

Chapter 13

Achieving Energy Sustainability

Energy from the Moon

- Tidal energy
 - “Moon power”
 - Capture energy in moving water
 - Clean source of energy
 - Efficient source of energy
- Roosevelt Island
 - First commercial tidal energy plant in US (RITE)
- Why is RITE good for environment?
- Moving to 3rd development phase of RITE
 - Downside

What is renewable energy?

- Renewable energy categories:
 - Potentially renewable – can be rapidly regenerated
 - Nondepletable – can never be depleted, no matter how much of them we use
- Used by humans for thousands of years
 - Biomass
- Impact of use:

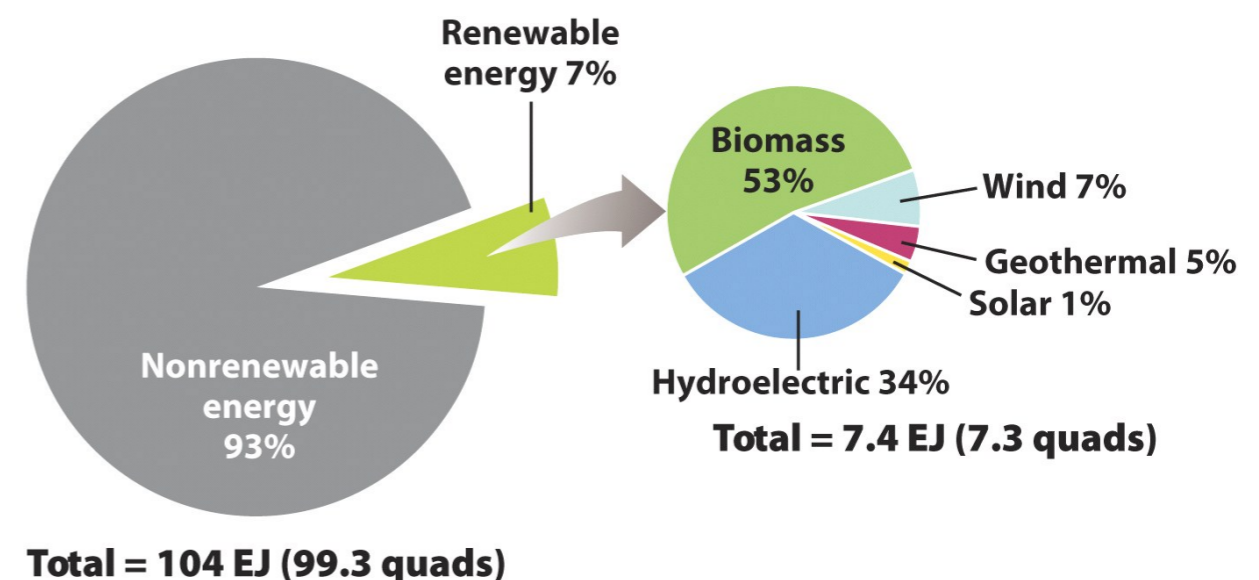


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Types of Energy Resources

Nonrenewable



Natural gas



Oil



Coal



Nuclear

Potentially renewable



Wood



Biofuel

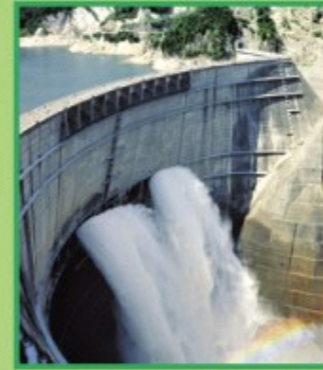
Nondepletable



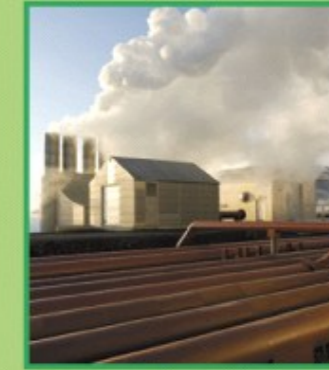
Wind



Solar



Hydroelectric



Geothermal

Figure 13.1

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How can we use less energy?

- Must improve both:
 - Energy conservation- finding ways to use less energy.
 - Small scale examples
 - Large scale examples
 - Tiered rate system
 - Energy efficiency- getting the same result from using a smaller amount of energy
 - Examples:

How to use less 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.**



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Benefits of Energy Conservation and Efficiency

- Especially important during peak demand
 - Peak demand
 - How to reduce use during peak demand?
 - Variable price structure
- Remember $\sim 2/3$ of energy is lost as heat in a typical nuclear or fossil fuel power plant

Sustainable Design

- Improving the efficiency of the buildings we live and work in
- Includes:
 - Building homes closer to employment (reduces transportation)
 - Low impact/recycled materials
 - Gray water systems
 - Composts
 - In addition to...

