is mostly methane and the cleanest-burning of the fossil fuels. **Tar sands** are a mixture of clay, sand, water, and bitumen from which crude oil can be recovered. **Refined petroleum products** are made from crude oil for particular uses: gasoline and diesel for vehicles, jet fuel for aircraft, and heating oil.

Cogeneration uses one fuel source to generate both useful heat and electricity. Making both from the same fuel wastes less energy than producing them separately.

Trap. Cleanest of the fossil fuels is a ranking inside a dirty category. Natural gas combustion still produces carbon dioxide. The phrase compares gas to coal and oil, not to solar or wind. If an option claims natural gas is emission-free, it is wrong.

6.4 Distribution of Natural Energy Resources

Coal, crude oil, natural gas, and ores are not spread evenly around the world. Where they sit depends on each region's **geologic history**. That uneven distribution is the reason energy trade exists and the reason energy shows up in geopolitics.

6.5 Fossil Fuels

Fossil fuel combustion is a chemical reaction between the fuel and oxygen. It yields carbon dioxide and water and releases energy. That sentence is worth memorizing exactly, because it names both the products and the point of the reaction.

Power generation follows one chain for every fuel-burning plant. Burn the fuel to make heat, use the heat to boil water into steam, let the steam spin a turbine, let the turbine spin a generator, and the generator produces electricity. Coal, oil, natural gas, and nuclear plants all use this chain. Only the heat source differs.

Extraction methods include surface and subsurface mining for coal, drilling for oil and natural gas, and hydraulic fracturing. **Fracking** can cause groundwater contamination and the release of volatile organic compounds.

Trap. Fracking is an extraction method, not a fuel. A question asking for the environmental effects of fracking wants groundwater contamination and volatile organic compounds, not the carbon dioxide released later when the gas is burned. Keep the extraction effects separate from the combustion effects.

6.6 Nuclear Power

Nuclear fission starts when a neutron strikes a uranium-235 atom stored in a fuel rod. The atom splits into smaller parts and releases a large amount of heat. From there the chain is familiar: heat makes steam, steam turns a turbine, the turbine spins a generator, and electricity comes out.

Radioactivity is the process in which the nucleus of an unstable isotope loses energy by emitting radiation. **Half-life** is the time required for half of a sample's atoms to decay, and it is used to calculate how much of a sample remains at a given time.

Uranium-235 stays radioactive for a very long time, which is the core of the **nuclear waste disposal** problem. There is no way to switch the radioactivity off; the waste must be isolated until it decays.

Nuclear power is **nonrenewable**, because the uranium supply is fixed. It is considered cleaner than fossil fuels because it produces no air pollutants during generation, but it does release **thermal pollution**, which is waste heat discharged into water, and **hazardous solid waste**.

Three Mile Island, Chernobyl, and Fukushima are the three cases where accidents or natural disasters released radiation, with short-term and long-term environmental impacts.

Trap. No air pollutants is not the same as no pollution. Nuclear plants discharge waste heat into nearby water and produce solid waste that stays hazardous far longer than any human institution has lasted. When an option says nuclear power produces no pollution, that is the distractor.

Trap. After one half-life, half the atoms remain. After two half-lives, a quarter remains, not zero. Each half-life halves whatever is left, so the amount approaches zero but never reaches it in a finite number of half-lives. Questions that ask how much remains after three half-lives are testing whether you keep halving.

6.7 Energy from Biomass

Burning **biomass** produces heat at a relatively low cost, but the emissions list is long: carbon dioxide, carbon monoxide, nitrogen oxides, particulates, and volatile organic compounds. Overharvesting trees for fuel also causes deforestation, which removes the very resource the fuel depends on.

Ethanol can substitute for gasoline. Burning it does not introduce additional carbon into the atmosphere, because the carbon it releases was recently absorbed by the plants it was made from. The catch is the **energy return on energy investment**: growing, harvesting, and refining the crop costs nearly as much energy as the ethanol delivers, so the net gain is small.

Trap. Biomass is renewable, which tempts students to file it with solar and wind as clean. The emissions list above says otherwise. Renewable describes the supply. The smoke is still smoke, and the exam will list those pollutants as the answer.

6.8 Solar Energy

Photovoltaic solar cells capture light energy from the sun and transform it directly into electrical energy. Their output is limited by sunlight availability, so they produce nothing at night and less on cloudy days.

Active solar systems use mechanical and electrical equipment, like pumps and controls, to heat a liquid with sunlight and store the captured warmth. **Passive solar systems** use no machinery at all. The building's design absorbs heat directly from the sun and stores it in thermal mass such as thick walls and floors.

