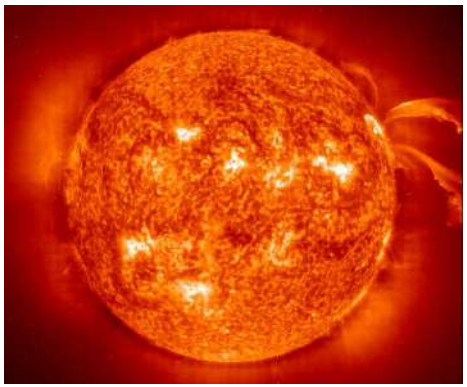
Visualizing Environmental Science

Renewable Energy Resources

Chapter 18

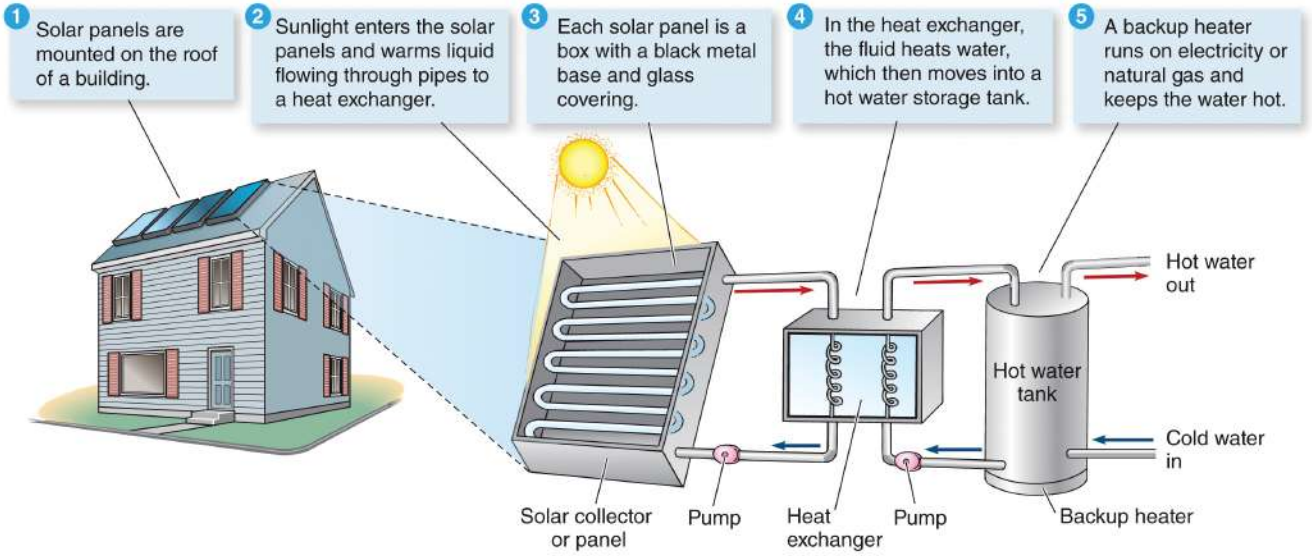
Direct Solar Energy

- Only a _____ portion of the sun's energy reaches the Earth's surface
- Solar energy is always available; we cannot use it up like _____ and nuclear fuels
- Solar energy must be _____ and _____ into other forms for it to be useful as an energy source for human use



Heating Buildings and Water

- _____ solar heating
  - Collectors absorb solar energy as _____, and pumps and fans distribute the collected heat
  - Primarily used for heating _____
    - Household use and swimming pools
    - Can provide a family with hot water year-round



