



Chapter 17 Energy Efficiency and Renewable Energy



“It’s A Small World After All”

Outline

Reducing energy waste and improving energy efficiency

- A. Energy efficiency is a measure of the useful energy produced compared to the energy that is converted to low-quality heat energy.
 1. Energy efficiency can be achieved by using more efficient technologies that are available and are being developed. An example is the use of fluorescent bulbs in place of incandescent bulbs (5% efficient).
 2. About 84% of all commercial energy used in the U.S. is wasted. About 41% is wasted because of the degradation of energy quality imposed by the 2nd law of thermodynamics.
 3. About 43% of the energy used in the United States is unnecessarily wasted by such things as motor vehicles, furnaces and living and working in leaky, poorly designed buildings.
 4. When buying energy consuming items the life cycle cost (initial cost plus lifetime operating costs) is an important factor in making a decision.
 5. Since the 1980s the U.S. has reduced the amount of energy used/person. Unnecessary energy waste still costs the U.S. about \$300 billion/year.
 6. Four energy devices commonly used waste large amounts of energy: the incandescent light bulb (95% waste), a nuclear power plant (86-92% waste), an internal combustion engine (94% waste), and a coal-burning power plant (66% waste).
- B. Net energy efficiency is how much useful energy we get from an energy resource after subtracting the energy used and wasted in making the energy available.
 1. Net energy efficiency includes the efficiency of each step in the process of making energy available for use.
 2. A comparison of electricity produced by a nuclear power plant and passive solar heating indicates that only about 14% of the initial energy produced is useful compared to 90% for passive solar heat.
 3. Two general principles for saving energy are:
 - a. keep the number of steps in an energy conversion process as low as possible
 - b. strive to have the highest possible energy efficiency for each step in an energy conversion process.

Ways to improve energy efficiency

- A. Industry can save energy and money by producing both heat and electricity from one energy source and by using more energy-efficient electric motors and lighting.
 1. The same fuel source may produce both steam and electricity. About 9% of U.S. electricity is produced by cogeneration.
 2. Another method is to replace energy-wasting electric motors. Most are inefficient because they run at full speed with output throttled to match the task. The cost of replacing such motors with adjustable speed drive motors would be paid back in about 1 year and save enormous amounts of energy.
 3. Switch from low-efficiency incandescent lighting to higher-efficiency fluorescent lighting.
- B. We can save energy in transportation by increasing fuel efficiency and making vehicles from lighter and stronger materials.
 1. Between 1973 and 1985 fuel efficiency rose sharply for new cars sold in the U.S. This occurred because of government-mandated standards.
 2. Between 1988 and 2006 the average fuel efficiency for new cars sold in the U.S. decreased by 6%.
 3. Fuel-efficient cars are available but gasoline prices in the U.S. do not reflect the actual cost of gasoline to society. U.S. consumers prefer larger, more fuel inefficient vehicles, and the efficiency standards have not been raised.
 4. China now has stricter fuel-economy standards than the U.S.
 5. It has been suggested that fuel inefficient vehicles should be subject to more taxes than fuel-efficient vehicles as a means to promote fuel efficiency.
- C. Hybrid gasoline-electric engines with an extra plug-in battery could be powered mostly by electricity produced by wind and get twice the mileage of current hybrid cars.