An Energy Efficient Home

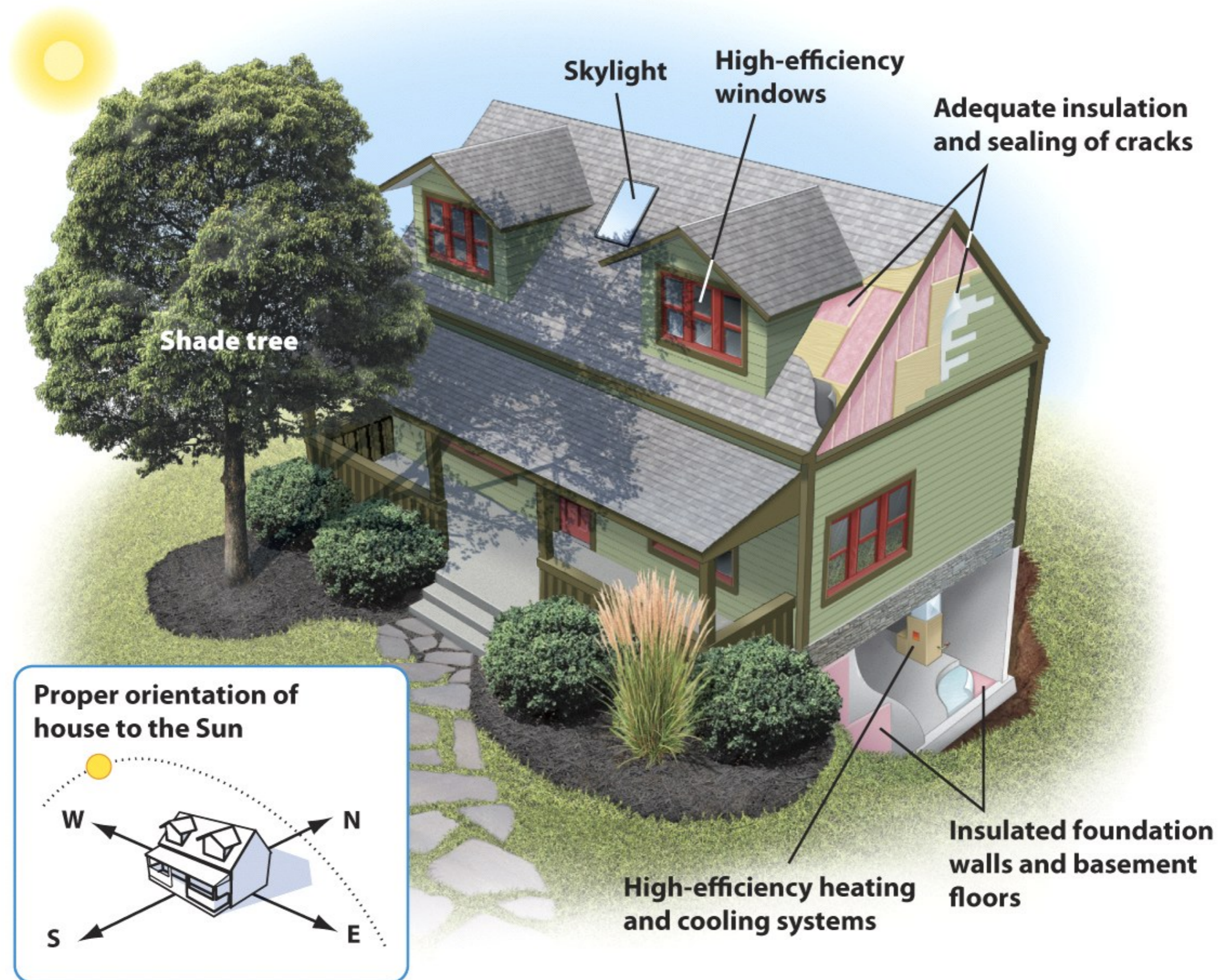


Figure 13.5

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Passive Solar Energy

- Stabilizes indoor temperatures without the need for pumps or other mechanical devices
 - To reduce electricity bill
- Examples:

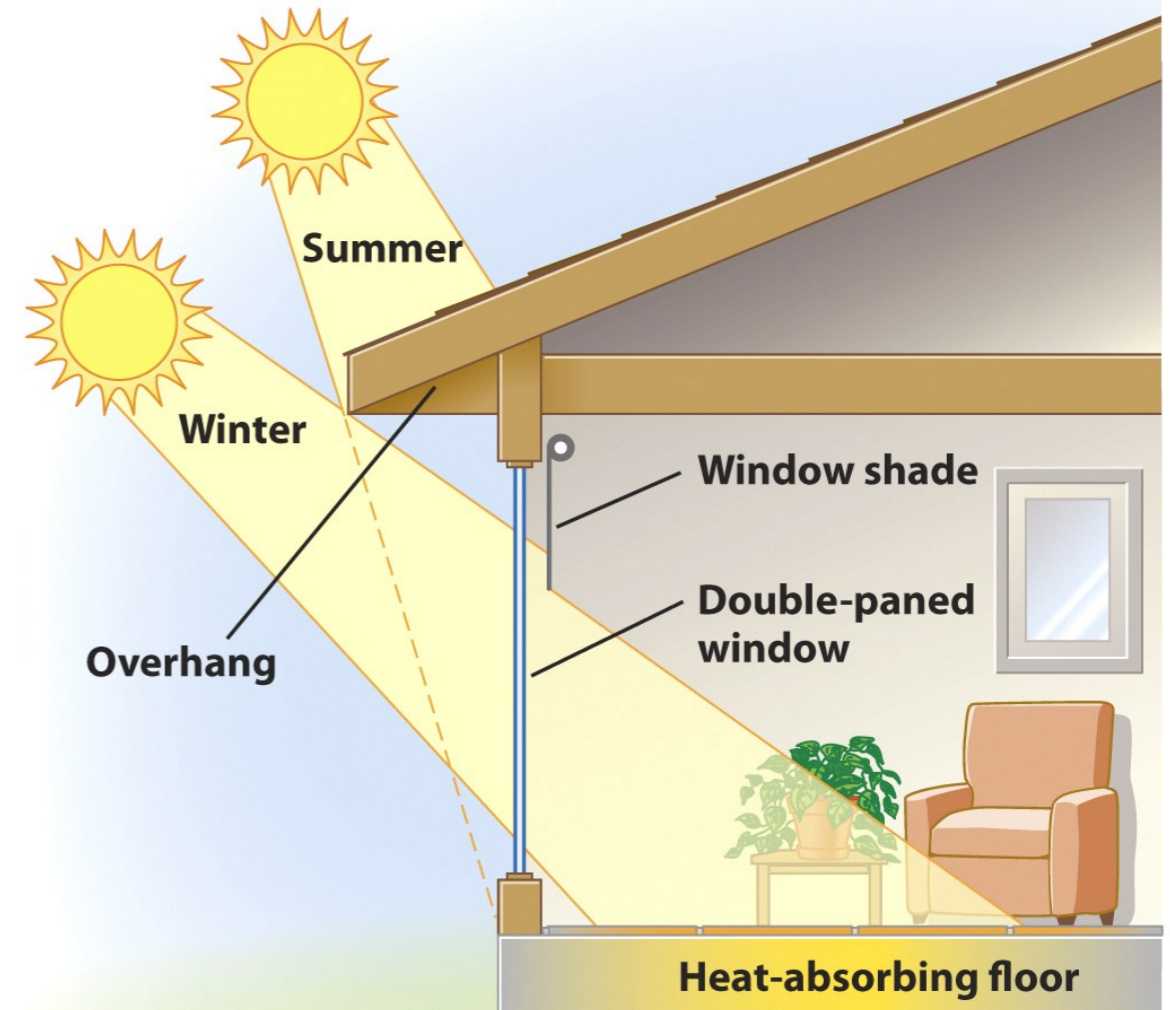


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A “Green” Building

Biomass is energy from the Sun

- Sun – ultimate source of almost all types of energy
- Biomass – large class of fuel types

