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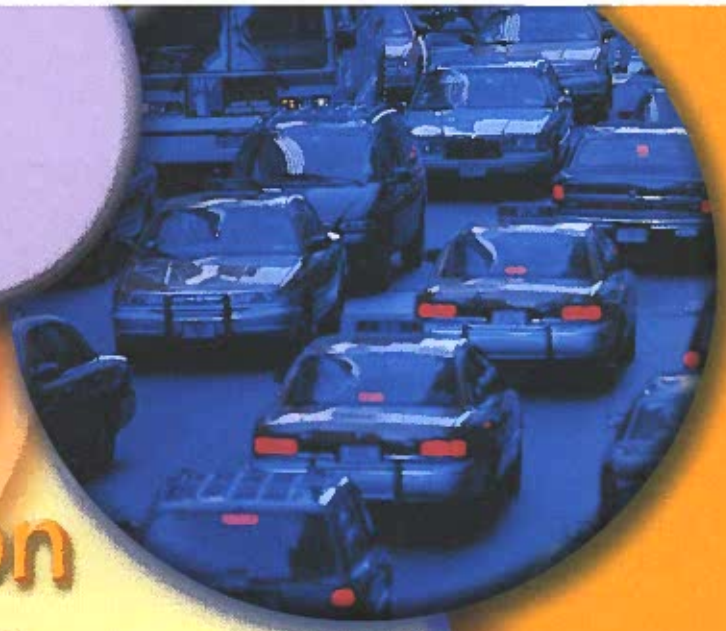
Energy, Power, and Transportation Technologies



Basic Concepts

- List the various forms of energy and power.
- Define *energy*, *power*, and *transportation*.
- Name the various modes of transportation.
- Identify a technological system.

Intermediate Concepts

- Discuss the importance of the study of energy, power, and transportation.
- Explain various factors affecting technological development.
- Describe the elements of a technological system.
- Recognize the inputs of a technological system.
- Give examples of the components of transportation systems that are common to all modes of transportation.

Advanced Concepts

- Differentiate between the scientific method and the technological method of problem solving.
- Summarize the technological method of problem solving.

The study of energy, power, and transportation technologies is, in many ways, the study of the evolution of society. The quality of energy consumed, the power produced, and the transportation modes of choice are linked to quality of life, at least as defined by the standards of Western civilization. This book is about the energy resources that fuel our society, the power we produce from energy for comfort and convenience, and the methods by which we transport people and products from place to place. The transportation sector is one of the largest energy-consuming sectors in the United States. This is based in part on America's dependence on automobiles. See **Figure 1-1.**

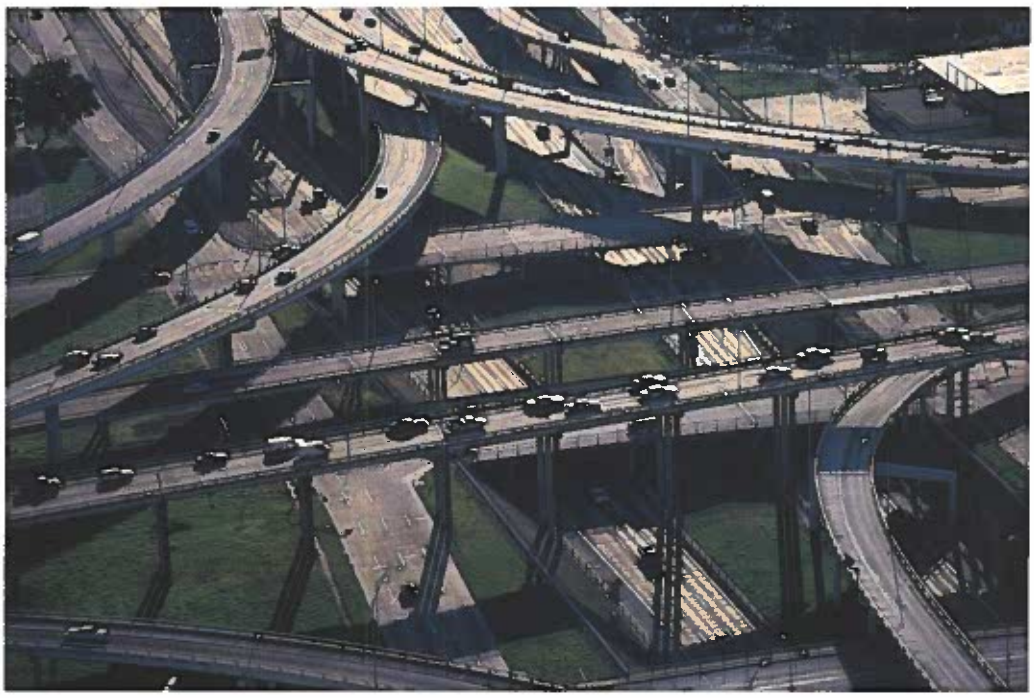


Figure 1-1. In the United States, the transportation sector—especially private automobiles—is one of the largest consumers of energy resources.

