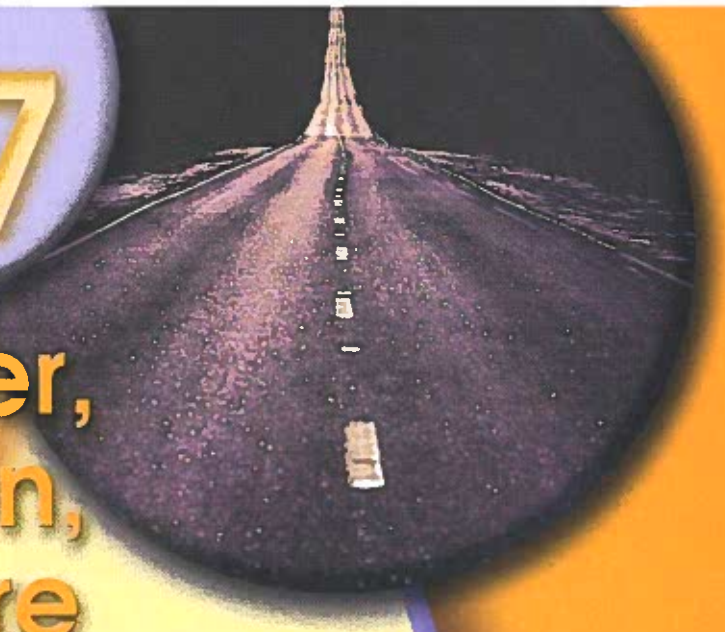
27

Energy, Power, Transportation, and the Future



Basic Concepts

- List future trends in energy technology.
- Name future advances in power technology.
- Identify future trends in transportation technology.

Intermediate Concepts

- Describe how space planes differ from airplanes and space shuttles.
- Explain how fuel cells operate.

Advanced Concepts

- Discuss nanotechnology.

If you ask your grandparents and great-grandparents about the technological changes they have seen in their lifetimes, you will hear many stories. Automobiles have gone from being a replacement for horse-drawn vehicles to becoming a major force in changing people's lifestyles. See **Figure 27-1.** Airplanes have made tremendous advances in design since the first flying machine. Not all that long ago, space travel was only for dreamers and science fiction writers. Houses that were heated by wood and coal are now heated by electricity and natural gas. The number of electronic devices used in homes and businesses would have been unimaginable. Today, we hardly give it a thought to warm food in the microwave or to surf the Internet on our computers or handheld devices.

When you consider that all this has occurred within the last 100 years, it seems incredible. There has been an explosion of innovative ideas that have helped to shape energy, power, and transportation technologies. New and improved transportation vehicles and energy systems continue to affect the way we live, work, and relax. What was new and exciting even 10 years ago seems commonplace now.

Figure 27-1. Evolution of the automobile. A—The Model T Ford was a "horseless carriage" with a body style that resembled a buggy or carriage. (Ford) B—Rugged sport-utility vehicles (SUVs) can function on highways or off-road, reflecting changing lifestyles. (Subaru)

A

B

Trends of the past will continue, and inventions will continue to come from creative people. Transportation technology will continue to evolve. Improvements will be made to existing systems. New systems will emerge.

The Future of Energy Technology

Today, the main energy sources used to heat and cool homes and businesses, generate electricity, and propel vehicles are primarily based on fossil fuels. Natural gas, coal, and oil are the three main energy sources. See **Figure 27-2.** These three, combined, account for two-thirds of the electricity generated and 99% of all transportation fuels. Unfortunately, these energy sources are nonrenewable and have major impacts on the environment.

Figure 27-2. Fossil fuels, such as this coal being stockpiled at a generating plant, remain the main energy source for industrial societies. Generating facilities that use coal are often located along waterways to allow low-cost transportation of fuel by barge. (Howard Bud Smith)

Current Trends in Energy Technology

Current projections show that the demand for and use of fossil fuels will continue to rise for at least the next 20 years. In the future, it will become necessary to find alternative energy sources. In order for alternative energy sources to compete with fossil fuels, the alternative sources must be affordable and easy to use. Many consumers are not ready to make drastic changes in their energy use or pay more for energy because they do not see the value in it. There are, however, several trends and initiatives in the use of renewable and inexhaustible energy sources that may have the potential to impact the current dependence on fossil fuels.

GREEN TECH
It is hoped that solar energy may one day help power transportation vehicles. There have been many ideas for different vehicles, such as a solar train that would use overhead solar panels for power.

Solar energy

Solar energy has been on the minds of energy researchers for several decades. Much research and many solar energy installations have been made across the nation. Solar energy, however, only makes up a very small portion of the energy used in the United States. The potential for solar energy to create a large impact is present, and new systems are being explored. In the future, it is very possible that solar energy will make up a large portion of the energy used to create electricity.

There are two main types of solar energy systems being heavily researched. Photovoltaic cells and active solar collectors are being studied, and technology is being created to make these systems more efficient and available at a lower cost. See **Figure 27-3.** There are also other solar applications that may see use in the future. The first is ***solar lighting***. Solar lighting systems use a collector, located on a rooftop, which sends light into the building through fiber-optic cables. These cables are used in conjunction with the lighting system inside the building. On sunny days, the fiber-optic cables can be used to supply all the light needed in the

Solar lighting: A system that uses a collector, located on a rooftop, which sends light into the building through fiber-optic cables.