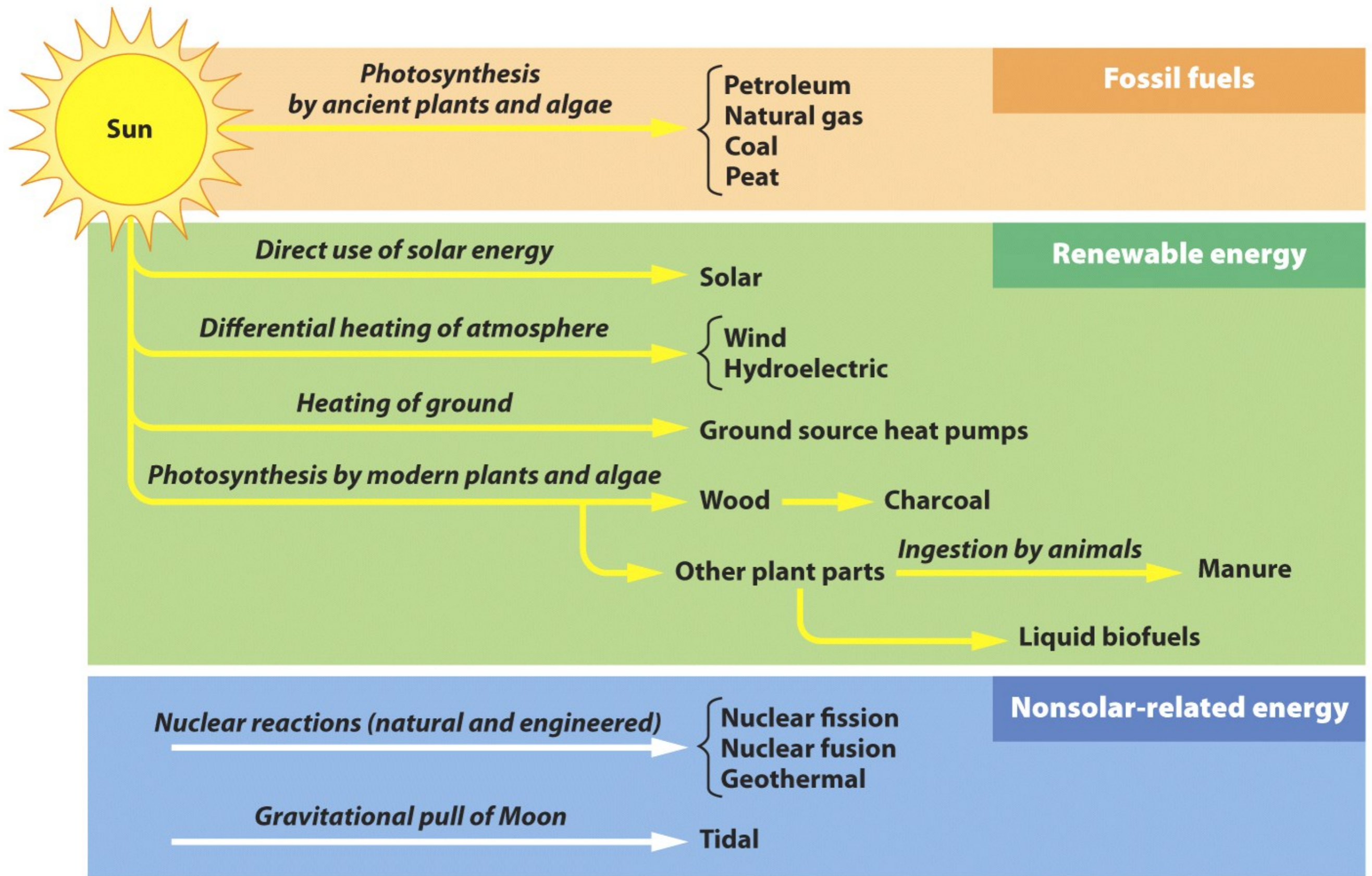


Figure 13.8

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Modern Carbon vs. Fossil Carbon

- Why is burning biomass such as wood is better than burning coal?
- Fossil carbon – carbon in fossil fuels
- Modern carbon – carbon in biomass
 - IN THEORY
 - Carbon neutral

Solid Biomass

- Wood, Charcoal and Manure- used to heat homes throughout the world
 - WOOD:
 - Problems:
 - Benefits to tree removal:
 - CHARCOAL:
 - [How to Make Charcoal](#)
 - Benefits
 - ANIMAL MANURE:
 - Benefits:
 - Downsides

Biofuels (liquid)

- Ethanol and Biodiesel – used as substitutes for gasoline and diesel fuel
 - Ethanol – an alcohol
 - Disadvantages
 - Alternatives
 - Biodiesel – substitute for regular petroleum diesel
 - In US – policy makers are pushing for production of biofuels as way to reduce dependence on foreign oil
 - 2007
 - 2009
 - BUT... biofuel only accounts for ~0.6% of US energy supply



1. Today's commercial ethanol production begins by grinding corn kernels into a powder.



2. It is then heated and liquefied into a starchy "mash."



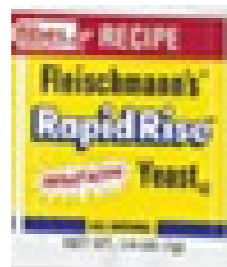
3. Enzymes break down the "mash" into fermentable sugars.



+



4. Yeast is added to ferment the sugars to ethanol.



+



Solid residue, distillers grains, is a byproduct used for livestock feed.

10% Alcohol

Water

+



Heat

=



Fuel ethanol

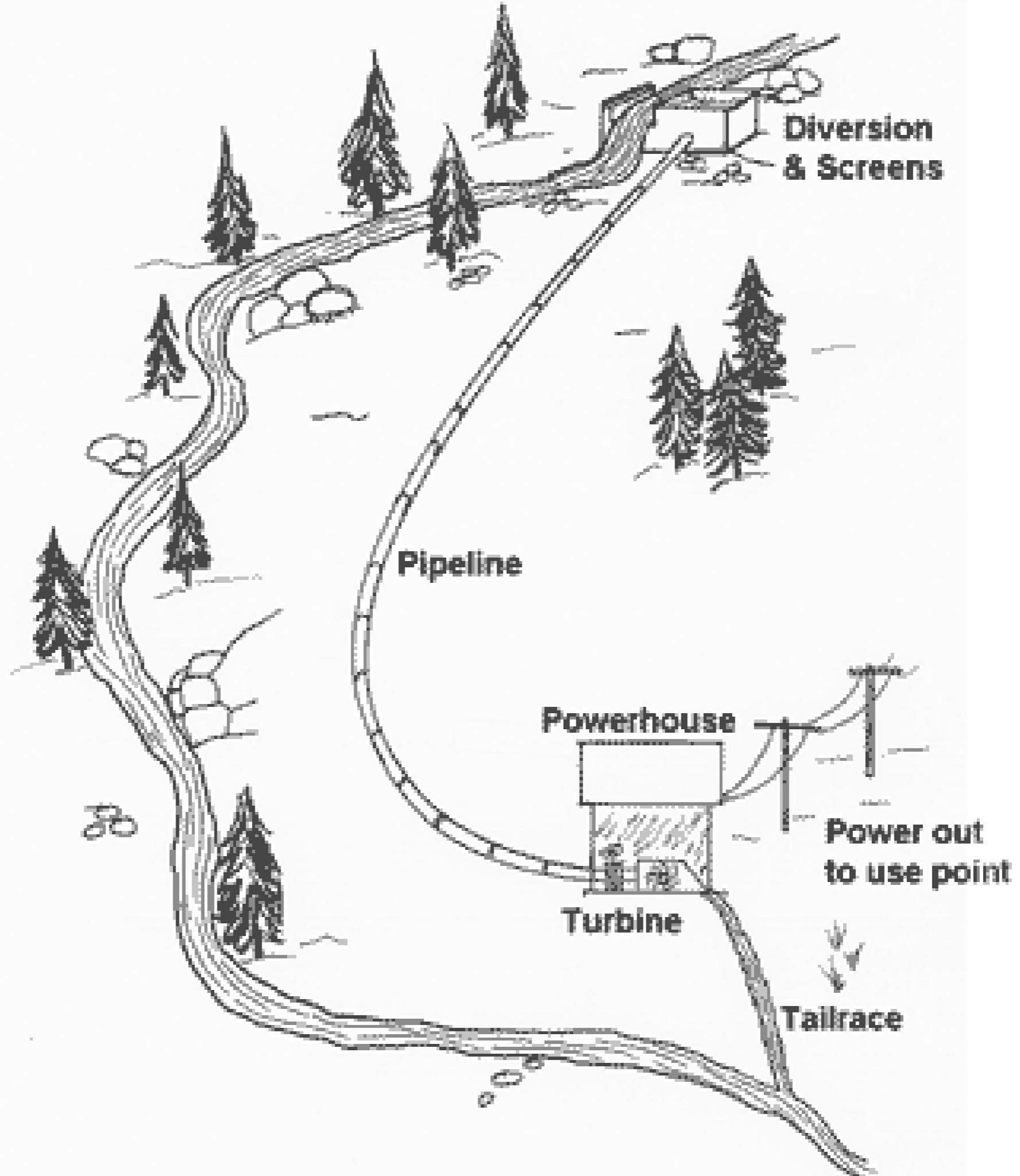
Distilled alcohol + 2-5% gasoline "denaturant"

