



# Chapter 13

## Achieving Energy Sustainability

# What is renewable energy?

- ▣ Renewable energy can be rapidly regenerated, and some can never be depleted, no matter how much of them we use.



## Nonrenewable



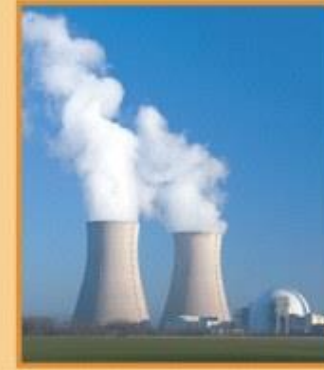
**Natural gas**



**Oil**



**Coal**



**Nuclear**

## Potentially renewable



**Wood**



**Biofuel**

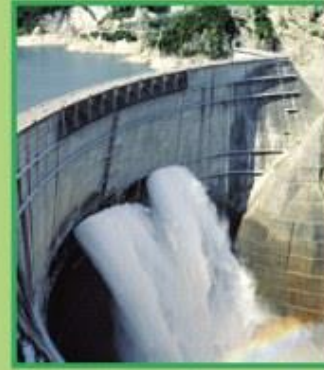
## Nondepletable



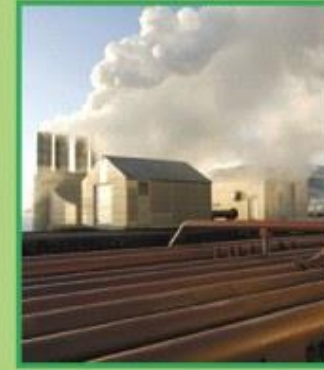
**Wind**



**Solar**



**Hydroelectric**



**Geothermal**

**Figure 13.1**

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# How can we use less energy?

- Energy conservation- finding ways to use less energy. For example, lowering your thermostat during the winter or driving fewer miles.
- Energy efficiency- getting the same result from using a smaller amount of energy.



## Home

- Weatherize (insulate, seal gaps).
- Turn thermostat down in winter, up in summer.
- Reduce use of hot water (do laundry in cold water/take shorter showers).
- Replace incandescent bulbs with compact fluorescents or LEDs.



## Transportation

- Walk or ride a bike.
- Take public transportation.
- Carpool.
- Consolidate trips.

## Electrical and electronic devices

- Buy Energy Star devices and appliances.
- Unplug when possible or use a power strip.
- Use a laptop rather than a desktop computer.



**Figure 13.4**

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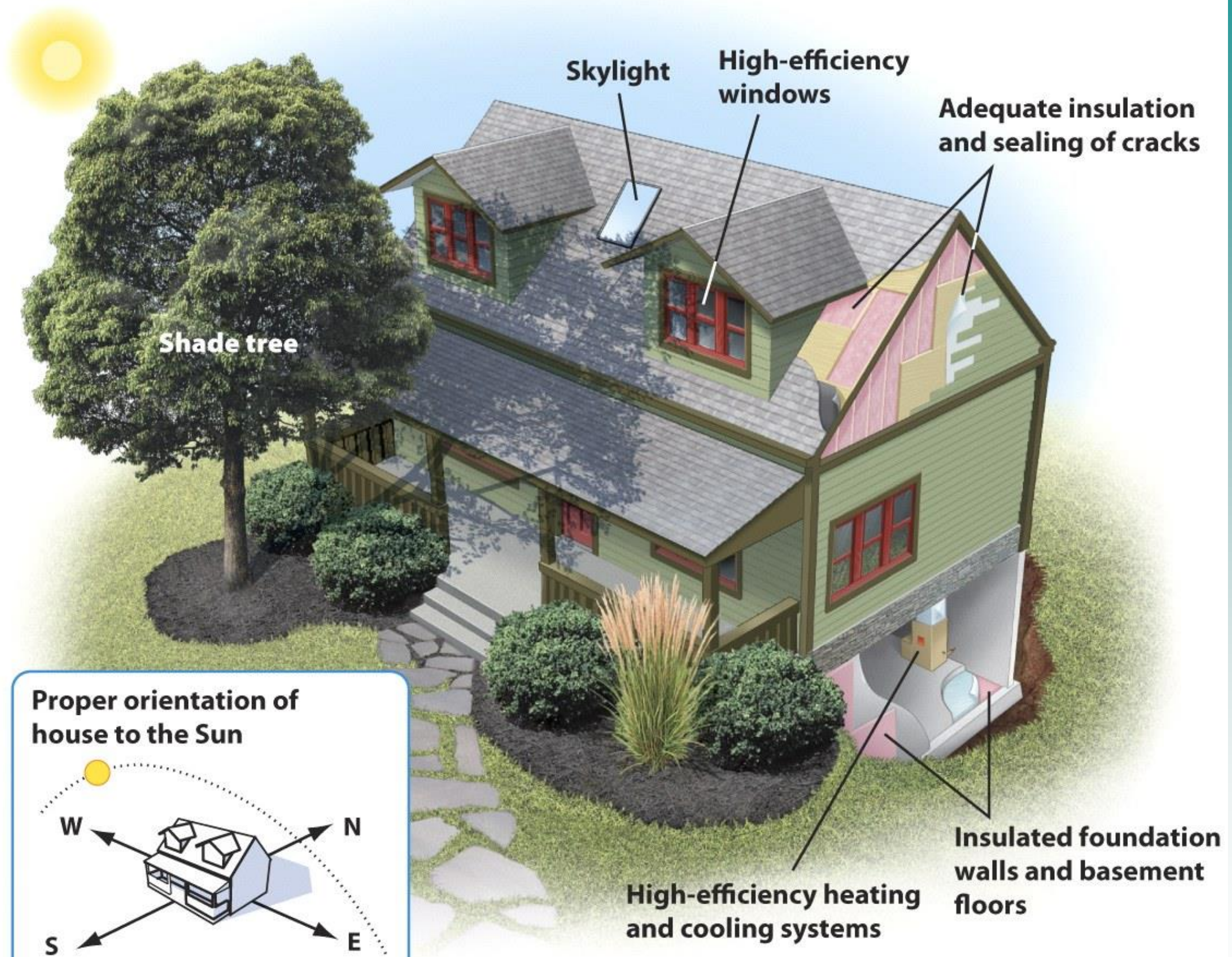
# Benefits of Conservation and Efficiency