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1. There is increased interest in developing superefficient and ultralight cars that could get 80-300 miles per gallon.
 2. These vehicles run on gas, diesel fuel or natural gas PLUS a small battery.
 3. Such cars are available from a number of manufacturers.
 4. Sales of hybrid vehicles are projected to grow rapidly and could dominate sales by 2025.
 5. Plug-in hybrids are a next step and could be used for short trips.
 6. Another option is an energy-efficient diesel car, which accounts for 45% of new passenger-car sales in Europe.
- D. Fuel-efficient vehicles powered by a fuel cell that runs on hydrogen gas are being developed. The hydrogen fuel combines with oxygen in the air to produce electrical energy for power and produce water vapor.
1. Fuel cells are at least twice as efficient as internal combustion engines.
 2. They have no moving parts and require little maintenance.
 3. They produce little or no pollution.
 4. Affordable fuel-cell vehicles should be on the market by 2020.
 5. The fuel-cell car is expected to have high fuel efficiency.
- E. We can save energy in buildings by getting heat from the sun, super insulating them, and using plant-covered green roofs.
1. Atlanta’s Georgia Power Company building uses 60% less energy than conventional office buildings of the same size.
 2. Each floor extends out over the floor below it to block out the summer sun, let in the winter sun.
 3. Lights focus on desks, not the entire room.
 4. The U.S. Green Building Councils Leadership in Energy and Environmental Design (LEED) program established building standards with a silver, gold and platinum scoring system used by more and more architects, developers and elected officials in the U.S.
 5. A superinsulated house is another energy efficient design. They generally cost 5% more to build, but savings within 5 years pays this extra cost. In Sweden these homes use 90% less energy than a typical American home.
 6. Strawbale houses use wall made of compacted straw covered with plaster or adobe.
 7. Living roofs or green roofs are covered with plants, provide good insulation, absorb storm water, outlast conventional roofs, and make a building more energy efficient.
- F. We can save energy in existing buildings by insulating them, plugging leaks, and using energy-efficient heating and cooling systems, appliances, and lighting.
1. Insulate and plug leaks since about 1/3rd of heated air escapes through closed windows, holes and cracks.
 2. Use energy-efficient windows with low-E (low-emissivity) to cut heat losses by 2/3rds and reduce CO2 emissions.
 3. Stop other heating and cooling losses by wrapping ducts in attics and basements.
 4. In order, these are the most energy-efficient methods to heat space:
 - a. superinsulation
 - b. a geothermal heat pump
 - c. passive solar heating
 - d. a conventional heat pump (in warm climates only)
 - e. small cogenerating microturbines
 - f. a high efficiency natural gas furnace
 5. Heat water more efficiently by use of a tankless instant water heater fired by natural gas of LPG – NOT electricity. They cost 2-4 times more but last 3-4 times longer and cost less to operate than conventional tank heaters.
 6. Use energy-efficient appliances.
 7. Use energy-efficient lighting; it could cut electricity costs by using fluorescent bulbs. Brown University students in environmental studies program showed the university it could save \$40,000/year by replacing incandescent bulb in the exit signs with fluorescent ones.
 8. Within 20 years we may be using even more efficient white-light LEDs (light-emitting diodes) and organic LEDs.
- G. Low-priced fossil fuels and few government tax breaks or other financial incentives for saving

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energy promote energy waste. A glut of low-cost oil and gasoline are part of the reason for energy wastage. The price does not include the harmful costs.

1. Government tax breaks and other economic incentives for consumers and businesses would help promote improving energy efficiency.
2. Invest in improving the energy efficiency of one’s home and within a few years the investment would be repaid and about 20% more money would be there for use.