Figure 27-3. Photovoltaic cells are seeing increasing use as an alternative energy source. This large array covers the roof of a solar cell manufacturing plant in the Netherlands. (Shell Energy)

building, cutting down on the building's use of electricity. Another solar system currently being discussed involves the use of solar collectors as satellites or placed on the moon. The collectors would be placed on the sunny side of the moon, gather solar energy, and then beam it down to earth in the form of microwaves. The microwaves would be collected by receivers on earth and converted into electricity.

Wind energy

Wind energy has been the largest growing energy source in the last 10 years. The Department of Energy's Wind Powering America program spurred much of the growth. This program ensures that wind energy will be a large contributor to the energy grid in the future. In the future, ***wind farms***, collections of wind turbines, will dot the American landscape and perhaps the oceans as well. See **Figure 27-4.**

Wind farm: A collection of wind turbines used to create electricity.

In order to generate electricity at a cost comparable to current methods, wind turbines must be designed to be highly efficient. The National Wind Technology Center is researching and developing new wind turbine technology. One of their main focuses is the development of low wind speed turbines. These will generate electricity at much lower wind speeds than the current wind turbines. By creating more electricity, the cost of each watt produced is decreased. In the future, these turbines may make wind energy a viable source of energy for large-scale power production.

Figure 27-4. Wind farms are increasingly important energy sources, especially in the American West. This large installation is located in Montana. Wind turbines not only help to create electricity, but they also have economic benefits. Farmers who allow wind turbines to be placed on their property receive royalty payments that help to subsidize their farming efforts. (Shell Wind Energy)

Ocean energy

The ocean is a largely untapped source of energy. There are several ways the ocean can be used to create energy, including harnessing the power of the tides and waves and using the temperature differences between surface waters and depth waters to generate electricity. These sources of energy are not being heavily researched in the United States, but they are being examined and developed in several European and Asian countries. As these countries further develop their technology, ocean energy will be used more extensively across the globe.

Bioenergy

Bioenergy, or biomass, is currently the most widely used renewable energy source. It is used to supply 3% of the U.S. energy demand. Biomass is also the most likely energy source to have the quickest impact in the future. It is energy generated by releasing the energy stored in organic materials. Biomass energy can be used for a number of purposes, including transportation fuel, electricity generation, industrial heat, and chemical

production. The materials used in creating biomass energy are currently centered on agricultural crops and industrial residues. See **Figure 27-5.**

One of the future developments of biomass energy will be the creation of biorefineries. Biorefineries will function similarly to petroleum refineries, except they will convert organic materials to fuels, chemicals, and other products, rather than oil. They have the potential to help alleviate the dependence on foreign oils, create jobs, and reinforce the U.S. economy.

Fossil fuels

While the renewable and inexhaustible energy sources will definitely be used in the future, fossil fuels are the main source of current energy. For this reason, technologies are being developed and will continue to be developed to lessen the impacts of fossil fuels on the environment and to improve the efficiency of fossil fuels. The Department of Energy's Office of Fossil Energy oversees much of the research. One development includes the design of a future zero-emission coal power plant. The plant, known as FutureGen, will create electricity and hydrogen gas from coal, without generating pollutants. New technologies will also be created in the future to effectively locate and obtain fossil fuels from the earth. Currently, much energy is wasted exploring and collecting fossil fuels.

Figure 27-5. Agricultural crops, such as corn and the soybean plants shown here, provide most of the biomass for energy generation and vehicle fuels. In the future, however, biomass energy will be generated using agriculture and forestry residues. Eventually, the biomass industry will grow special plants and grasses to be used in the generation of bioenergy. (U.S. Department of Agriculture)

Conserving Energy for the Future

New and exciting energy sources are on the horizon of the future. There are also, however, many things that we can do in the present to better utilize our current energy supply. In our everyday lives, we waste energy that we could conserve with several easy steps.

Our homes are large sources of wasted energy. The primary source of wasted home energy in most homes is air leaks. These leaks allow cold air into the home, which is known as ***infiltration***. Infiltration can be reduced by sealing cracks with caulk, foam, weather stripping, and other specialty products, such as gaskets for wall outlets. Another main source of heat loss in a home is ***conduction***, or the flow of heat through the walls as a result of poor insulation. Building codes of the future will require greater insulation (R) values to help conserve energy in homes. They are also beginning to require insulation in the bottom floor of a home, and some municipalities may even require infiltration tests to ensure that the houses are tightly built to conserve energy.

Infiltration: Cold air forcing its way into a home through cracks and other penetrations.

Conduction: The transfer of heat from molecule to molecule, straight through a material or group of materials.