GREEN TECH
Energy, power, and transportation technologies have had great impacts on the environment. Green technologies are being invented to repair and prevent damage.

Throughout this book, you will learn about the technological aspects of energy, power, and transportation. You will also learn about other aspects of these technologies. Technology does not exist in a vacuum. There are a host of other factors that come into play when considering the development or expansion of a particular energy, power, or transportation technology. These factors include economic considerations, environmental concerns, and even political and social influences. You will learn about technological trade-offs. ***Trade-offs*** are situations in which technological developments solve one problem, only to create other problems. Such is the nature of technology. All citizens need to know how to make good decisions about the development of energy, power, and transportation technologies for present and future generations. The decisions we make now about these technologies will undoubtedly have a profound impact on more than just our nation. They will also affect our entire planet in the not so distant future. Good decisions can only come from a well-informed citizenry.

Trade-off: A situation in which a technological development solves one problem, only to create other problems.

Energy

Energy: The ability to do work.

Energy is defined as the ability to do work. Without energy resources, there would be no ability to produce power. Without power, there would be no modern conveniences. Electricity and contemporary forms of transportation make many conveniences possible. Some of what you will learn about energy may surprise you. For instance, did you know that almost all the energy utilized worldwide is in the form of fossil fuels? Well, unfortunately, this is true. See **Figure 1-2.**

Solar, nuclear, tidal, and wind energy are some alternative types of energy. They are in various stages of use or development. These sources offer some inherent advantages over the continued extensive use of fossil fuels. They all, however, offer some inherent disadvantages as well.

Curricular Connection

Social Studies: Society's Impact on Technology

Using available science and technology, many items have been developed that are intended to make life easier or help society reach a particular goal. After widespread use, sometimes the side effects of the application or handling of these items proves hazardous to the people involved or those exposed. In such cases, the government often bans the use of the substance or develops guidelines that alter its use for the sake of public safety. Asbestos is one such substance.

Asbestos is a naturally occurring mineral that was widely used during the 1800s for insulation on machinery and related items that reached high operating temperatures, such as boilers and steam pipes. It was also commonly used in roofing and flooring materials. The mineral was an extremely effective insulator that was strong and long lasting. Asbestos has also been used in brake pads of various transportation vehicles.

In the early 1900s, it was discovered that inhaling airborne fibers of asbestos, created while mining and working with the substance, caused a condition called asbestosis. This condition affects the airways and air sacs in both lungs and impairs breathing. People diagnosed with asbestosis are also at a greater risk of developing lung cancer.

While the benefits of using asbestos in energy conservation and transportation are great, the effect of exposure on the workers and general public are dire. The trade-offs for taking advantage of this effective material are the health and well-being of the society in which it is used. Other examples of items developed through technology that proved harmful to society include the following:

- Foam insulation.
- Lead paint.
- DDT (a pesticide).
- Agent Orange (an herbicide).

Society obviously impacts the development of technology. It is imperative that new products are proven acceptable, in terms of effectiveness and safety. Regardless of the benefits of any technology, if the side effects are harmful, the technology will not be used in society.