Heating Buildings and Water

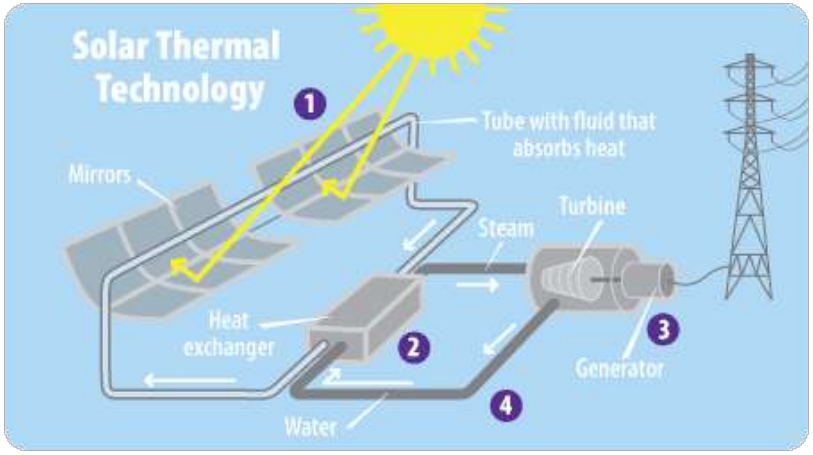
- Passive _____ heating
  - Does not require _____ devices to distribute the collected heat
  - Design features are used to _____ buildings in the winter and keep them cool in the summer
    - South facing windows receive more sunlight
      - Sunlight provides heat, stored in floors and walls
      - Heat is transmitted by _____
    - Building must be well-insulated to maintain heat

Photovoltaic Solar Cells

- _____ cells are constructed of a wafer/thin film of solid-state materials treated with certain metals. This film will generate electricity when it absorbs solar energy
- No pollution, minimal maintenance
- Absorbs sunlight even on _____ or rainy days
- Currently limited by _____ efficiency
  - Large-scale power generation requires too much land to generate sufficient electricity
- Can be economical in rural areas of _____ countries vs. installing power lines

Solar Thermal Electric Generation

- Means of producing electricity by concentrating solar energy via _____ or lenses onto fluid-filled pipes
- More _____ than other solar technologies
- Becoming cost-competitive with fossil fuels
- No pollution, acid deposition, or _____ change
- Does require alternate energy source (_____) at night or on cloudy days



Solar Generated Hydrogen

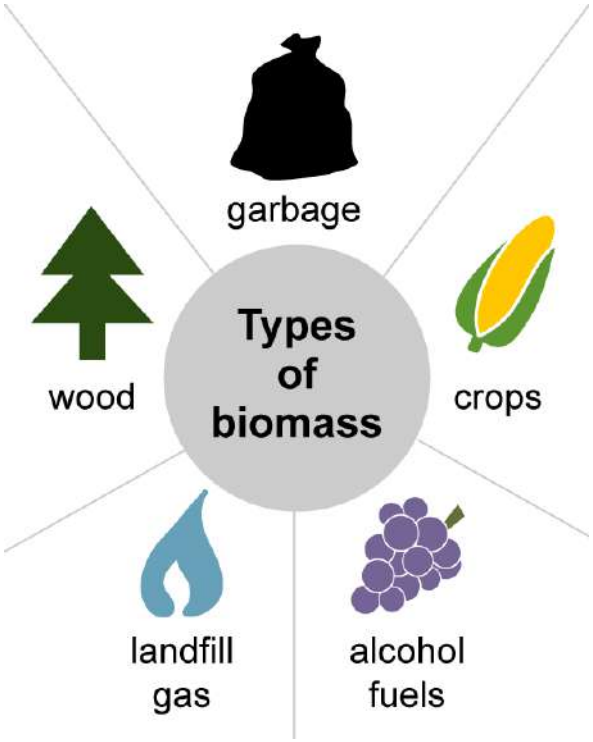
- Hydrogen—fuel of the _____
  - Abundant, easily produced
  - Electricity from any source can split _____ into oxygen and hydrogen gases
  - Environmental impact depends on the source of electricity used
  - Hydrogen itself is a clean fuel
    - Produces _____ and heat as byproducts
- Potential to provide energy for transportation, heating buildings, producing _____
  - Solar electricity must be used immediately, whereas hydrogen can be stored and transported by pipeline

Indirect Solar Energy

- Some renewable energies use the sun's energy _____
  - Combustion of _____ (organic matter)
    - Plants use solar energy for photosynthesis and store the energy as biomass
  - _____ energy
    - Uses wind to generate electricity
  - Hydropower
    - Uses dammed rivers and streams to generate _____