Technology Link

Construction: R-Values for Common Building Materials

Every building material has an R-value relating to its ability to resist heat flow by conduction. The R-value has little to do with the thickness of a given construction material. Rather, the R-value reflects the material's ability to resist heat flow by conductivity so energy conservation can be planned and heating and cooling systems can be sized appropriately. The following products are commonly used in the construction industry to provide insulation, thus conserving energy:

- *Fiberglass insulation* is the most widely used product to prevent heat loss by conduction and infiltration. It is available as rolled batt insulation and as bagged clumps of loose-fill insulation. The standard 3 1/2" thick insulation is made to fit the stud cavity of a 2 × 4 exterior wall. The 5 1/2" thick insulation is designed for use with 2 × 6 exterior wall studs or in the attic or floor of a home. Loose-fill insulation is generally only used in the attic of a home. The vapor barrier is a layer attached to the face of most batt insulation and is designed to face the warm, moist air to block moisture from entering the stud cavity.
- *Rigid foam board insulation* is made of phenolic foam and offers a better R-value per thickness than fiberglass insulation (up to R-10 per inch, or an equivalent of about 3" of fiberglass insulation). It has such a good R-value that it is often used as a replacement for plywood or flake board sheathing under finished siding. Other applications include insulating the foundation of homes.
- *Blown-in batt insulation* is sometimes used to fill stud cavities of new homes. This insulation is literally sprayed into the stud cavities and smoothed down with a striker before drying in place. It offers a better R-value than fiberglass insulation. Blown-in batt insulation is, however, usually more expensive than fiberglass insulation.
- *Foam bead insulation* is sometimes used to retrofit older homes that did not have insulation installed when they were constructed. It can be pumped into the stud cavities high in the walls and allowed to settle into the cavity. This process is one of the only cost-effective means of adding some insulation without major expenditures to renovate the exterior or interior of a home.

Home lighting uses a large amount of energy that could be saved using energy conservation techniques. Most homes use incandescent lighting. These lights are typically inexpensive lightbulbs. They are much less efficient, however, than fluorescent lightbulbs. Fluorescent lightbulbs often cost 25 times more than incandescent lights, but they use 75% less energy and can last several years longer. The Department of Energy (DOE) suggests that, by replacing 25% of the incandescent lights in high-use areas of your home with fluorescent lightbulbs, you can save 50% of the energy that would have been used.

Transportation vehicles also use a great amount of energy. Typically, as the size of a vehicle becomes larger, the more fuel it uses. A large sport-utility vehicle (SUV) uses more fuel per gallon than a small sedan does. Often, families buy larger vehicles than they really need and, therefore,

When considering the appropriate R-values for construction or renovation, it is important to conform to all applicable state and local building codes. Recommended R-value for walls, ceilings, and floors in different parts of the country vary widely based on weather patterns and geography. **Figure 27-A** shows a sampling of R-values for typical building materials.

Figure 27-A. This chart shows the insulation values of common construction materials.

Material	R-Value
1/8″ vinyl floor	0.05
15-lb. building paper	0.06
1″ concrete, sand, and gravel masonry	0.08
Tile or slate	0.08
1/4″ mineral fiber	0.21
4″ concrete or stone	0.32
Vinyl siding	0.33
1/2″ plasterboard	0.50
1/2″ sheathing board (flake board)	0.50
1/2″ wood siding	0.50
1″ maple, oak, and other hardwoods	0.91
3/4″ plywood, softwood	0.93
3/4″ wood bevel siding	1.05

Material	R-Value
4″ lightweight aggregate concrete blocks	1.50
8″ concrete blocks	1.60
Carpet and fibrous pad	2.08
1″ cellular or foam glass	2.50
1 3/4″ wood door with storm door	3.12
1/2″ sheathing board (insulation board)	3.60–5.00
3 1/2″ fir, pine, and other softwoods	4.35
1″ expanded polyurethane insulation	7.00
3 1/2″ fiberglass insulation	11.00–13.00
4″ mineral batt insulation	14.00
5 1/2″ fiberglass insulation	19.00–23.00

waste energy. There are, however, ways to conserve energy with all vehicles. Keeping vehicles in good working order is one of the best ways to conserve energy. When the tires are properly inflated and the air filter is clean, the vehicle will use less energy than when the tires are low and the filter is clogged. Lastly, carpooling and decreasing the amount of short trips in automobiles can also conserve energy.

The Future of Power Technology

The future of power is centered on greater efficiency. Improved batteries and new propulsion technologies are also possible in the near future. We will look at these possibilities in the following sections.

Efficiency

Over the years, the use of energy to power products and devices has become more efficient, due to technological advances. For example, if you examine an early computer, it is easy to see that the large machine required much more electricity to do much less work than a modern computer. This is even the case in transportation. Advances in wheels, axles, bearings, aerodynamics, and a host of other aspects have made vehicles easier to move, if you compare vehicles by their weight. This trend will continue, largely due to advancements in materials science and computer control.

Materials science

Advances in materials science will allow devices, homes, buildings, and other products to require less energy for power. For example, as future materials are designed for lighting, lights will shine brighter and use less power. A compact fluorescent bulb requires two-thirds less electricity to produce the same amount of light as a standard incandescent screw-in lightbulb. Additionally, a compact fluorescent bulb will last six to ten times longer than a regular lightbulb. The same increasing efficiency is true of insulation materials. As materials are created to serve as better insulators of buildings, the buildings will require less energy to power the heating and cooling systems. Through persistent research, fiberglass insulation measuring 3.5" in thickness now provides an R-value of 13. Only a few years ago, fiberglass insulation of the same thickness offered an R-value of only 11, and 20 years prior to that, it offered an R-value of only 9. In transportation, materials science often concentrates on lowering the weight of the materials. Generally, the less the vehicles weigh, the less power is required.

