Chapter 14:
Energy: Some Basics

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Overview

- Outlook for Energy
- Energy Basics
- Energy Efficiency
- Energy Sources and Consumption
- Energy Conservation, Increased Efficiency and Cogeneration
- Sustainable-Energy Policy

Outlook for Energy

- Energy today and tomorrow
  - Many questions—no easy answers
  - The use of fossil fuels
    - Has improved sanitation, medicine, and agriculture
    - Imposes growing environmental costs, ranging from urban pollution to a change in the global climate
  - Energy picture for tomorrow
    - Filled with uncertainty
    - Energy policy needs to be examined

Outlook for Energy

- New sources of oil and natural gas
- Environmentalists prefer pursuing a sustainable energy policy that can endure for generations and not harm the environment

Energy Basics

- Energy quality
  - The ability of the energy to do work
  - Higher quality of the energy = more easily converted to work
  - Lower energy quality = more difficult to convert to work
- Second law of thermodynamics
  - Energy always tends to go from a more usable (higher-quality) form to a less usable (lower-quality) form
  - When you use energy, you lower its quality

Energy Efficiency

- Two fundamental types of energy efficiencies
  - Derived from the first and second laws of thermodynamics
    - First-law efficiency
    - Second-law efficiency
- First-law efficiency
  - Deals with the amount of energy without any consideration of the quality or availability of the energy

Energy Efficiency

- Second-law efficiency
  - Refers to how well matched the energy end use is with the quality of the energy source
  - Low values indicate where improvements in energy technology and planning may save significant amounts of high-quality energy

Energy Efficiency

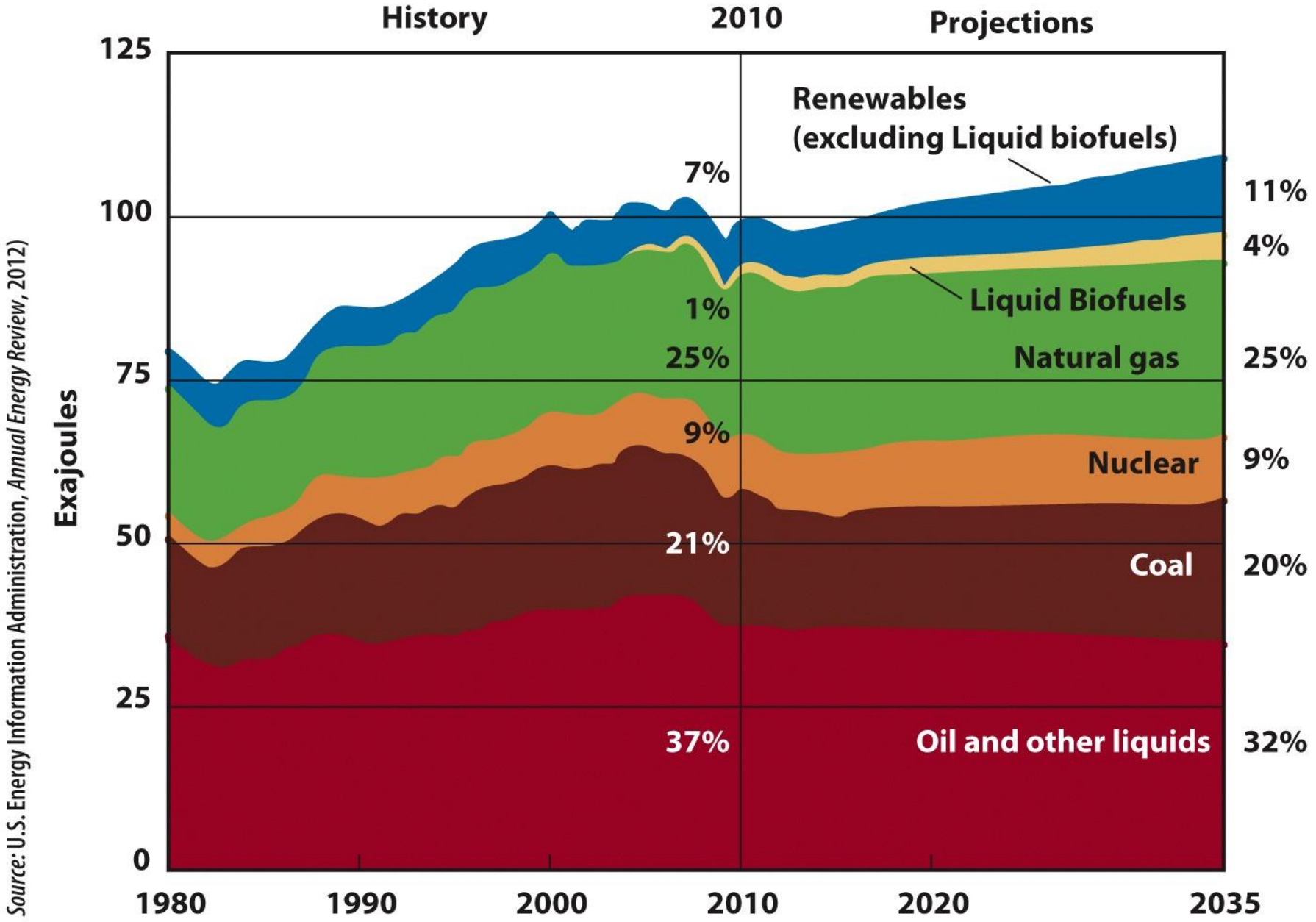
- Electricity-generating plants have nearly the same first-law and second-law efficiencies
  - Generating plants are examples of heat engines
  - Produces work from heat
  - Most electricity generated in the world comes from heat engines
    - Use nuclear fuel, coal, gas, or other fuels