Using renewable energy to provide heat and electricity

- A. A variety of renewable-energy resources are available but their use has been hindered by a lack of government support compared to fossil fuels and nuclear power. Types of renewable energy are solar, flowing water, wind, biomass, geothermal, and hydrogen.
 1. Each of the renewable energy alternatives has advantages and disadvantages.
 2. Renewable energy is not being developed because there is no financial incentive to migrate to this type of energy.
 3. The prices we pay for our current energy do not include their harm to the environment and to human health.
 4. The European Union aims to get 22% of electricity from renewable energy by 2010.
 5. Costa Rica gets 92% of its energy from renewable sources.
 6. In 2005, China set a goal of getting 25% of its electricity from renewable sources by 2020.
 7. IN 2004, California got about 12% of its electricity from renewable resources and plans to get 20% by 2010.
 8. Denmark now gets 20% of its electricity from wind and plans to increase this to 40% by 2030.
 9. Brazil gets 40% of its automotive fuel from energy-efficient production of ethanol from sugarcane residue.
 10. in 2004, the world’s renewable-energy industries provided 1.7 million jobs, most of them skilled and well paying.
- B. We can heat buildings by orienting them toward the sun (passive solar heating) or by pumping a liquid such as water through rooftop collectors (active solar heating).
 1. Energy-efficient windows and attached greenhouses face the sun to collect solar energy by direct gain.
 2. Walls and floors (made of concrete, adobe, brick, stone, water in containers) store collected solar energy as heat and release it slowly.
 3. Active solar heating systems absorb energy from the sun in a fluid (air, water, antifreeze solution) that is pumped through special collectors on the roof or on racks to face the sun.
 - a. Some heat is used directly.
 - b. The rest of the heat is stored in a large insulated container filled with gravel, water, clay or a heat-absorbing chemical to be released as needed.
 4. The major advantages and disadvantages are listed in figure 17-14.
- C. We can cool houses by superinsulating them, taking advantage of breezes, shading them, having light-colored or green roofs, and using geothermal cooling.
- D. Large arrays of solar collectors in sunny deserts can produce high-temperature heat to spin turbines and produce electricity, but costs are high. Solar thermal systems can collect and transform radiant energy to high-temperature thermal energy (heat), which can be used directly or converted to electricity.
 1. One type of system uses a central receiver system/power tower.
 2. Heliostats/computer-controlled mirrors track and focus the sunlight on a central heat collection tower.
 3. A solar thermal plant collects sunlight and focuses it on oil-filled pipes running through the middle of a large area with curved solar collectors. The sunlight produces temperatures high enough to produce steam to run turbines and produce electricity.
 4. Inexpensive solar cookers can be used by individuals to concentrate sunlight and cook food. This is especially true in sunny, developing countries. They reduce indoor air pollution, deforestation and save labor and time needed to collect wood.
- E. Solar cells convert sunlight to electricity, and their high costs are expected to fall.
 1. Photovoltaic (PV) cells/solar cells convert solar energy directly into electrical energy. The solar cell is a transparent wafer that is energized by sunlight, which causes electrons in the

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- semiconductor to flow, creating an electrical current.
2. The solar cells can be incorporated into roof and glass walls/windows.
 3. Banks of solar cells or arrays of solar cells can be used to generate electricity.
 4. Less developed countries such as India are installing solar-cell systems in thousands of villages.
 5. Organic solar cells, incorporated into carbon-based polymers could enter the marketplace within a few years. They could be printed on a sheet of paper and placed anywhere, such as a house, car, or even on clothing.
 6. A technology in the works is a nano solar cell that can be embedded in plastic materials; manufactured in large volumes for very low cost.
 7. Solar cells currently supply less than 1% of the world’s electricity, but by 2040 they could supply 1/4th of the world’s supply.

Producing electricity from the water cycle

- A. Water flowing in rivers and streams can be trapped in reservoirs behind dams and released as needed to spin turbines and produce electricity.
 1. Hydropower is an indirect form of renewable solar energy.
 2. Several methods are used to produce such electricity.
 - a. Large-scale hydropower uses a high dam across a large river to create a reservoir. The advantages and disadvantages of this method are given in Figure 17-20.
 - b. Small-scale hydropower uses a low dam with little or no reservoir across a small stream with the turbines turned by the stream’s flow. A micro-hydrogenerator, a small turbine can even be used to provide electricity for a single home.
 3. Hydropower supplied 20% of the world’s electricity in 2004.
 4. There is pressure on the World Bank to stop funding large-scale dams because of environmental and social consequences of them. Small-scale projects eliminate most of the harmful environmental effects of large-scale projects.
- B. Ocean tides and waves and temperature differences between surface and bottom waves in tropical waters are not expected to provide much of the world’s electricity needs. The costs are high and there are few favorable locations for this technology.