Biomass Energy

- Biomass
  - Plant and _____ material used as fuel
  - Renewable if used properly
- _____
  - Biomass can be converted into a mixture of gases
  - Mostly _____
  - Biogas has the potential to power methane fuel cells to generate _____

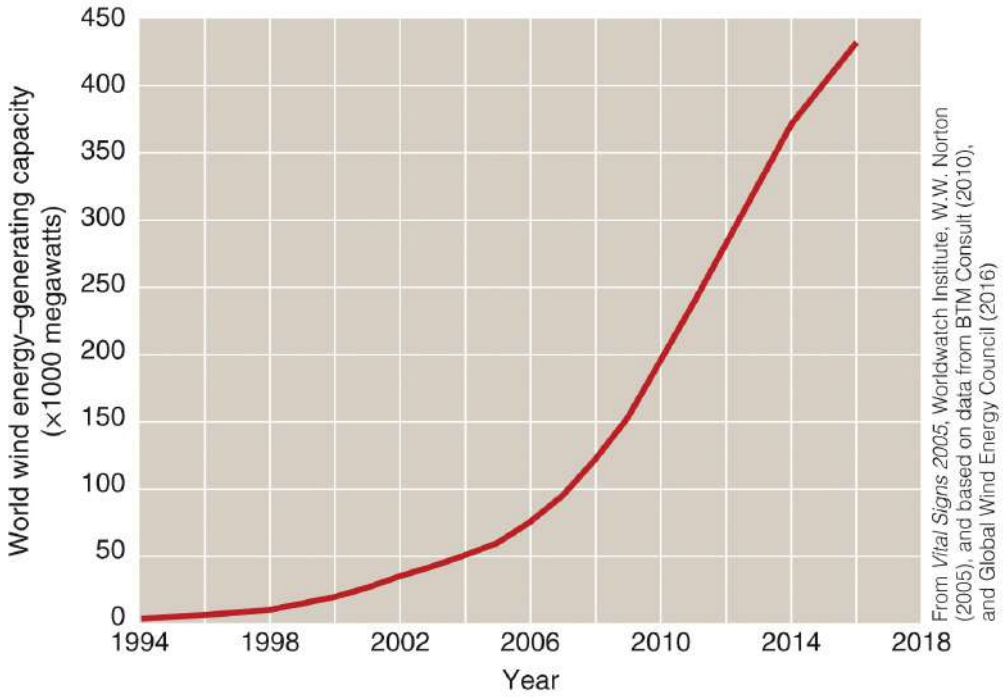


Biomass Energy

- Biomass can also be converted into _____ fuels
  - Methanol, ethanol, and biodiesel
- Biomass is attractive to politicians and consumers as source of energy
  - Reduces dependence on _____
  - Produces lower levels of sulfur and ash than coal
- Problems with biomass
  - Use of _____ and water that might be dedicated to food production
  - Unsustainable use of _____
  - Harm to soil quality

Wind Energy

- Electric energy obtained from surface air currents caused by _____ warming of air
- Wind turbines are _____, and becoming more efficient (100m tall)
  - $0.40/kwh in 1980 to $0.04–0.07/kwh now
  - _____ competitive with most conventional energy