- ▣ Many energy companies have an extra backup source of energy available to meet the peak demand, the greatest quantity of energy used at any one time.
- ▣ Variable price structure- utility customers can pay less to use energy when demand is lowest and more during peak demand.

# Sustainable Design

- ▣ Improving the efficiency of the buildings we live and work in.





**Figure 13.5**

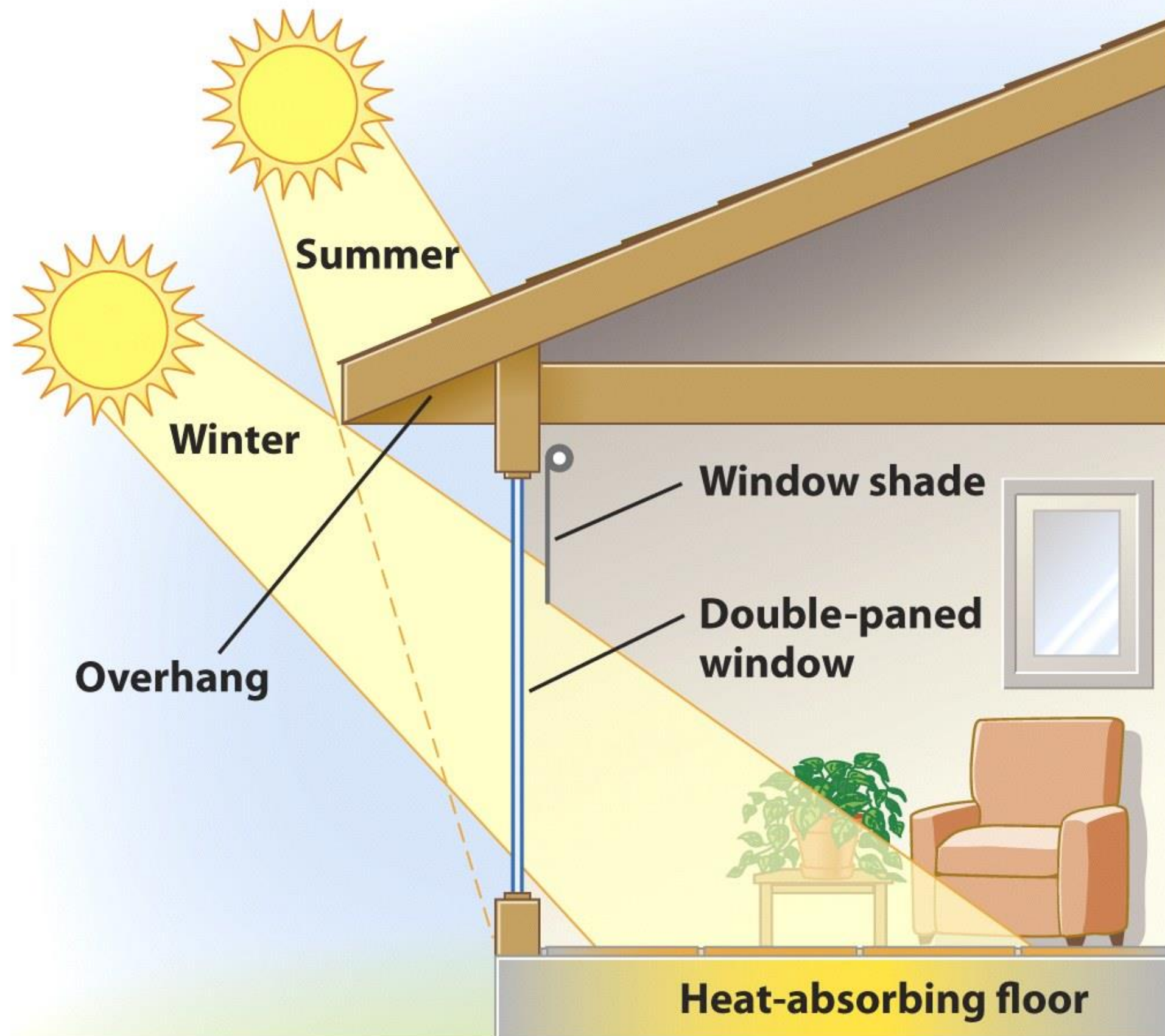
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# Passive Solar Energy

- ▣ Using passive solar energy can lower your electricity bill without the need for pumps or other mechanical devices.
- ▣ Building the house with windows along a south-facing wall which allows the Sun's rays to warm the house would be an example.

