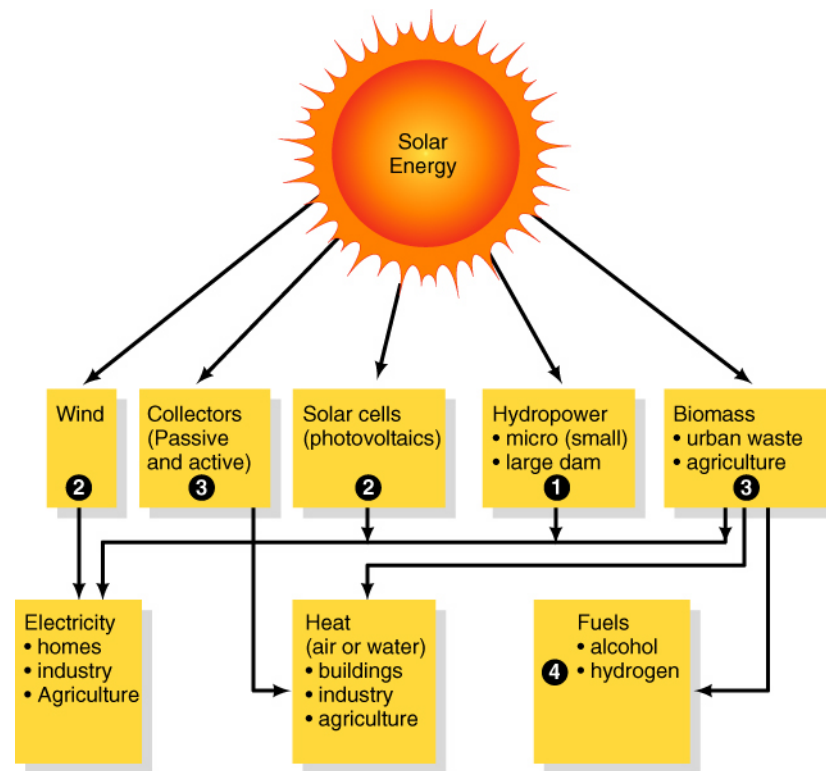


Renewable Energy Resources



- 1 Produces most electricity from renewable solar energy
- 2 Rapidly growing, strong potential (wind and solar are growing at 30% per year.)
- 3 Used today; important energy source
- 4 Potentially a very important fuel to transition from fossil fuels

US Renewable energy use

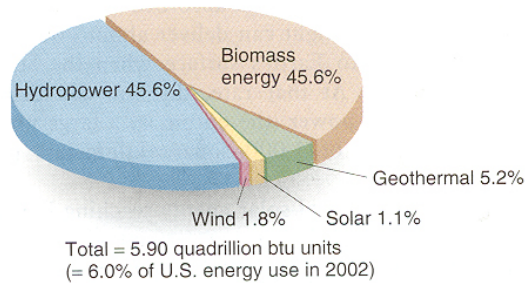


Figure 14-4 Renewable-energy use in the United States. A mix of sources of renewable energy provided 6% of the nation's energy use in 2002. (Source: Data from Department of Energy, Energy Information Agency, *Renewable Energy Annual 2002*, November 2003.)

