Learning Objectives

By the end of this chapter, students should be able to.

• Describe arguments for alternative energy
• Explain the following aspects of solar energy:
  ◦ How passive solar energy works and provide examples of its use.
  ◦ How solar panels (photovoltaic cells) work.
  ◦ The limitations and environmental costs associated with solar energy.
• Explain the following aspects of biofuels / biomass energy:
  ◦ Describe what is meant by the term “carbon neutral” and explain how biomass energy can and cannot be carbon neutral.
  ◦ Describe current achievements in biofuels and potential of this area for growth.
• Describe wind energy and explain the advantages and disadvantages.
• Describe geothermal energy and explain the advantages and disadvantages
• Describe hydroelectric energy, advantages and disadvantages

Energy sources that are more or less continuously made available in a time frame useful to people are called **renewable energy**. Renewable energy sources are often considered alternative sources because, in general, most industrialized countries do not rely on them as their main energy source. Instead, they tend to rely on the conventional energy sources such as fossil fuels or nuclear power that are non-renewable. Because of the energy crisis in the United States during the 1970s, dwindling supplies of fossil fuels and hazards associated with nuclear power, use of renewable energy sources such as solar energy, hydroelectric, wind, biomass, and geothermal has grown. Renewable energy comes from the sun (considered an "unlimited" supply) or other sources that can theoretically be renewed at least as quickly as they are consumed. If used at a sustainable rate, these sources will be available for consumption for thousands of years or longer. Renewable alternatives derive from wind, water, solar or biomass (Figure \(\PageIndex{1}\)). Note that wind, water and biomass energy sources are indirect sources of solar energy. One limitation currently associated with most forms of renewable energy is that the energy is not concentrated and not easily portable.
Energy is an important ingredient in all phases of society. We live in a very interdependent world, and access to adequate and reliable energy resources is crucial for economic growth and for maintaining the quality of our lives. However, current levels of energy consumption and production are not sustainable because of the heavy reliance on non-renewable energy sources. The principal energy resources used in the world are shown in Figure 5.1.2. The fuel mix has changed over the years but now is dominated by oil, although natural gas and solar contributions are increasing. About 80% of our energy comes from nonrenewable fossil fuels and nuclear. The link between global warming and fossil fuel use, with its production of carbon dioxide through combustion, has made, in the eyes of many scientists, a shift to non-fossil fuels of utmost importance – but it will not be easy. About 40% of the world’s energy comes from oil, and much of that goes to transportation uses.

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5.1.1: The World’s Growing Energy Needs

World energy consumption continues to rise especially in countries like China where the economy is improving. Global demand for energy has tripled in the past 50 years and might triple again in the next 30 years (Figure 5.1.3). While much of this growth will come from the rapidly booming economies of China and India, many of the industrialized countries, especially those in Europe, are hoping to meet their energy needs by expanding the use of renewable sources. Although presently only a small percentage, renewable energy is growing very fast, especially wind energy. For example, Germany plans to meet 20% of its electricity and 10% of its overall energy needs with renewable resources by the year 2020. Energy is a key constraint in the rapid economic growth of China and India. In 2003, China surpassed Japan as the world’s second largest consumer of oil. However, over 1/3 of this oil is imported. Unlike most Western countries, coal dominates the commercial energy resources of China, accounting for 2/3 of its energy consumption. In 2009 China surpassed the United States as the largest emitter of CO₂. In India, the main energy resources are biomass (wood and dung) and coal. Half of India’s oil is imported. About 70% of India’s electricity is generated by highly polluting coal. Yet there are sizeable strides being made in renewable energy. India has a rapidly growing wind energy base, and it has the largest solar cooking program in the world. While non-renewable sources dominate, some countries get a sizeable percentage of their electricity from renewable resources. For example, about 67% of New Zealand’s electricity demand is met by hydroelectric. Renewable resources, primarily hydroelectric, generate only 10% of the U.S. electricity.
5.1.2: Why Use Renewable Energy Sources?

Majority of renewable energy sources including solar, wind, water, and biomass can be directly or indirectly attributed to the sun. The fact that the sun will continue burning for another 4-5 billion years makes it inexhaustible as an energy source for human civilization. With appropriate technology, renewable energy sources allow for local, decentralized control over power. Homes, businesses, and isolated communities can use sources such as solar to produce electricity without being near a power plant or being connected to a grid. This eliminates problems such as spills associated with extraction and transportation of fossil fuels that is needed in order to supply these fossil fuels to those areas that are lacking. Most renewable energy sources do not pollute the air with greenhouse gas emissions and other air pollutants associated with fossil fuels. This is especially important in combating climate change.