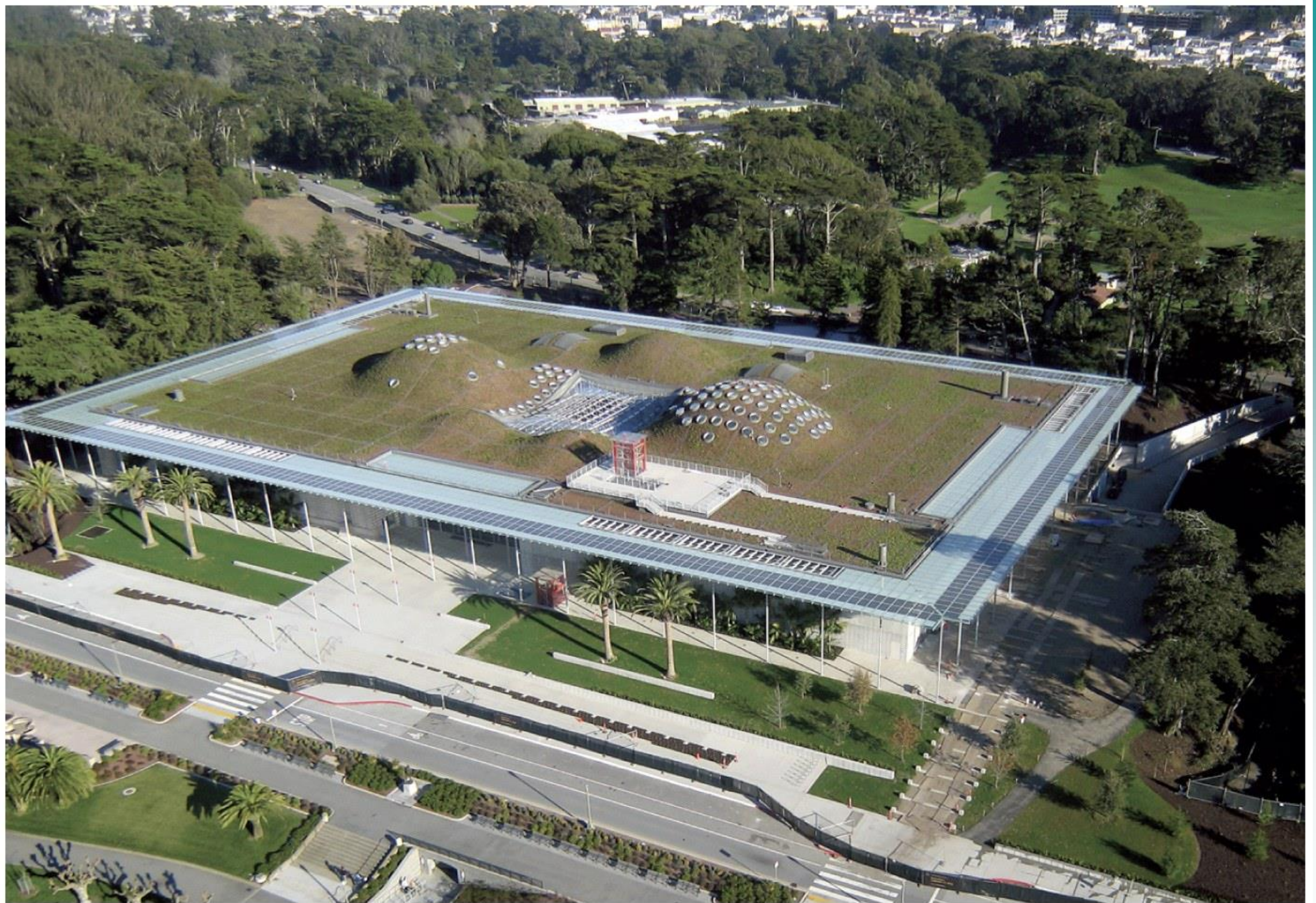


**Figure 13.6**

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**Figure 13.7**

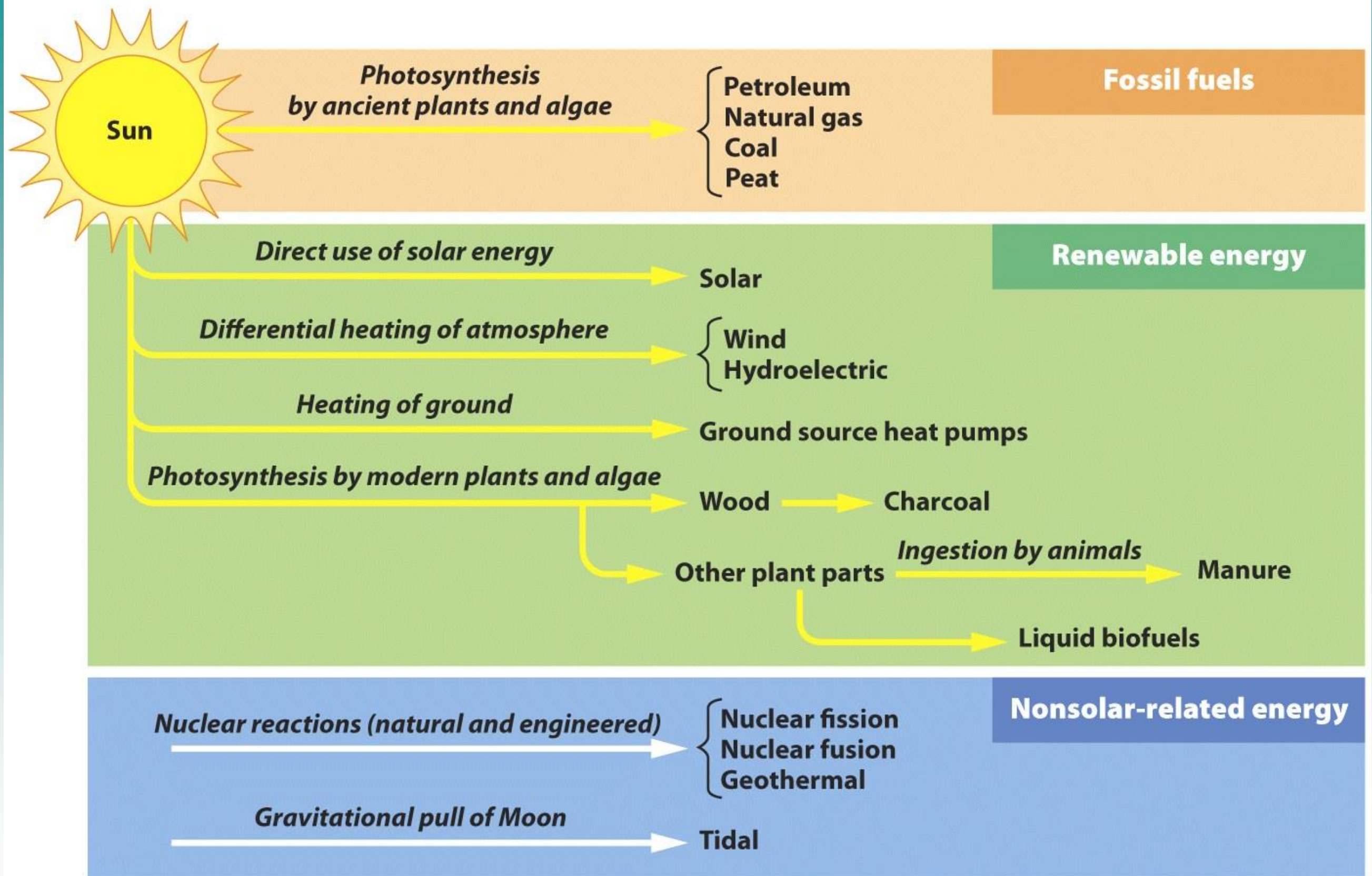
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# Biomass is energy from the Sun

- ▣ The Sun is the ultimate source of almost all types of energy



**Figure 13.8**

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# Modern Carbon vs. Fossil Carbon

- Many people are confused how burning biomass such as wood is better than burning coal.
- The carbon found in biomass was in the atmosphere as carbon dioxide, taken in by the tree, and by burning it we put it back into the atmosphere
- Burning coal is carbon that has been buried for millions of years and was out of circulation until we began to use it. This results in a rapid increase in the concentration of carbon dioxide in the atmosphere.



# Biomass

- ▣ Wood, Charcoal and Manure- used to heat homes throughout the world.
- ▣ Ethanol and Biodiesel (biofuels)- used as substitutes for gasoline and diesel fuel.





