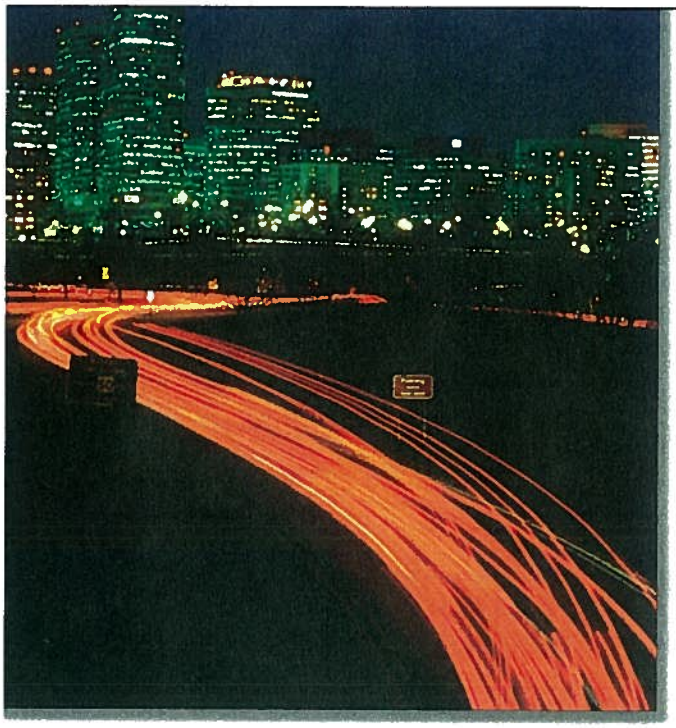


CHAPTER 8

ENERGY AND CIVILIZATION: PATTERNS OF CONSUMPTION

Modern societies are highly dependent on the use of energy. This scene of Rosslyn, Virginia, shows the use of energy for transportation and lighting.

CHAPTER OUTLINE

OBJECTIVES

After reading this chapter, you should be able to:

- Explain why all organisms require a constant input of energy.
- Describe how per capita energy consumption increased as civilization developed from hunting and gathering to primitive agriculture to advanced cultures.
- Describe how advanced modern civilizations developed as new fuels were used to run machines.
- Correlate the Industrial Revolution with social and economic changes.
- Explain how cheap oil and natural gas led to a consumption-oriented society.
- Explain how the automobile changed people's lifestyles.
- Explain why energy consumption is growing more rapidly in developing countries than in the industrialized world.
- Describe the role of OPEC in determining oil prices.

HISTORY OF ENERGY CONSUMPTION

Every form of life and all societies require a constant input of energy. If the flow of energy through organisms or societies ceases, they stop functioning and begin to disintegrate. Some organisms and societies are more energy efficient than others. In general, complex industrial civilizations use more energy than simple hunter-gatherer or primitive agricultural cultures. If modern societies are to survive, they must continue to expend energy. However, they may need to change their pattern of energy consumption as current sources become limited.

Biological Energy Sources

Energy is essential to maintain life. In every ecosystem, the sun provides that energy. (See chapter 5.) The first transfer of energy occurs during photosynthesis, when plants convert light energy into the chemical energy in the organic molecules they produce. Herbivorous animals utilize the food energy in the plants. The herbivores, in turn, are a source of energy for carnivores.

Because nearly all of their energy requirements were supplied by food, primitive humans were no different from other animals in their ecosystems. In such hunter-gatherer cultures, nearly all human energy needs were met by using plants and animals as food, tools, and fuel. (See figure 8.1.)

Early in human history, people began to use additional sources of energy to make their lives more comfortable. They domesticated plants and animals to provide a more dependable supply of food. They no longer needed to depend solely on gathering wild plants and hunting wild animals for sustenance. Domesticated animals also furnished a source of energy for transportation, farming, and other tasks. (See figure 8.2.) Wood or other plant material provided a source of fuel for heating and cooking. Eventually, this biomass energy was used in simple technologies, such as shaping tools and extracting metals.

Increased Use of Wood

Early civilizations, such as the Aztecs, Chinese, Indians, Greeks, Egyptians, and Romans were culturally advanced, but their societies used human muscle, animal muscle, and burned biomass as sources of energy. Except for limited use of some wind-powered and water-powered devices such as ships and canoes, the controlled use of fire was the first use of energy in a form other than food. Wood was the primary fuel. (Wood was also used for building materials and other cultural uses.) The energy provided by wood enabled people to cook their food, heat their dwellings, and develop a primitive form of metallurgy. Such advances separated humans from other animals. When dense populations of humans made heavy use of wood for fuel and building materials, they eventually used up the readily available sources and had to import wood or seek alternative forms of fuel.

Because of a long history of high population density, India and some other parts of the world experienced a wood shortage hundreds of years before Europe and North America did. In many of these areas, animal dung replaced wood as a fuel source. It is still used today in some parts of the world.

Western Europe and North America were able to use wood as a fuel for a longer period of time. The forests of Europe supplied sufficient fuel until the thirteenth century. In North America, vast expanses of virgin forests supplied adequate fuel until the late nineteenth century. Fortunately, when local supplies of wood declined in Europe and North America, coal, formed from fossilized plant remains, was available as an alternative energy source. By 1890, coal had replaced wood as the primary energy source in North America.

FIGURE 8.1 Hunter-Gatherer Society In a hunter-gatherer society, people obtain nearly all of their energy from the collection of wild plants and the hunting of animals.

FIGURE 8.2 Animal Power The domestication of animals was an important stage in the development of human civilization. Domesticated animals provided people with a source of power other than their own muscles.

Fossil Fuels and the Industrial Revolution

Fossil fuels are the remains of plants, animals, and microorganisms that lived millions of years ago. (The energy in these fuels is stored sunlight, just as the biomass of wood represents stored sunlight.) During the Carboniferous period, 286 million to 362 million years ago, when the Earth's climate was warmer and wetter than it is now, conditions were conducive to the formation of large deposits of coal.

Oil and natural gas formed primarily from one-celled marine organisms whose bodies accumulated in large quantities on the seafloor and became compressed over millions of years. Heat and pressure from overlying sediment layers eventually converted the organic matter into oil and gas. Ever since machines replaced muscle power, the major energy sources for the world have been fossil remains from the distant past.

Historically, the first fossil fuel to be used extensively was coal. In the early eighteenth century, regions of the world that had readily available coal deposits were able to switch to this new fuel and participate in a major cultural change known as the **Industrial Revolution.** (See figure 8.3.) The Industrial Revolution began in England and spread to much of Europe and North America. It involved the invention of machines that replaced human and animal labor in manufacturing and transporting goods. Central to this change was the invention of the steam engine, which could convert heat energy into the energy of motion. The steam engine made possible the large-scale mining of coal. Before steam engines, coal mines flooded and thus were not economical. The source of energy for steam engines was either wood or coal; wood was quickly replaced by coal in most cases. Nations without a source of coal or those possessing coal reserves that were not easily exploited did not participate in the Industrial Revolution.

Prior to the Industrial Revolution, Europe and North America were predominately rural. Goods were manufactured on a small scale in the home. However, as machines and the coal to power them became increasingly available, the factory system of manufacturing products replaced the small home-based operation. Because expanding factories required a constantly increasing labor supply, people left the farms and congregated in areas surrounding the factories. Villages became towns, and towns became cities. Widespread use of coal in cities resulted in increased air pollution. In spite of these changes, the Industrial Revolution was viewed as progress. Energy consumption increased, economies grew, and people prospered. Within a span of 200 years, the daily per capita energy consumption of industrialized nations increased eightfold.