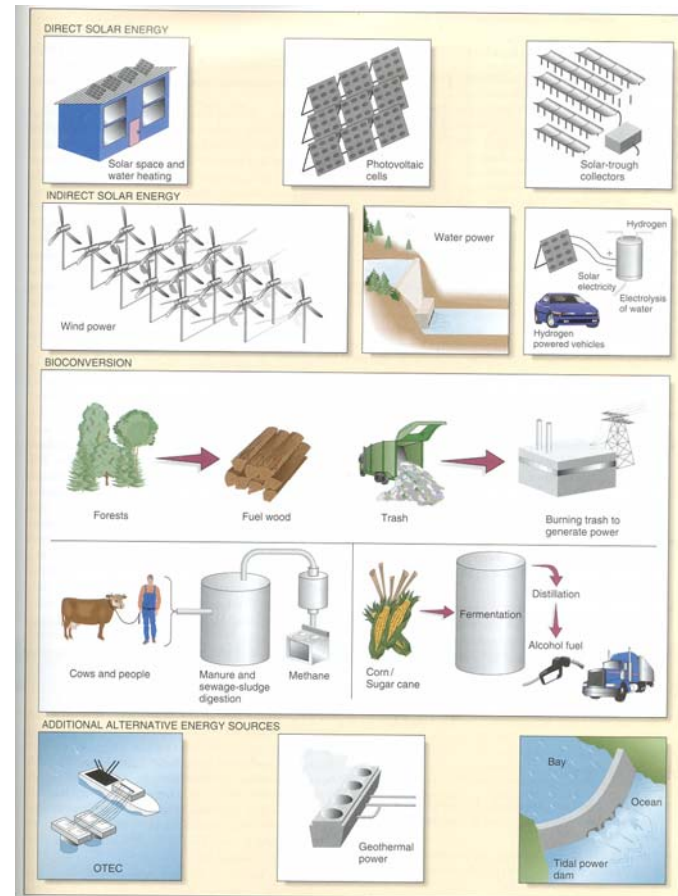
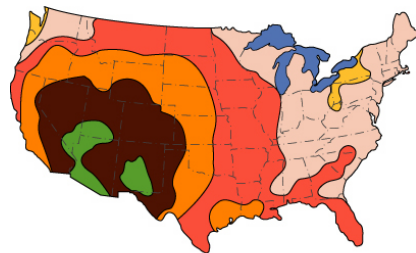


Figure 14-25 Renewable-energy resource alternatives. At the present time, direct solar heating of space and water, photovoltaic cells, solar-trough collectors, wind power, the production of hydrogen from solar or wind power, fuel cells, and the production of methane from animal manure and sewage sludges seem to offer the greatest potential for supplying sustainable energy with a minimal environmental impact.

Solar Energy

- Passive vs Active systems
- Water Heating
- Electricity



Figure 16.1 • Roman bathhouse (lower level) in the town of Bath, England. The orientation of the bathhouse and the placement of windows are designed to maximize the benefits of passive solar energy.

Passive Solar systems

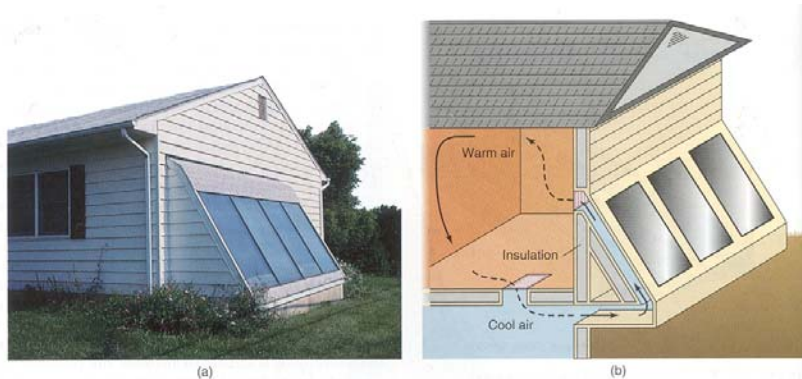


Figure 14-8 Passive hot-air solar heating. (a) Many homeowners could save on fuel bills by adding homemade solar collectors such as that shown here. (b) Air heated in the collector moves into the room by passive convection.

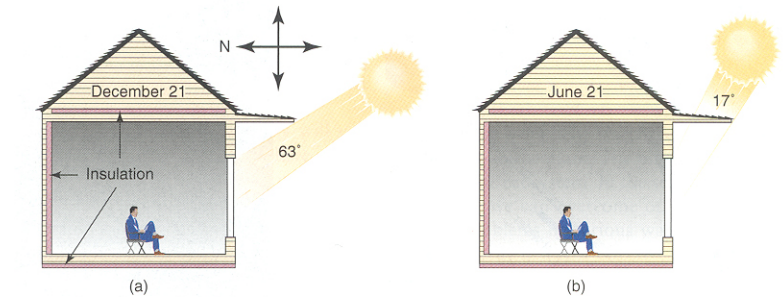


Figure 14-9 Solar building siting. In contrast to utilizing expensive and complex active solar systems, solar heating *can* be achieved by suitable architecture and orientation of the home at little or no additional cost. (a) The fundamental feature is large, Sun-facing windows that permit sunlight to enter during the winter months. Insulating drapes or shades are drawn to hold in the heat when the Sun is not shining. (b) Suitable overhangs, awnings, and deciduous plantings will prevent excessive heating in the summer.