Biofuel Use

- Gasohol – fuel that is 10% ethanol, 90% gasoline
- Flex Fuel Vehicles – can run on gasoline or E-85
- B-20 – mixture of 80% petroleum diesel and 20% biodiesel
- SVO – straight vegetable oil

The kinetic energy of water can generate electricity

- Hydroelectricity- electricity generated by the kinetic energy of moving water
 - Second most common form of renewable energy in the world
 - 7% of electricity in US; common states: Washington, California, Oregon
 - China – worlds leading producer of hydroelectricity



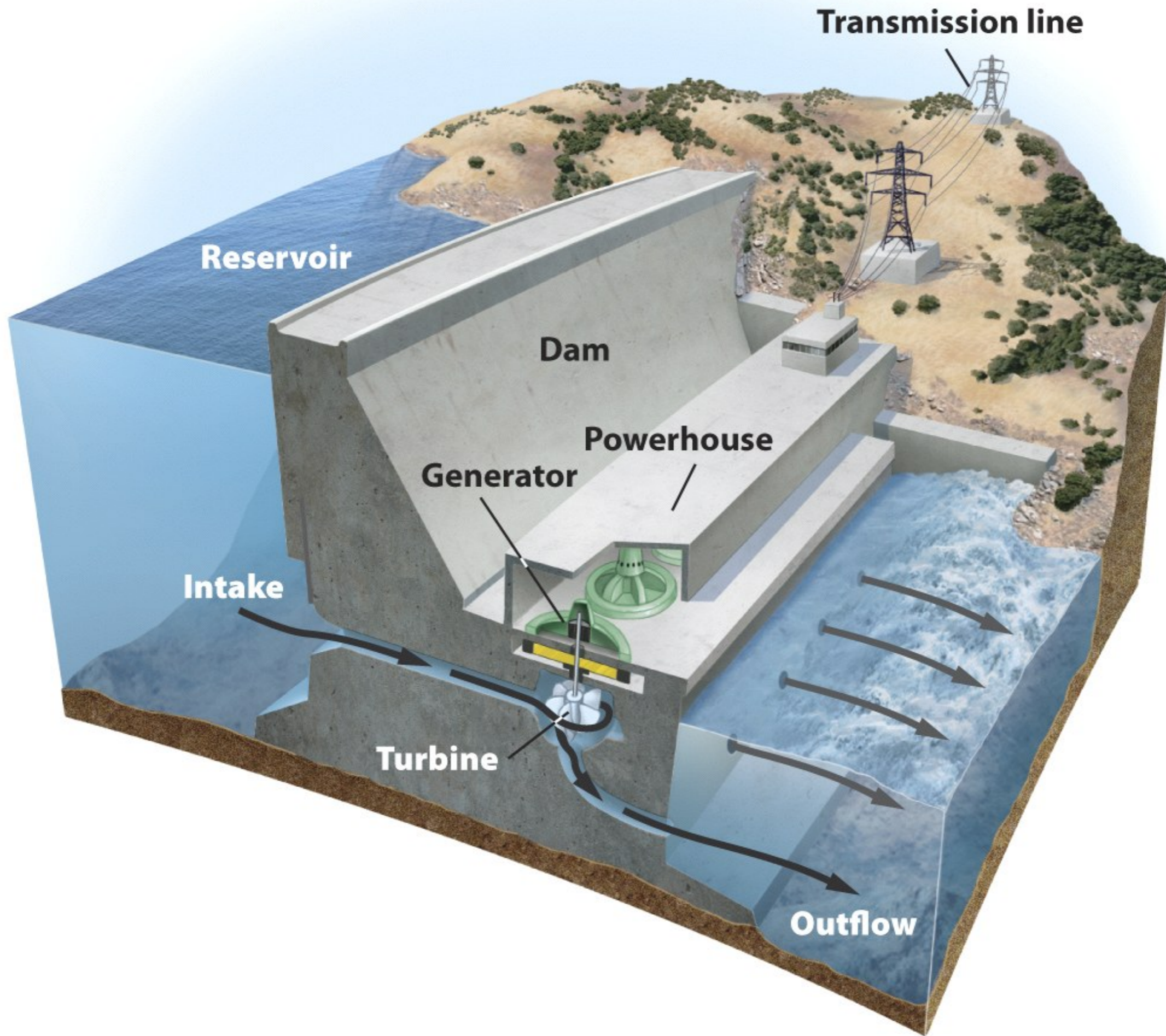


Figure 12.12

Is Hydroelectricity Sustainable?

- Expensive to build
- Benefits:
- Downsides:
 - Reservoir :
 - Changes river downstream
 - Fossil fuel use during construction
 - Siltation

The Sun's energy can be captured directly

- Passive Solar Heating – capturing the energy of sunlight without the use of mechanical devices
- Active solar energy- capturing the energy of sunlight with the use of a pump or photovoltaic cell and generating electricity

Passive Solar Heating

- We've talked about a bunch previously
- Solar ovens – concentrates sunlight as it strikes reflector on top of oven
 - Benefits:
 - Replaces wood = less deforestation
 - Not having to look for firewood

Active Solar Technologies

- Solar Water Heating Systems – can range from providing domestic hot water/heating swimming pools to business and home heating purposes
- Photovoltaic cells – capture energy from sun as light and convert it to electricity
- Concentrating Solar Thermal Electricity Generation – uses lenses/mirrors and tracking system to focus sunlight falling on large area into small beam
 - Drawbacks