Producing electricity from wind

- A. Wind power is the world’s most promising energy resource because it is abundant, inexhaustible, widely distributed, cheap, clean, and emits no greenhouse gases.
 1. Use of wind power has increased.
 2. The DOE points out that the Great Plains states could produce electricity from wind that would more than meet the nation's electricity needs.
 3. The advantages and disadvantages of using wind power are shown in figure 17-22.
 4. Wind power has more advantages and fewer disadvantages than any other energy resource.
- B. The United States once led the wind power industry, but Europe now leads this rapidly growing business.
 1. About 3/4ths of the world’s wind power is produced in Europe in inland and offshore wind farms.
 2. Denmark, Germany, and Spain manufacture 80% of the wind turbines sold in the global marketplace.
 3. There are concerns the effect of wind turbines has on birds and bird migration patterns.

Producing energy from biomass

- A. Plant materials and animal wastes can be burned to provide heat or electricity or converted into gaseous or liquid biofuels.
 1. Most biomass is burned directly for heating and cooking.
 2. This comprises up to 95% of the energy used in the poorest developing countries.
 3. About 2.7 billion people in 77 developing countries face a fuelwood crisis and harvesting wood faster than it can be replenished.
 4. Biomass plantations plant and harvest large amounts of fast-growing trees, shrubs, perennial grasses and water hyacinths to produce biomass fuel.

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5. Crop residues and animal manure can be converted to biofuels.
 6. Ecologists argue that it makes more sense to use animal manure as a fertilizer and crop residues to feed livestock, retard soil erosion, and fertilize the soil.
 7. The general advantages and disadvantages of burning solid biomass are listed in figure 17-25.
- B. Motor vehicles can run on ethanol, biodiesel, and methanol produced from plants and plant wastes.
1. The biggest producers (Brazil, the U.S., the European Union, and China) plan to double their production of biofuels by 2020.
 2. Biofuels have advantages over gasoline and diesel fuel. Crops that are used to produce biofuels can be grown almost anywhere. The plants must be produced and harvested sustainably resulting in no net increase in carbon dioxide. Biofuels are available now and are easy to store and transport.
 3. Biofuels may help increase economic growth and reduce poverty in tropical countries.
 4. However, can growing crops to produce biofuels be done sustainably? Expanding land area to grow such crops may decrease the earth’s biodiversity. There could be competition between using land to grow crops for food and for biofuels.
- C. Crops such as sugarcane, corn, and switchgrass and agricultural, forestry, and municipal wastes can be converted to ethanol.
1. Ethanol can be made by the fermentation and distillation of sugars in plants. Gasohol is made of gasoline mixed with 10-23% of pure ethanol and can be used in gasoline engines.
 2. Brazil leads the world in ethanol production
 3. Increased ethanol production by Brazil and India could threaten biodiversity.
 4. The United States is the world’s second largest ethanol producer. Farmers receive government subsidies fro growing corn to produce ethanol.
 5. If all of the corn that is grown in the United States were used for ethanol production, it would cover only about 55 days of current driving, and leave none for cattle feed and food.
 6. Another approach is to use cellulosic ethanol, which utilizes bacteria to convert cellulose in plants into ethanol
 7. Figure 17-27 lists the advantages and disadvantages of using ethanol as a vehicle fuel compared to gasoline.
- D. We can convert solid biomass to liquid fuels such as biodiesel and methanol.
1. Biodiesel is a diesel fuel made by combining alcohol with vegetable oil extracted from renewable resources such as soybeans, rapeseed, sunflowers, palm plants, and fats, including used vegetable oils from restaurants.
 2. Germany, France, and Italy produce about 95% of the world’s biodiesel.
 3. Biodiesel production is growing in the Unites States after the government provided a subsidy of \$1 per gallon in 2005. Most is produced in Iowa from soybeans.
 4. The problem is that devoting huge areas to growing soybean and canola crops for biodiesel production is neither economically feasible nor physically possible because of their low-acre yields.
 5. Other countries are developing biodiesel production. Figure 17-29 lists the advantages and disadvantages of using biodiesel as vehicle fuel compared to gasoline.
 6. Methanol, generally made from natural gas, can be produced from carbon dioxide, coal, and biomass.
 7. One chemist, George A. Olah, advocates producing a methanol economy by producing methanol chemically from carbon dioxide in the atmosphere. He maintains that this will slow global warming.