- Architectural designs
- Heat absorbing tiles
- Protection from weather, can build into hillside

Passive Home

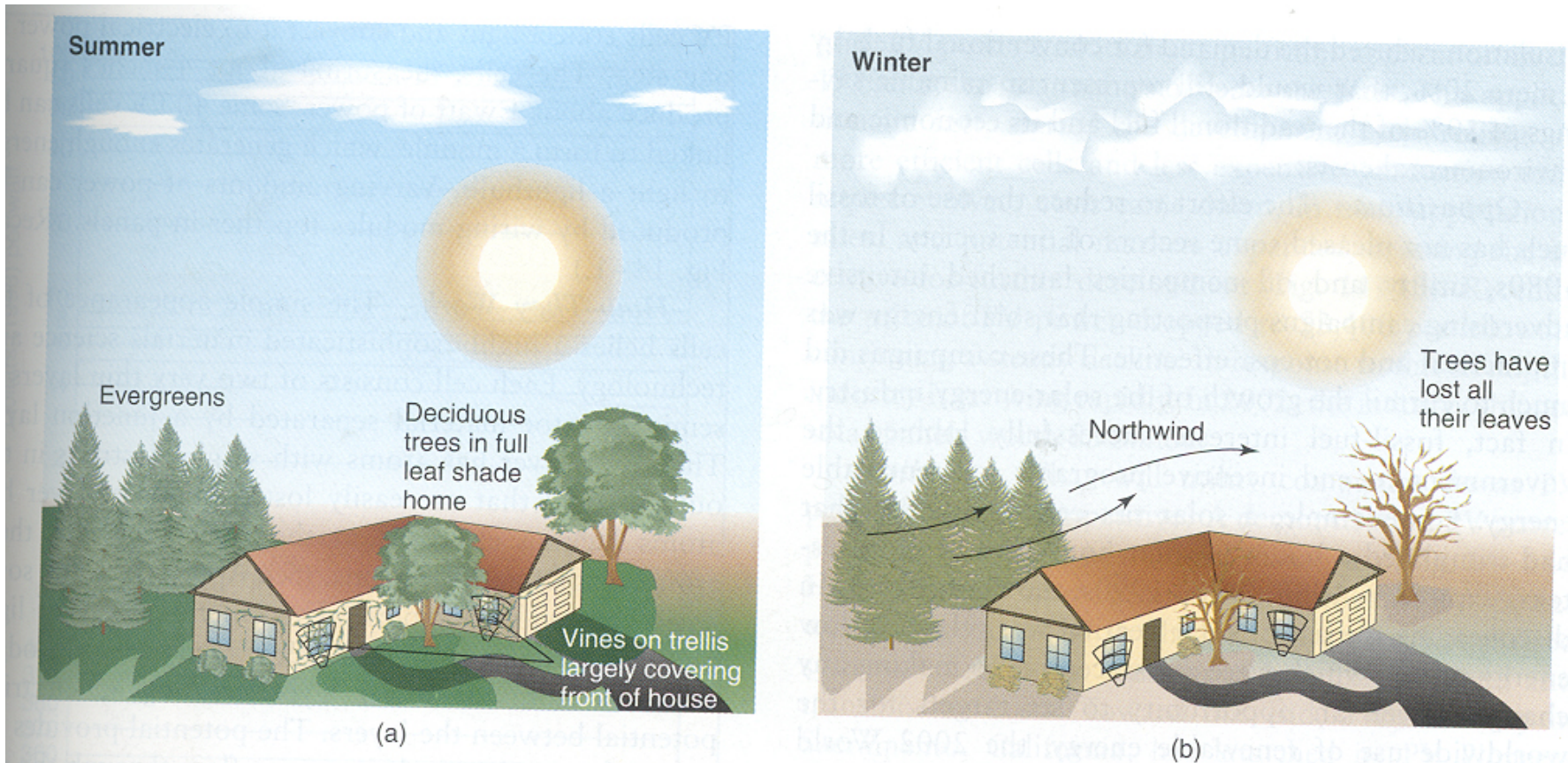
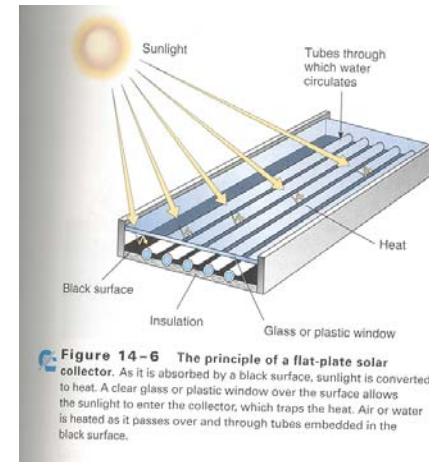
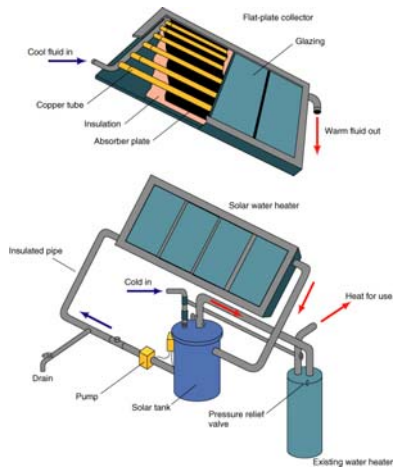