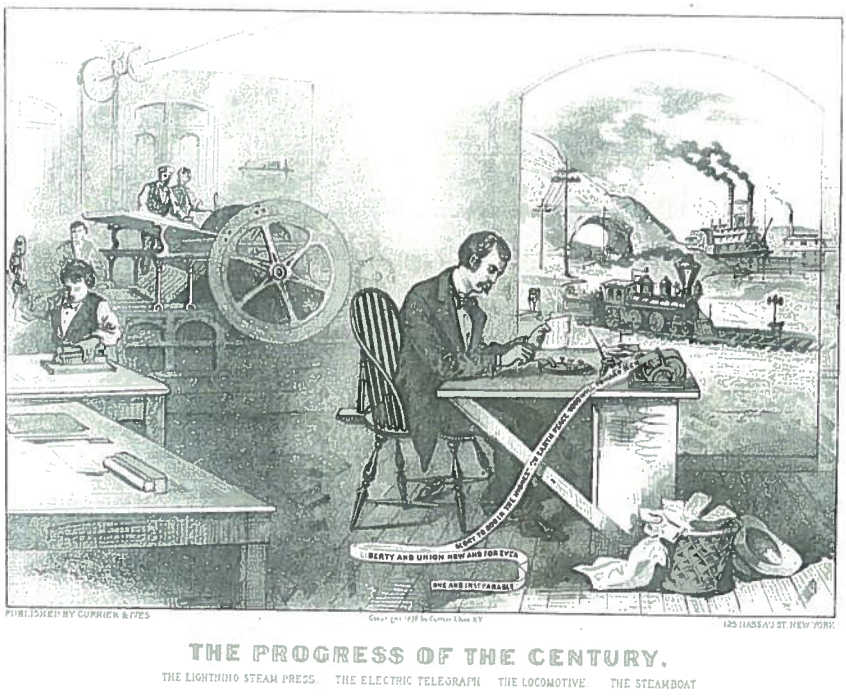


FIGURE 8.3 The Industrial Revolution The invention of the steam engine led to the development of many machines during the Industrial Revolution.

The Role of the Automobile

Although the Chinese used some oil and natural gas as early as 1000 B.C., the oil well that Edwin L. Drake, an early oil prospector, drilled in Pennsylvania in 1859 was the beginning of the modern petroleum era. For the first 60 years of production, the principal use of oil was to make kerosene, a fuel burned in lamps to provide lighting. The gasoline produced was discarded as a waste product. During this time, oil was abundant relative to its demand, and thus, it had a low price.

The invention of the automobile dramatically increased the demand for oil products. In 1900, the United States had only 8000 automobiles. By 1950, it had over 40 million cars, and by 2000, over 200 million. More oil was needed to make automobile fuel and lubricants. During this period, the percentage of energy provided by oil increased from about 2 percent in 1900 to about 40 percent by 1950 and has remained at about 40 percent to the present. (See figure 8.4.)

The growth of the automobile industry, first in the United States and then in other industrialized countries, led to roadway construction, which required energy. Thus, the energy costs of driving a car were greater than just the fuel consumed in travel. As roads improved, higher speeds were possible. Bigger and faster cars required more fuel and even better roads. So roads were continually being improved, and better cars were being produced. A cycle of *more chasing more* had begun. In North America and much of Europe, the convenience of the automobile encouraged two-car families, which created a demand for more energy.

More cars meant more jobs in the automobile industry, the steel industry, the glass industry, and hundreds of other industries. Constructing thousands of kilometers of roads created additional jobs. Thus, the automobile industry played a major role in the economic development of the industrialized world. All this wealth gave people more money for cars and other necessities of life. The car, originally a luxury, was now considered a necessity.

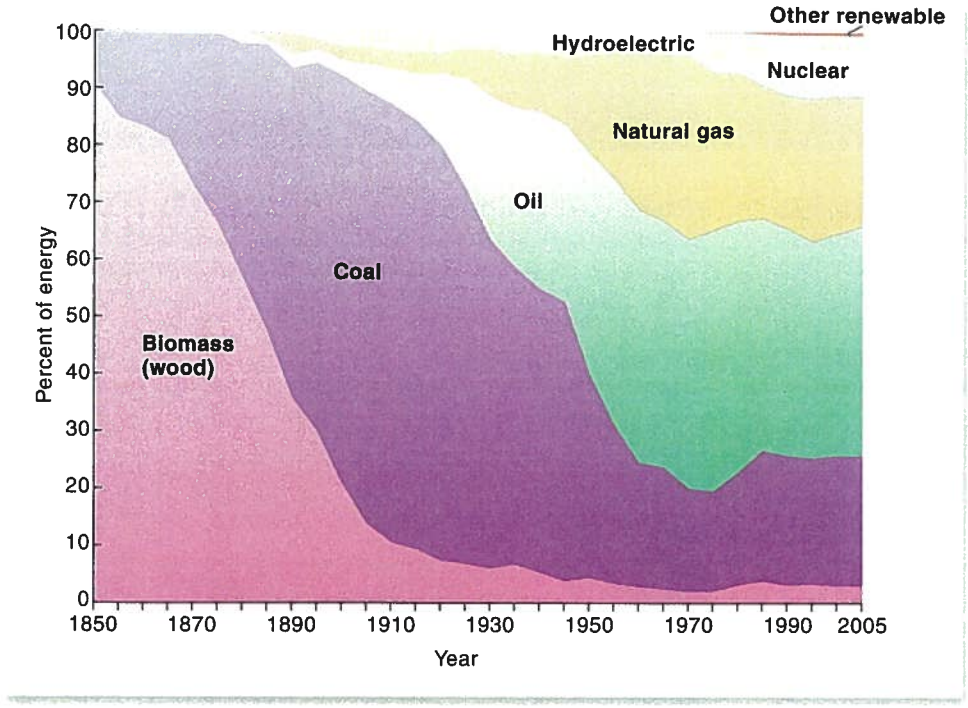


FIGURE 8.4 Changes in Energy Sources This graph shows how the percentage of energy obtained from various sources in the United States has changed over time. Until 1900, wood and coal were the predominant sources of energy. These sources declined in importance as oil and natural gas increased. Since 1950, oil and natural gas have provided over 60 percent of the energy, while coal has fallen to about 20 percent and wood to about 3 percent. Nuclear power has grown to about 8 percent, and hydroelectric power provides less than 3 percent. Other renewable sources (geothermal, solar, and wind) collectively account for less than 1 percent.
Source: Data from *Annual Energy Review, 2007*, Energy Information Administration.

The car also altered people's lifestyles. Vacationers could travel greater distances. New resorts and chains of motels, restaurants, and other businesses developed to serve the motoring public, creating thousands of new jobs. Because people could live farther from work, they began to move to the suburbs. (See figure 8.5.)

As people moved to the suburbs, they also changed their buying habits. Labor-saving, energy-consuming devices became essential in the home. The vacuum cleaner, dishwasher, garbage disposal, and automatic garage door opener are only a few of the ways human power has been replaced with electrical power. About 25 percent of the electrical energy produced in North America is used in homes to operate lights and appliances. Other aspects of our lifestyles illustrate our energy dependence. Regardless of where we live, we expect Central American bananas, Florida oranges, California lettuce, Texas beef, Hawaiian pineapples, Ontario fruit, and Nova Scotia lobsters to be readily available at all seasons. What we often fail to consider is the amount of energy required to process, refrigerate, and transport these items. The car, the modern home, the farm, and the variety of items on our grocery shelves are only a few indications of how our lifestyles are based on a continuing supply of cheap, abundant energy.

Growth in the Use of Natural Gas

Initially, natural gas was a waste product of oil production that was burned at oil wells because it was difficult to store and transport. Before 1940, natural gas accounted for less than 10 percent of energy consumed in the United States. In 1943, in response to World War II, a federally financed pipeline was constructed to transport oil within the United States.

(a)

(b)

FIGURE 8.5 Energy-Demanding Lifestyle (a) Building private homes on large individual lots some distance from shopping areas and places of employment is directly related to the heavy use of the automobile as a mode of transportation. (b) Heating and cooling a large, enclosed shopping mall, along with the gasoline consumed in driving to the shopping center, increase the demand for energy.

Going Green

Reducing Automobile Use in Cities

Although people like the convenience of the personal automobile, cars are the least energy-efficient means of transportation in cities. Ironically, the desire to use cars has resulted in traffic congestion in most large cities that has further reduced efficiency and eliminated the convenience of cars. To convince people to use other, more efficient public transport and to relieve congestion, many cities have passed regulations that use financial or other means to discourage automobile traffic in highly congested areas. Several different mechanisms have been successful.

London

Automobiles entering central London have their license plates photographed. Drivers of cars in the central city must pay a fee of £5 (about US $20) a day. Those who do not pay by 10 P.M. face a doubled fee.