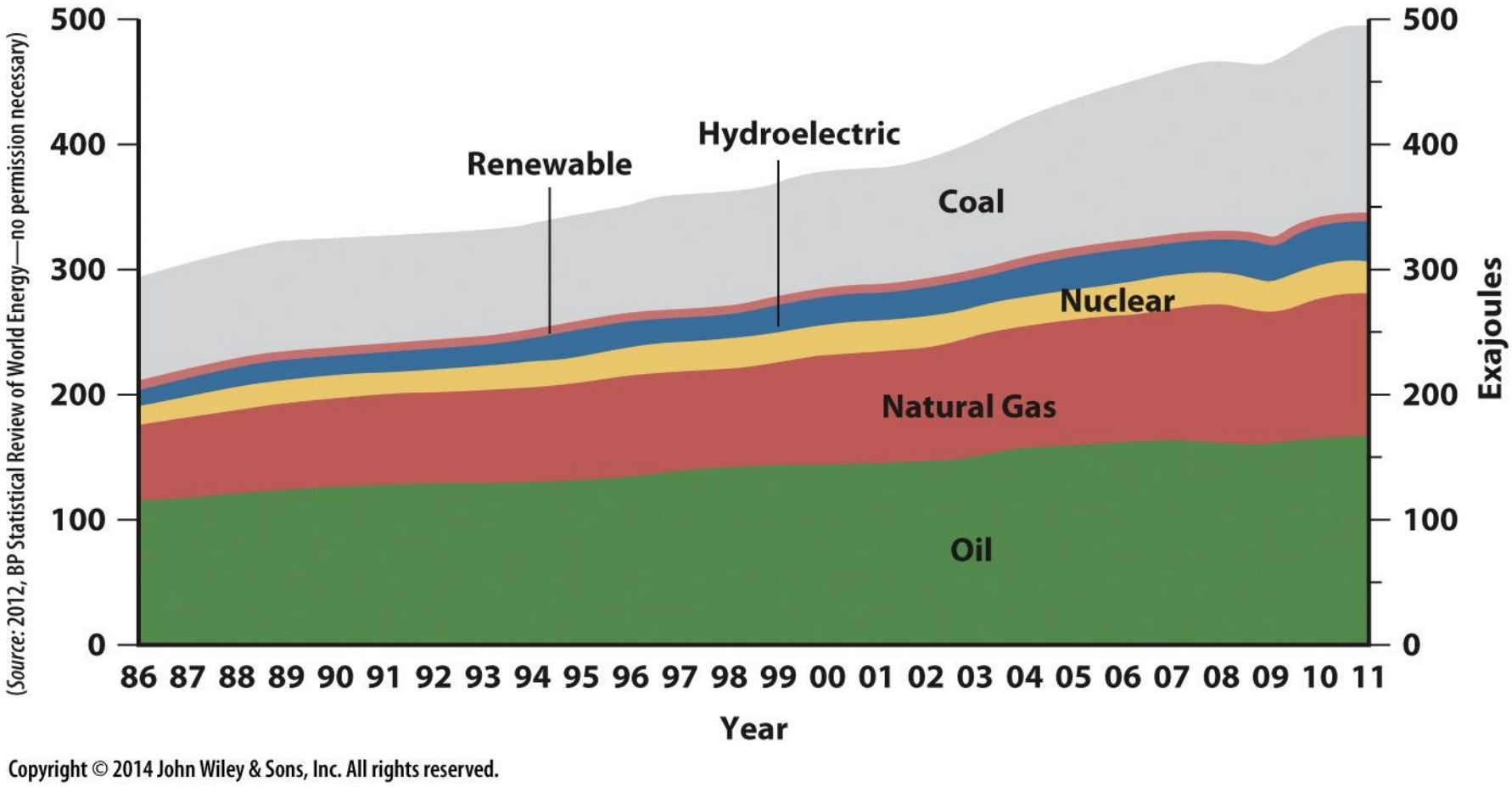
Energy Sources and Consumption

- Industrialized countries
  - Small percentage of the total population
  - Large user of total energy produced
- Example: United States
  - Only 5% of the world's population
  - Uses ~25% of the total energy consumed

Fossil Fuels and Alternative Energy Sources

- 90% of the energy consumed in the U.S. comes from fossil fuels
  - Petroleum, natural gas, and coal
  - They are essentially nonrenewable
- Other sources of energy
  - Alternative energy sources
    - Geothermal, nuclear, hydropower, and solar
  - Renewable energy sources
    - Solar and wind
    - Not depleted by consumption





Energy Conservation, Increased Efficiency and Cogeneration

- Conservation of energy
  - Using less energy
  - Adjusting our energy needs and uses to minimize the amount of high-quality energy necessary for a given task
- Increased energy efficiency
  - Designing equipment to yield more energy output from a given amount of input energy (first-law efficiency)
  - Better matches between energy source and end use (second-law efficiency)

Energy Conservation, Increased Efficiency and Cogeneration

- Cogeneration
  - Processes designed to capture and use waste heat (no thermal pollution)
    - Captured waste heat increases overall efficiency of a typical power plant from 33% to 75%
    - Could provide ~ 10% of the power capacity of the U.S.