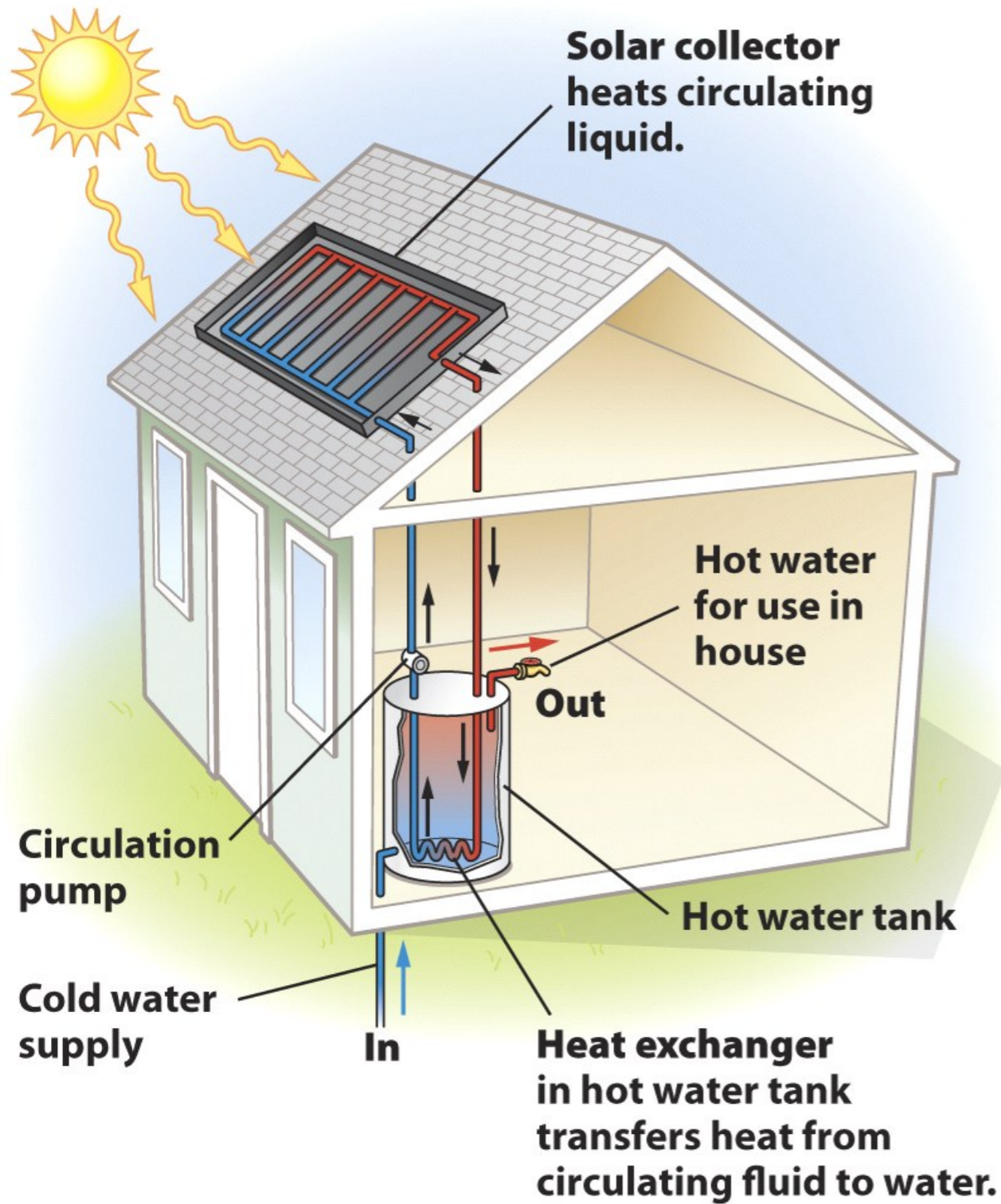
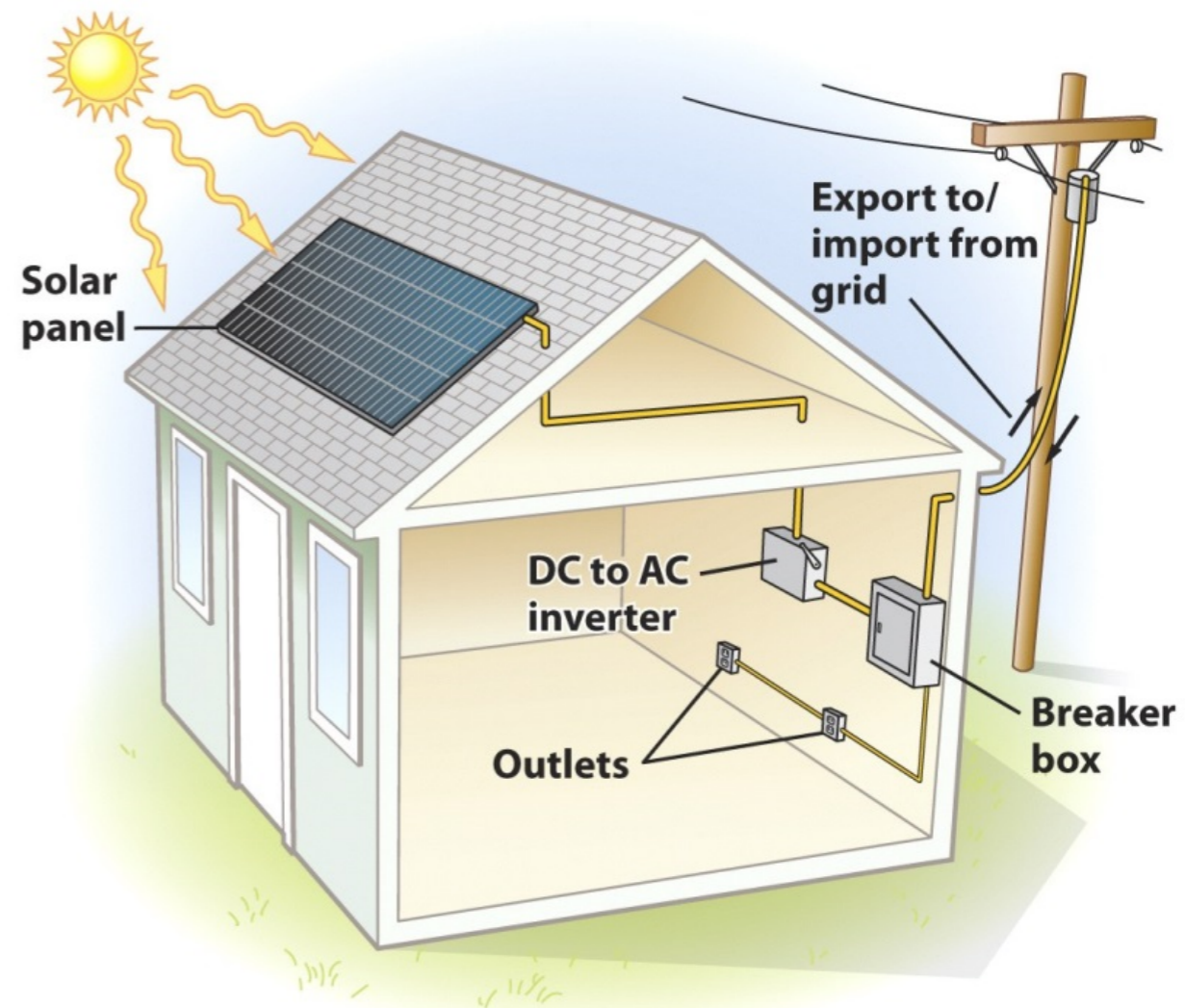