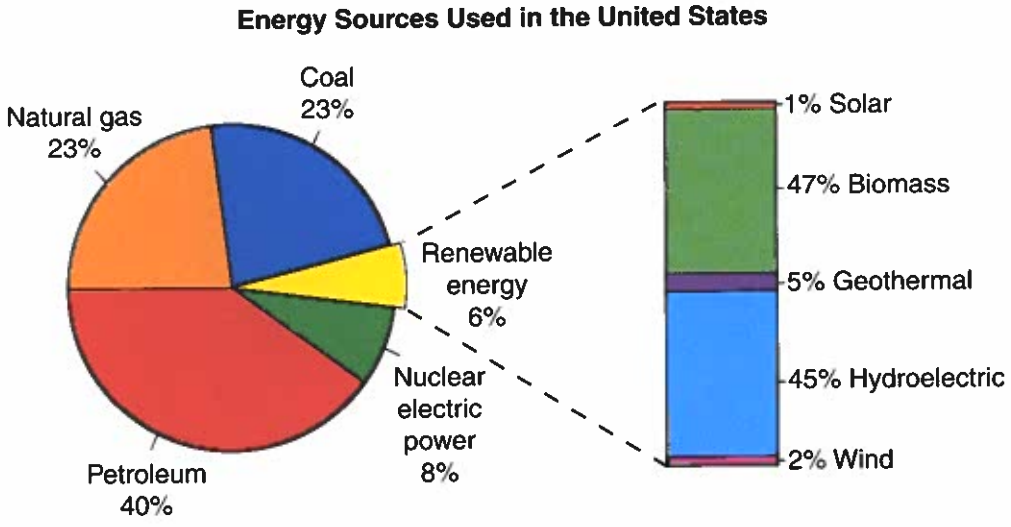


Figure 1-2. Fossil fuels are the largest source of energy used in the United States. In a recent year, renewable energy accounted for only about 6% of the total, as shown in this graph. (U.S. Energy Information Administration)

Energy is divided into the categories of nonrenewable energy resources and renewable and inexhaustible energy resources. Nonrenewable energy resources include the fossil fuels and uranium. Renewable and inexhaustible energy resources include wind and solar energy. You will learn about these resources and specific ways to help conserve energy. Several examples of ways in which energy can be conserved include reducing heat loss from structures, using energy-efficient appliances, and wisely selecting means of transportation.

Power

Power: The rate at which work is performed or energy is expended.

Power is defined as the rate at which work is performed or energy is expended. The amount of energy available in a given quantity of material is rather useless on its own. It is usually more beneficial if the energy can be converted to useful power to perform work. There are three main forms of power. They are electrical power, mechanical power, and fluid power. See **Figure 1-3.** All three forms of power are used extensively throughout society.

We see the results of electrical power, or electricity, everywhere. It is, perhaps, the most versatile of the three forms of power. Electricity can be used to power many things. It is used extensively for lighting, heat, tools, and appliances. Even within an automobile where electricity is not primarily responsible for motive power, its uses are critical to the function of the vehicle. Imagine a car without headlights, a charging system, and all the dashboard gauges powered by electricity.

Mechanical power predates electrical power. It is the easiest form of power to conceptualize because the components of mechanical power are all visual in nature. Some of these components are gears, levers, cables, and shafts. Mechanical power is very useful for performing work. Electrical power and fluid power are often converted back into mechanical power for end use. For instance, an electric drill uses electricity as a power source. The electricity must be converted to mechanical power, however, to perform the task of drilling a hole. Earth-moving equipment, like a

Figure 1-3. The three forms of power.


Electrical Power


Mechanical Power


Fluid Power

backhoe, uses fluid power to provide strength. The fluid power must be converted back to mechanical power, however, to scoop the earth.

Fluid power is not as common as the other two forms of power. Its applications, however, are critical to many industries. Fluid power is used widely in the manufacturing, construction, and transportation industries. This is because fluid power is ideal for pure strength applications. The wing flaps on an airplane can be adjusted by fluid power, even though they are meeting massive air resistance when the plane is in flight. The braking and steering systems on most modern cars are assisted by fluid power. Most heavy construction equipment involves the extensive use of fluid power.

Control technology and automation also affect our lives in many ways. Automation relies on input sensors and output devices. The sensors often send signals to a computer programmed for decision making. Output devices include motors, lights, buzzers, and relays. These fundamental concepts of automation are discussed in more detail later in this book.

There are many devices that perform conversions from one form of power to another or from a form of power into a form of energy. Some, however, are used much more extensively than others. For instance, the ability to convert electricity into visible light allows us to see when it is dark out. The lightbulb is certainly one of the most popular conversion devices ever invented. Speakers convert electricity into sound. Other converters are used for convenience and automation. One of the most practical and popular sensors is the thermostat. It allows the home to remain at a relatively constant temperature without constant adjustments to the furnace. Perhaps you have a photoelectric eye that turns on a night-light. This device can convert visible light to an electrical signal.

Technology Link

Agriculture: Irrigation Pumps

Agriculture often relies on power technology to ensure successful crops. Irrigation systems can be used to support agriculture in dry or unpredictable climates. These systems provide artificial watering to maintain proper plant growth.

A sprinkler irrigation system produces artificial rain to water the crops. A pump forces water from a lake, a river, a reservoir, or an underground aquifer into the main distribution lines. The pressurized water flows through the main lines to a series of lateral pipes. At the end of each pipe is a sprinkler head. The water enters the sprinkler heads, which spray water onto the land. Valves between the main and lateral lines control the water flow.