Hong Kong

Electronic sensors on cars record highway travel and time of day. Drivers are issued a monthly bill (commuter hours are the most expensive).

Singapore

Automobiles and motorcycles are equipped with an in-vehicle unit that automatically deducts money from a cash card when the vehicle passes through a sensor and enters the restricted zone of downtown Singapore between 7:30 A.M. and 7 P.M.

Gothenburg, Sweden

To encourage pedestrian traffic, the central business district has been divided like a pie into zones, with cars prohibited from moving directly from one zone to another. Autos move from zone to zone by way of a peripheral ring road.

Rome and Florence

All traffic except buses, taxis, delivery vehicles, and cars belonging to area residents have been banned between 7:30 A.M. and 7:30 P.M.

Tokyo

Before closing the sale, the buyer of a standard-size vehicle must show evidence that a permanent parking space is available for the car. To comply with the law, some drivers have constructed home garages with lifts to permit parking one car above the other.

After the war, the federal government sold these pipelines to private corporations. The corporations converted the pipelines to transport natural gas. Thus, a direct link was established between the natural gas fields in the Southwest and the markets in the Midwest and East. By 1970, about 30 percent of energy needs were being met by natural gas. Currently, about 23 percent of the energy consumed in the United States is from natural gas, primarily for home heating and industrial purposes.

HOW ENERGY IS USED

The amount of energy consumed by countries of the world varies widely. (See figure 8.6.) The highly industrialized countries consume much more energy than less-developed countries. However, even among countries with the same level of development, great differences exist in the amount of energy they use as well as in how they use it. To maintain their style of living, individuals in the United States use about twice as much energy as people in France, Germany, or Japan, 5.5 times more energy than the people of China, and about 20 times more energy than the people of India.

Differences also exist in the purposes for which people use energy. Industrialized nations use energy about equally for three purposes: (1) residential and commercial uses, (2) industrial uses, and (3) transportation. Less-developed nations with little industry use most of their energy for residential purposes (cooking and heating). Countries that are making the transition from less-developed to industrial economies use large amounts of energy to develop their industrial base.

Residential and Commercial Energy Use

The amount of energy required for residential and commercial use varies greatly throughout the world. For example, about 22 percent of the energy used in North America is for residential purposes and 18 percent for commercial purposes, while in India, 44 percent

CASE STUDY 8.1

BIOMASS FUELS AND THE DEVELOPING WORLD

Although most of the world uses fossil fuels as energy sources, much of the developing world relies on *biomass* as its source of energy. The biomass can be wood, grass, agricultural waste, or dung. According to the United Nations, 2 billion people (30 percent of the world's population) use biomass as fuel for cooking and heating dwellings. In developing countries, nearly 40 percent of energy used comes from biomass. In some regions, however, the percentage is much higher. For example, in sub-Saharan Africa, fuelwood provides about 80 percent of energy consumed. Worldwide, about 60 percent of wood removed from the world's forests is used for fuel.

This dependence on biomass has several major impacts:

- Often women and children must walk long distances and spend long hours collecting firewood and transporting it to their homes.
- Because the fuel is burned in open fires or inefficient stoves, smoke contaminates homes and affects the health of the people. The World Health Organization estimates that in the developing world, 40 percent of acute respiratory infections are associated with poor indoor air quality related to burning biomass. A majority of those who become ill are women and children because the children are in homes with their mothers who spend time cooking food for their families.
- Often the fuel is harvested unsustainably. Thus, the need for an inexpensive source of energy is a cause of deforestation. Furthermore, deforested areas are prone to soil erosion.
- When dung or agricultural waste is used for fuel, it cannot be used as an additive to improve the fertility or organic content of the soil. Thus, use of these materials for fuel negatively affects agricultural productivity.

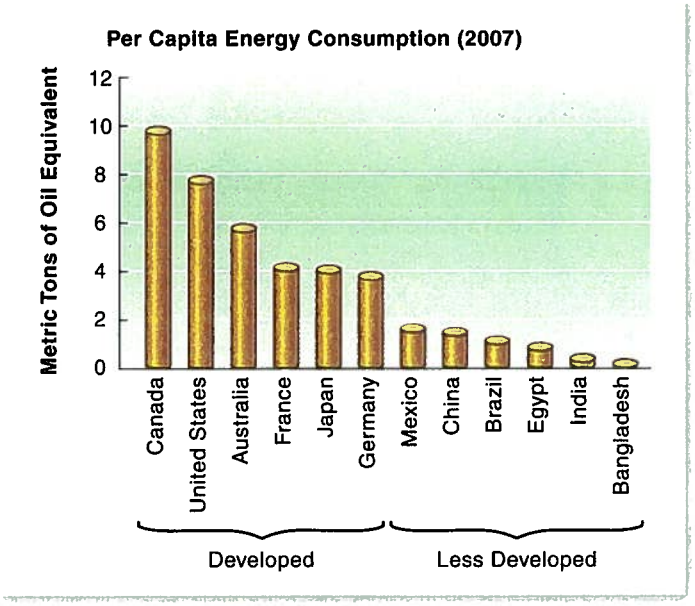


FIGURE 8.6 Per Capita Energy Consumption Countries of the developed world use much more energy per person than do countries of the less-developed world. However, there are great differences in energy use among developed nations. France, Germany, and Japan use about half the energy per person as does the United States.

Source: Data from *BP Statistical Review of World Energy,* June 2008; and *Population Reference Bureau, 2007 Population Data Sheet.*

of the energy is for residential uses and 3.4 percent for commercial purposes. The ways that residential energy is used also vary widely. In the United States, 47 percent is used for space heating. In Canada, which has a cold climate, 60 percent of the residential energy is used for heating. However, in many parts of Africa and Asia much of the energy used in the home is for cooking, and much of that energy comes from firewood.

In much of the less-developed world, cooking is done over open fires. Using fuel-efficient stoves instead of open fires could reduce these energy requirements by 50 percent. Improving efficiency would protect wood resources, reduce the time or money needed to obtain firewood, and improve the health of people because they would breathe less wood smoke. (See figure 8.7.)

Computer systems and the Internet are a relatively new segment of the economy that consumes energy. Although early estimates suggested that this segment of the economy would consume over 10 percent of the U.S. electrical energy supply, more recent estimates put the energy consumed at about 2 percent of the electrical energy supply.

INDUSTRIAL ENERGY USE

The amount of energy countries use for industrial processes varies considerably. Nonindustrial countries use little energy for industry. Countries that are developing new industries dedicate a high percentage of their energy use to them. They divert energy to

Water Connections

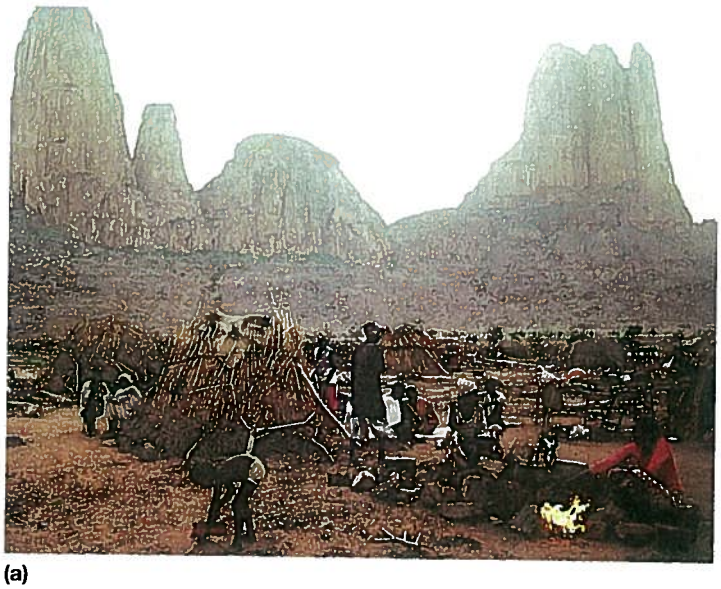
Heating Water—Saving Energy

Water is a substance with a high heat capacity. That means that it takes a great deal of heat energy to increase its temperature. Conversely, a great deal of heat needs to be transferred from water for it to cool.