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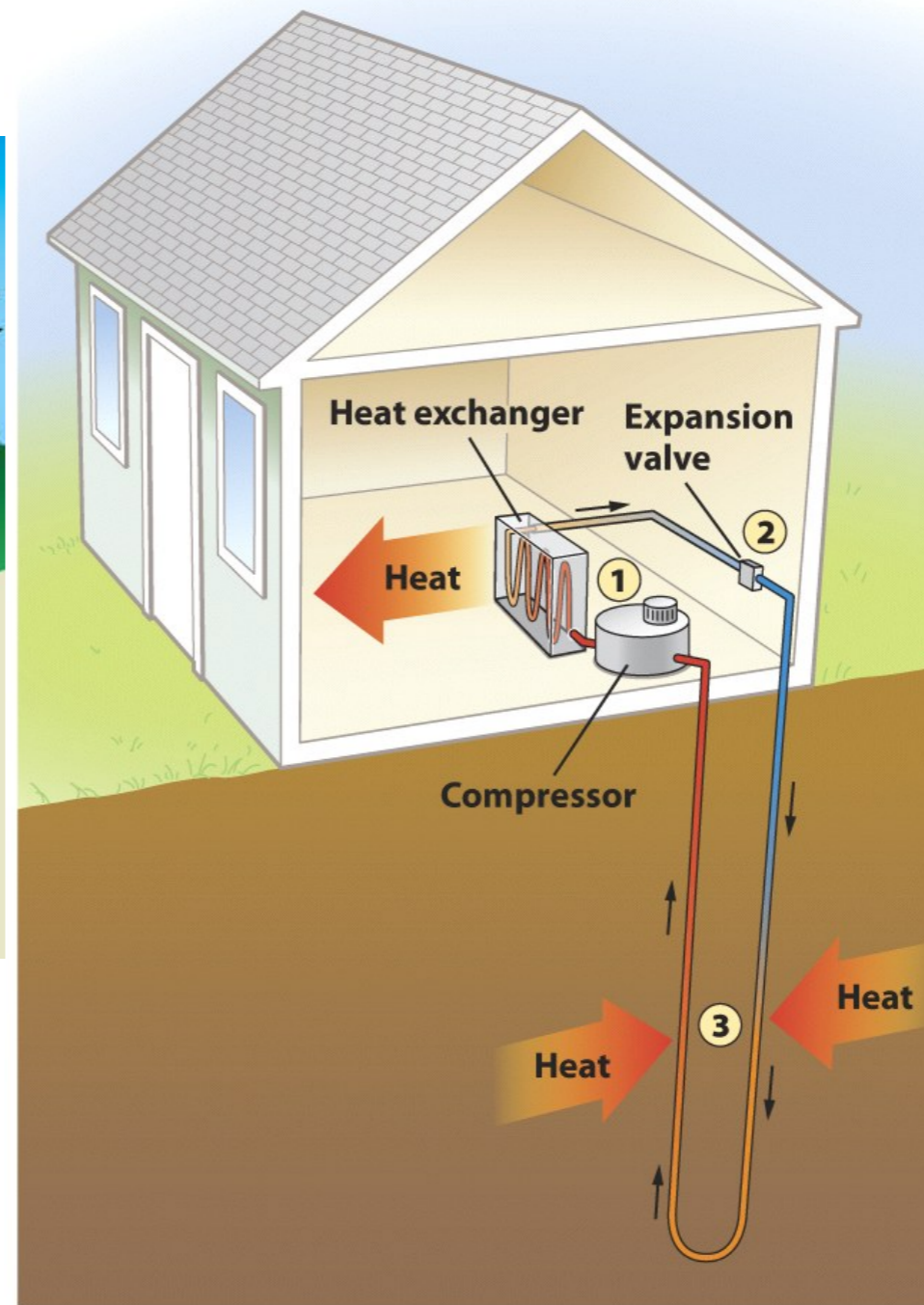
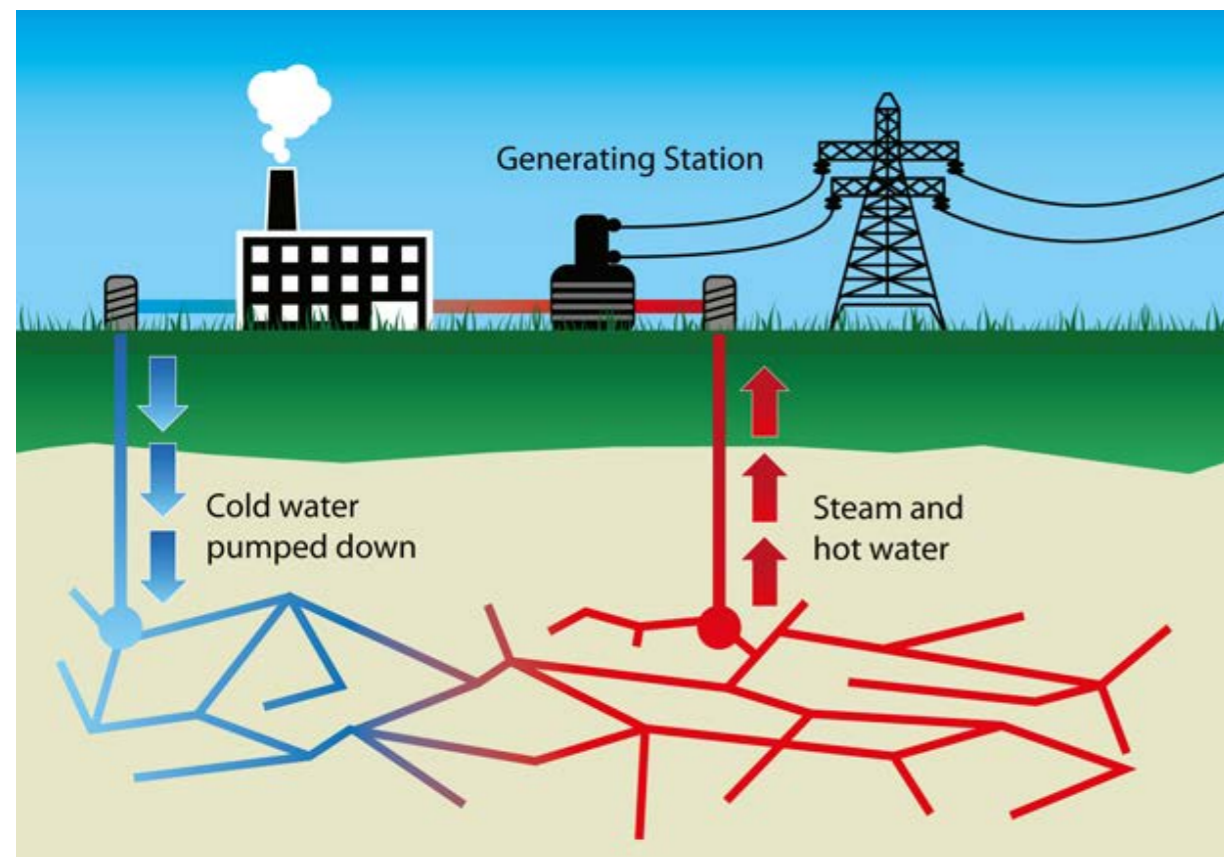


Schematic of photovoltaic (PV) system

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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
 - Can be used to:
 - Drawbacks:
- Ground source heat pumps – technology that transfers heat from ground to a building



- 1** At the compressor, the circulating fluid is compressed to form a hot gas. Heat is given off into the house from the heat exchanger as the gas cools to form a liquid.
- 2** As the fluid expands and cools, it becomes a gas that is much cooler than the ground through which it will move.
- 3** The warmer ground heats the cool fluid, which cycles through buried tubing. Thus heat from the ground is essentially "pumped" into the building.

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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
 - Where found?
 - Fastest growing major source of electricity in world
- Advantages:
- Disadvantages:

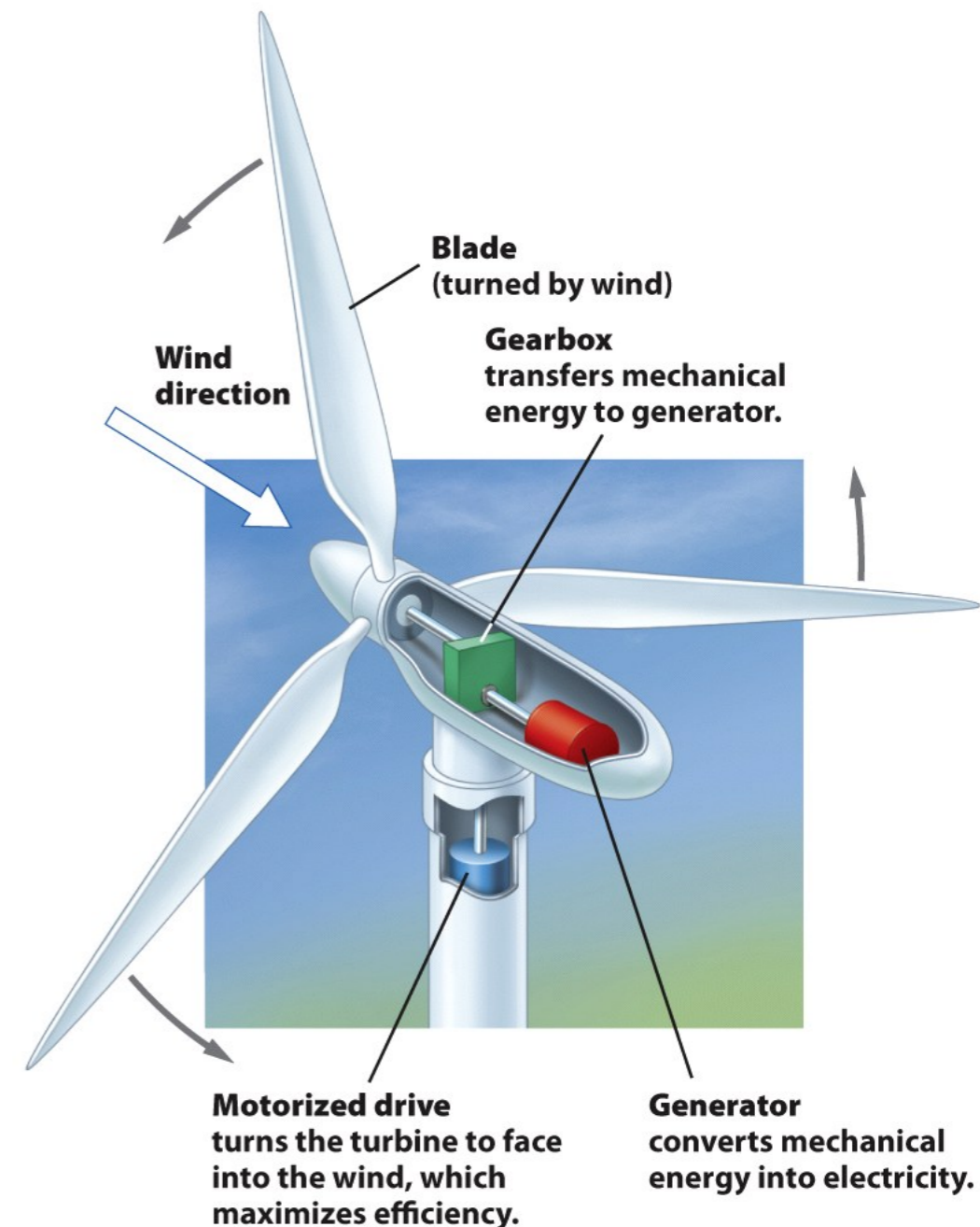
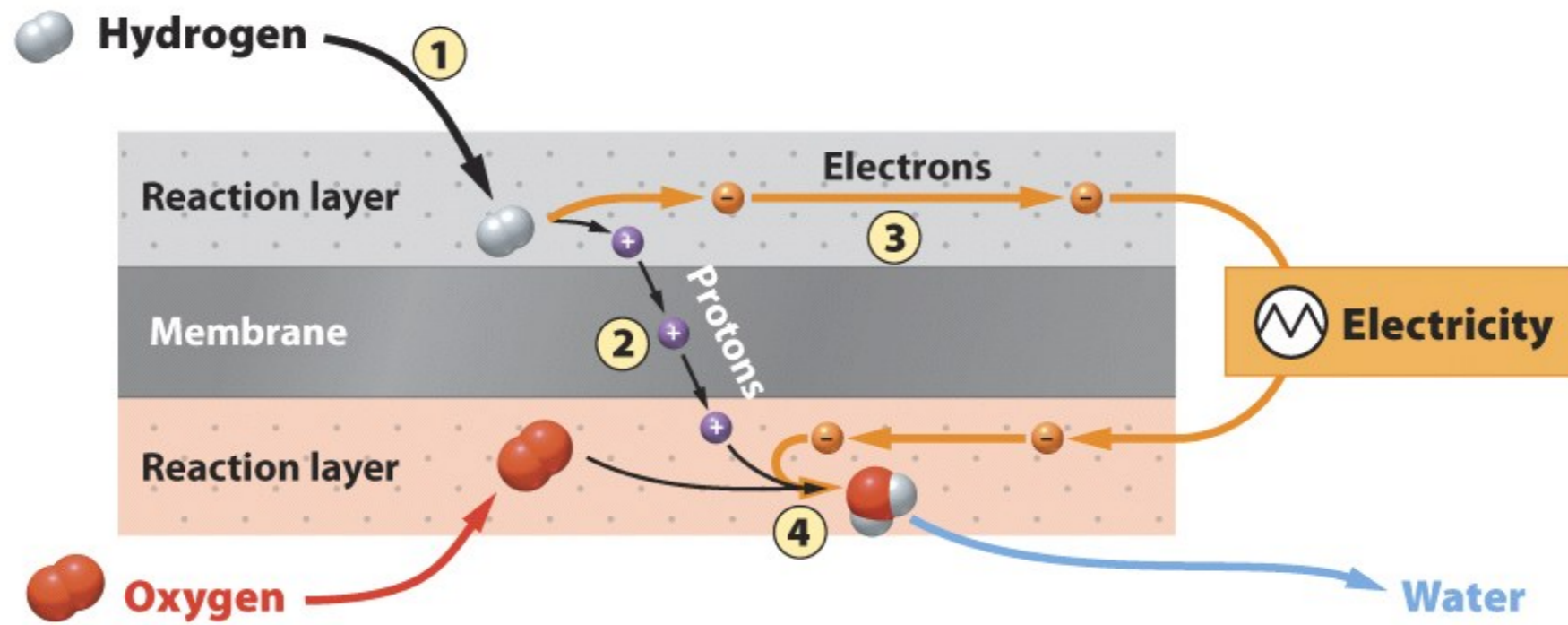