**Figure 13.9a**  
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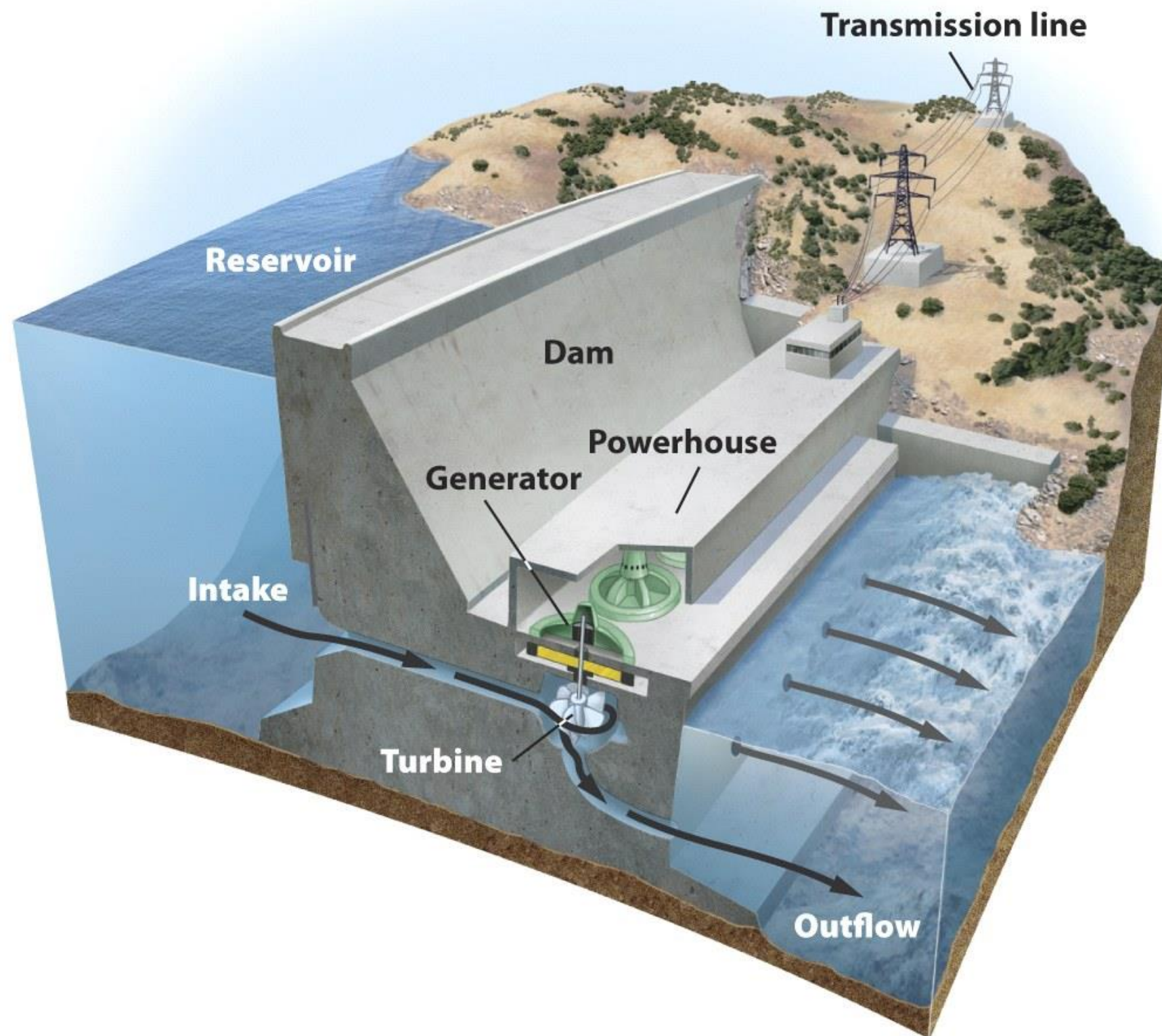
**Figure 13.9b**  
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# The kinetic energy of water can generate electricity

- Hydroelectricity- electricity generated by the kinetic energy of moving water. This is the second most common form of renewable energy in the world.





**Figure 13.12**

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# Types of hydroelectric power systems

- ❑ Run-of-the-river systems- water is held behind a dam and runs through a channel before returning to the river.