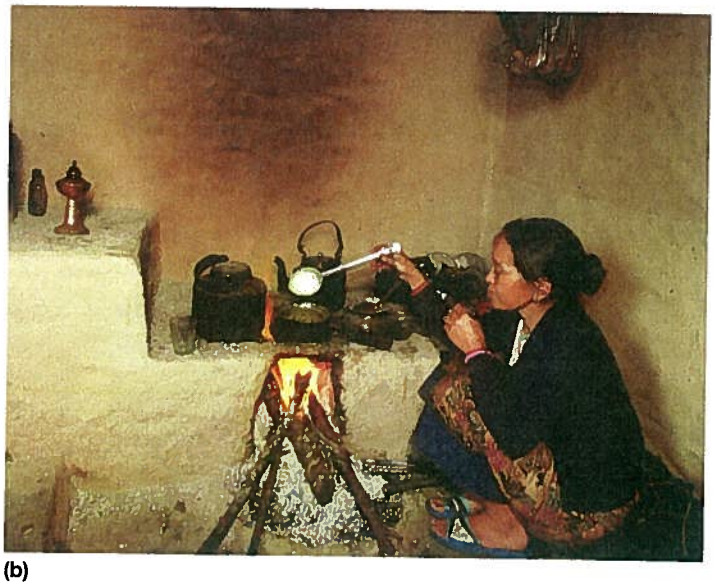
This property of water has several significant connections to the way we produce and use energy. Access to hot water for washing clothes and dishes and for bathing is considered a necessity in modern society, but this convenience carries a cost. About 17 percent of the energy used in households is used to heat water.

There are several simple things you can do to reduce the cost of heating water:

1. Use less hot water by installing low-flow fixtures on showers and faucets and take shorter showers.
2. Reduce the thermostat setting on the water heater to 120°F (49°C). This saves energy because energy is not used to raise the temperature above that which is needed.
3. Insulate the hot water tank so that the heated water does not lose heat through the surface of the tank.
4. Insulate the pipes that carry the hot water to reduce the rate at which the water loses heat.



(a)



(b)

FIGURE 8.7 Wood Use for Cooking Many people in the developing world use wood as a primary fuel for cooking. Reliance on wood is a major cause of deforestation. (a) In many parts of the world such as Africa, cooking is often done over open fires. This is a very inefficient use of fuel. (b) The use of simple mud stoves as in this home in Nepal greatly increases efficiency.

the developing industries at the expense of other sectors of their economy. Highly industrialized countries use a significant amount of their energy in industry, but their energy use is high in other sectors as well. In the United States, industry claims about 32 percent of the energy used.

The amount of energy required in a country's industrial sector depends on the types of industrial processes used. Many countries use inefficient processes and could reduce their energy consumption by converting to more energy-efficient ones. However, they need capital investment to upgrade their industries and reduce energy

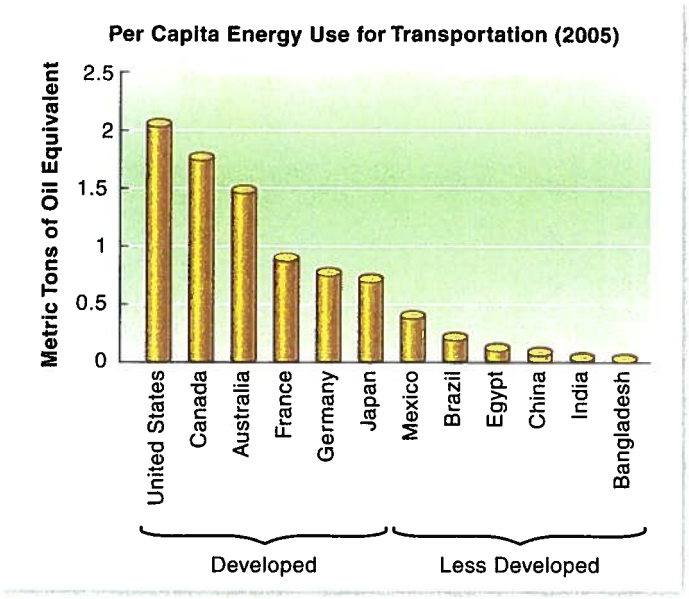


FIGURE 8.8 Per Capita Energy Use for Transportation (2005) Per capita energy use for transportation is highest among developed countries. However, there are great differences among countries. Most European countries and Japan use less than half the energy per person compared to the United States and Canada.
Source: International Energy Agency on-line statistics.

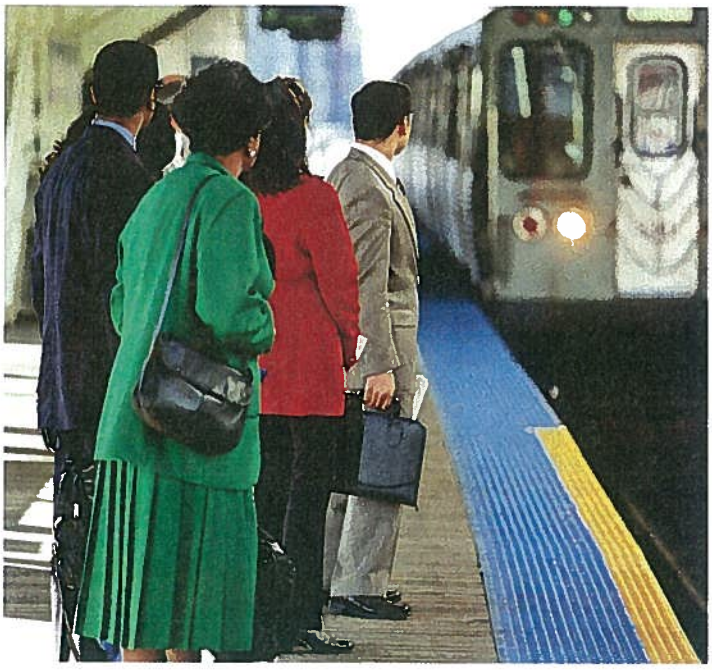


FIGURE 8.9 Public Transportation People will use public transportation in situations where automobile travel is inconvenient, time consuming, or expensive. Public transportation is more energy efficient than travel by private automobile.

consumption. Some countries cannot afford the upgrade. For example, many countries of the former Soviet Union still use outdated, inefficient open-hearth furnaces to produce steel. These furnaces require nearly double the worldwide energy average to produce a metric ton of steel compared to more efficient processes. By contrast, China, the world's largest steel producer, has closed all its open-hearth steelmaking operations in favor of more efficient processes.

Transportation Energy Use

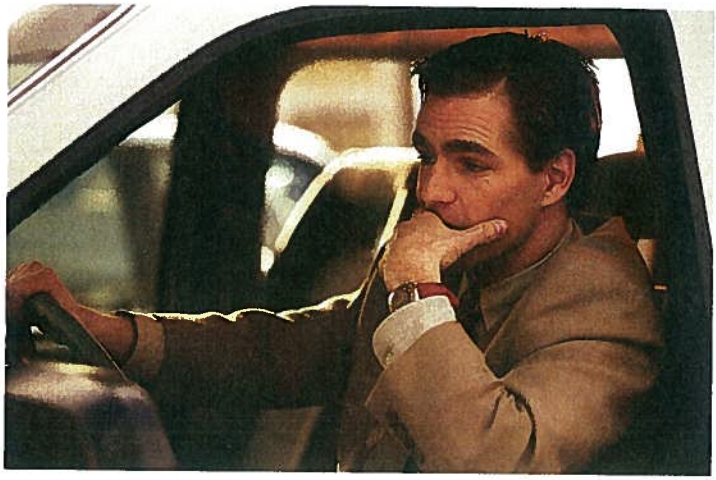
As with residential, commercial, and industrial uses, the amount of energy used for transportation varies widely throughout the world. In some of the less-developed nations, transportation uses are very small. Per capita energy use for transportation is larger in developing countries and highest in highly developed countries. (See figure 8.8.) There are also great differences in the percentage of energy devoted to transportation. Bangladesh, India, and China use about 10 percent or less of their energy for transportation, while most developing and industrialized countries use 25 to 40 percent for the same purpose.