Geothermal energy

- A. We can use geothermal energy stored in the earth’s mantle to heat and cool buildings and to produce electricity.
1. Geothermal heat pumps use a pipe and duct system to bring heat stored in underground rocks and fluids. The earth is used as a heat source in winter and a heat sink in summer.
 2. Geothermal exchange or geexchange uses buried pipes filled with fluid to move heat in or out of the ground for heating/cooling needs. The EPA declared this the most-energy-efficient, cost-effective, and environmentally clean way to heat or cool a building.

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3. In deeper and more concentrated underground hydrothermal reservoirs of geothermal energy, we find dry steam (with no water droplets) and wet steam (steam and water droplets).
4. There is also hot water trapped in porous or fractured rock. Wells can be used to withdraw wet and dry steam as well as hot water for heat or to produce electricity.
5. Three other nearly nondepletable sources of geothermal energy are molten rock (magma), hot dry-rock zones, and warm-rock reservoir deposits.
6. The United States is the world’s largest producer of geothermal electricity.
7. The advantages and disadvantages of geothermal energy are listed in figure 17-32.
8. Two problems with geothermal energy is that it is too expensive to tap except for the most concentrated and accessible sources, and it may be depleted if heat is removed faster than it can be renewed.

Hydrogen

- A. Some energy experts view hydrogen gas as the best fuel to replace oil during the last half of this century, but there are several hurdles to overcome. Hydrogen gas can be produced from water and organic molecules and produces nonpolluting water vapor when burned.
 1. Widespread use of hydrogen as a fuel would eliminate most of the air pollution problems we face today.
 2. There are some problems with widespread use of hydrogen as fuel:
 - a. Hydrogen is chemically locked up in water and organic compounds
 - b. It takes energy and money to produce hydrogen from water and organic compounds. It is not a source of energy, it is a fuel produced by using energy.
 - c. Current versions of fuel cells are expensive, but are the best way to use hydrogen to produce electricity.
 - d. Whether a hydrogen-based energy system produces less carbon dioxide than a fossil fuel depends on how the hydrogen is produced.
 3. Difficulties with using hydrogen include lack of free hydrogen, and the need to use other energy sources to produce hydrogen.
 4. It could be produced by electricity from coal-burning power plants, from coal itself, or strip it from organic compounds, but this could add more carbon dioxide to the atmosphere.
 5. It may be possible to produce hydrogen by growing bacteria and algae that will produce hydrogen gas rather than oxygen as a byproduct.
- B. Iceland plans to run its economy mostly on hydrogen, but doing this in industrialized nations is more difficult.
 1. The United States gets 65% of its electricity from burning nonrenewable coal and natural gas and only 10% from renewable hydroelectric power. Making changes is a difficult political and cultural challenge.
 2. Running motor vehicles on hydrogen would require building and strategically placing at least 12,000 hydrogen-fueling stations throughout the United States at a cost of \$1 million each.
 3. The cost of hydrogen fuel cells is high.
 4. Nanotechnology could make fuel cells more efficient and cheaper.
 5. Once produced, hydrogen can be stored in pressurized tanks as liquid hydrogen and in solid metal hydride compounds or sodium borohydride. Scientists are also looking at ways to absorb hydrogen gas on activated charcoal or graphite nanofibers.
 6. Hydrogen may be safer than gasoline because it disperses into the atmosphere quickly, so does not pose a fire hazard, and metal hydrides, charcoal powders and graphite carriers will not explode or burn if a vehicle’s tank ruptures.
 7. Some experts say the best way to use hydrogen involves using larger stationary fuel cells to produce electricity and heat for commercial and industrial users; the next market being homeowners.
 8. The advantages and disadvantages of using hydrogen for fuel are given in figure 17-33.

A sustainable energy strategy

- A. We need to answer several questions before deciding which mix of energy resources to promote.
 1. Figure 17-34 shows the shift in use of commercial sources of energy in the United States over time.