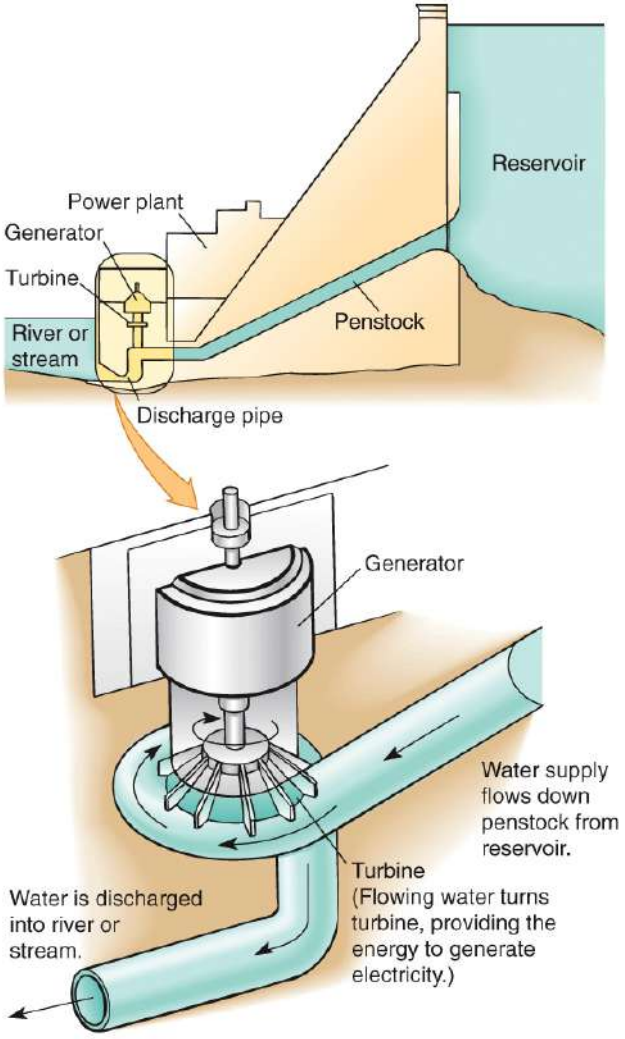


Wind Energy

- Currently, _____ power is captured and placed in regional electricity grids
- No waste, _____ energy
- Problems with wind turbines
  - Can cause bird _____ if turbines are on bird migration pathways (Altamont Pass, CA)
  - Aesthetic issues

Hydropower

- A form of _____ energy that relies on flowing or falling water to generate electricity
- Sun drives the _____ cycle
- Potential energy of water held back by a dam can be converted into _____
- More efficient than any other source of energy
  - _____ of potential energy is converted to electricity



Hydropower

- Problems with _____
  - Dams change natural _____ of rivers
    - Water backs up, floods large areas of land to form reservoir, destroys _____ and animal habitats
    - Downstream lands no longer receive nutrient-rich silt
    - Disrupts fishes' ability to _____

Other Renewable Energy Resources

- Other sources of renewable energy that are not derived from solar energy are increasingly being utilized for heating and/or electricity generation
  - _____ energy
  - _____ energy

Geothermal Energy

- Energy from the Earth's _____, used for space heating or generation of electricity
  - _____ activity heats groundwater forming a hydrothermal reservoir
    - Contains hot water, possibly steam → hot springs
    - Drilling a well can bring up hot water/steam and used to generate electricity, or to supply heat directly to consumers
    - Inexpensive and _____, where available
- U.S. is largest producer of geothermal electricity
- Iceland is a volcanic island
  - Generates _____
  - Heats 2/3 of homes directly with geothermal energy
- Geothermal energy is renewable on a human timescale

Tidal Energy

- Tides are caused by the _____ pull of the moon and sun
  - A dam across a bay can harness the energy of large tides to generate _____
    - Water at high tide gets trapped on the land side. As tide recedes, the water falls through the dam's spillway and turns a _____
  - Problems
    - Few places in the world have tides large enough to support this mode of energy
    - High economic _____
    - Potentially high environmental costs in estuaries

Energy Solutions: Conservation and Efficiency

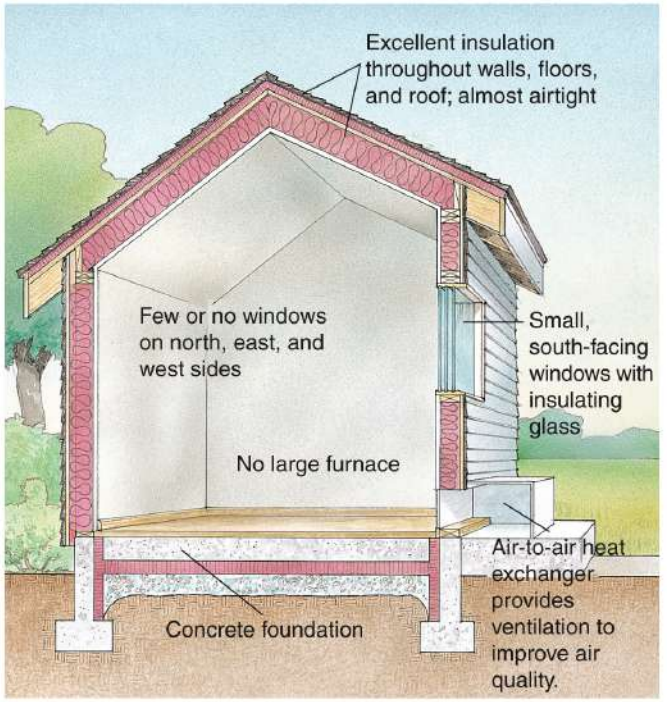
- Energy _____ and energy efficiency accomplish the same goal, but through different means
  - Energy conservation
    - Using less energy- by _____ energy use and waste, for example
  - Energy efficiency
    - Using less energy to accomplish a given task- by using _____ technology, for example and energy star appliance