Career Connection

Science Technicians

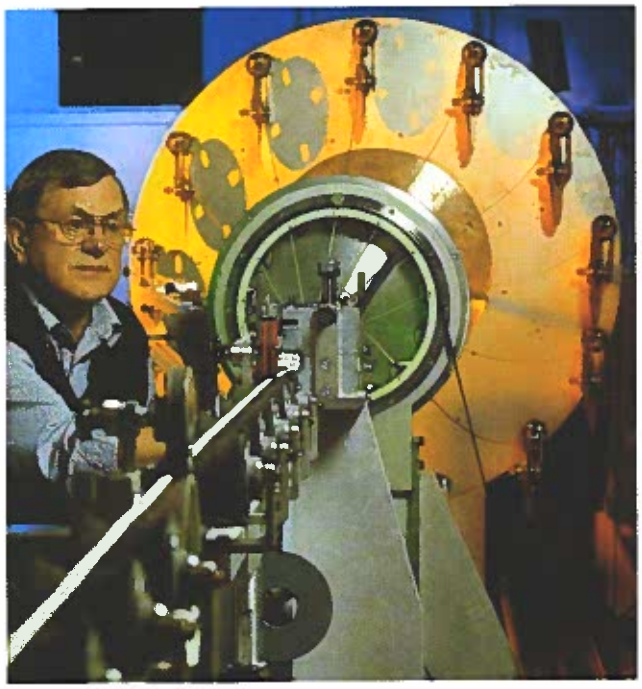
Science, Technology, Engineering & Mathematics

The future of energy, power, and transportation is heavily linked with science. New advances in technology often have scientific components. A key role in the many science industries is the science technician. Science technicians normally work in either research or production roles in various industries. Agriculture, materials science, nuclear technology, biotechnology, oil and gas extraction, and metallurgy are all industries that will be important in the future of energy, power, and transportation and that employ science technicians.

Science technicians work under a scientist and prepare and conduct experiments, monitor conditions, and calculate results. Technicians must be very detailed and keep good logs of their work. Most technicians work in highly computerized labs that require a working knowledge of specific computer software. Knowledge of mathematics, good language skills, problem-solving abilities, and scientific knowledge relevant to the industry they work in are required. Technicians typically have high school diplomas and associate degrees in science or technology. They may also have certification in a specific area of science. The average salary of a science technician ranges from around $15 to $32 per hour, depending on the specific industry.

These advances will also allow electrical devices to be designed in ways that require less power. See **Figure 27-6.** In the future, nanotechnology will be used to create devices that are more powerful, but use much less electricity. ***Nanotechnology*** is the design of products and devices at a molecular level. For example, a nanosized computer processor chip would be smaller than a grain of sand and thousands of times more powerful than today's supercomputer processors. Such a chip would also require less power because the material is less resistant to the flow of electricity than the silicon used in current processor chips.

Figure 27-6. Improved technology is allowing electrical devices and systems to become smaller and more efficient. This scientist is observing production of superconducting ceramic ribbon that can carry 50 times more electrical current than a copper conductor of the same diameter. (Siemens)



Nanotechnology: The design of products and devices at a molecular level.

Computer control

Computer control will also affect the use of power in a very positive manner. Computers and automated networks will be used more heavily in the future to monitor and control power systems. Networks will send power to areas that need it, without wasting power in other areas of the network. This type of control will be used in all areas of technology. For example, nuclear power plants will be controlled by computers. See **Figure 27-7.** This type of computer control is already available in automobile traction control systems. Automated networks will be developed in more depth and used in many other areas in the future.