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2. Making projections and converting such projections into energy policy involves answering many questions for each energy alternative, such as availability, net energy yield, costs involved in each stage, government subsidies and tax breaks, security issues, and environmental effects.
- B. A more sustainable energy policy would improve energy efficiency, rely more on renewable energy, and reduce the harmful effects of using fossil fuels and nuclear power.
 1. There will a gradual shift from large, centralized macropower systems to smaller, decentralized, micropower systems.
 2. The best alternatives combine improved energy efficiency and the use of natural gas and sustainably produced biofuels to make the transition to a diverse mix of locally available renewable-energy resources and possibly nuclear fusion in the distant future (if it becomes feasible and affordable)
 3. Over the next 50 years, the choice is not between using nonrenewable fossil fuels and renewable-energy sources. Figure 17-36 lists strategies for making the transition to a more sustainable energy future over the next 50 years.
- C. Governments can use a combination of subsidies, tax breaks, rebates, taxes, and public education to promote or discourage use of various energy alternatives. Economics and politics are the basic strategies to help stimulate or dampen the short-term and long-term use of a particular energy resource.
 1. Several strategies include:
 - a. Keep energy prices artificially low to encourage use of selected energy resources. Our current system actually encourages energy waste.
 - b. Keep energy prices artificially high to discourage use of a resource.
 - c. Increase taxes on fossil fuels to reduce air and water pollution, slow greenhouse gas emissions and encourage improvements in energy efficiency with greater use of renewable energy resources.
 - d. emphasize consumer education.

Summary

1. The advantages of improving energy efficiency include benefits to the environment, people, and the economy through prolonged fossil fuel supplies, reduced oil imports, very high net energy yield, low cost reduction of pollution, and improved local economies.
2. The advantages of solar energy include reduction of air pollution, reduction of dependence on oil, and low land use. Disadvantages include production of photocells results in release of toxic chemicals, life of systems is short, can damage deserts, need backup systems, and high cost.
3. The advantages of hydropower include high net energy yield, low cost electricity, long life span, no carbon dioxide emissions during operation, food control below dam, water for irrigation, and reservoir development. Disadvantages include high construction cost, high environmental impact, high carbon dioxide emissions from biomass decay, flooding of natural areas, conversion of land habitats to lake habitats, danger of dam collapsing, people relocation, limits fish populations below dam, and decrease flow of silt.
4. The advantages of wind power include high net energy yield and efficiency, low cost and environmental impact, no carbon dioxide emissions, and quick construction. Disadvantages include need for winds and backup systems, high land use, visual and noise pollution, interfering with bird migrations, and causing the death of birds of prey.
5. The advantages of biomass include large potential supplies, moderate costs, no net carbon increase, and make use of agricultural, timber, and urban wastes. Disadvantages include nonrenewable resource, moderate to high environmental impact, low photosynthetic efficiency, soil erosion, water pollution, and loss of wildlife.
6. The advantages of geothermal energy include very high efficiency, low carbon dioxide emissions, low

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cost and land use, low land disturbance, and moderate environmental impact. Disadvantages include suitable sites are scarce, potential depletion, moderate to high air pollution, noise and odor, and high cost.

7. The advantages of hydrogen gas include the fact that it can be produced from water, the low environmental impact, no carbon dioxide emission, competitive price, ease of storage, safety, and high efficiency. Disadvantages include energy need to produce the fuel, negative energy yield, nonrenewable, high cost, and no fuel distribution system exists.
8. The advantages of using smaller, decentralized micropower sources include size, fast production and installation, high energy efficiency, low or no CO₂ emissions, low air pollution, easy repair, reliable, increased national security, and are easily financed.
9. We can improve energy efficiency by increasing fuel efficiency standards, large tax credits for purchasing energy efficient cars, houses, and appliances, encouraging independent energy production, and increasing research and development.