Solar systems have low environmental impact during operation and produce clean energy, but they are expensive to install. Large solar farms can also harm desert ecosystems by covering habitat.

Trap. Active versus passive is about equipment, not about electricity. Active systems use pumps and controls to move heat around. Passive systems use building design. A photovoltaic panel is neither one; it makes electricity directly. Match each term to its mechanism before answering.

6.9 Hydroelectric Power

Hydroelectric generation works several ways. Dams built across rivers collect water in reservoirs, and the released water spins a turbine. Turbines can also sit in small rivers without a dam. **Tidal energy** uses the energy of tidal flows to turn a turbine.

Hydroelectric power generates no air pollution and no waste during operation. The costs are the expensive construction and what the dam does to the river: flooding land destroys habitats upstream and changes ecosystems downstream.

Trap. No waste refers to operation. The construction phase floods valleys and displaces everything living in them. When a question asks for hydroelectric's environmental cost, the answer is habitat loss and ecosystem change, not air emissions.

6.10 Geothermal Energy

Geothermal energy taps heat from Earth's interior. Underground water warmed by that heat returns to the surface as steam, which drives an electric generator.

The drawbacks are access and cost. Usable geothermal heat sits in specific regions, and reaching it elsewhere is prohibitively expensive. Plants can also release hydrogen sulfide.

Trap. Geothermal is renewable but not universally available. Sunlight falls everywhere, but concentrated underground heat does not. Renewable never meant available anywhere, and exam questions use geothermal's geographic limits as the tradeoff.

6.11 Hydrogen Fuel Cell

A **hydrogen fuel cell** combines hydrogen gas with atmospheric oxygen to form water and release electricity. Water is the only emission at the point of use.

The environmental picture depends on where the hydrogen comes from. When hydrogen is produced from water using clean energy, the cell produces no carbon dioxide. But the technology is expensive, and energy is still needed to create the hydrogen gas. If that energy comes from fossil fuels, the climate benefit shrinks.

Trap. The tailpipe is clean, but the supply chain may not be. Hydrogen is an energy carrier, not an energy source. Someone has to spend energy to make the hydrogen, and the exam will ask what happens when that energy comes from fossil fuels.

6.12 Wind Energy

Wind power uses the kinetic energy of moving air to spin a turbine, which spins a generator and produces electricity.

Wind is renewable and clean during operation. Its environmental cost is wildlife: birds and bats can be killed by the spinning blades.

Trap. Intermittency matters as much as the wildlife toll. Turbines generate only when the wind blows, the same way photovoltaic cells generate only in sunlight. When a question pairs clean and renewable with a drawback, the answer is usually intermittency or wildlife, so read which one the options offer.

6.13 Energy Conservation

Home conservation methods include adjusting the thermostat to cut heating and cooling use, conserving water, using energy-efficient appliances, and conservation landscaping.

Large-scale conservation includes improving vehicle fuel economy, using battery electric and hybrid vehicles, expanding public transportation, and designing green buildings.

Every Source, Side by Side

SOURCE	BENEFIT	COST OR LIMIT
Fossil fuels	Abundant, cheap, and energy dense; the dominant global supply	CO ₂ and water from combustion; extraction damage; uneven geologic distribution
Nuclear	No air pollutants during generation; large energy output	Nonrenewable; long-lived hazardous waste; thermal pollution; accident risk
Biomass	Renewable; low-cost heat; ethanol substitutes for gasoline	CO, CO ₂ , NO _x , particulates, VOCs; deforestation; low EROEI for ethanol
Solar	Clean during operation; low environmental impact	Expensive; limited by sunlight; large farms harm desert ecosystems
Hydroelectric	No air pollution or waste during operation	Expensive dams; habitat loss and ecosystem change from flooding
Geothermal	Renewable; steady output where available	Geographically limited; expensive to access; hydrogen sulfide release
Hydrogen fuel cell	Only water emitted at point of use	Expensive; energy required to produce the hydrogen
Wind	Renewable; clean during operation	Intermittent; kills birds and bats

Practice Questions

Original questions written for this guide in the style of the AP exam. Answers and explanations are on the next page, so complete the questions before checking them.