The fluid power used to pump water from the water source to the farming fields is crucial to agricultural technology. Without these irrigation systems, it would be difficult to distribute water to areas where it is needed. Agricultural water pumps allow water to reach much more land than would ever be possible without them, and they make farming a more efficient enterprise.

The internal combustion engine is a conversion device. It has many applications in today's society. Small gas engines power everything from weed whackers and snowblowers to generators and irrigation pumps. Larger internal combustion engines form the backbone of a large segment of the transportation sector of our economy.

Transportation

Transportation: The movement of people or products from one place to another.

Transportation is defined as the movement of people or products from one place to another. Most people take transportation for granted. They usually do not think about how it affects their lives. Transportation is, however, essential in nearly everything you do. See **Figure 1-4.** Think of what your life would be like if you had no transportation. There are various modes of transportation. They are land, water, air, and space. ***Intermodal*** transportation systems also move many people and products. These systems combine various modes of transportation. You will learn about the vehicular systems common to all forms of transportation. These include guidance, control, and suspension systems.

Intermodal: A transportation system that combines various modes of transportation to move people and products.

Environmental Impacts and Looking Ahead to the Future

It is an unfortunate reality that the same use and development of energy, power, and transportation technologies that improve our quality of life also pollute our environment. In fact, the consumption of coal for the production of electricity and the consumption of gasoline to power the transportation sector of our economy are responsible for much of our pollution. Throughout this book, environmental concerns are emphasized. We will take a specific look at environmental impacts of energy, power, and transportation technologies and what is being done to improve the

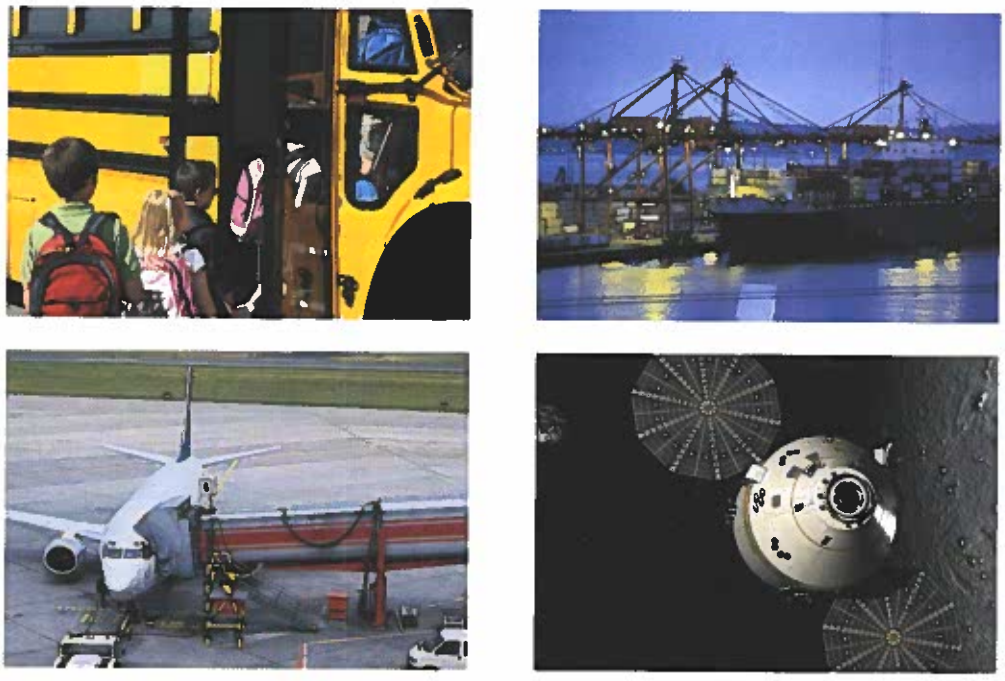


Figure 1-4. We depend on several modes of transportation in our daily lives. The four main modes of transportation are land, water, air, and space. (NASA)

GREEN TECH
The use of coal and gasoline for electricity and transportation have impacted our supplies of these resources. Coal and fossil fuels are nonrenewable energy sources.

Career Connection

NASCAR Race Car Mechanics

Many professions are necessary for energy, power, and transportation technologies to function properly. These technologies make our lives easier, safer, and more convenient. Sometimes, these technologies also make our lives more fun! NASCAR race car mechanics play an important role in the sport of racing, and they help provide us with entertainment.

