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Energy, Power, Transportation, and the Environment

Basic Concepts

- State the various aspects of the environment that pollution from the energy, power, and transportation industries most commonly affects.
- List ways in which producing power has been harmful to the environment.
- Name ways in which present-day methods of transportation are harmful to the environment.
- Identify ways in which obtaining energy resources has been harmful to the environment.

Intermediate Concepts

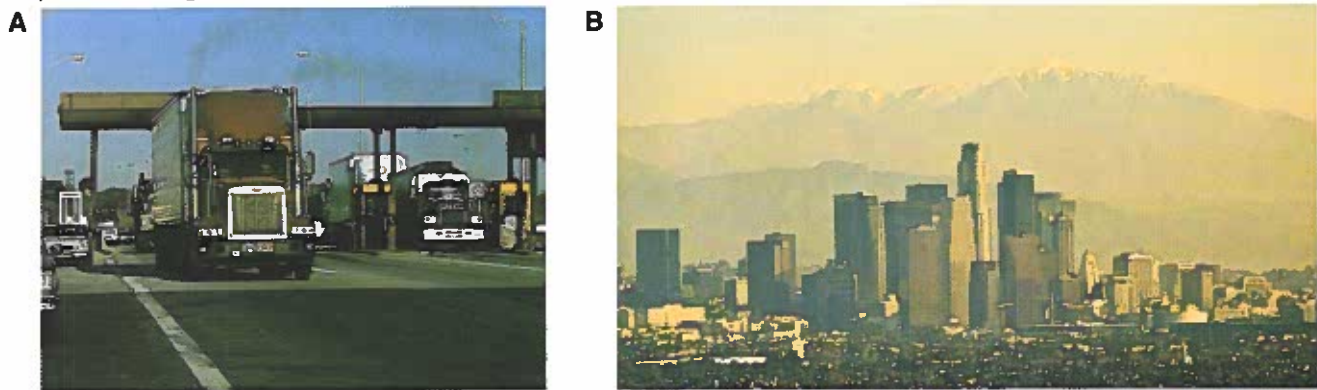
- Discuss the steps that have been taken to minimize environmental impacts associated with the transportation of goods and people.
- Describe the steps that have been taken to minimize the environmental impacts of harvesting and refining energy for use.
- Give examples of the steps that have been taken to minimize environmental impacts associated with the generation of large-scale power.

Advanced Concepts

- Explain one major piece of legislation associated with environmental protection.
- Summarize advanced and futuristic concepts associated with environmental protection emerging from the energy, power, and transportation industries.

There is an ever-growing concern that activities such as large-scale power generation and the transportation of goods and people are having a profoundly adverse effect on our global environment. See **Figure 26-1**. At the local level, energy, power, and transportation technologies can have effects such as producing smog and haze, reducing the quality of

Figure 26-1. The very conveniences that make our lives easier and improve our standard of living are also harmful to the environment. A—Vehicle exhausts from cars and trucks are a major source of pollutants. B—Although air quality has been improved in recent years, many major cities still experience high levels of pollution at times.



breathing air, and polluting lakes and streams. At the global level, there is concern that the rapid consumption of so many fossil fuels over such a short period of time is resulting in worldwide climate change.

Environmental Pollution

Contaminants in the air, water, and land cause environmental pollution. *Air pollution* is the action of contaminating the mixture of gases surrounding the earth, especially with human-made waste. The greatest source of air pollution is a direct result of the burning of fossil fuels. Fuels are consumed to produce electricity, for industrial processes, and to power internal combustion engines. See **Figure 26-2**.

Air pollution: The action of contaminating the mixture of gases surrounding the earth, especially with human-made waste.

GREEN TECH

In order to help battle the air pollution in California, the state not only requires emissions testing, but smog testing as well.

Figure 26-2. Air pollution can occur through natural phenomena or human activity. Fossil fuel consumption for transportation and power generation is responsible for many pollutants.