Figure 14-10 Landscaping in solar heating and cooling. (a) In summer, the house may be shaded with deciduous trees or vines. (b) In winter, leaves drop, and the bare trees allow the house to benefit from sunlight. Evergreen trees on the opposite side protect against, and provide insulation from, cold winds.

Active Solar



- Water Heater
- Heating of house

Solar



Figure 14-3 Solar thermal power in southern California. A solar-trough power plant. Sunlight striking the parabolic-shaped mirrors is reflected onto the central pipe, where it heats a fluid that is used, in turn, to boil water and drive turbogenerators.

Solar Panels



Figure 14–15 Power tower Solar Two. Sun-tracking mirrors are used to focus a broad area of sunlight onto a molten-salt receiver mounted on the tower in the center. The hot salt is stored or pumped through a steam generator that drives a conventional turbogenerator.

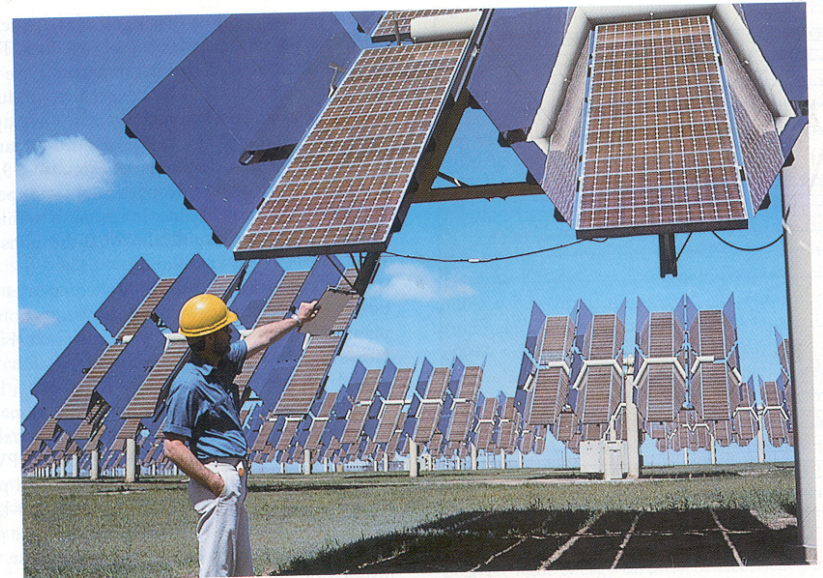


Figure 14–14 PV power plant. The world's first photovoltaic (solar cell) power plant, located near Bakersfield, California. The array of 220 thirty-four-foot (eleven-m) panels produces 6.5 MW at peak, enough energy for 6,500 homes.