Objectives

1. List the advantages and disadvantages of improving energy efficiency so that we do more with less. Define *life cycle cost* and *cogeneration* and describe their potential for saving energy. Describe changes which can be made in industry, transportation, buildings, lights, and appliances which would improve energy efficiency.
2. List the advantages and disadvantages of using direct solar energy to heat air and water for buildings. Distinguish between active and passive solar heating. Compare the following solar technologies and evaluate the advantages and disadvantages of each: solar power tower, solar thermal plant, nonimaging optical solar concentrator, solar cooker.
3. List the advantages and disadvantages of using water in the forms of hydropower, tidal power, wave power, and ocean thermal currents to produce electricity.
4. List the advantages and disadvantages of using wind to produce electricity.
5. List the advantages and disadvantages of using biomass to heat space and water, produce electricity, and propel vehicles. Consider burning wood, agricultural wastes, and urban wastes as well as conversion of biomass to biofuels.
6. List the advantages and disadvantages of using hydrogen gas to heat space and water, produce electricity, and propel vehicles. State the energy source that is needed to produce hydrogen to create a truly sustainable future. Describe constraints to a solar-hydrogen revolution.
7. Distinguish among dry steam, wet steam, and hot water sources of geothermal energy. List the advantages and disadvantages of using geothermal energy for space heating, high-temperature industrial heating, and electricity production.
8. Analyze the interactions of economic policy and energy resources. In particular consider the results of using free-market competition, keeping energy prices low, and keeping energy prices high.
9. List ways that the United States could build a more sustainable energy future.

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Key Terms (Terms are listed in the same font style as they appear in the text.)

<p>active solar heating system (p. 395) <i>animal manure</i> (p. 404) <i>biobots</i> (p. 412) <i>biodiesel</i> (p. 407) biofuels (p. 403) <i>biomass</i> (p. 403) <i>biomass plantations</i> (p. 404) <i>cellulosic ethanol</i> (p. 406) <i>central receiver system</i> (p. 397) <i>coal-burning power plant</i> (p. 386) energy efficiency (p. 385) <i>energy-efficient diesel car</i> (p. 390) <i>ethanol</i> (p. 405) <i>fuel cells</i> (p. 384) <i>fuelwood crisis</i> (p. 404) <i>gasohol</i> (p. 406) geothermal energy (p. 409) <i>geothermal heat pump</i> (p. 409) <i>green roofs</i> (p. 392) <i>heat bulb</i> (p. 386) <i>heliostats</i> (p. 397) <i>hot water</i> (p. 409) <i>hybrid car</i> (p. 389) <i>hydropower</i> (p. 400) <i>hydrothermal reservoirs</i> (p. 409) <i>incandescent light bulb</i> (p. 386) <i>internal combustion engine</i> (p. 386) <i>large-scale hydropower</i> (p. 400) <i>Living roofs</i> (p. 392) <i>Methanol</i> (p. 408) <i>methanol economy</i> (p. 408) <i>micro-hydrogenerators</i> (p. 401)</p>	<p>cogeneration (p. 387) <i>combined cycle turbines</i> (p. 397) combined heat and power systems (CHP) (p. 387) <i>Corporate Average Fuel Economy (CAFE) standards</i> (p. 387) <i>crop residues</i> (p. 404) <i>dry steam</i> (p. 409) <i>earth tubes</i> (p. 396) <i>energy and environmental design</i> (p. 391) energy conservation (p. 385) <i>net energy</i> (p. 386) <i>net energy efficiency</i> (p. 386) <i>nuclear power plant</i> (p. 386) <i>ocean thermal energy conversion (OTEC)</i> (p. 401) passive solar heating system (p. 395) photovoltaic (PV) cells (p. 398) <i>plug-in hybrids</i> (p. 389) <i>power tower</i> (p. 397) <i>Sewer power</i> (p. 404) <i>solar cells</i> (p. 384) solar cells (p. 398) <i>solar cookers</i>(p. 397) <i>solar thermal plant</i> (p. 397) <i>solar thermal systems</i> (p. 397) <i>strawbale houses</i> (p. 392) <i>superefficient and ultralight cars</i> (p. 389) <i>superinsulated house</i> (p. 391) <i>switchgrass</i> (p. 406) <i>wet steam</i> (p. 409) <i>wind</i> (p. 401) <i>wind farms</i> (p. 384)</p>
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