Pollutant	Natural Source	Human Source
Carbon dioxide	Decay from oceans	Wood and fossil fuel combustion
Nitrogen oxides	Lightning, bacteria in soil	High-temperature combustion
Sulfur dioxide	Decay, volcanic eruptions	Coal and oil combustion, smelting of ores
Ozone	Produced in the troposphere	Smog from auto and industrial emissions
*Particulate matter	Forest fires, volcanic eruptions, wind erosion	Waste building, road building, mining
Methane	Termites, anaerobic decay, animal waste	Combustion, natural gas leaks
Ammonia	Anaerobic decay	Sewage treatment plants

*Not a specific chemical substance, but still classified as a pollutant

Air Pollution

Air pollution is known to have certain effects on the body. See **Figure 26-3**. As Americans began to recognize and acknowledge the significant air quality problems associated with the modernization of our nation, it became evident that steps must be taken to protect the environment. One of the most significant steps taken was the Air Pollution Control Act of 1955.

Prior to the mid-1950s, air pollution and air quality issues were the responsibility of state and local governments. In 1955, the first federal legislation controlling air pollution was passed. It was known as the Air Pollution Control Act. Congress passed the *Clean Air Act (CAA)* in 1963. This act set emissions standards for certain sources of pollution. Subsequent amendments to the legislation strengthened the federal role in preserving air quality. The most significant of these amendments are associated with the CAA amendments of 1990. This series of amendments included provisions for an acid rain control program, funding for state-run permit programs for the operation of many sources of air pollutants, and even funding for the retraining of displaced workers who lost their jobs as a direct result of implementation of the CAA amendments. Changes implemented in 1990 include the following:

- More stringent automobile emissions standards.
- Reformulated gasoline and alternative fuels for some of the most populated areas of the country.
- A phaseout schedule for many of the most ozone-depleting chemicals.
- The establishment of National Ambient Air Quality Standards for various types of air pollutants.
- The strengthening of the Environmental Protection Agency (EPA)'s role in oversight and authority to assess penalties for noncompliance.

Clean Air Act (CAA): The Act Congress passed in 1963 that set emissions standards for certain sources of pollution.

Figure 26-3. Sources of various pollutants and their effects on human health. Other effects are suspected as well.

Pollutant	Source	Effects
Carbon monoxide	Automobile emissions	High concentrations can cause death, low concentrations impair judgment
Lead	Smelting and manufacturing processes	Lead poisoning—impaired mental ability in younger children
Nitrogen oxides	Fossil fuel consumption	Smog, acid rain, respiratory and eye irritation
Ozone	Photochemical reactions with by-products of combustion	Respiratory irritation, reduced lung function
Particulate matter	Smoke, dust, automobile emissions, industrial processes	Breathing difficulties
Sulfur oxides	Industrial processes involving combustion	Smog, upper respiratory disease
Toxic air pollutants	Asbestos, arsenic, benzene, chemical and industrial processes	Lung disease, cancer

Nonattainment: A classification of an area in which the Environmental Protection Agency (EPA)'s minimum air quality guidelines are not met.

Water pollution: The action of contaminating the liquid that descends from the clouds as rain, especially with human-made waste.

Suspended particle: A particle in water that absorbs light and makes water cloudy.

The EPA has the authority to establish minimum air quality guidelines. It is the state, however, that implements plans to meet the air quality guidelines. Each state has to submit a state implementation plan to the EPA to ensure guidelines are being met. Those guidelines not met are referred to as *nonattainment* areas. Nonattainment areas are classified as marginal, moderate, serious, severe, or extreme. A plan is then submitted to the EPA, along with a timeline to bring the air quality for a particular pollutant into compliance. In the case of severe or extreme air pollution, a timeline of up to 20 years may be necessary to improve air quality to the guidelines established in 1990.