Batteries

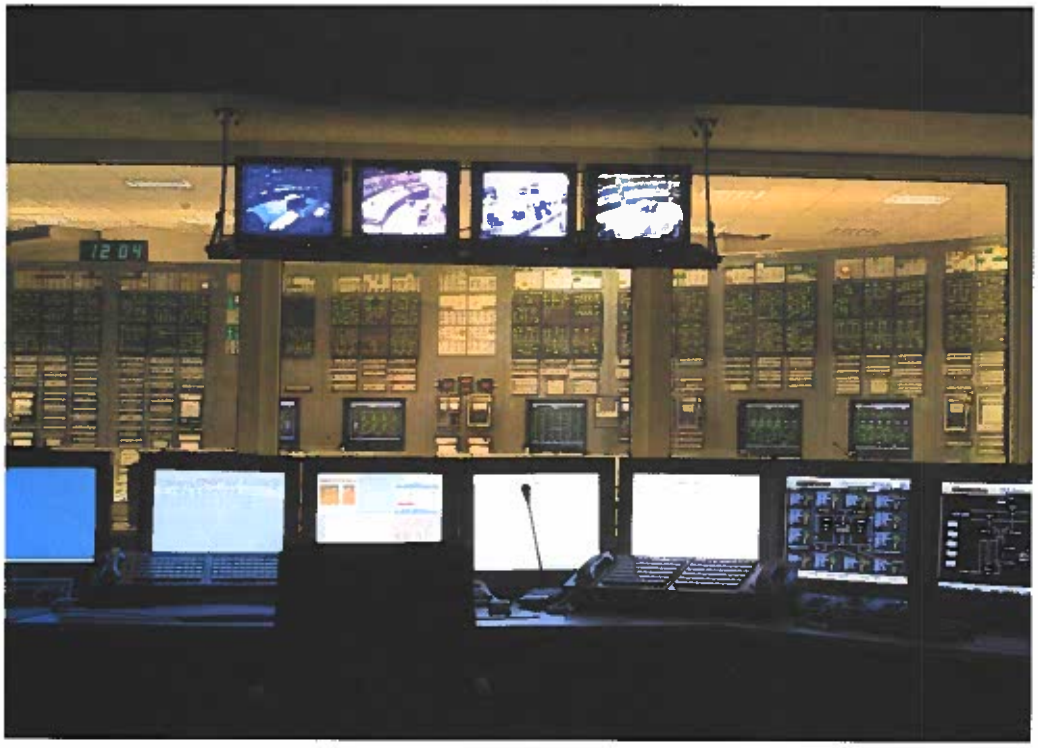
Batteries have been a part of life since the late eighteenth century, when Alessandro Volta produced a current from zinc and silver plates. Today, they are used to power everything from household products and cellular telephones to medical devices and transportation vehicles. See **Figure 27-8.** Currently, lithium-ion batteries are the most advanced batteries. In the future, however, it is expected that several new technologies will take over the battery market.

Paper batteries

One new technology is the paper battery. ***Paper batteries*** are ultrathin dry batteries. The batteries function like larger dry batteries, but they can be printed on a number of different products, including paper products. Since the paper batteries are dry batteries, they do not contain harmful chemicals. Imagine flyers and bulletin boards that can light up or play recorded messages. This may not be far off, with paper battery technology. These ideas, however, are just the beginning of the impacts of this technology. In the future, it may be possible to power laptops or cell phones using these thin paper batteries.

Paper battery: An ultrathin dry battery that functions like larger dry batteries, but can be printed on a number of different products, including paper products.

Figure 27-7. Computer systems at a nuclear power plant.



Fuel cells

Another technology that will surely change the face of batteries is the fuel cell. Fuel cells are typically discussed in regards to automobiles. There are a number of future uses, however, large and small, for fuel cells. Fuel cells, like batteries, produce electricity through a chemical reaction. The

Figure 27-8. Batteries are a vital power source for many devices in our lives. In the future, this will be no different. Batteries will be used more than ever. A—Dry cell batteries provide portable power for devices ranging from large flashlights to small personal music devices. B—The starting system of automobiles and other transportation vehicles depends on the 12-volt lead-acid battery that can be discharged and recharged many times. (Exide)

A

B

reaction, however, is quite different. Fuel cells operate by passing hydrogen atoms through a catalyst. The catalyst frees the electrons from the hydrogen. The remainder of the hydrogen atom passes through a membrane to the positive side of the cell. The electrons, however, must pass through an electrical circuit to reach the positive side. This creates electricity.

Fuel cells, unlike batteries, never lose their power. As long as fuel cells have a supply of hydrogen, they will produce electricity. Supplying the hydrogen is the biggest challenge today and in the future. The fuel cells work best and create no pollution when pure hydrogen is used. Pure hydrogen is hard to store, however, and there is not a network of hydrogen stations like there are gasoline stations. Fuel cells can also be designed to operate on fuels rich in hydrogen, such as natural gas and methane. See **Figure 27-9.**

Once issues of size, cost, and availability are worked out, fuel cells may be a substantial source of power. Fuel cells can be used to power everything from handheld devices to automobiles to homes. Many people believe that, in the future, fuel cells may be used as neighborhood power plants to supplement the power received by larger power stations.

GREEN TECH
In order to benefit from hydrogen fuel cells, vehicles will have to be equipped with at least two pieces of equipment that are not currently standard. One is a hydrogen storage tank, and the other is a fuel cell stack, which would convert the hydrogen to electricity.

Figure 27-9. Mass transit vehicles and automobiles using efficient and pollution-free fuel cells are achieving growing popularity. Iceland's public transportation system operates fuel cell buses, such as the one shown here refueling its hydrogen supply at a service station. In this type of system, a reformer is used to convert the fuels to hydrogen prior to entry into the fuel cell. This kind of system is currently more practical than one that uses pure hydrogen, but it increases the size, complexity, and cost of the fuel cell system. As fuel cell use grows, more and more hydrogen refueling stations will be available. (Shell Energy)

Propulsion Technologies

Providing power for transportation vehicles is one of the largest uses of energy. There will be several technologies in the future that will help to decrease the use of transportation energy. Hybrid vehicles will decrease the use of fossil fuels to generate power. They use both electric motors and gasoline engines to power vehicles. See **Figure 27-10.** Fuel cells will also transform the power used to propel vehicles. In fuel cell cars, the electricity the cells generate will power the electric motors that propel the vehicle.