NASCAR race car mechanics often travel to racing events, so their schedules are constantly changing. Usually, they spend a few days every week working in the shop on cars they are preparing for upcoming events. Some mechanics have specializations, such as working on the brakes or engines of the cars. A brake specialist, for example, might be responsible for the brakes, the hydraulics, and the cooling systems. He also could be in charge of restocking the trucks with all the brakes that will be needed at the next event.

After traveling to the race track, the mechanics check in at the track and have their cars inspected. The drivers practice and qualify their cars. The brake specialist helps make changes to the suspension and brakes during the practice sessions. Additional preparations are made to the cars after the practice sessions are complete. On the day of the race, the mechanics finish preparing the cars and help set up the pit area. See **Figure 1-A.** After the race, they help load the cars back onto the transporter and head back to the shop to start working on the cars for the next race.

One advantage of this job is that it is always changing. The cars are different from week to week, as are the tracks and racing locations. Some disadvantages, however, are the long season and the lack of time off.

To become a NASCAR race car mechanic, at least a high school diploma is required, though most positions require some sort of engineering degree. An enthusiasm for cars and experience working on them are also essential to get into this profession. Race car mechanics can make anywhere from $45,000 to $150,000 a year.

Figure 1-A. NASCAR mechanics have to work quickly at the pit stop during a race. (Sears, Roebuck and Co.)

environmental impacts of such technologies. The future of energy, power, and transportation technologies is also worth investigating. Some new research on power production and transportation techniques will be discussed. We will also look at ideals necessary for future technological developments in energy, power, and transportation technologies.

Science: The body of knowledge related to the natural world and its phenomena.

Technology: The body of knowledge related to the human-made world. The technological world includes human-made products and their impacts.

Scientific method: Methodology that pursues new knowledge by the collection of data through observation and experimentation to test a hypothesis.

Studying Technology and Science

The terms *science* and *technology* are frequently used hand in hand. To many people, there is little difference between science and technology. Other people associate technology with computers. Neither of these explanations of technology, however, is correct. A better way to explain the difference between the study of science and the study of technology is to consider their definitions.

- ***Science*** is the body of knowledge related to the natural world and its phenomena.
- ***Technology*** is the body of knowledge related to the human-made world. The technological world includes human-made products and their impacts.

Another means of differentiating technology from science is to review the methodology used by scientists and technologists. Scientists use the ***scientific method*** of inquiry. This method pursues new knowledge by the collection of data through observation and experimentation to test a hypothesis. Technologists use the ***technological method*** of problem solving to yield new products through a process of researching, testing, and refining. The two methods are compared in **Figure 1-5.**

Figure 1-5. A comparison of the scientific method and the technological method.

The Scientific Method

State the Problem
Gather Information
Formulate a Hypothesis
Test the Hypothesis
Record and Analyze the Data
State a Conclusion

The Technological Method

Identify the Problem/Analyze the Situation
Clarify and Specify the Problem
Research and Investigate—Gather Information
Brainstorm Alternative Solutions
Choose the Best Solution
Model and Prototype a Solution
Test and Evaluate
Refine the Solution
Observe/Analyze/Synthesize

The technological method is probably not as ingrained in you as the scientific method is. It is, however, a method that is well known to American industry. This method is used extensively to test and refine new products prior to large-scale manufacturing. It involves a design loop. This loop allows for continuous evaluation and modification.

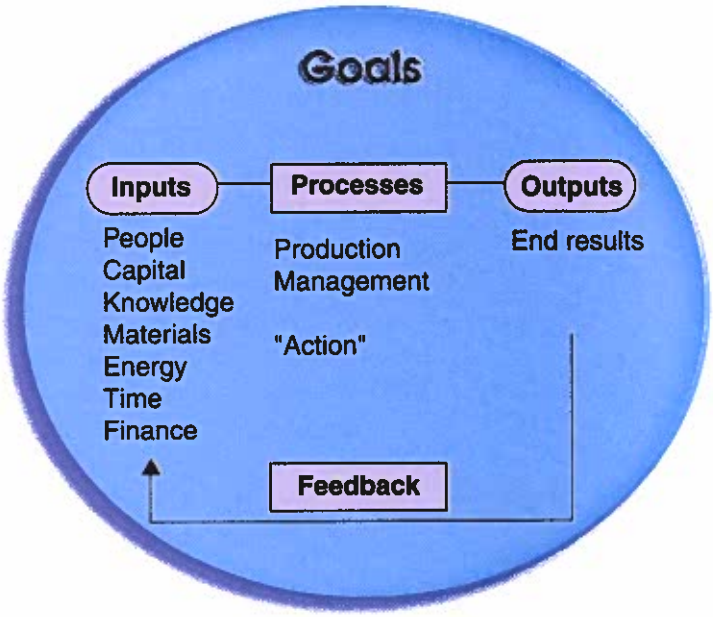
Technological method: Method of problem solving that yields new products through a process of researching, testing, and refining.