Once a country's state of development has been taken into account, the specific combination of bus, rail, waterways, and private automobiles is the main factor in determining a country's energy use for transportation. In Europe, Latin America, and many other parts of the world, rail and bus transport are widely used because they are more efficient than private automobile travel, governments support these transportation methods, or a large part of the populace is unable to afford an automobile. In countries with high population densities, rail and bus transport is particularly efficient. (See figure 8.9.) In general, automobiles require about twice the energy per passenger kilometer than does bus or rail transport. In addition, most of these countries have high taxes on fuel, which raise the cost to the consumer and encourage the use of public transport.

In North America, the situation is different. Government policy has kept the cost of energy artificially low and supported the automobile industry while removing support for bus and rail transport. Consequently, the automobile plays a dominant role, and public transport is used primarily in metropolitan areas. (See figure 8.10.) Rail and bus transport are about twice as energy efficient as private automobiles. Private automobiles in North America, with about 5 percent of the world's population, consume about 40 percent of the gasoline produced in the world. Air travel is relatively expensive in terms of energy, although it is slightly more efficient than an automobile carrying a single passenger. Passengers, however, are paying for the convenience of rapid travel over long distances.

ELECTRICAL ENERGY

Electrical energy is such a large proportion of energy consumed in most countries that it deserves special comment. Electricity is both a way that energy is consumed and a way that it is supplied. Almost all electrical energy is produced as a result of burning fossil fuels. Thus, we can look at electrical energy as a use to which fossil fuel energy is put. In the same way we use natural gas to heat homes, we can use natural gas to produce electricity. Because the transportation of electrical energy is so simple and the uses to



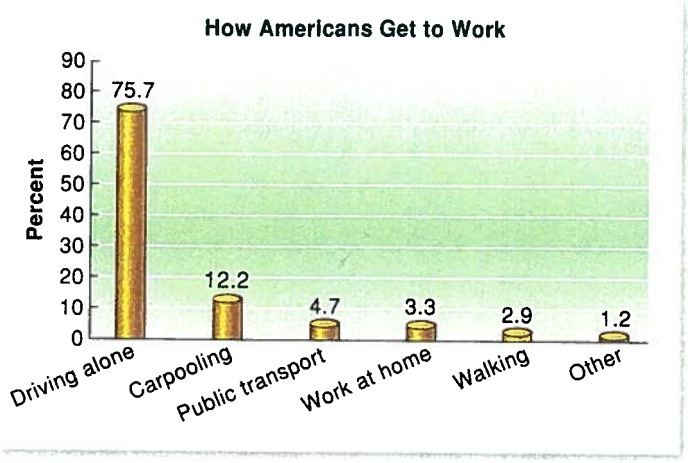


FIGURE 8.10 **How Americans Get to Work** The vast majority of Americans commute to work in an automobile with one person in it.

which it can be put are so varied, electricity is a major form in which energy is supplied to people of the world.

Electrical energy can be produced in many ways. The primary methods of generating electricity are burning fossil fuels, nuclear power plants, hydroelectric plants, and other renewable methods (geothermal, wind, tidal, solar). The combination of methods used to generate electricity in any country depends on the natural resources of the country and government policy. Figure 8.11 shows several countries that were selected to show how individual countries use different combinations of technologies to produce electricity. Norway gets nearly all of its electricity from hydroelectric plants. Iceland gets its electricity from a combination of hydroelectricity and geothermal energy. France relies heavily on nuclear power. Most countries have a substantial amount of their energy produced from fossil fuels, primarily coal.

As with other forms of energy use, electrical consumption in different regions of the world varies widely. The industrialized countries of the world, with about 20 percent of the world's population, consume 60 percent of the world's electricity. Less-developed nations of the world, which have about 80 percent of the world's population, use 40 percent of the world's electricity. The per capita use of electricity in North America is 10 times greater than average per capita use in the less-developed countries. In Bangladesh, the annual per capita use of electricity is about 147 kilowatt hours, which is enough to light a 100-watt lightbulb for less than two months. The per capita consumption of electricity in North America is about 100 times greater than in Bangladesh. Electrical consumption among developed countries also varies widely. For example, the per capita use in Japan and the 15 countries of the European Union is about 60 percent of that in North America.

The production and distribution of electricity is a major step in the economic development of a country. In developed nations, about a quarter of the electricity is used by industry. The remainder is used primarily for residential and commercial

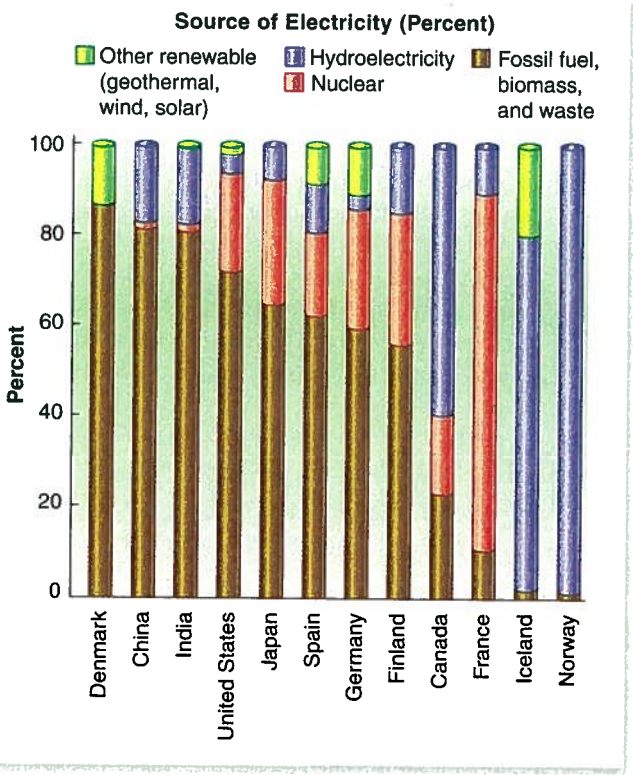


FIGURE 8.11 **Sources of Electricity** Electricity is generated from fossil fuels, nuclear power, hydropower, and other renewable forms of energy (wind, solar, geothermal, tidal). However, countries differ in the combination of technologies used to produce electricity. The differences are based on available natural resources and government policy. The countries shown here were selected to show these differences. Norway and Iceland have abundant hydroelectricity resources. In addition, Iceland has much geothermal energy. France has made the political decision to generate most of its electricity from nuclear power plants. Denmark, Spain, and Germany have made commitments to produce electricity from renewable technologies—particularly wind.

Sources: *BP Statistical Review of World Energy 2007* and other sources.

purposes. In nations that are developing their industrial base, over half of the electricity is used by industry. For example, industries consume about 50 percent of the electricity used in South Korea.

THE ECONOMICS AND POLITICS OF ENERGY USE

A direct link exists between economic growth and the availability of inexpensive energy. The replacement of human and animal energy with fossil fuels began with the Industrial Revolution and was greatly accelerated by the supply of cheap, easy-to-handle, and highly efficient fuels. Because the use of inexpensive fossil fuels allows each worker to produce more goods and services, productivity increased. The result was unprecedented economic growth in Europe, North America, and the rest of the industrialized world.

Because of this link between energy and productivity, most industrial societies want to ensure a continuous supply of affordable energy. The higher the price of energy, the more expensive goods and services become. To keep costs down, many countries have subsidized their energy industries and maintained energy prices at artificially low levels. International trade in fossil fuels has a major influence on the world economy and politics. The emphasis on low-priced fuels has encouraged high rates of consumption.

Fuel Economy and Government Policy

Governments fashion policies that influence how people use energy. Automobile fuel efficiency is one area in which government policy has had significant impact. For example, the price of a liter of gasoline is determined by two major factors: (1) the cost of purchasing and processing crude oil into gasoline and (2) various taxes. Most of the differences in gasoline prices among countries are a result of taxes and reflect differences in government policy toward motor vehicle transportation. The cost of taxes to the U.S. consumer is about 12 percent of the retail gasoline price, and in Canada, about 30 percent of the price of gasoline is taxes, while in Japan and many European countries, taxes account for 40 percent to 60 percent of the cost of gasoline. (See figure 8.12.) When we compare the kinds of automobiles driven, we find a direct relationship between the cost of fuel and fuel efficiency. In the United States and Canada, the average fleet fuel economy is about 8.8 liters per 100 kilometers (26.7 miles per gallon) and about 8.6 liters per 100 kilometers (27 miles per gallon), respectively. This compares with a European average of about 6 liters per 100 kilometers (40 miles per gallon). The average European car driver pays more than twice as much for fuel as U.S. and Canadian drivers and uses about 26 percent less fuel to drive the same distance as a U.S. driver. Since taxes make up the majority of the price of gasoline in Europe, government tax policy has provided an incentive for people to purchase fuel-efficient automobiles.