Photovoltaics

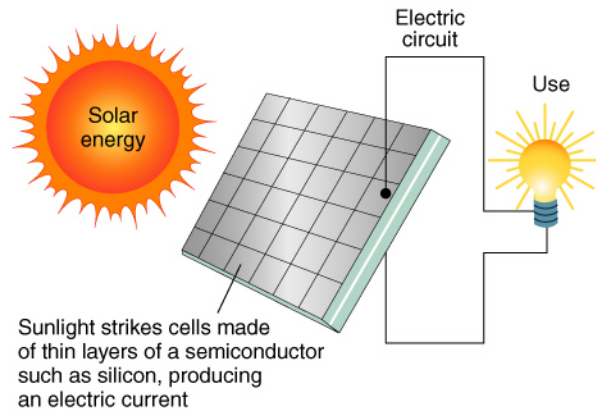


Figure 14-2 Rooftop hot water. In warm climates, solar hot-water heaters are becoming commonplace. Note the solar water-heating panels on each of the homes in this development in southern California.

- Sunlight into electricity
- 10% efficiency
- Cost of central power plants

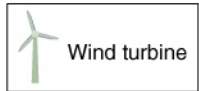
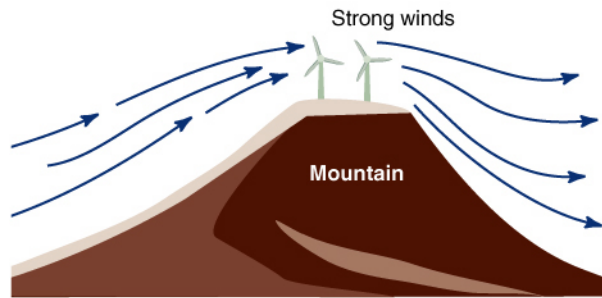
Geothermal

- Use of Earth's internal heat
- Generate electricity in Iceland, US, New Zealand, Japan
- Use of hydrothermal convection
- Water circulates to bring heat up

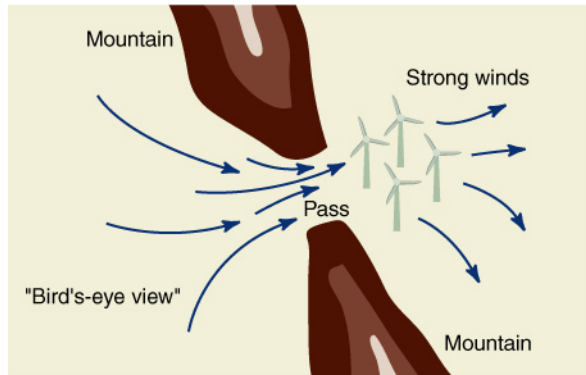
Figure 14-23
Geothermal energy. One of the 11 geothermal units operated by the Pacific Gas & Electric Company at The Geysers in Sonoma and Lake counties, California. California geothermal energy produces 1,600 MW of power, roughly 7% of California's energy needs.