Water Pollution

Water pollution is the action of contaminating the liquid that descends from the clouds as rain, especially with human-made waste. It can affect ponds, streams, rivers, and even oceans. There are natural impurities and human activities that pollute water supplies. Naturally occurring particles that appear in water are not always pollutants. They are typically divided into three categories of particles. *Suspended particles* absorb light and make water cloudy. Colloidal particles require special filtration to be removed from water. Dissolved matter, including molecules and ions of various substances, is the tiniest of all particles. Human activities are often

Career Connection

Safety Professionals

The roles of safety professionals vary with the company or organization with whom they are employed. Safety professionals are prepared to identify hazards in the workplace and to implement ways to minimize those hazards. Some industries require highly specific safety expertise. Most trained safety professionals are well prepared to recognize hazards, conduct safety inspections and audits, implement fire protection plans, and ensure regulatory compliance with agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). They also manage hazardous materials, improve the workplace through an understanding of ergonomics (the physiological and psychological limitations of the body), ensure environmental protection, and provide safety training to employees. Safety professionals are often responsible for conducting accident investigations, advising management by helping to establish safety objectives, maintaining an accurate record keeping system for safety-related data, and implementing and managing a comprehensive safety program.

The largest percentage of safety professionals are employed in the manufacturing and production sector of the economy. Many safety professionals are employed in the insurance industry, for governmental agencies such as OSHA or the EPA, or as independent consultants. The minimum educational requirement for a safety professional is a bachelor's degree in a safety-related field. Most safety professionals earn a Certified Safety Professional (CSP) designation by passing a professional exam administered by the Board of CSPs. Salaries for safety professionals range from about \$30,000 for a safety inspector to over \$180,000 for an experienced manager of a comprehensive safety program in a large industry. The average starting salary for an entry-level safety professional is approximately \$48,000.



the cause of localized water pollution. For instance, industrial spills, agricultural runoff, or untreated sewage runoff can contaminate rivers. Even oceans can be subjected to large-scale pollution, due to garbage dumping and oil spills. Oceans rich in animal and plant life cover more than 70% of the earth. Protecting the earth from water pollution is essential to the long-term survival of the human species. Water is also essential to maintaining our quality of life. It takes an estimated 400 gallons of water to produce 1 gallon of gasoline. 50,000 gallons of water are needed to produce an automobile.

There are certain water pollutants specifically associated with the power generation and transportation industries. These pollutants are oils, hydrocarbons, and lead. See **Figure 26-4**. Another water pollution problem that is a direct result of burning fossil fuels is acid rain.

Acid rain forms when water vapor and certain elements combine chemically with natural and human-made pollutants in the stratosphere. Emissions, such as sulfur dioxide and nitrogen oxide, combine with water vapor in the air to form sulfuric and nitric acids. When this mixture combines with rain and falls back to earth, it can contaminate lakes, rivers, and streams. Acid rain can make these bodies of water more acidic than they would be naturally. The subsequent effects can be detrimental to plant and animal life. Acid rain is also known to leach natural aluminum from the soil. This aluminum is extremely toxic to many organisms, such as plants that exist in the water.

It is estimated that *natural pollutants*, such as acid rain and smog created as the result of wildfires caused by lightning strikes, account for only about 10% of all the acid rain on the planet. The remaining 90% is estimated to be occurring as a result of the combustion of fossil fuels. This problem was first noticed around the beginning of the Industrial Revolution in the late eighteenth century. At that time, fish kills in ponds located close to industrial plants were reported. A *fish kill* results in the death of a large number of fish, due to a rapid change in the characteristics of their environment. The change could be a severe temperature change in a short period of time or a severe change in the toxicity of the water. The solution of the Industrial Revolution era was to build taller smokestacks so the waste would be dispersed over a larger area.

The *pH* of a solution is a measure of its acidity. The pH scale consists of a range from 0 to 14. A 7 on the pH scale represents a perfectly neutral solution. *Acidic solutions* have a pH rating of less than 7. A rating above 7

GREEN TECH

The Deepwater Horizon oil spill in 2010 caused damage to the environment and animal life in the Gulf of Mexico. It took three months to stop the oil leak, after which oil was still found in the surrounding area.