Technological Systems

You are surrounded by various technological systems. Technology is the application of knowledge and creative thinking that changes resources to meet human needs. This usually results in a more convenient lifestyle. A ***system*** involves a combination of related parts. These parts work together to accomplish a desired result. A familiar system is the circulatory system located within your body. You may also know about our system of government. Both of these systems have separate, but related, parts working together. When you combine the two terms, *technology* and *system*, the result is a technological system. See **Figure 1-6.** Note that the technological systems model is sometimes referred to as the universal systems model because it can be applied to virtually any technology.

System: A combination of related parts that work together to accomplish a desired result.

Figure 1-6. Inputs, processes, outputs, and feedback are the vital components of the technological systems model.



All ***technological systems*** consist of inputs, processes, and outputs. Technological systems are designed to meet human needs and wants. In the technological systems model, these needs and wants can be expressed as goals. One goal of construction technology is to build habitats. The primary goal of manufacturing technology is to convert raw materials into useful products. The main goal of transportation technology is to move people and products from place to place. In order to determine how well the goal is being met, all technological systems require feedback. ***Feedback*** provides information on how the system is performing or has performed. It is usually provided in multiple forms. An aircraft pilot, for example, looks at the instrument panel for feedback. Several gauges provide information about the altitude and speed of the aircraft. This lets the pilot know the performance of the aircraft. In a similar manner, power plant operators monitor electrical output and coolant temperature.

Technological system: The inputs, processes, and outputs designed to meet human needs and wants.

Feedback: Information on how a system is performing or has performed.

System Inputs

The ***inputs*** of a system are the resources needed to begin the system. These resources are needed to make the system operate. There are several different types of resources, or inputs, that must be considered for a technological system to function properly. See **Figure 1-7.** These resources are the following:

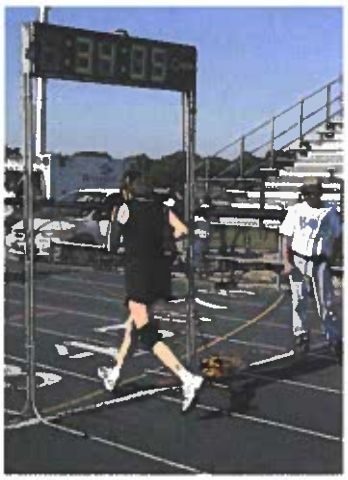
Input: A resource needed to begin a system and make it operate.

Figure 1-7. These inputs are necessary for any technological system to operate properly. (Ford Motor Company)


People


Capital


Energy


Time


Knowledge


Materials


Finance

- **People.** Humans are a very important resource for any technological system. People design, create, and maintain systems.
- **Capital.** Capital is all the tangible items needed and used within a technological system. Storage buildings, roads, computers, and vehicles are all examples of capital within a transportation system, and power plants and repair trucks are parts of an energy and power system.
- **Knowledge.** Through experience and application, people acquire knowledge and skills necessary to reach the goals of technological systems. For example, a train engineer must have the knowledge to read the instruments in order for the train to stay on schedule and function properly.
- **Materials.** Materials are major resources used to make any technological system function. Some materials can be used as they are, while others are changed by the system.
- **Energy.** All energy, power, and transportation systems operate from some source of energy. Sources include humans, animals, the wind, the sun, and petroleum.
- **Time.** Time is the duration of any activity. Scheduling and time are essential considerations for any technological system.
- **Finance.** Finance is money. Money is used to buy the resources used to begin a system.

GREEN TECH
The use of green materials is meant to not only help preserve resources, but also to reduce the amount of waste and pollution caused by obtaining or changing materials.

System Processes

Process: The portion of the technological systems model in which the desired goal is in sight. The inputs are being changed in this step.

Output: The end result of a system.

All the inputs feed into the process portion of the technological systems model. During a ***process***, the desired goal is in sight. The inputs you started with are now being changed. This change will produce an ***output***, or result. The inputs are combined to make the system run. For the system to run properly, the system must be managed. People manage systems. For transportation to be efficient, management is a necessity. The job of a manager is to plan, organize, and control the system. For example, people who manage bus lines route the schedules of the buses so people can plan their trips in advance. Railroads and trucklines also need to be managed. The

movement of people and cargo begins once the transportation process is started. Plant engineers monitor and manage power distribution grids so enough electricity is available to the grid during varying demand periods. Suppliers manage resource recovery and processing so enough energy is available to a specific location, in order to meet the needs of the population.