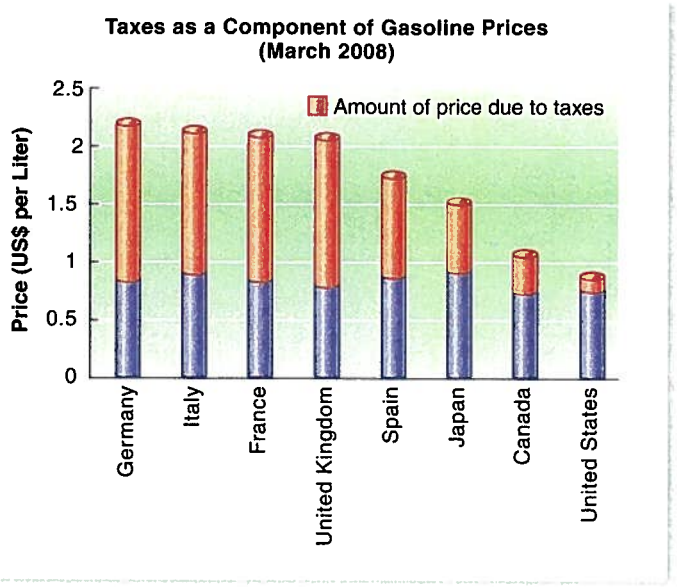


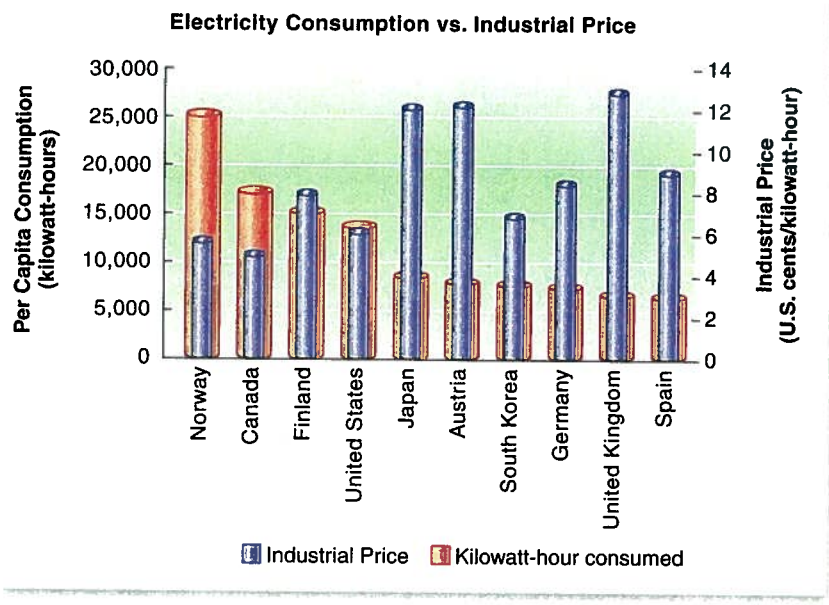
FIGURE 8.12 Gasoline Taxes and Fuel Efficiency The price paid for fuel is greatly influenced by the amount of tax paid. High fuel prices cause consumers to choose automobiles with greater fuel efficiency.
Source: International Energy Agency.

Another objective of governments is to have a mechanism for generating the money needed to build and repair roads. Many European countries raise more money from fuel taxes than they spend on building and repairing roads. The United States, on the other hand, raises approximately 60 percent of the monies needed for roads from fuel taxes. The relatively low cost of fuel in the United States encourages more travel, which increases road repair costs.

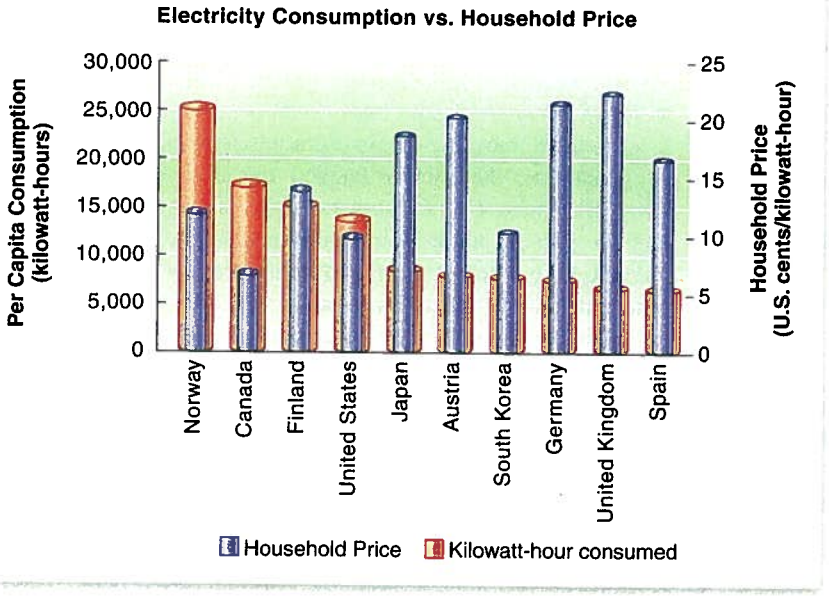
The European Union has also taken steps to comply with the Kyoto Treaty that mandates reductions in the amount of carbon dioxide released into the atmosphere. To achieve carbon dioxide reduction targets, European automobile manufacturers had voluntarily agreed to reduce their carbon dioxide emissions to 140 grams of carbon dioxide per kilometer by 2008. They did not meet the goal and have expressed doubts that they will meet the 130 gram level set by the European Union for 2012. Many European countries have instituted taxes based on the amount of carbon dioxide emitted by a car. People who own cars that emit higher amounts pay much higher taxes. By contrast, the United States has not signed the Kyoto Treaty and had falling fuel efficiency throughout the 1990s as more people bought and drove SUVs until about 2005. There have been tiny gains in fuel efficiency in the United States since 2005.

Electricity Pricing

Since electricity is such an important source of energy for many uses, it is interesting to look at how different countries structure electricity prices. Because of the nature of the electrical industry, most countries regulate the industry and influence the price utilities



(a)



(b)

FIGURE 8.13 **Electricity Price and Consumption** The price of electricity is directly related to the amount consumed. In most countries, electric utilities are monopolies and governments regulate the price charged to the consumer. Most countries have separate prices for industrial and household use with industrial use prices being lower. Graph (a) shows the relationship between the price charged to industry and national per capita use. Graph (b) shows the relationship between the price charged to households and national per capita use.
Source: Data from International Energy Agency, Key Energy Statistics 2007.

are able to charge. Furthermore, the cost to industrial users is typically about half that charged to residential customers. Figure 8.13 shows industrial and residential costs per kilowatt-hour (including charges per kilowatt-hour used, fees, surcharges, and taxes) for electricity in several countries. Obviously, higher prices discourage use. The United States, Canada, Norway, and Finland, which have some of the lowest prices for electricity, have the highest rates of consumption. Canada, Norway, and Finland have high proportions of their electricity generated by hydroelectric plants, which contributes to the low cost of electricity in those countries. Countries such as Japan, which must import fossil fuels to generate electricity, have a higher cost to generate the electricity, which is reflected in the price.

The Importance of OPEC

The Organization of Petroleum Exporting Countries (OPEC) began in September 1960, when the governments of five of the world's leading oil-exporting countries agreed to form a cartel. Three of the original members—Saudi Arabia, Iraq, and Kuwait—were Arab countries, while Venezuela and Iran were not. Today, 13 countries belong to OPEC. These include seven Arab states—Saudi Arabia, Kuwait, Libya, Algeria, Iraq, Qatar, and United Arab Emirates—and six non-Arab members—Iran, Indonesia, Nigeria, Ecuador, Angola, and Venezuela. OPEC nations control over 75 percent of the world's estimated oil reserves of 1200 billion barrels of oil. Middle Eastern OPEC countries control over 60 percent of this total, which makes OPEC and the Middle East important world influences. Today, OPEC countries control more than 40 percent of the world's oil production and are a major force in determining price. (See table 8.1.)