Natural pollutant: Something produced by nature that contaminates the environment.

Fish kill: The death of a large number of fish, due to a rapid change in the characteristics of their environment.

pH: A measure of a solution's acidity.

Acidic solution: A solution with a pH rating of less than 7.

Figure 26-4. Water pollutants associated with transportation and power generation.

Pollutant	Source	Effects
Oils and hydrocarbons	Oil spills, oil leaks, oil field run-off	Death of fish, disruption of food chain, contamination of drinking water, possible liver and kidney damage from eating contaminated fish
Lead	Some hydrocarbon fuels	Lead poisoning



Curricular Connection

Social Studies: The Exxon Valdez and Oil Spills

On March 24, 1989, the supertanker *Exxon Valdez* strayed from its course in Prince William Sound and slammed into rocks underneath the surface. See **Figure 26-A**. The result of the disaster was an oil spill that took more than three years to clean up. Approximately 11 million gallons of oil were spilled over an area that grew to reach hundreds of square miles. More than 1300 miles of shoreline were affected. Of those, about 200 miles were moderately to heavily oiled, with the remainder receiving a lighter coating to only trace amounts of oil. See **Figure 26-B**.

A team of more than 10,000 workers used various techniques to clean the shoreline of the oil until 1992, when the U.S. Coast Guard declared the cleanup operations complete. Despite the fact that many fish and birds were killed by the oil spill, Prince William Sound continues to yield record harvests for salmon. The *Exxon Valdez* disaster remains one of the worst accidental oil spills in American waters and cost more than \$2.1 billion to clean up, according to Exxon. As of 2003, the *Exxon Valdez* spill was no longer considered to be one of the top 50 oil spills worldwide. It is still widely considered to be the worst spill, however, in terms of environmental damage, due to the pristine nature of Prince William Sound and the abundance of unique fish and wildlife found there.

One of the major lessons learned by the *Exxon Valdez* disaster was that spill prevention, response, and containment procedures were totally inadequate. Since the time of the accident, the following improvements have been made to oil shipping through Prince William Sound:

Figure 26-A. The *Exxon Valdez* tanker aground in Prince William Sound. (National Oceanic and Atmospheric Administration)



Figure 26-B. Workers cleaning the shoreline of oil from the *Exxon Valdez* oil spill. (National Oceanic and Atmospheric Administration)



Basic solution: A solution with a pH rating above 7.

represents a **basic solution**. Pure water has a pH of 7, while rainwater and stream water are slightly acidic. Most organisms can tolerate minor acidity, but higher levels of acidity can significantly reduce the health of ecosystems. Acid rain includes precipitation with a pH lower than 5.6. Some of the most acidic rains have reported pH ratings as low as 2.4.

- All fully laden tankers are now satellite monitored by the U.S. Coast Guard from departure at the Trans-Alaska Pipeline terminal until they exit Prince William Sound.
- Two escort vessels now accompany each tanker through the entire sound.
- Special marine pilots with specific knowledge of Prince William Sound board tankers and work with the tanker crew to navigate the 25 most difficult miles of the 70-mile journey through the sound.
- Weather criteria for safe navigation have been established so ships cannot leave the terminal unless weather conditions are favorable.
- Congress has enacted legislation that will require all tankers operating in Prince William Sound to be double hulled by 2015. A double-hulled vessel is much more likely to contain a spill, in the unlikely event of an accident.
- Emergency crews practice and plan for oil spills in Prince William Sound on an annual basis. The spill scenario they train for is 12.6 million gallons.
- Skimming equipment is now in place that can skim 10 times the amount of oil from the water as the equipment available at the time of the *Exxon Valdez* spill.

The worst oil spill worldwide occurred in 1991. It was not accidental at all. During the Persian Gulf War of 1991, Saddam Hussein, dictator of Iraq, ordered 250 million gallons of crude oil dumped into the waters of the Persian Gulf. This deliberate oil spill was the magnitude of 20 times greater than the *Exxon Valdez* disaster. Hussein's army also set fire to approximately 600 oil wells in Kuwait, creating an environmental disaster of epic proportion. See **Figure 26-C**. Using private contractors, the well fires were extinguished in about one year.