Energy Consumption Trends and Economics

- Even though the U.S. has become more _____ efficient, energy consumption continues to increase
- Per capita consumption in developing nations is substantially _____ than in developed nations
  - However, greatest per capita increase in consumption is occurring in developing countries—_____ and India
  - This rising demand accompanies increases in economic development and population, and use of older, less expensive, less efficient technology
  - Need to balance economic development with controlling environmental _____

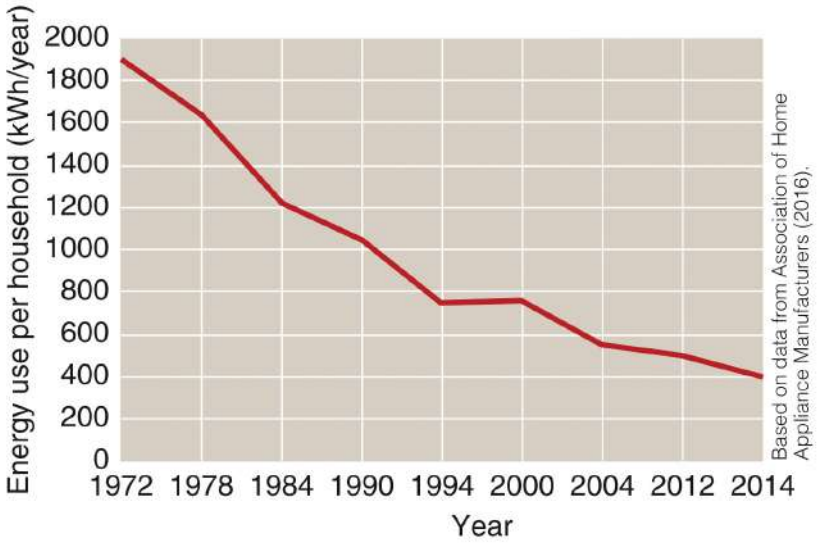
Energy Efficient Technologies

- Development of more _____ appliances, automobiles, buildings, industrial processes helps reduce energy consumption
- _____ produce light comparable to that of incandescent light bulbs, but require only 25% of energy and last up to 15% longer
- Condensing furnaces require _____ less fuel
- _____ buildings use 70–90% less energy



Energy Efficient Technologies

- National Appliance Energy Conservation Act (NAECA) sets U.S. national _____ efficiency standards
  - Refrigerators today use _____ less energy than in early 1970s
- Automobile efficiency has improved dramatically since 1970s—lighter _____ and drag-reducing design
  - Fuel efficiency _____ between mid 70s and mid 80s
  - Declined after that as larger vehicles became popular