System Outputs

The outputs of a system are the end results. Inputs and processes assist in reaching the output. Technological systems are designed to meet human needs and wants. Therefore, it makes sense that many of the outputs are desired outputs, such as tangible products. Without inputs, processes, and outputs, there would be no system. An example of a desired output from the transportation industry would be a safe and successful trip from point A to point B in a timely fashion. See **Figure 1-8.** An example of a desired output from the energy and power industry would be safe and successful power generation without interruption.

Sometimes, in the course of producing desired outputs, some undesirable outputs also occur. Can you think of any undesirable outputs from the transportation or energy and power industries? One unintended consequence common to both industries is various forms of pollution. Technology often creates air, water, visual, and noise pollution. The burning of fossil fuels puts hydrocarbons and other pollutants into the atmosphere. Aircraft cause noise pollution, especially for people living near airports. Can you think of other undesirable outputs of transportation? Sometimes, undesired consequences are inevitable. Hydroelectric dams produce inexpensive electricity without the concern of fossil fuel pollutants. They also change the ecology of rivers, however, thus creating a different form of environmental pollution.

Figure 1-8. Completing a journey from one airport to another is an example of achieving a desired output.

Goals of a System

The success of all technological systems involves desirable goals. The goal could be to be the best package delivery service in the world. This is a particular system goal of a company. There are also societal and personal goals that apply to any technological system. To arrive at a destination comfortably and in style is a personal goal. Societal goals are much broader than system goals. They might include the following:

- Maintaining a low rate of unemployment.
- Maintaining a high standard of living.
- Maintaining technological superiority.
- Maintaining national safety.

Society puts restrictions on technological systems. It does this for good reason. Cars often need to pass exhaust inspections. Workers at nuclear plants are limited to a certain amount of yearly radiation exposure. A nuclear plant is limited to a certain amount of radiation emission. American culture generally sets high expectations for technological systems. We like our products to function properly and safely. Also, we want them produced inexpensively and quickly. The goals of a technological system and the goals of society are sometimes aligned. They are, however, sometimes opposed. Because of this, technological systems are constantly being adjusted. For example, a car that gets 60 miles per gallon, but is regarded as a safety hazard while on the road, would probably not be accepted by society. A nuclear power plant that could produce cheap electricity by eliminating the costs of an environmental containment structure and a security staff would also probably not be accepted.

Agricultural technology: Systems that produce outputs by growing plants and animals. The outputs are typically foods and fibers.

Communication technology: Systems associated with the dissemination of information and ideas. Products include schematics, advertisements, Web pages, and media messages.

Construction technology: Systems associated with the creation of structures for residential, commercial, industrial, and civil use.

Seven Major Technological Systems

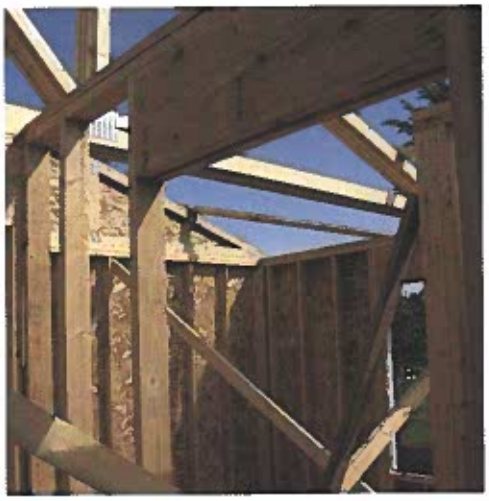
The components of a technological system were briefly described in the previous section. Each of those components can be applied to any of the major technological systems. There are seven major technological systems. See **Figure 1-9.**

Most technological systems are of an industrial nature. Systems like manufacturing and communication are designed to serve very large numbers of people. There are seven major technological systems that can be used to classify different technologies.

- ***Agricultural technologies*** include systems that produce outputs by growing plants and raising animals. The outputs of agricultural technologies are typically foods and fibers.
- ***Communication technologies*** are systems associated with the dissemination of information and ideas. Products of communication technologies include schematics, advertisements, Web pages, and media messages.
- ***Construction technologies*** include systems associated with the creation of structures for residential, commercial, industrial, and civil use.