- ❑ Water impoundment- water is stored behind a dam and the gates of the dam are opened and closed controlling the flow of water.
- ❑ Tidal systems- the movement of water is driven by the gravitational pull of the Moon.

# The Sun's energy can be captured directly

- ▣ Active solar energy- capturing the energy of sunlight with the use of a pump or photovoltaic cell and generating electricity.





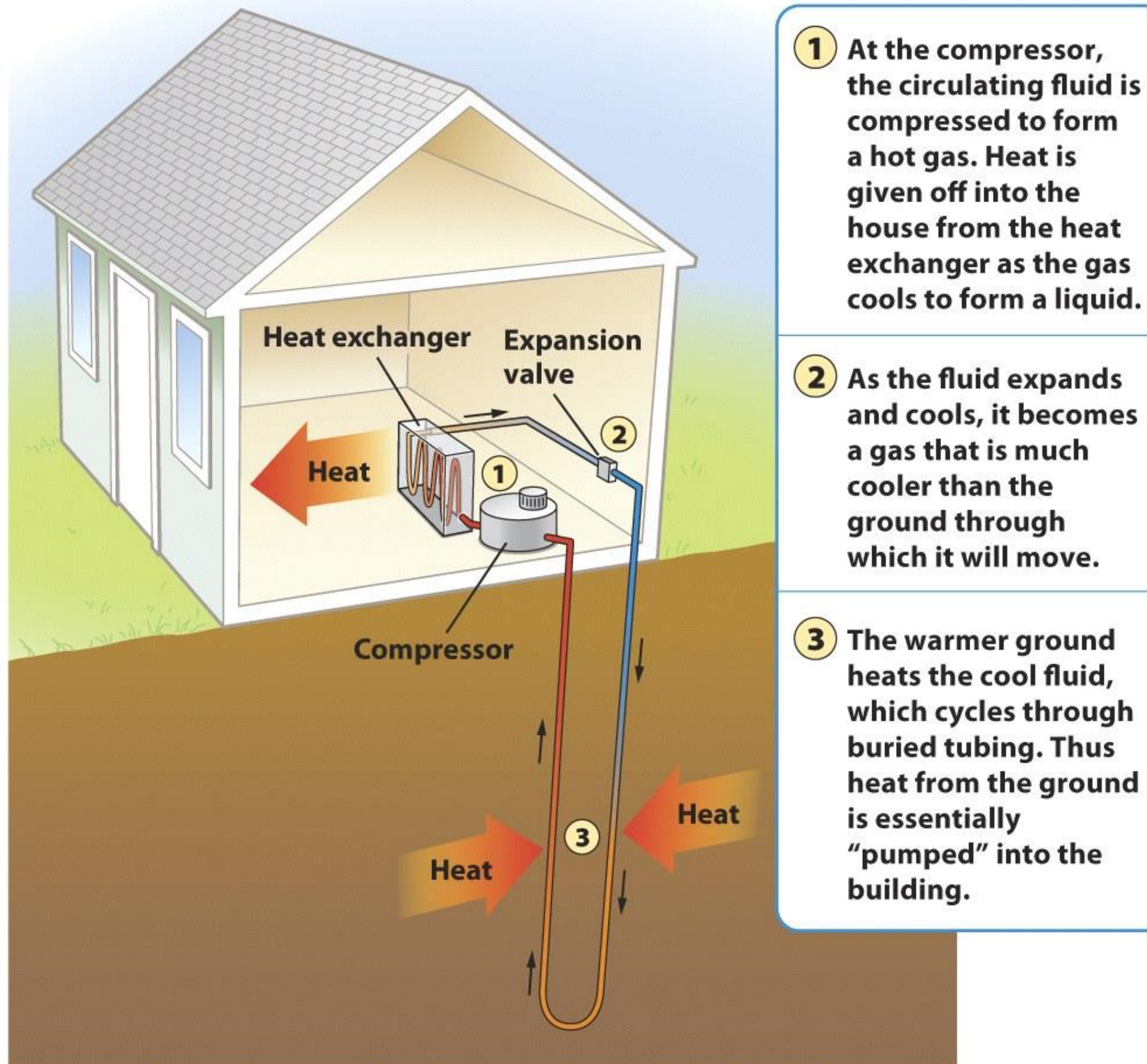
**Figure 13.19**  
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# Earth's internal heat produces geothermal energy