Wind



Convergence of wind over a ridge or mountain

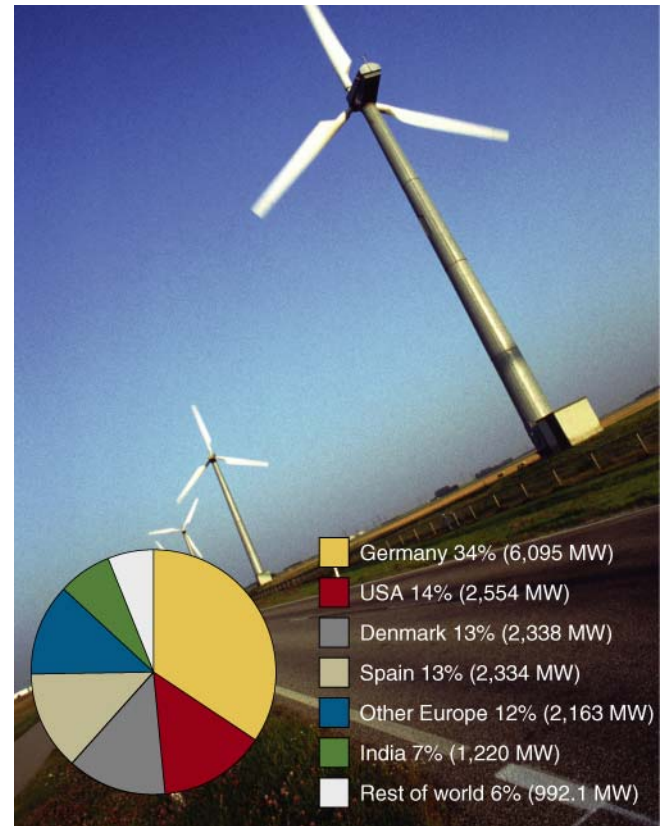
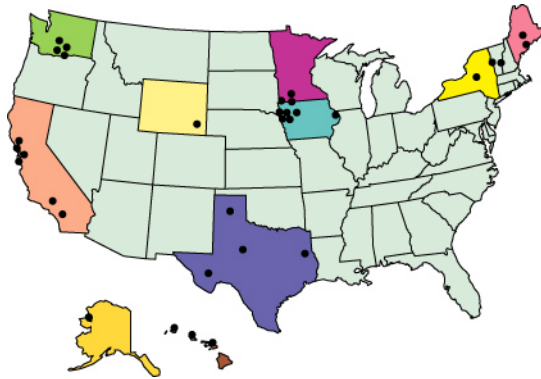


Topography and wind



Windmill

Wind power



Biogas

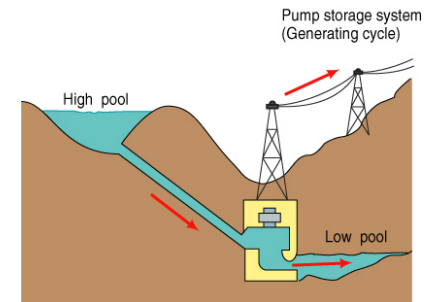
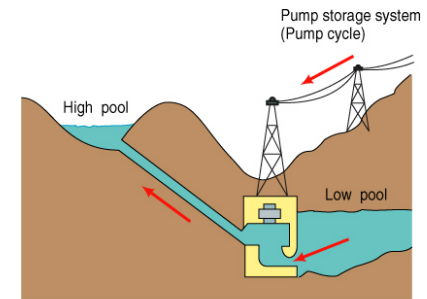
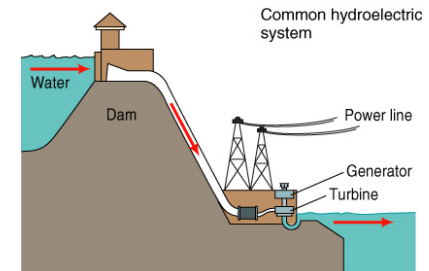
- Ethanol
- Methane
- Wood, sugarcane, corn, manure
- Bagasse



Figure 14-20 Biogas power. Animal wastes are introduced to this unit in rural India and mixed with water. The wastes then decompose under anaerobic conditions, producing biogas.

Hydroelectric

- Dams
- Tidal power



Economics of Renewable resources

- Hydrogen fuel technology
- Energy efficient systems
- Tree farms
- Co-generation plants
- Encourage funding for renewable resources



Figure 12-21 Energy-efficient lightbulbs. Replacing standard incandescent lightbulbs with screw-in fluorescent bulbs shown here can cut the energy demand for lighting by 75–80%. The higher cost of the fluorescent bulbs is more than offset by the greater efficiency and much longer lifetime of the bulb.