Figure 26-C. Oil well fires in Kuwait during the 1991 Persian Gulf War. (National Oceanic and Atmospheric Administration)



Other Forms of Pollution

Air and water pollution are the most obvious forms of pollution. There are, however, many other more subtle forms of pollution. Some of these have been brought about as a result of energy, power, and transportation industries.

Lead poisoning: Chronic intoxication produced by the absorption of lead into the system.

Electromagnetic field (EMF): A field of electromagnetic energy produced by electricity flowing through power lines.

Light pollution: The excessive amount of light in the nighttime sky that often surrounds urban areas.

Noise pollution: Annoying or harmful noise in an environment.

Land pollution: The action of contaminating the surface of the earth and its natural resources.

Surface mining: The process of working the external layer of the earth and extracting mineral substances.

Reclamation: A technique that requires land that has been disturbed to be graded and covered with topsoil, so as to be suitable for alternate use at the conclusion of mining operations.

Lead contamination, or *lead poisoning*, was more prevalent many years ago, when lead was a primary additive in gasoline. Breathing lead fumes could lead to lead poisoning, leaving victims with permanently diminished mental capacity. Lead was phased out as a gasoline additive and is no longer used in gasoline today.

Electromagnetic fields (EMFs) are all around us. Electricity flowing through power lines produces them. There is considerable debate about the health effects of EMFs. People who live in close proximity to high-voltage power transmission lines are of particular concern for health risks. Reputable studies have not proven that exposure to EMFs causes any significant health risks at this time. There is concern, however, that chronic exposure to EMFs may increase the risk of incidence for some specific types of cancer. The effects of chronic exposure to electricity on cell structure and development have not been thoroughly researched.

Light pollution is a term used to describe the excessive amount of light in the nighttime sky that often surrounds urban areas. The primary consequence of light pollution is that artificially created light can trick plants, birds, and animals. Migrating birds can be drawn toward the light, as they confuse it for daylight on the horizon. Plants can bloom prematurely if exposed to too much artificial light. Nocturnal animals living near an urban area can also become confused between day and night.

Noise pollution is a problem commonly associated with some forms of power generation and many forms of transportation. Regarding the installation of a wind farm to generate electricity, noise can be a primary concern. Geothermal power plants are also known to be very noisy. Concern about noise pollution has resulted in the modifications of airplane approach ways to airports and even aircraft engine design.

Land pollution is a form of pollution that occurs when land is harvested (typically surface mined) to the extent that it renders the remaining land unusable. It is a particular problem in the fossil fuel energy industry, especially regarding the mining of coal. **Surface mining**, often referred to as *strip mining*, refers to the process of extracting natural resources, such as coal, from the earth by digging the coal out from the surface, as opposed to extracting it from underground mines. Years ago, strip or surface mining plots were simply left ungraded and unusable for alternate purposes at the conclusion of a mining operation. Legislation now mandates that strip mining tracts undergo **reclamation** at the conclusion of mining operations. This technique requires the land that has been disturbed to be graded and covered with topsoil so as to be suitable for alternate use at the conclusion of mining operations.

Thermal pollution is a form of pollution most commonly associated with power plants. Historically, it has been easier and cheaper to simply expel waste heat, a by-product of the combustion process, into the atmosphere. Many power plants were constructed in the 1950s and 1960s. At that time, little attention was paid to the effects on aquatic life. Today, as a result of more stringent regulations, power plant cooling systems must be designed to take the local environmental characteristics of lakes, rivers, and streams into account. For instance, let us say an environmental impact study determines that the discharge water from a proposed power plant

will significantly warm the water in a river near the location where the power plant is to be built. Such a change would be drastic enough to change the ecosystem of the river. Therefore, the water would have to be cooled to within a few degrees of the temperature of the river, prior to discharge. This is typically accomplished with the use of cooling towers, which are responsible for transferring the excess heat from the discharge water to the surrounding air, prior to letting the water flow back into the river. See Figure 26-5.