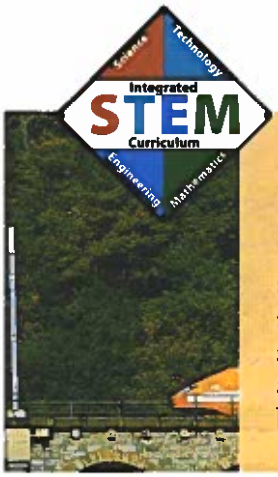
The power used in space vehicles will also be much different in the future. Space vehicles are limited to the amount of power they can carry onboard because of size and weight restrictions. In the future, space vehicles may use a technology to propel the spacecraft that does not require onboard power. ***Solar sails*** may be this future technology. They are large sails that operate on the principle that light exerts a small force on the objects it touches. The solar sails would be used to collect light energy. The more light they collect, the greater the "push" they receive. It is believed that space vehicles using solar sails may be able to generate a great amount of speed and would be able to reach distant planets much faster than by current methods. Solar sails may also be beneficial because the power used to move the vehicle would be free and readily available.

Solar sail: A large sail that operates on the principle that light exerts a small force on the objects it touches. It will be used to collect light energy to propel spacecraft.

Figure 27-10. Hybrid vehicles, such as the one shown in this ghost view, are powered by both a gasoline engine and electric motors. Depending on the driving situation, the vehicle automatically switches from the gasoline engine to electric motors to a combination of the two. This can cut down on the amount of gasoline the vehicle uses by up to 50%. (Ford Motor Company)

The Future of Transportation Technology

Transportation systems have been evolving and changing since early humans made sleds and rafts. In the future, transportation technology will advance in ways that will make the vehicles of today seem as primitive as those early sleds and rafts. There will be advances in each environment of transportation, as well as trends in all vehicles.



STEM Connection

Technology: Futuristic Large-Scale Power Generation

One futuristic application of solar energy envisions a huge solar collector assembled in space that could receive sunlight almost 24 hours a day. The sunlight would also be much stronger than what we receive on earth, since it would not have to penetrate earth's atmosphere. The energy would then be sent by microwave to an antenna located on earth. The antenna could require a five-mile diameter area. The microwaves would then be converted back to electricity.

Curricular Connection

Language Arts: Understanding Technical Terms

Technical terms are identified in each chapter of this textbook. These terms are new vocabulary specific to the subject being studied. It is important to determine and understand the exact meaning of each technical term. Various tools may be used to decipher each term's definition.

Glossaries or dictionaries are great resources to help determine a word's definition. In addition, some terms have multiple meanings. The content surrounding each term in this text will often help to discern the word's meaning. For instance, the term "bearing" has two different meanings in this textbook, first to describe a mechanical part and then again in reference to desired direction of travel. Context clues and dictionary entries help distinguish the correct use of the word.

Once you fully understand the meaning of a word, you are able to use it properly in speaking and writing. To be successful in the workplace, you must be able to speak, write, and understand the specific terminology of the industry.

Trends in Transportation

There are several future trends that will guide the development of technology in all transportation environments. Most vehicle operators and passengers are concerned with several aspects of their vehicles. First, they want their vehicles to be safe for all passengers. Accidents do occur in all environments and modes of transportation, and passengers want to know that their vehicles are as safe as possible. Second, operators are concerned with fuel efficiency. When gas prices rise, efficiency becomes even more important because driving a vehicle with low fuel efficiency means a greater amount of money is spent at the gas pump. These two trends, safety and efficiency, will guide the development of technology in all transportation environments.

Safety

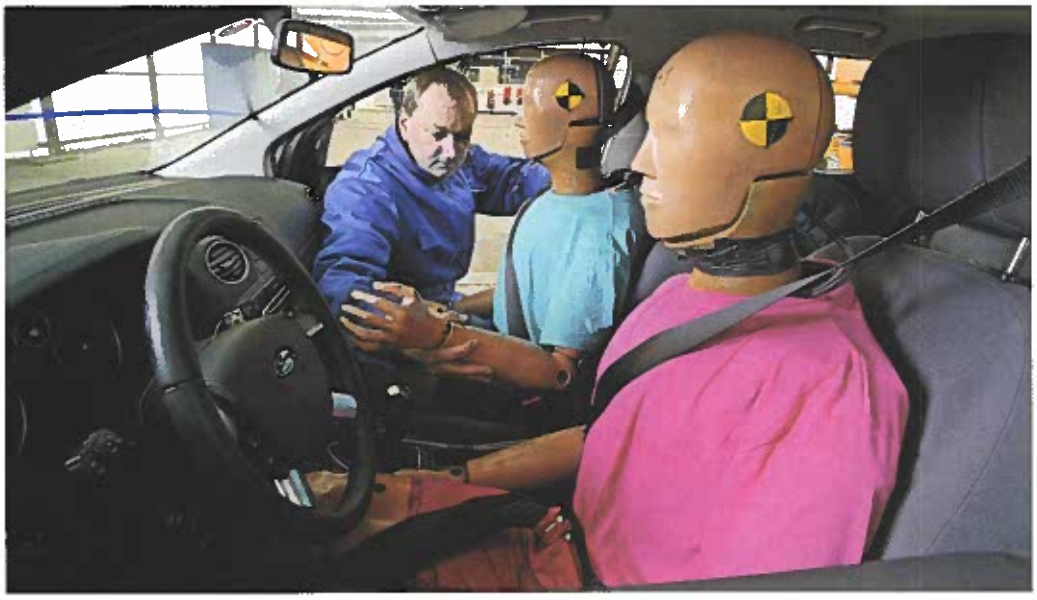
Safety is naturally an important factor for the traveling consumer. It is stressed in commercial transportation. The travel industry wants passengers to return to use its services. Vehicles in the future will be designed to better handle accidents. In transportation, this is known as ***crashworthiness***. When vehicles are crashworthy, it is believed that they can handle and provide safety during an accident. Private vehicle owners also know the need for safe transportation. Changes are being made so travel will be safer for the private car owner. In the future, safety will be better tested using more sensitive crash test dummies. See **Figure 27-11.**