- ▣ Geothermal energy- using the heat from natural radioactive decay of elements deep within Earth as well as heat coming from Earth.





**Figure 13.20**

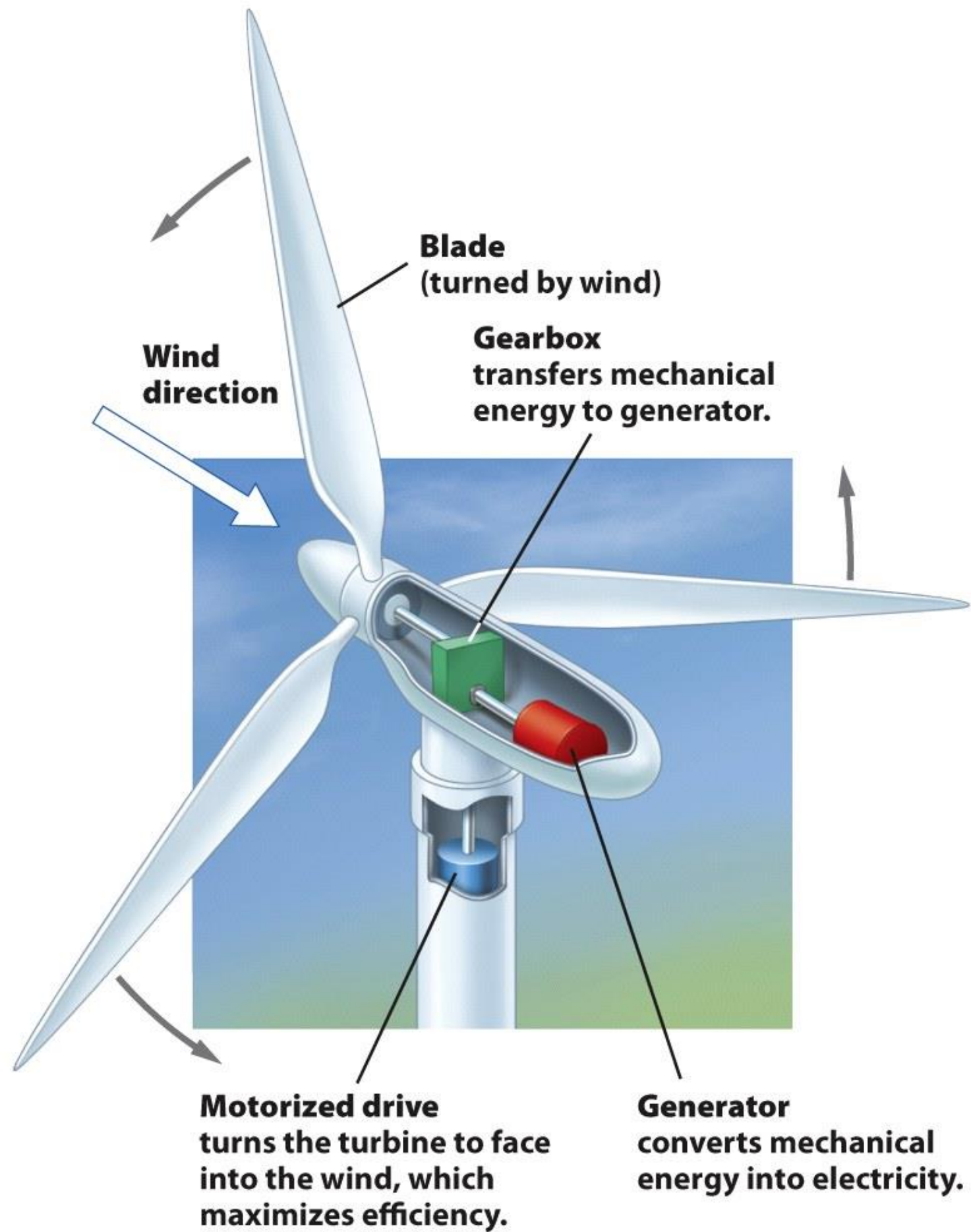
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# Wind energy is the most rapidly growing source of electricity

- Wind energy- using a wind turbine to convert kinetic energy into electrical energy.