Choosing Environmentally Friendly Energy, Power, and Transportation Sources

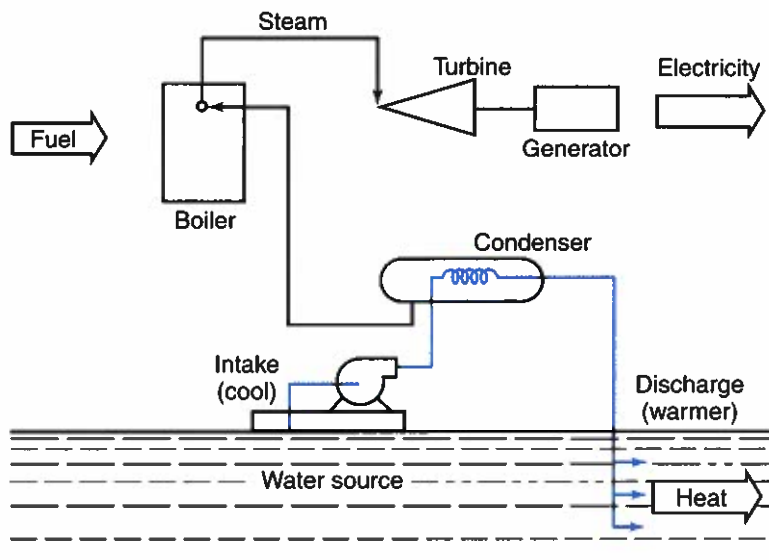
There are many environmentally friendly alternatives to using conventional energy, power, and transportation sources. These alternatives, however, are often not as economical or convenient as traditional sources. For instance, let us say you live in a suburb and work in a city less than 10 miles away. You typically drive to work, but you would like to consider some environmentally friendly transportation alternatives. Riding a bicycle is the most economical and environmentally friendly alternative (in addition to being the healthiest), but it is also the least convenient. A compromise might be to consider commuting with other people from the neighborhood who also work in the city, thereby using only one vehicle, instead of three or four. Another popular and economical alternative is to use mass transit, such as a subway or bus system. This method of

Thermal pollution:
A form of pollution most commonly associated with power plants, in which expelled waste heat adversely affects aquatic life.

GREEN TECH

Carpooling helps reduce the environmental impact of commuters. To help encourage carpooling, over 20 states so far have added high-occupancy vehicle lanes to their highways. It is illegal for single riders to use these lanes.

Figure 26-5. A typical thermal electric generating station, shown in schematic form. Large power plants require tremendous amounts of cooling water. The cooling water, shown in color, flows from the intake through the condenser to remove heat from the steam in the turbine loop. The water is returned to its source at a higher temperature, which can affect fish and other forms of aquatic life. A system must be designed to accommodate a specific site in a way that is not harmful to the environment.



transportation is more environmentally friendly than driving yourself, and it is also more economical. It might be slightly less convenient than driving yourself, but this might be an inconvenience with which you can live.

Ultimately, factors such as convenience, economics, and available technology influence decisions about energy, power, and transportation that affect the environment. Such technological trade-offs are common—we make them all the time. In the summer, when your house is hot, you have several options. The most environmentally friendly option is to open the windows, but this can be inconvenient and might not work without a breeze. The least environmentally friendly is to use air conditioning. It is also the most expensive choice, but it would require only the flick of a switch. A good compromise might be to use a fan. Fans require much less electricity to run than air conditioning and are equally easy to use. Again, this might be an environmentally friendly option with which you can live.