Building Design

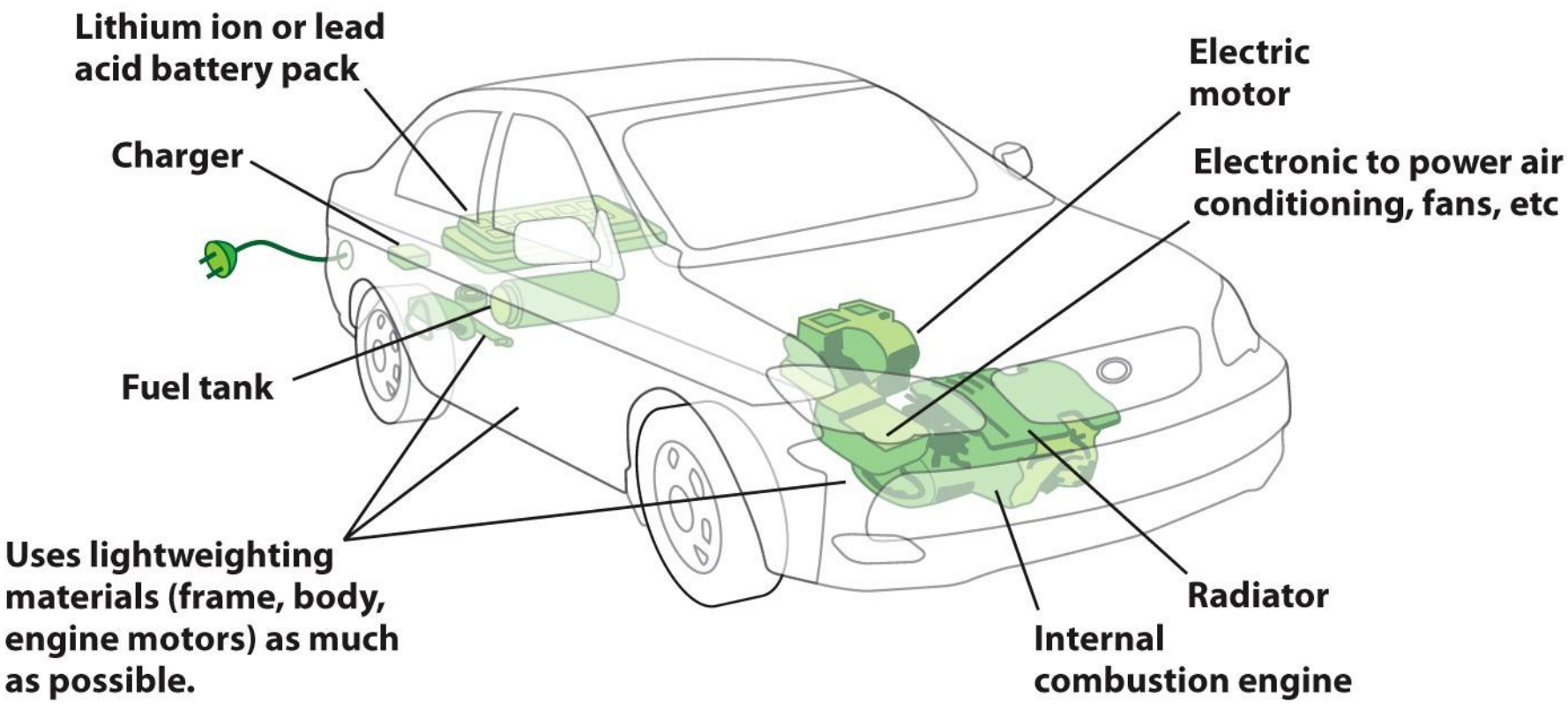
- Many ways to increase energy efficiency and conservation in residential buildings
  - Design and construct homes that minimize the energy consumption
  - Design buildings to take advantage of passive solar potential
  - For older homes: insulation, caulking, weather stripping, installation of window coverings, storm windows, and regular maintenance

Industrial Energy

- Industrial production of goods continues to grow significantly
  - U.S. industry consumes ~1/3 of the energy produced
  - More industries are using cogeneration and more energy-efficient machinery