Crashworthiness: The ability to handle and provide safety during an accident.

Efficiency

We also need to increase energy efficiency in transportation. This will conserve the earth's limited supply of fossil fuels. There is a need to reduce our dependence on these precious, limited resources. Vehicle

Figure 27-11. Crash test dummies simulate the effects of vehicle impacts on human drivers and passengers. Dummies in the future will be better designed to react like humans would in crashes. In this photo, a technician is preparing dummies for a crash test. (Ford Motor Company)



designers will continue to experiment with new types of energy-efficient propulsion systems. Though still using petroleum fuels, new engines are more efficient than those just a few years ago. Many vehicles are built much larger, however, than they were in the past. When the more efficient engines have to propel larger vehicles, the benefits are lost. A change in the outlook of drivers is also needed. Fuel economy must be a priority for those buying new vehicles, in order for major changes to take place.

Future Land Transportation

The U.S. Department of Transportation has created a division that examines and studies how to improve vehicles for the future. This program, known as the Intelligent Vehicle Initiative, has the goal of improving the safety of all highway vehicles in all types of driving conditions. Its main objectives are improving vehicle warning systems so accidents can be avoided, enhancing the vision of drivers using technology, and creating more stable vehicles that are safer to drive and can better withstand accidents. See **Figure 27-12.** Technologies that enhance these areas will be present in the highway vehicles of the future.

The Department of Transportation is also concerned with the highway infrastructure of the future. The highway ***infrastructure*** is the roadways, bridges, ramps, and other structures that make up the highway and

Infrastructure: The roadways, bridges, ramps, and other structures that make up the highway and roadway system.

Figure 27-12. "Heads-up" vehicle information systems, similar to those used on military fighter aircraft, are being developed for use in automobiles. The systems display vehicle speed, vehicle condition, and navigation as a projected image in the driver's line of sight, eliminating the need for the driver to take her eyes off the road to check instruments on the dashboard. Global positioning systems (GPSs) to aid in vehicle navigation are being offered as original equipment on some production models. Key information from the GPS display, to the right of the steering wheel, will be included in the "heads-up" display. (Siemens)

roadway system. In the future, the infrastructure will be designed to take advantage of new communication, data processing, navigation, and computer technologies. One example of future infrastructure is the creation of a smart road. ***Smart roads*** will communicate with vehicles and help to control the speed, braking, and steering of the vehicles. This will help to minimize the congestion and accidents on highways. The design and construction of smart roads will require automobile and truck manufacturers and road builders to work together to design a feasible system for the vehicle and roadway.

Smart road: A component of future highway infrastructure that will communicate with vehicles and help to control the speed, braking, and steering of the vehicles.

Small Aircraft Transportation System (SATS): An organization formed by the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) to research a solution to the overcrowding of major airports.

Future Water Transportation

Water transportation currently carries roughly 95% of the freight the United States imports and exports. The volume of this freight is expected to triple in the next 20 years. The infrastructure of water transportation facilities is not equipped to handle the increased traffic. Many of the facilities must be improved to handle increased traffic. This will include dredging current channels and creating more channels to harbors. Locks and canals must be modernized and improved to handle new ships. See **Figure 27-13.** Ships and terminals will have to use a greater amount of computer technology to enhance the efficiency of docking, loading, and unloading. The unloading of freight will also become more computerized. Containers will use digital devices to communicate with robotic machines, in order to be properly unloaded and placed in storage or on intermodal vehicles for further transport.

The vessels used in water transportation will also change in the future. One future change will be in the propulsion of water vessels. Many believe that fuel cells being developed in space and land transportation may also serve a purpose in water transportation. Another possibility in the future of water vessels is the creation of floating cities. For years, designers have been creating plans of large ships that could serve as entire cities.

Figure 27-13. Locks on the Panama Canal and many other waterways must be expanded in the near future to permit use by the larger and more efficient ships now being launched.