The most environmentally friendly options are usually selected when they are also the most cost-effective and convenient. A hybrid vehicle typically offers similar performance to that of a regular automobile, but it has much better gas mileage. Hybrid vehicles are more environmentally friendly than regular automobiles. Although they currently cost more to purchase than regular automobiles, the cost will come down as more people express interest in purchasing them. The high initial cost is also offset by lower fuel costs, due to the good gas mileage. Future hybrid vehicles may truly represent a technology that is not only the most environmentally friendly alternative to owning a regular car, but also the most economical and convenient.



Technology Link

Agriculture: Environmentally Friendly Uses of Energy

There is no question that our supplies of fossil fuels will eventually run out. For this reason, we need to develop alternate forms of energy. It is important that any form of energy we use harms the environment as little as possible.

One renewable source of energy that is gaining popularity is using waste from cows to produce electricity. The development of methane digesters has made it possible for a dairy farm to produce enough energy to operate the farm and fuel the family car! Using material created by the farm to operate the farm greatly reduces energy costs, and the methane digester also reduces the amount of harmful gases released into the atmosphere.

A methane digester is located in a lagoon near the farm, and it captures naturally occurring gas from the cow waste and converts it into electricity. Creating energy from dairy biogas is a good solution because it turns waste into something usable, while decreasing air and water pollution. The economic and environmental benefits the methane digester provides are very promising. Digesters will be more common on farms in the future, and they will help to make farms self-sufficient and less dependent on other sources of energy.



Reducing Pollution in the Energy, Power, and Transportation Industries

Much pollution is directly attributable to the power generation and transportation industries. It makes sense to focus on what these industries are doing to reduce pollution. The worldwide motor vehicle fleet is now estimated to be over 700 million vehicles. These vehicles produce significant pollution, particularly in urban areas. The automobile is now responsible for about 33% of all crude oil consumption worldwide. Driving automobiles is now widely regarded as the single most polluting human activity on earth. As a result, North America, Europe, and Japan have developed significant pollution control standards for automotive vehicles. These standards have resulted in tremendous advancements in pollution control for gasoline-powered automobiles. Some of these advancements are beginning to make their way into the small gas engine industry as well. Similar technologies are under development for diesel-powered vehicles. This is important because diesel fuel emits 30–70 times more particulate waste than gasoline fuel. Diesel is a popular fuel in the trucking industry in North America and in many third world nations.

Automobile Emissions

A strong relationship between automobile emissions and air quality was suggested as long ago as the 1940s. Eye and throat irritation and decreased visibility as the result of smog were detected in Los Angeles as early as 1943. By 1948, the California legislature established air pollution control districts that had the authority to curb emissions sources. Of course, the technology available to reduce pollution in the 1940s was very limited, in comparison to that of today. The initial efforts generally focused around reducing particle emissions flowing from industrial smokestacks, not automobiles. As a result of these efforts, visibility improved. Eye irritation and smog, however, remained. The particulate matter was not the primary cause of these effects. Further research showed that, when in the presence of sunlight, nitrogen dioxide and hydrocarbon compounds (by-products of burning fossil fuels) react to form ozone and other irritants. This discovery led to a series of emission control requirements for automobiles.

A catalytic converter is part of the exhaust system of an automotive engine. It contains a chemical that acts as a catalyst to reduce polluting emissions. The catalytic converter is one of the most effective pollution control devices for reducing internal combustion engine exhaust gases that has been invented to date.

Studies have shown that lowering the peak temperature of combustion within an engine will lower the amount of nitrous oxides emissions produced during combustion. An exhaust gas recirculation (EGR) system performs this task by routing some of the exhaust gas from the engine into the air intake of the engine. The system will reduce nitrous oxide pollutants as long as it is functioning properly.

Fossil Fuel Power Plant Emissions

Over the years, a variety of filtering techniques have evolved to improve the emissions from power plants. Large-scale power generation requires the consumption of tremendous volumes of fuel. There is some advantage, however, in producing so much power in one location. The advantage is that advanced emissions control techniques can be implemented that are not possible to use in smaller power generation applications.

The following is an overview of techniques used independently or in conjunction with one another to help reduce power plant emissions.