Agricultural Technologies

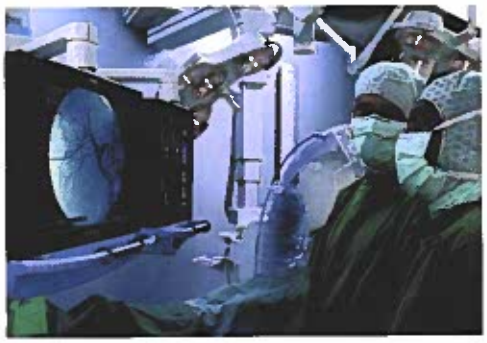
Communication Technologies



Construction Technologies

Energy and Power Technologies

Manufacturing Technologies



Medical Technologies

Transportation Technologies

Figure 1-9. The seven major types of technological systems.

- ***Energy and power technologies*** are systems that gather energy and convert it to useful power for the use and benefit of society. Products of energy and power technologies include electricity for household use and the engines that produce mechanical power for automobiles.
- ***Manufacturing technologies*** include systems that transform raw materials into useful products in a central location. These products must be marketed, transported, and distributed for end use.
- ***Medical technologies*** include systems used to maintain health and treat injuries and illnesses. The end product of medical technologies is a healthier society.
- ***Transportation technologies*** include systems designed to move people and products from one place to another. Systems involved with transportation technologies include propulsion, guidance, control, suspension, structure, and support.

This book focuses on two of these major technological systems: energy and power systems and transportation systems.

Energy and power technology: Systems that gather energy and convert it to useful power for the use and benefit of society. Products include electricity for household use and the engines that produce mechanical power for automobiles.

Manufacturing technology: Systems that transform raw materials into useful products in a central location. These products must be marketed, transported, and distributed for end use.

Medical technology: Systems used to maintain health and treat injuries and illnesses. The end product of medical technologies is a healthier society.

Transportation technology: Systems designed to move people and products from one place to another.

Summary

Technology is associated with the study of the human-made world. Science is associated with the phenomena of the natural world. All technological systems rely on a model known as the technological systems model. This model describes a series of inputs, processes, and outputs to accomplish goals. It can be applied to any major technological system. Feedback is used to constantly adjust the performance of the technological system. When addressing a technological problem, it is often helpful to make use of the technological method. This method of inquiry differs from the scientific method in that a useful product is usually the desired end result. Steps in the technological method include gathering information and researching, brainstorming alternative solutions, prototyping the best solution, testing and refining the solution, and synthesizing the entire process. Energy, power, and transportation technologies are part of a larger family of technological systems. This group of systems also includes agricultural, communication, construction, manufacturing, and medical technologies.

Key Words

All the following words have been used in this chapter. Do you know their meanings?

agricultural technology
communication technology
construction technology
energy
energy and power technology
feedback
input
intermodal
manufacturing technology
medical technology
output
power
process
science
scientific method
system
technological method
technological system
technology
trade-off
transportation
transportation technology

Test Your Knowledge

Write your answers on a separate sheet of paper. Do not write in this book.

1. *True or False?* The quality of energy, power, and transportation systems available to a culture greatly affects that society's quality of life.
2. The development of any particular technology is influenced by many factors besides technical know-how. Identify and describe three of these factors in one sentence each.
3. _____ is defined as the ability to do work.

4. The majority of all energy converted to power comes from _____.
5. _____ is defined as the rate of doing work.
6. Power is produced in these three forms: _____, _____, and _____.
7. Modes of transportation include air, land, _____, and _____.
8. Name two vehicular systems found in all forms of transportation systems.
9. *True or False?* Intermodal transportation is a synonym for land transportation.
10. The study of _____ is concerned with the natural world and its phenomena.
11. The study of _____ is concerned with the human-made world and its impacts and consequences.
12. Explain how the technological method differs from the scientific method.
13. Identify and briefly describe the steps in the technological problem-solving method. Use one sentence per step.
14. *True or False?* A transportation system is a technological system.
15. Gauges on an airplane and quarterly sales reports from a manufacturing firm are similar in that they both provide _____ in the universal systems model.
16. Time, capital, and finance are all considered _____ in the universal systems model.
17. *True or False?* A finished product is an output of a manufacturing system.
18. Power generation is a desired result of any power plant. What is an example of an undesired result?
19. *True or False?* Undesired consequences of particular technologies are sometimes inevitable.
20. Transportation is one of seven major technological systems. Energy and power is another. _____, _____, _____, _____, and _____ are also major technological systems.

STEM Activities

1. Choose topics on alternative energy resources to research. Identify current uses for these forms of energy. Try to determine why these forms of energy are not used more extensively.
2. Invite a representative from a bus company to address your class on how the company sets up routes to transport people around town.
3. Analyze the desired and undesired results of using the automobile as a primary source of transportation.