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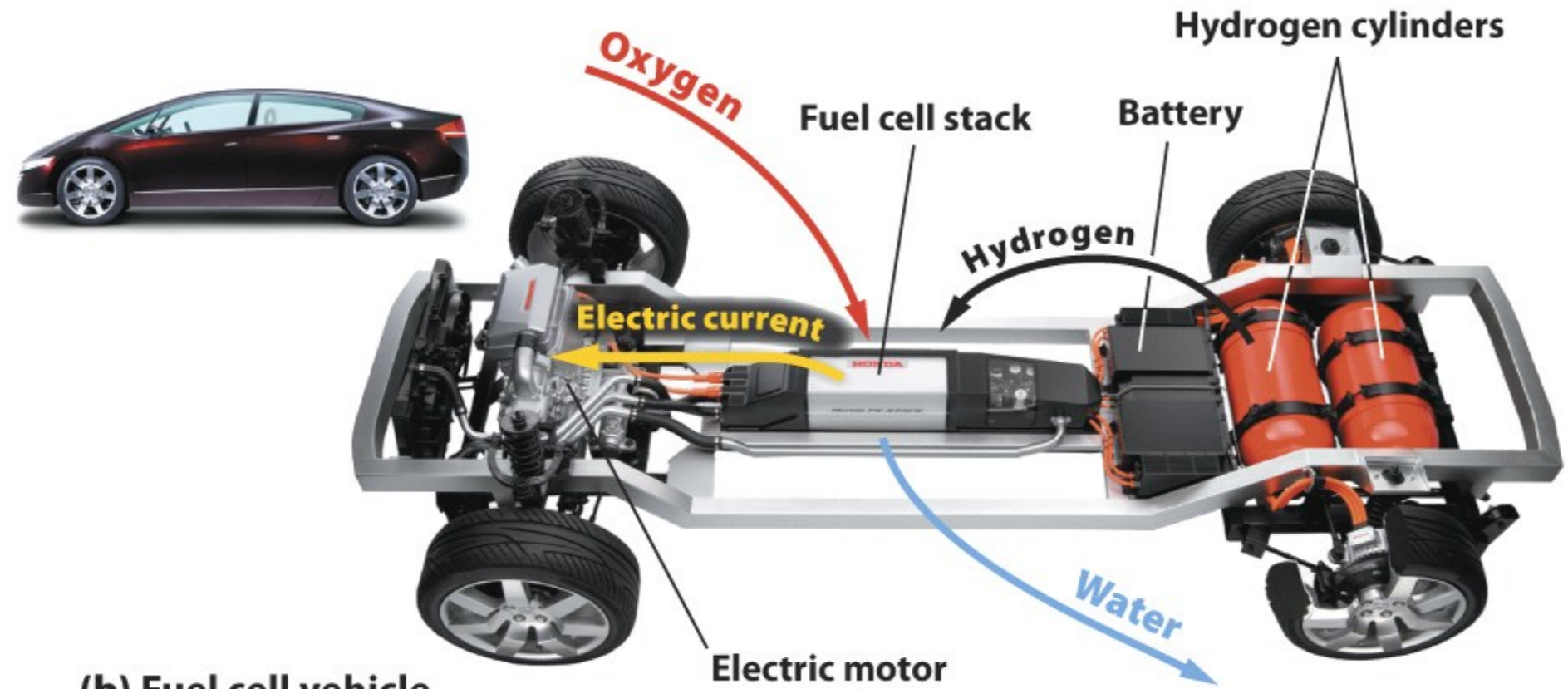
Hydrogen fuel cells have many potential applications

- Fuel cell- a device that operates like a common battery where electricity is generated by a reaction between two chemicals
 - Hydrogen fuel cell:
 $2\text{H}_2 + \text{O}_2 \rightarrow \text{energy} + 2\text{H}_2\text{O}$
 - How do we get H₂?
 - Benefits:
 - Downsides:



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

TABLE 13.1 Comparison of renewable energy resources					
Energy resource	Advantages	Disadvantages	Emissions (pollutants and greenhouse gases)	Electricity cost (\$/kWh)	Energy return on energy 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	CO ₂ and methane		1.3 (from corn) 8 (from sugarcane)
Solid biomass	Potentially renewable Eliminates waste from environment Available to everyone Minimal technology required	Deforestation Erosion Indoor and outdoor air pollution Possible net increase in greenhouse gas emissions	Carbon monoxide Particulate matter Nitrogen oxides Possible toxic metals from MSW Danger of indoor air pollution		
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	0.2	8
Solar water heating systems	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 of panels		
Hydroelectricity	Nondepletable resource Low cost to run Flood control Recreation	Limited amount can be installed in any given area High construction costs Threats to river ecosystems 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
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	None during operation	0.05–0.30	8
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 Storage batteries required for off-grid systems	None during operation	0.04–0.06	18
Hydrogen fuel cell	Efficient Zero pollution	Producing hydrogen is an energy-intensive process Lack of distribution network Hydrogen storage challenges	None during operation		8

How do we plan our energy future?

- Challenge of renewable energy strategy?
- Improving the electrical grid
- Addressing energy cost and storage

A Smart House

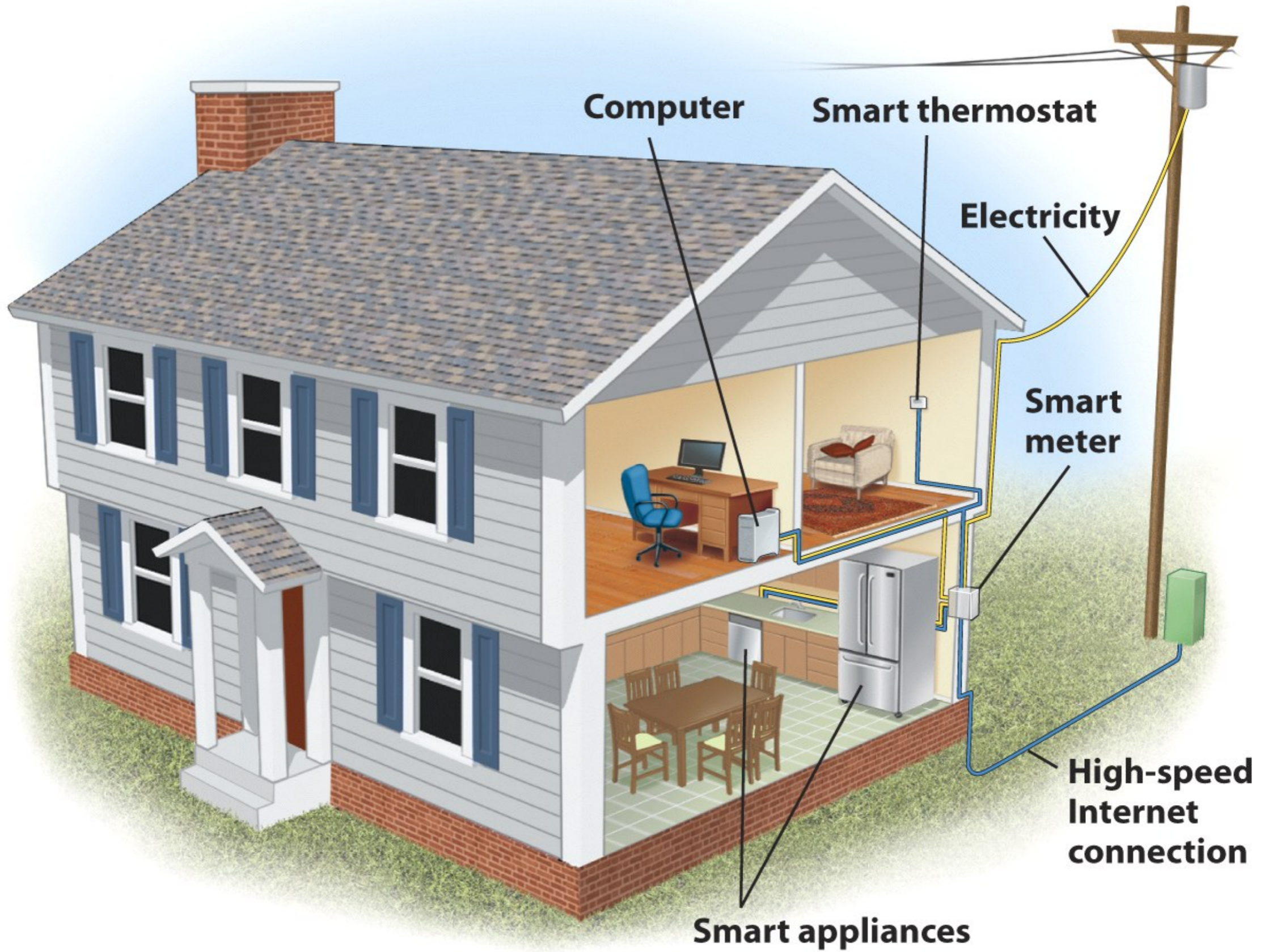


Figure 13.26

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