Future Air Transportation

The future of air transportation, like other forms of transportation, looks to be crowded. Many airports are currently faced with overcrowding and long delays. An organization formed by the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) is researching a potential future solution to this problem, called the ***Small Aircraft Transportation System (SATS)***. SATS's solution to the overcrowding of major airports is to better utilize smaller regional and rural airports. One of the main ideas in this initiative is to create a system of air taxis. The air taxis will be smaller general aviation aircraft, as well as business jets. Along with air taxis, SATS is also examining ways to make flying easier and more accessible to

people. New technologies are being developed and will continue to develop in the future that may potentially make flying a plane as easy as driving a car. These technologies will monitor and track the current position of the aircraft and also the position of nearby aircraft. This information will be displayed on a screen in the digital cockpit. See **Figure 27-14.**

In the future, it may be common to build airports on islands in the sea. These large airports will serve as hubs for international flights. The island airports will allow airlines to use larger aircraft because the noise created would not affect people living near the airport. Since it will be many years until offshore airports are designed, built, and used, several airplane manufacturers are currently trying to design new aircraft that are faster and create much less noise. A current problem in air transportation is, when an airplane breaks the sound barrier, it creates a sonic boom that can be heard on land. If commercial airliners all created this sonic boom every time they passed Mach 1, it would be highly distracting, if not deafening, to people near the airports. Being able to fly at speeds of over Mach 1 would be extremely beneficial for commercial airline companies, however, because they could transport people to their destinations faster. See **Figure 27-15.**

Figure 27-14. Digital displays have replaced many analog gauges and displays in the cockpits of both commercial airliners and smaller aircraft. This is the pilot-side instrument panel on a medium-range jet airliner. (Airbus)

Figure 27-15. Although no supersonic airliners remain in service today, the concept remains attractive because of the ability to move passengers more rapidly between distant locations. This is a concept drawing of a supersonic transport (SST). No major aircraft manufacturer, however, is currently developing such an airplane. (The Boeing Company)

Future Space Transportation

The largest wave of the future of space transportation is space tourism. Space tourism is the ability for anyone to travel to space and experience what it is like to be outside the earth's atmosphere. In order for space tourism to be functional, new vehicles must be designed, built, and tested. These new vehicles—several are currently under development—are a combination of airplanes and space shuttles. The idea behind the ***space planes*** is that they will be reusable and more cost-efficient than space shuttles. See **Figure 27-16.** The first step in the development of space tourism is for the space planes to safely take passengers to suborbital heights. Suborbital flight occurs above 62 miles from the earth, but at speeds not fast enough to enter orbit. These flights will allow passengers to view the earth from above the atmosphere for a short period of time.

Space plane: A combination of an airplane and a space shuttle that will be reusable and more cost-efficient than space shuttles.

Another method of reaching space is also being examined. NASA and other space organizations have studied the idea of a space elevator. A ***space elevator*** will, in essence, be a long cablelike structure extending from the earth to space. Elevator cars will be attached to the cable and used to transport people to and from space.

Space elevator: A long cablelike structure with cars attached, extending from the earth to space, that could be used to transport people to and from space.

Figure 27-16. Space planes are reusable passenger and cargo vehicles that will be more cost efficient to produce and operate than the National Aeronautics and Space Administration (NASA) space shuttle. *SpaceShipOne*, shown landing in California after a recent test flight, is a privately developed space plane that has successfully flown beyond earth's atmosphere. (Scaled Composites)

Summary

The future of energy, power, and transportation promises to bring exciting changes. There will be changes and improvements to existing systems and totally new, innovative designs. Advances in energy technology will provide viable alternatives to the use of fossil fuels as the main source of energy. Biomass, hydrogen, solar, and wind energies seem to be the most promising energy sources in the future. The future of power systems will be based around increased efficiency, new batteries, and advanced propulsion systems. Fuel cells will surely be one of the largest innovations in power technology. The future of transportation will see improvement in vehicles and infrastructure in all transportation environments. The safety, efficiency, and speed of transportation are sure to increase in the future. Consider all the advancements we have made in the last 100 years. Imagine what you will see in your lifetime!

Key Words

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

conduction
crashworthiness
infiltration
infrastructure
nanotechnology
paper battery
Small Aircraft Transportation System (SATS)
smart road
solar lighting
solar sail
space elevator
space plane
wind farm

Test Your Knowledge

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

1. Today, energy for heating, cooling, electricity, and propulsion are generated using _____, _____, and _____.
2. Give examples of two possible future solar energy technologies.
3. Discuss the purpose behind the design of low wind speed turbines.
4. State three uses for biomass energy.
5. Summarize how materials science will affect power technology.
6. Explain nanotechnology.
7. Computers will be used to _____ and _____ power systems.
8. Identify two possible future advances in batteries.
9. Supplying the _____ is the largest challenge in fuel cell technology.

10. Explain how solar sails are powered.
11. _____ and _____ are two trends that affect all transportation systems.
12. Write the goal of the Intelligent Vehicle Initiative.
13. _____, _____, and _____ are examples of highway infrastructure.
14. Describe one possible future change in water transportation.
15. Discuss the concept of a digital cockpit.
16. Airports in the future may be built in the _____.
17. Space _____ will be the largest focus in future space transportation.
18. Identify how space planes are different from airplanes and space shuttles.
19. Summarize the differences between suborbital and orbital flights.

STEM Activities

1. Research information on a future energy, power, or transportation technology. Prepare a written report of the results of your research.
2. Imagine what transportation might be like in the year 2050 and write a scenario about traveling from one city to another 250 miles away.
3. Design a model of a future vehicle and prepare sketches of it.
4. Choose a topic or technology in energy, power, or transportation and conduct research that will allow you to create a forecast about the use of that technology in 50 years. Report your findings.