**Figure 13.22**

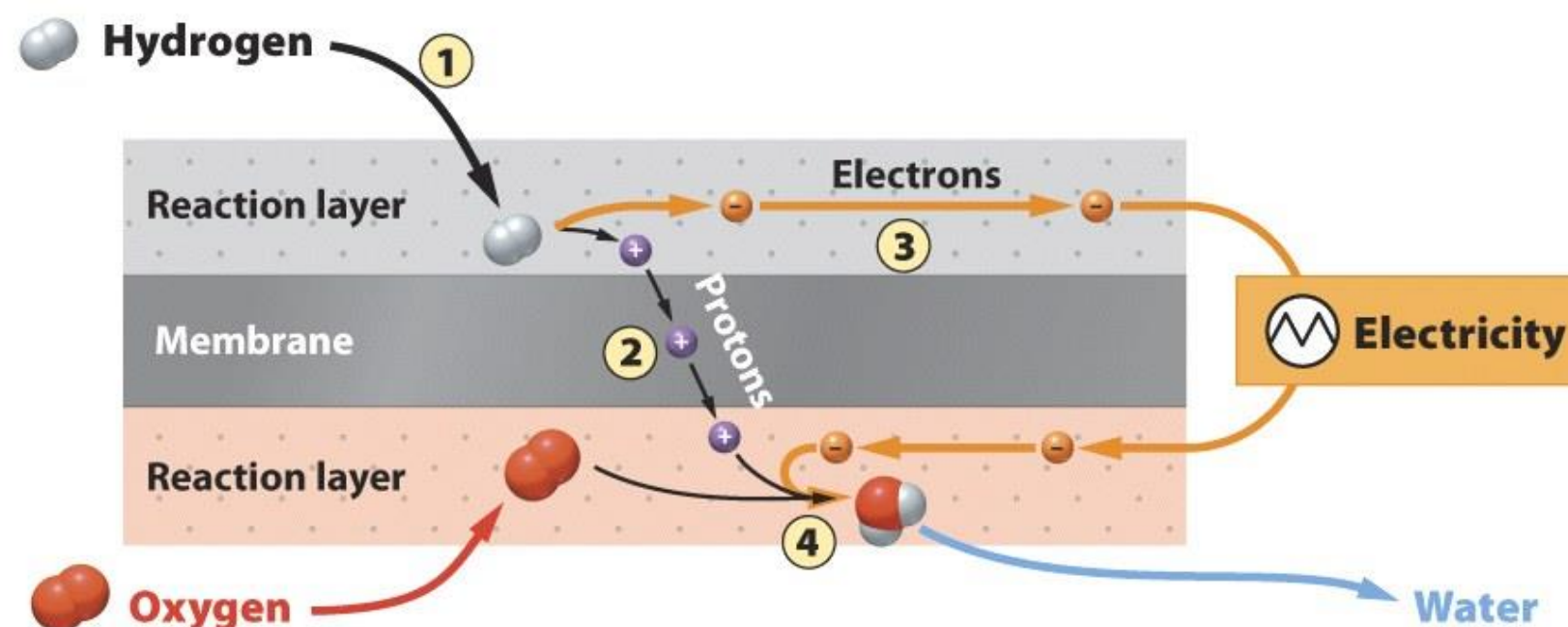
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# Hydrogen fuel cells have many potential applications