- 1.** A town is replacing a coal-fired power plant and is comparing nuclear power with a large solar farm. Which statement about the two options is accurate?
 - A. Nuclear power produces no pollution of any kind during operation
 - B. The solar farm will generate electricity at night if its panels are large enough
 - C. Nuclear power produces no air pollutants during generation but creates long-lived hazardous solid waste
 - D. The solar farm will have no environmental impact because solar energy is renewable

- 2.** A sample of a radioisotope has a half-life of 20 years. Starting with 800 grams, how much of the original isotope remains after 60 years?
 - A. 0 grams
 - B. 100 grams
 - C. 200 grams
 - D. 400 grams

- 3.** A student argues that ethanol is an ideal gasoline substitute because burning it adds no new carbon to the atmosphere. What is the strongest limitation of that argument?
 - A. Ethanol is a nonrenewable resource
 - B. Ethanol cannot be used in standard vehicle engines
 - C. The energy return on energy investment for ethanol is low
 - D. Ethanol combustion produces no carbon dioxide at all

- 4.** Which of the following is a large-scale energy conservation strategy rather than a household-level one?
 - A. Adjusting the thermostat to reduce heating and cooling use
 - B. Installing energy-efficient appliances
 - C. Expanding public transportation systems
 - D. Using conservation landscaping around a home

Answer Key

- 1. C.** Nuclear fission produces no air pollutants during generation, but uranium-235 stays radioactive a long time, creating a hazardous solid waste disposal problem. A is the classic distractor: no air pollutants is not no pollution, since nuclear plants release thermal pollution and solid waste. B is wrong because photovoltaic output is limited by sunlight; larger panels do not generate at night. D confuses renewable with impact-free; large solar farms can harm desert ecosystems.
- 2. B.** Sixty years is three half-lives of 20 years. Halve three times: 800 to 400 to 200 to 100 grams. A assumes the sample vanishes after enough half-lives, but halving never reaches zero. C stops after two half-lives. D stops after one.
- 3. C.** Burning ethanol returns carbon the plants recently absorbed, so it adds no new carbon, but the EROEI is low: growing, harvesting, and refining the crop costs nearly as much energy as the ethanol delivers. A is wrong because ethanol from crops is renewable. B is wrong because ethanol can substitute for gasoline. D misstates the chemistry; ethanol combustion does produce carbon dioxide, it is just recycled carbon rather than new carbon.
- 4. C.** Expanding public transportation is a large-scale strategy, alongside fuel economy standards, electric and hybrid vehicles, and green building design. A, B, and D are all household-level methods: thermostat adjustment, efficient appliances, and conservation landscaping.

One-Page Recall Check

- State the difference between renewable and nonrenewable energy sources, with one example of each.
- Explain why global energy consumption is uneven and what happens to demand as developing countries industrialize.
- Name the three factors that influence which energy sources people use.
- List the three ranks of coal and explain what determines rank.
- Write the fossil fuel combustion reaction and name its products.
- Trace the full power generation chain from fuel to electricity.
- Name the environmental risks of hydraulic fracturing.
- Explain how nuclear fission generates electricity, starting with the neutron strike.
- Define half-life and calculate what remains of a 400-gram sample after two half-lives.
- Explain why nuclear waste disposal is a long-term problem.
- Explain why nuclear power is nonrenewable even though it produces no air pollutants.
- List the pollutants released by burning biomass and explain the ethanol EROEI problem.
- Distinguish photovoltaic cells, active solar systems, and passive solar systems.
- Explain how hydroelectric power works and name its main environmental cost.
- Explain how geothermal energy works and why it is not available everywhere.
- Explain why a hydrogen fuel cell's climate benefit depends on how the hydrogen is produced.
- Name wind energy's wildlife cost and its intermittency limit.
- Sort four conservation methods into household-level and large-scale.

Where to go next. Turn every missed item above into flashcards and drill them spaced out over several days rather than in one sitting. In Rycal, open the AP Environmental Science deck. The deck covers the terms in this guide, and its practice questions target the same traps named here. If you have a test date, add it in the Test Planner. You can also start your next review with a Brain Dump, then check what you missed against this guide.

Key terms for this unit

Nonrenewable energy sources, Renewable energy sources, Uneven global energy consumption, Fossil fuels dominate energy use, Development and energy demand, Factors influencing energy source choice, Wood fuel, Peat, Types of coal, Natural gas, Tar sands, Specialized fuel types, Cogeneration, Geologic distribution of energy resources, Fossil fuel combustion, Fossil fuel power generation, Fossil fuel extraction methods, Hydraulic fracturing (fracking), Nuclear fission power, Radioactivity, Nuclear waste disposal, Nuclear power as nonrenewable, Nuclear accidents, Half-life, Biomass burning impacts, Ethanol fuel, Photovoltaic solar cells, Active solar energy systems, Passive solar energy systems, Solar energy environmental effects, Hydroelectric power generation, Hydroelectric environmental effects, Geothermal energy, Geothermal drawbacks, Hydrogen fuel cells, Hydrogen fuel cell effects, Wind power, Wind energy environmental effects, Home energy conservation, Large-scale energy conservation

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