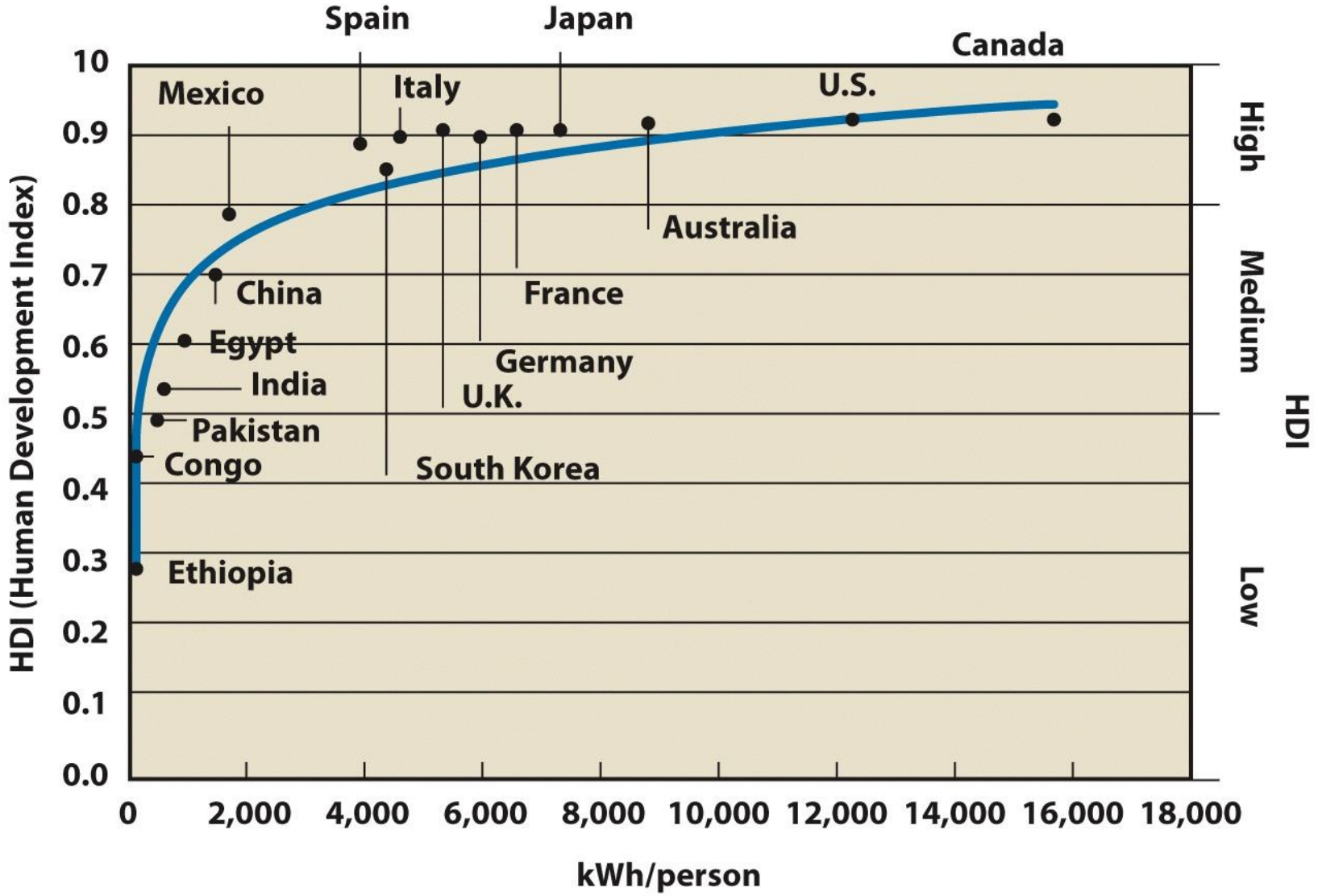
Automobile Design

- Today, some hybrid (gasoline-electric) vehicles exceed 90 mpg on the highway and 60 mpg in the city
- Improvement has several causes
  - Increased efficiency and resulting conservation of fuel
  - Cars that are smaller; engines constructed of lighter materials
  - Combo of a fuel-burning engine and an electric motor
- Plug-in hybrids are now available
  - Where and how we produce the electricity to power these cars will be an issue



Values, Choices, and Energy Conservation

- The United Nations has developed the Index of Human Development (HDI)
  - Varies from about 0.3 (low) to 0.5 (medium) to 0.9 (high)
  - The relationship between human development (a measure of life expectancy, education, and wealth) and use of energy per person
  - See comparisons on next slide



(*Source:* Modified (with updates) after Pasternak, D. 2000. *Global Energy Futures and Human Development: A Framework for Analysis*. U.S. Department of Energy. UCRL-ID-140773.)