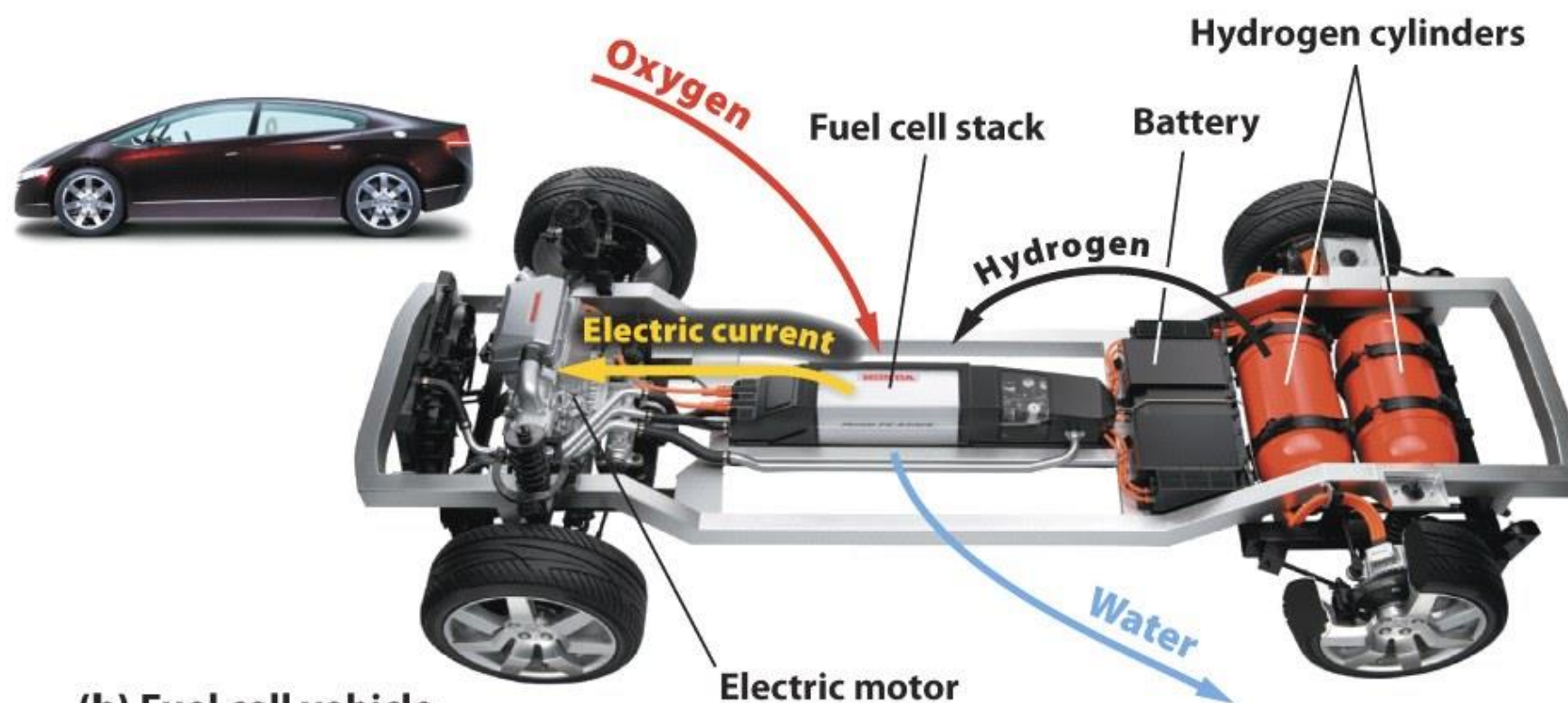
- Fuel cell- a device that operates like a common battery where electricity is generated by a reaction between two chemicals.





- |                                                                                                                                            |                                              |                                                                   |                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>1</b> Hydrogen molecules (<math>H_2</math>) are split into protons (<math>H^+</math>) and electrons in the upper reaction layer.</p> | <p><b>2</b> Protons move across membrane</p> | <p><b>3</b> Electrons take alternate route (electric current)</p> | <p><b>4</b> Oxygen molecules (<math>O_2</math>) are split and combine with protons and electrons to form water in the lower reaction layer.</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|

**(a) One common fuel cell design**



**(b) Fuel cell vehicle**

**Figure 13.25**

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TABLE 13.1 Comparison of renewable energy options					
Energy type	Advantages	Disadvantages	Pollution and greenhouse gas emissions	Electricity cost (cents/kWh)	Energy return on investment
Liquid biofuels	Potentially renewable Can reduce our dependence on fossil fuels Reduces trade deficit Possibly more environmentally friendly than fossil fuels	Loss of agricultural land Higher food costs Lower gas mileage Possible net increase in greenhouse gas emissions	Carbon dioxide and methane		1.3 (from corn)  8 (from sugarcane)
Solid biomass	Potentially renewable Eliminates waste from environment Available to everyone No technology required	Deforestation Erosion Indoor and outdoor air pollution Possible net increase in greenhouse gas emissions Less energy content per liter of fuel	Carbon monoxide Particulate matter Nitrogen oxides Possible toxic metals from MSW Danger of indoor air pollution		
Hydroelectric power	Nondepletable resource Low cost to run Flood control Recreation	Limited amount can be installed in any given area High construction costs Threats to river ecosystem Loss of habitat, agricultural land, and cultural heritage; displacement of people Siltation	Methane from decaying flooded vegetation	0.05–0.11	12
Tidal energy	Nondepletable resource After initial investment, no cost to harvest energy	Potential disruptive effect on some marine organisms Geographically limited	None during operation		15
Photovoltaic solar cells	Nondepletable resource After initial investment, no cost to harvest energy	Manufacturing materials requires high input of metals and water No plan in place to recycle solar panels Geographically limited High initial costs Storage batteries required for off-grid systems	None during operation Some pollution generated during manufacturing of panels	0.20	
Solar water heating	Nondepletable resource After initial investment, no cost to harvest energy	Manufacturing materials requires high input of metals and water No plan in place to recycle solar panels Geographically limited High initial costs	None during operation Some pollution generated during manufacturing energy	0.05–0.11	
Geothermal energy	Nondepletable resource After initial investment, no cost to harvest energy Can be installed anywhere (ground source heat pump)	Emits hazardous gases and steam Geographically limited (deep well geothermal)	None during operation	0.05–0.30	8 (to electricity)
Wind energy	Nondepletable resource After initial investment, no cost to harvest energy Low up-front cost	Turbine noise Deaths of birds and bats Geographically limited to windy areas near transmission lines Aesthetically displeasing to some Energy storage can be difficult	None during operation	0.04–0.06	18
Hydrogen	Efficient Zero pollution	Energy-intensive process to extract hydrogen Lack of distribution network Hydrogen storage challenges	None during operation		18