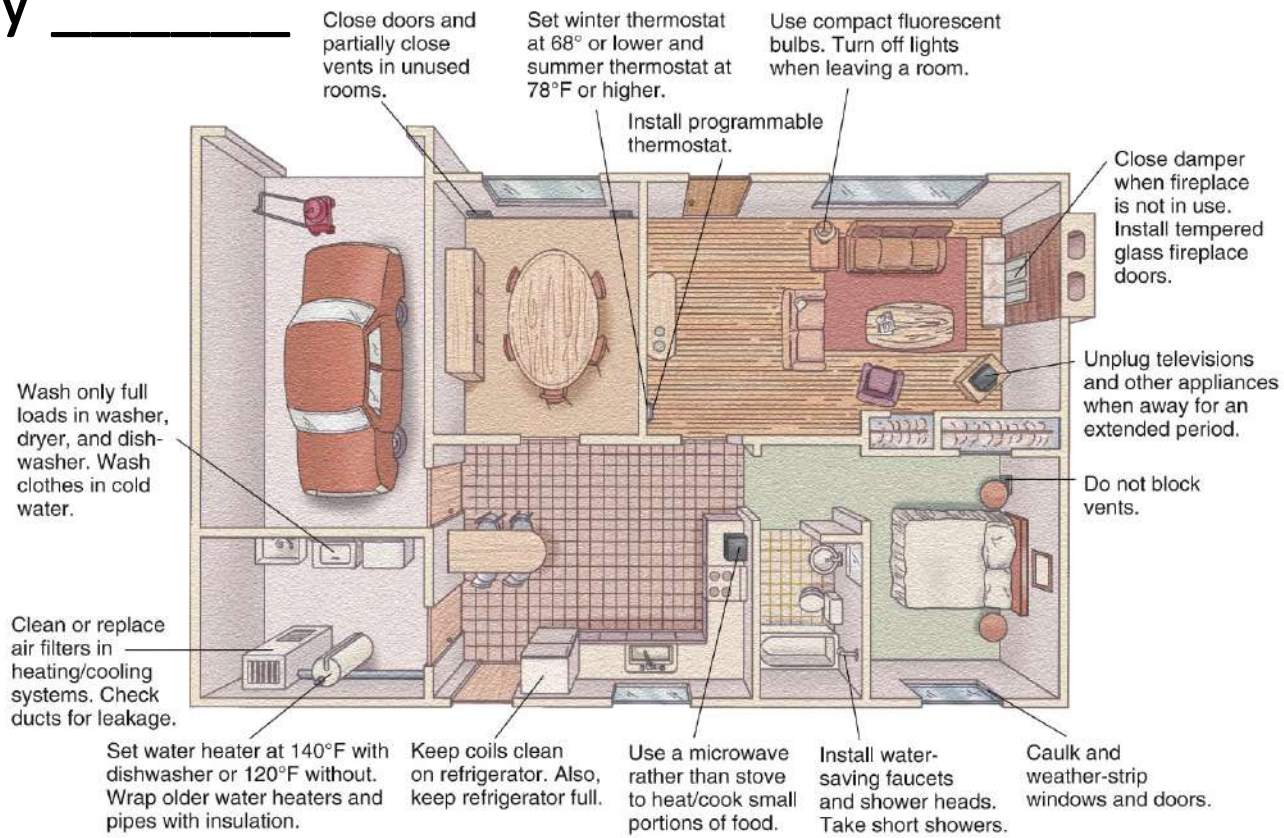
Energy use standard for new refrigerators, 1972–2014

Electric Power Companies and Energy Efficiency

- Changes in regulations allow _____ to make more money by generating less electricity
  - These programs provide incentives for conservation, which ultimately results in _____ emissions
  - Utilities make money if they help consumers save energy—because they don't have to build very costly new power plants
    - Consumer incentives used are _____ awards, free energy efficient light bulbs, energy efficient air conditioners and/or other appliances
  - Utilities themselves need to be more energy _____
    - Use cogeneration
    - Improve power grids, reduce transmission loss

Energy Conservation at Home

- Average household spends several thousand dollars per year on utility _____
  - _____ could be reduced by having an energy-efficient home
    - Costs more up front, but many improvements pay for themselves in _____ years



Case Study: Green Architecture

- Hearst Tower, Manhattan, NY
- _____ higher efficiency than standard office buildings
  - 'Diagrid' design floods interior with natural light and uses 2000 tons less steel (90% of steel used is recycled)
  - Efficient cooling and heating systems
    - Ten story "Icefall" _____ the atrium and irrigates plants
      - Water comes from collected _____
    - Natural _____ enhanced by careful wall and partition use
    - Low-vapor paints, low toxicity sealants, low toxicity carpets and sustainable materials