Baghouse: A technique used to reduce power plant emissions in which particles are trapped on filters made of cloth, paper, or similar materials. These particles are then shaken or blown from the filters down into a collection hopper.

Wet scrubber: A technique used to reduce power plant emissions in which particulates, vapors, and gases are controlled by passing the gaseous stream of emissions through a liquid solution.

- **Baghouses.** Particles are trapped on filters made of cloth, paper, or similar materials. These particles are then shaken or blown from the filters down into a collection hopper. Baghouses are used to control air pollutants from power plants, as well as steel mills, foundries, and other industrial furnaces. They can collect more than 98% of the particulates.
- **Electrostatic precipitators.** By use of static electricity, these precipitators attract particles in much the same way that static electricity in clothing picks up small bits of dust and lint. See **Figure 26-6**.
- **Wet scrubbers.** Particulates, vapors, and gases are controlled by passing the gaseous stream of emissions through a liquid solution, or “scrubber.” Scrubbers are used in coal-burning power plants, asphalt and concrete plants, and a variety of other facilities that emit gases that are highly soluble in water. Wet scrubbers are often used for corrosive, acidic, or basic gas streams.

These techniques have vastly improved the quality of power plant emissions. There is, however, still more work to be done. Fossil fuel pollutants and the consumption of coal for power generation, in particular, remain the principal causes of acid rain and the greenhouse effect.

Figure 26-6. Electrostatic precipitators and other control devices help to reduce the emissions of particulate matter and gases from pollution sources, such as this steel mill. They are regarded as being 98–99% effective. Electrostatic precipitators are often used instead of baghouses when the particles are suspended in very hot gases, such as in emissions from power plants, steel and paper mills, smelters, and cement plants.



Summary

The energy, power, and transportation industries are some of the most polluting industries on earth. They are also some of the industries most responsible for improving our quality of life. Therefore, it is necessary to continue to use these technologies, while striving to minimize the environmental damage they can cause. Pollution can come in many forms. The most obvious form is air pollution. Acid rain and other forms of water pollution can be attributed to power generation and our extensive use of the automobile. There are also a variety of other forms of environmental pollution that are not as well known. These forms of pollution include lead poisoning, light pollution, noise pollution, land pollution, thermal pollution, and even possible pollution from electromagnetic fields (EMFs). Many devices have been created to curb harmful emissions from escaping into the atmosphere.

Key Words

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

acidic solution

air pollution

baghouse

basic solution

Clean Air Act (CAA)

electromagnetic field
(EMF)

fish kill

land pollution

lead poisoning

light pollution

natural pollutant

noise pollution

nonattainment

pH

reclamation

surface mining

suspended particle

thermal pollution

water pollution

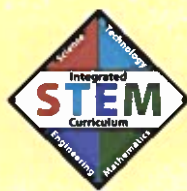
wet scrubber

Test Your Knowledge

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

1. *True or False?* The Clean Air Act (CAA) of 1955 was enacted at the state level.
2. *True or False?* Most acid rain can be attributed to natural causes.
3. _____ was a gasoline additive that was eventually phased out because of the adverse health effects it caused.
4. *True or False?* Electromagnetic fields (EMFs) from power lines have no proven side effects to date.
5. Write one or two sentences about how obtaining energy resources has harmed the environment.
6. *True or False?* Reclamation refers to the reconditioning of mined land for alternate use.

7. *True or False?* Thermal pollution from power plants has no serious consequences.
8. Automobiles are responsible for about _____ percent of all crude oil consumption worldwide.
9. *True or False?* Automobiles are collectively regarded as the most polluting of all human inventions.
10. Describe three common techniques used to reduce fossil fuel pollutants at power plants.
11. *True or False?* Environmental protection should be a primary concern when developing any new technology.



STEM Activities

1. Construct a wet scrubber or electrostatic precipitator in class.
2. Review automotive emissions control devices using a working automobile and with a professional mechanic.
3. Review state and federal environmental legislation on-line.
4. Research new and emerging pollution control techniques.