Values, Choices, and Energy Conservation

- Ways of modifying behavior to conserve energy include the following
  - Bike, walk, or take a bus or train to work
  - Carpools
  - Hybrid cars (gasoline–electric)
  - Turn off lights when leaving rooms
  - Take shorter showers
  - Turn down the thermostat
  - Use energy-efficient compact florescent light bulbs
  - Purchase energy-efficient appliances

Values, Choices, and Energy Conservation

- More ways to conserve energy
  - Seal drafts in buildings
  - Better insulate your home
  - Wash clothes in cold water whenever possible
  - Purchase local foods to reduce energy in transport
  - Use power strips and turn them off when not in use
  - Installing solar water heaters or collectors

Energy Policy

- Business-as-usual approach—our current approach
  - Philosophy
    - Find more fossil fuel
    - Build larger power plants
    - Use energy as freely as we always have
  - Requires no new thinking
  - Requires no realignment of political, economic or social conditions
  - Does not anticipate reductions in oil production

Lovins' Energy Policy

- Sustainable alternative energy policy will have the following characteristics
  - Rely heavily on renewable energy resources
  - Diverse and tailored for maximum effectiveness
  - Flexible, accessible and understandable to most people
  - Matched in energy quality, geographic distribution, and scale to end-use needs

Energy Policy for the 21st Century

- Promote conventional energy sources
  - But reduce our reliance on foreign sources
- Encourage alternative energy
  - Wind, solar, geothermal, hydrogen and biofuels
- Provide for energy infrastructure
- Promote conservation measures
  - Higher product efficiency standards, less waste energy, tax credits
- Evaluate the pros and cons of nuclear power
- Promote research into all energy sources

Integrated, Sustainable Energy Management

- No single energy source can provide all the energy required
- Range of options that vary from region to region will have to be employed
  - Fossil fuels
  - Alternative, renewable sources

Integrated, Sustainable Energy Management

- Basic goal is to move toward sustainable energy development
  - Implemented at the local level
- Would have the following characteristics
  - Provide reliable sources of energy
  - Not cause destruction or serious harm to our global, regional, or local environments
  - Help ensure that future generations inherit a quality environment with a fair share of the Earth's resources

Integrated, Sustainable Energy Management

- A good plan should do the following
  - Provide for sustainable energy development
  - Provide for aggressive energy efficiency and conservation
  - Provide for the diversity and integration of energy sources
  - Provide for a balance between economic health and environmental quality
  - Use second-law efficiencies as an energy policy tool

Integrated, Sustainable Energy Management

- The global pattern of ever-increasing energy consumption led by the U.S. cannot be sustained without a new energy paradigm
  - Includes changes in human values rather than a breakthrough in technology
  - Examples
    - Choosing to own fuel-efficient automobiles
    - Living in more energy-efficient homes

Chapter Summary

- The first law of thermodynamics states that energy is neither created nor destroyed but is always conserved and is transformed from one kind to another
- The second law of thermodynamics tells us that as energy is used, it always goes from a more usable (higher-quality) form to a less usable (lower-quality) form

Chapter Summary

- Two fundamental types of energy efficiency are derived from the first and second laws of thermodynamics
  - When considering first and second laws of energy efficiency, there is a high potential for saving energy through better matching of the quality of energy sources with their end uses
- Energy conservation and improvements in energy efficiency can have significant effects on energy consumption

Chapter Summary

- Energy policy is at a crossroads
  - Business-as-usual path
    - Long history of success
    - Has produced the highest standard of living ever experienced
    - Present sources of energy (based on fossil fuels) are causing serious environmental degradation and are not sustainable
  - Alternative energy sources path
    - Sources that are renewable
    - Decentralized
    - Diverse
    - Flexible
    - Provides a better match between energy quality and end use by emphasizing second-law efficiencies

Chapter Summary

- The transition from fossil fuels to other energy sources requires sustainable, integrated energy management
  - To provide reliable sources of energy that do not cause serious harm to the environment
  - That ensure future generations will inherit a quality environment
- The United States is approaching energy independence
  - New sources of oil & natural gas from oil shale
  - Increased possibility of additional environmental consequences