Increased solidarity among OPEC countries, continuing political instability in the Middle East, and increased demand by countries such as China and India coupled with changes in the value of the dollar and activities by oil speculators, caused oil prices to peak at over US $147 per barrel in mid-2008 before falling at the end of 2008 as the world economy entered a recession.

ENERGY CONSUMPTION TRENDS

From a historical point of view, it is possible to plot changes in energy consumption. Economics, politics, public attitudes, and many other factors must be incorporated into an analysis of energy use trends.

Growth in Energy Use

In 2007, world energy consumption was around 11,099 million metric tons of oil equivalent, an increase of 25 percent over 10 years. Of this total, conventional fossil fuels—oil, natural gas, and coal—accounted for nearly 90 percent.

TABLE 8.1 Major World Oil-Producing Countries

	Country	Production (thousand barrels/ day) 2007	Percent of Total
OPEC	**Saudi Arabia**	**10,233.9**	**12.1**
	Russian Federation	9875.8	11.7
	United States	8481.1	10.0
OPEC	**Iran**	**4043.4**	**4.8**
	China	3901.0	4.6
	Mexico	3501.4	4.1
	Canada	3358.5	4.0
OPEC	**United Arab Emirates**	**2947.7**	**3.5**
OPEC	**Venezuela**	**2666.6**	**3.2**
OPEC	**Kuwait**	**2613.2**	**3.1**
	Norway	2565.3	3.0
OPEC	**Nigeria**	**2352.4**	**2.8**
	Brazil	2279.0	2.7
OPEC	**Algeria**	**2173.2**	**2.6**
OPEC	**Iraq**	**2093.8**	**2.5**
OPEC	**Libya**	**1844.6**	**2.2**
OPEC	**Angola**	**1768.7**	**2.1**
	United Kingdom	1690.0	1.9
	Kazakhstan	1445.0	1.7
OPEC	**Qatar**	**1136.0**	**1.3**
OPEC	**Indonesia**	**1043.7**	**1.2**
OPEC	**Ecuador**	**300.7**	**0.4**
	World	**84,600.6**	

Source: U.S. Energy Information Administration.

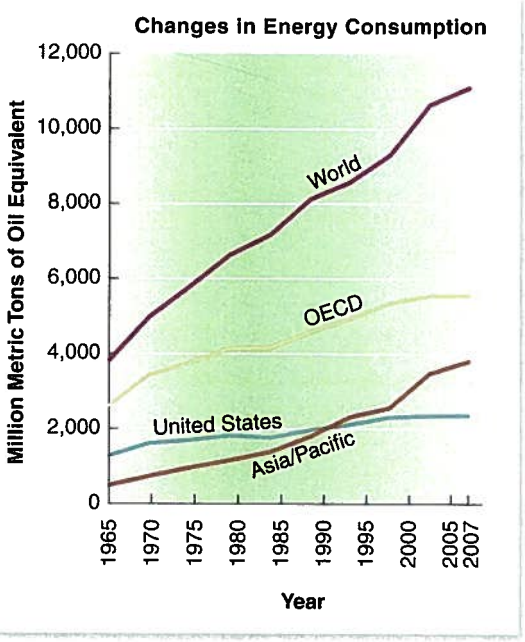


FIGURE 8.14 Changes in World Energy Consumption by Region World energy consumption has increased steadily. Currently the energy consumption of the economically developed nations (OECD) accounts for about half of world consumption. In recent years the fastest growth in energy use has been in the Asia Pacific region.
Source: Data from *BP Statistical Review of World Energy*, 2008.

Over half of world energy is consumed by the 25 countries that are members of the Organization for Economic Cooperation and Development (OECD). These countries (Australia, New Zealand, Japan, Canada, Mexico, the United States, and the countries of Europe) are the developed nations of the world. In the last decade, energy consumption in OECD countries has risen moderately (less than 1 percent per year) while economic growth has continued. There has also been a shift toward service-based economies, with energy-intensive industries moving to non-OECD countries. In contrast, in countries that are becoming more economically advanced (particularly parts of Asia), energy consumption is increasing at a faster rate (about 5 percent per year). Currently China's energy consumption is growing at 7.7 percent per year and India's is growing at nearly 7 percent per year. Since these two countries contain over 1/3 of the world's population, they are having a major impact on energy use in the world. Growing demand for oil from countries like China and India has led to higher oil prices. We should expect to see this pattern continue and countries with emerging economies increasingly demanding more energy. (See figure 8.14.)

Available Energy Sources

Oil remains the world's major source of energy, accounting for about 36 percent of primary energy demand. Coal accounts for 28 percent and natural gas for 24 percent; the remainder is supplied mainly by nuclear energy and hydropower. The current percentages are likely to remain the same into the future.

Political and Economic Factors

Political and economic factors have a great deal of influence on energy consumption. The two primary factors that determine energy use are political stability in parts of the world that supply oil and the price of that oil. Since OPEC and countries of the Middle East control over 40 percent of the world's oil production and 75 percent of the oil reserves, political stability in this region is very important. (See figure 8.15.)

The energy consumption behavior of most people is motivated by economics rather than by a desire to use energy resources wisely. When the price of energy increases, the price of everything else increases as well and eventually consumption falls. Conversely, when energy prices fall, consumption increases. During the 1980s, energy costs declined and people in North America and Europe became less concerned about their energy consumption. They used more energy to heat and cool their homes and buildings, bought and used more home appliances, and bought bigger cars. Governments can manipulate energy prices by increasing or decreasing taxes on energy, granting subsidies to energy producers, and using other means.

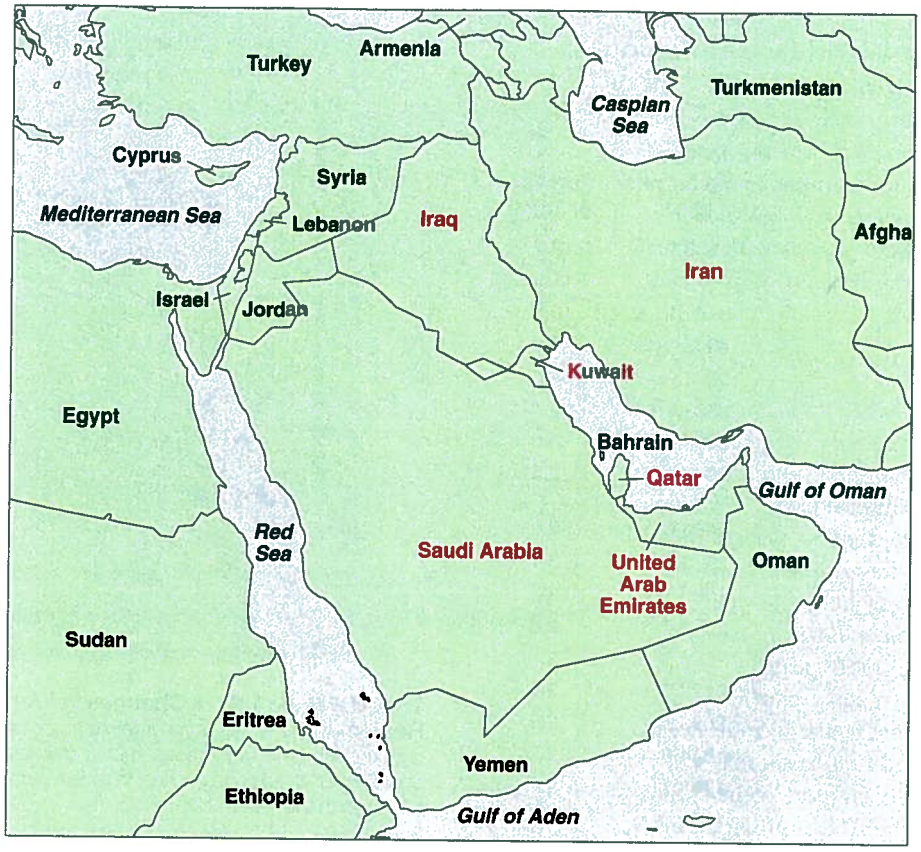


FIGURE 8.15 Persian Gulf OPEC Countries The six OPEC countries of the Persian Gulf (Saudi Arabia, Iraq, Iran, Kuwait, Qatar, and United Arab Emirates) control a major portion of the oil reserves and oil production of the world. Political instability in this region leads to increased oil prices.

Over the past several years, world oil prices have been extremely volatile. As recently as 1999, consumers benefited from oil prices that fell to under US $13 per barrel—a result of oversupply caused by lower demand for oil in both southeast Asia, which was suffering from an economic recession, and North America and Western Europe, which had warmer than expected winters. Since then there has been an increase in the price of oil due to increased demand from China, India, and other rapidly industrializing countries, political instability in the Middle East—in part the result of the wars in Iraq and Afghanistan—and increased solidarity among OPEC countries. In 2003, the price of oil was about $32 per barrel. In 2008, it exceeded $147 per barrel—a 360 percent increase in five years before falling at the end of 2008.

ISSUES & ANALYSIS

Government Action and Energy Policy

Governments use economic tools to encourage desired behaviors. Taxes on goods or services artificially increase the price and encourage a search for alternatives. Subsidies are a gift from government to encourage individuals or corporations to pursue certain kinds of activities. When regulations specify particular standards or actions, fines or fees are charged to those who do not meet the standards.

With respect to energy policy, there are several ways in which these tools are used:

1. The issue of global warming has generated the idea of a carbon tax. Carbon dioxide is released when fossil fuels are used, so a carbon tax would be a tax on energy. This tax would artificially raise the price of energy and cause people to change their behavior to use less energy or shift to forms of energy that release less carbon dioxide.
2. Taxes on gasoline and diesel fuel can be used to encourage consumers to change their driving habits or the kinds of vehicles they drive.
3. Oil companies receive large subsidies to encourage them to explore for oil. Small subsidies are also provided for the exploration of certain alternative energy sources such as solar energy and wind energy.
4. Fuel economy standards for motor vehicles require manufacturers to meet standards by a certain date or they must pay a fine.

All of these activities have their supporters and detractors. How do you feel?

- Do you support subsidies to companies to explore for oil?
- Would you support increased taxes on gasoline?
- Should government impose a carbon tax on all fossil fuels?
- Should automobile manufacturers be forced to make more fuel-efficient vehicles?

CAMPUS SUSTAINABILITY INITIATIVE

DELTA COLLEGE AND ENERGY EFFICIENCY

Delta College is a community college that serves, central Michigan. The campus is situated on a square mile of mixed farmland and woodlots. In the 1960s, the board of trustees agreed to preserve the woodlots as natural areas that could be used by the public and as a resource for biology, art, physical education, and other classes.

Delta College is one of 90 member colleges involved in the Sustainability Tracking, Assessment, and Rating System (STARS) of the Association for the Advancement of Sustainability in Higher Education (AASHE). The STARS project is designed to develop a rating system that will allow colleges to gauge their progress toward meeting sustainability goals. A "triple bottom" approach that weighs financial, environmental, and social benefits in departmental decision-making is a core philosophy.

The original campus was built in the early 1960s when energy efficiency was not a priority. Thus, energy conservation has been a long-term goal of the college for financial as well as environmental reasons. Whenever renovations occur, new energy-saving features are added. Some of the projects that support this goal include:

- An energy management system is programmed to automatically turn off heating/ventilation/air-conditioning systems and lighting during unoccupied hours.
- Heat recovery systems installed in renovated buildings capture the heat from air being exhausted from buildings and return it to the buildings.
- Energy-efficient lighting has been installed throughout the campus.
- Occupancy sensors in all classrooms and offices automatically turn off lights when the room is unoccupied.
- In corridors and rooms with windows, photocells record light levels and automatically shut off lights when incoming natural light meets minimum lighting levels.
- A system that allows the volume of air being supplied to a space to match the usage needs was built into renovated buildings.
- Single-glazed windows were replaced with energy-efficient, low-E insulated windows.
- Photovoltaic panels were installed on the roof of one of the buildings. This installation will serve as a demonstration and training site for several curricula.
- A chilled water system produces ice during the evening hours that is used to cool the building during the following day. This mechanism shifts electricity demand from peak daytime hours to off-peak nighttime hours.

SUMMARY

A constant supply of energy is required by all living things. Energy has a major influence on society. A direct correlation exists between the amount of energy used and the complexity of civilizations.

Wood furnished most of the energy and construction materials for early civilizations. Heavy use of wood in densely populated areas eventually resulted in shortages, so fossil fuels replaced wood as a prime source of energy. Fossil fuels were formed from the remains of plants, animals, and microorganisms that lived millions of years ago. Fossil-fuel consumption in conjunction with the invention of labor-saving machines resulted in the Industrial Revolution, which led to the development of technology-oriented societies today in the developed world.

The invention of the automobile caused major changes in the lifestyles of people that led to greater consumption of energy. Because of the high dependence of modern societies on oil as a source of energy, OPEC countries, which control a majority of the world's oil, can set the price of oil through collective action.

Throughout the world, residential and commercial uses, industries, transportation, and electrical utilities require energy. Because of financial, political, and other factors, nations vary in the amount of energy they use as well as in how they use it. In general, rich countries use large amounts of energy and poor countries use much less. Analysts expect the worldwide demand for energy to increase steadily and the growth in energy usage by those countries that are becoming industrialized to be greater than that of the countries that are already industrialized.

Thinking Green

1. List 10 activities you engage in each day that require fossil fuel or electrical energy. Choose one that you will abstain from for a week.
2. Keep a record of your transportation activities for one week. Record miles driven, subway fares paid, taxi fares, etc. How many of the trips were really necessary?
3. Write your governmental representative expressing your opinion on energy policy.
4. If a trip is less than 1 kilometer (0.6 mile), you can walk the round trip (2 km) in about half an hour and not use any fossil fuel energy.

What's Your Take?

The price of gasoline is a hot topic. Although Americans pay less than half as much for gasoline as people who live in other economically developed countries, many feel that U.S. prices are too high. Other people feel that increasing the price of gasoline is necessary to stimulate change in the way Americans use energy. Choose to support either the idea of keeping gasoline prices low or the idea of artificially increasing prices. Develop arguments that support your position.

Review Questions

1. Why was the sun able to provide all energy requirements for human needs before the Industrial Revolution?
2. In addition to food, what energy requirements does a civilization have?
3. Why were some countries unable to use the technologies developed during the Industrial Revolution?
4. What factors caused a shift from wood to coal as a source of energy?
5. How were energy needs in World War II responsible for the subsequent increased consumption of natural gas?
6. What part does government regulation play in changing the consumption of natural gas and oil?
7. Why was much of the natural gas that was first produced wasted?
8. What was the initial use of oil? What single factor was responsible for a rapid increase in oil consumption?
9. List the three purposes for which a civilization uses energy.
10. Why is OPEC important in the world's economy?
11. Give examples of how political and economic events affect energy prices and usage.

Critical Thinking Questions

1. Imagine you are a historian writing about the Industrial Revolution. Imagine that you also have your new knowledge of environmental science and its perspective. What kind of a story would you tell about the development of industry in Europe and the United States? Would it be a story of triumph or tragedy, or some other story? Why?
2. What might be some of the effects of raising gasoline taxes in the United States to the rate that most Europeans pay for gasoline? Why? What do you think about this possibility?
3. Some argue that the price of gasoline in the United States is artificially low because it does not take into account all of the costs of producing and using gasoline. If you were to figure out the "true" cost of gasoline, what kinds of factors would you want to take into account?
4. How has the ubiquitous nature of automobiles changed the United States? Do you feel these changes are, on balance, positive or negative? What should the future look like regarding automobile use in the United States? How can this be accomplished?
5. The Organization of Petroleum Exporting Countries (OPEC) controls over 75 percent of the known oil reserves. What political and economic effects do you think this has? Does this have any effect on energy use?
6. How do you think projected energy consumption will affect world politics and economics, given current concerns about global warming?