CHAPTER FOUR

RENEWABLE ENERGY SOURCE

4.1: Introduction:

Renewable energy is energy that is **regenerative** or, for all practical purposes, virtually inexhaustible. It includes solar energy, wind energy, hydropower, biomass (derived from plants), geothermal energy (heat from the earth), and ocean energy. Renewable energy resources can supply energy for heating and cooling buildings, electricity generation, heat for industrial processes, and fuels for transportation. The increased use of renewable energy could reduce the burning of fossil fuels (coal, petroleum, and natural gas), eliminating associated air-pollution and carbon dioxide emissions, and contributing to national energy independence and economic and political security. Before the 1900s, the world as a whole used wood (including wood converted to charcoal) for heat in homes and industry, vegetation for feeding draft animals, water mills for grinding grain and milling lumber, and wind for marine transportation and grain milling and water pumping. By the 1920s, however, coal and petroleum had largely replaced these energy sources in industrialized countries, although wood for home heating and hydroelectric power generation remained in wide use. At the end of the twentieth century, nearly 90 percent of commercial energy supply was from fossil fuels. Renewable energy, however, makes important contributions to world energy supplies. Hydroelectric power is a major source of electrical energy in many countries, including Brazil, Canada, China, Egypt, Norway, and Russia. In developing countries many people do not have access to or cannot afford electricity or petroleum fuels and use biomass for their primary energy needs. For example, most rural people in Africa use wood, scrub, grass, and even animal dung for cooking fuel. Small-scale renewable energy technologies are often the only practical means of supplying electricity in rural areas of these countries. The table indicates the relative consumption of energy sources in the United States.

4.2: Major Types of Renewable Energy Sources:

***4.2.1*: *Biomass*:** Biomass includes wood, agricultural crops and residues, municipal refuse, wood and paper products, manufacturing process waste, and human and livestock manure. It can be used to heat homes and buildings, produce electricity, and as a source of vehicle fuel. Wood and paper manufacturers and sugar mills use biomass residues for process heat and electricity production. There are power plants that burn wood, agricultural residues, and household trash to produce electricity. Biogas (composed of methane, carbon dioxide, and other gases) produced by decomposing biomass in **anaerobic** conditions is captured from landfills, municipal sewage treatment plants, and livestock waste management operations. This gas can be used for heat or to generate electricity. Ethanol is used as a transportation fuel in the United States, Brazil, and a few other countries. Nearly all the fuel ethanol in the United States is made from corn, although it can also be produced from other sources, including wastepaper. There is a small but growing consumption of "biodiesel" made from grain oils and animal fats.

Trees and other vegetation convert the sun's energy directly into the useful biomass. The biomass can be converted into biogas or bio-liquid (bio- diesel) and used as a source of energy. Using the wood and other agriculture waste directly by burning is the most inefficient way of energy conversion. By converting it into biogas at least 25%, more energy can be obtained along with the benefit of useful natural organic manure. Biomass is derived from the carbonaceous waste of various natural and human activities. Is obtained from numerous sources including the household waste. Biomass does not add CO_2 to the atmosphere because it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Unlike other renewable energy systems that require costly advanced technology, biomass can generate electricity with the same equipment/ power plant that are burning fossil fuels at present. In the biological conversion method biomass is converted into biogas by anaerobic decomposition method. The raw material may be cattle dung or the organic part of the municipal solid waste.

Sometimes the use of other biomass like Water Hyacinth (Jal Kumbhi) helps in the reduction of flow hazards produced by it in the water bodies. In a study made in the engineering college Kota in which water hyacinth was taken from the local reservoirs and used as the biomass for biogas production, it was observed that it could be used efficiently to produce biogas. Therefore, in the communities where cattle dung is scarce and water hyacinth is available in plenty it serve both purposes of water hyacinth eradication and biogas production. Even human excreta can produce biogas. Aryan society for environmental research and Development, Jaipur has installed a night soil based biogas plant at the police lines Udaipur and at the bus stand in Nathdwara. In the thermochemical, use of biomass the various crop residues like rice husk can be burnt in boilers or pallets can be made and electricity may be generated in the power plants. These methods not only help directly in the electricity production but also help in reducing the waste management problem.

***4.2.2*: *Geothermal systems*:** The core of earth is very hot. It is possible to make use of this geothermal energy. In some countries such as the U.S., hot water is pumped from underground water deposits and used to heat the residences. Geothermal energy (heat from the earth) created deep beneath the earth's surface is tapped to produce electricity in twenty two countries, some of which include the United States, Iceland, Italy, Kenya, and the Philippines. Geothermal hot springs can also heat buildings, greenhouses, fish farms, and bathing pools.

***4.2.3*: *Hydropower*:** Hydropower, produced from flowing water passing through hydroelectric **turbines**, is the leading renewable energy source, contributing to approximately 9 percent of the electricity generated in the United States. Most hydropower is produced at large dams, although there are many small systems operating around the world, such as the small hydropower plant in Namche Bazar, Nepal, which provides power for the tourist and market town near Mt. Everest. The production of hydroelectricity from year to year varies with precipitation. Hydropower generation is a conventional renewable energy resource utilization

method that is most environmental friendly but the problem of rehabilitation is typical. The uncertainty of rainfall and regional problems of water use and distribution are never ending. The ambitious river inter-linking project is yet to be tested. Mini and micro power plants can help in solving the problem. Small hydro Power (up to 25 MW), included in the category of renewables has a large share in the total achievement. The following photograph shows a dam for a hydroelectricity power plant.

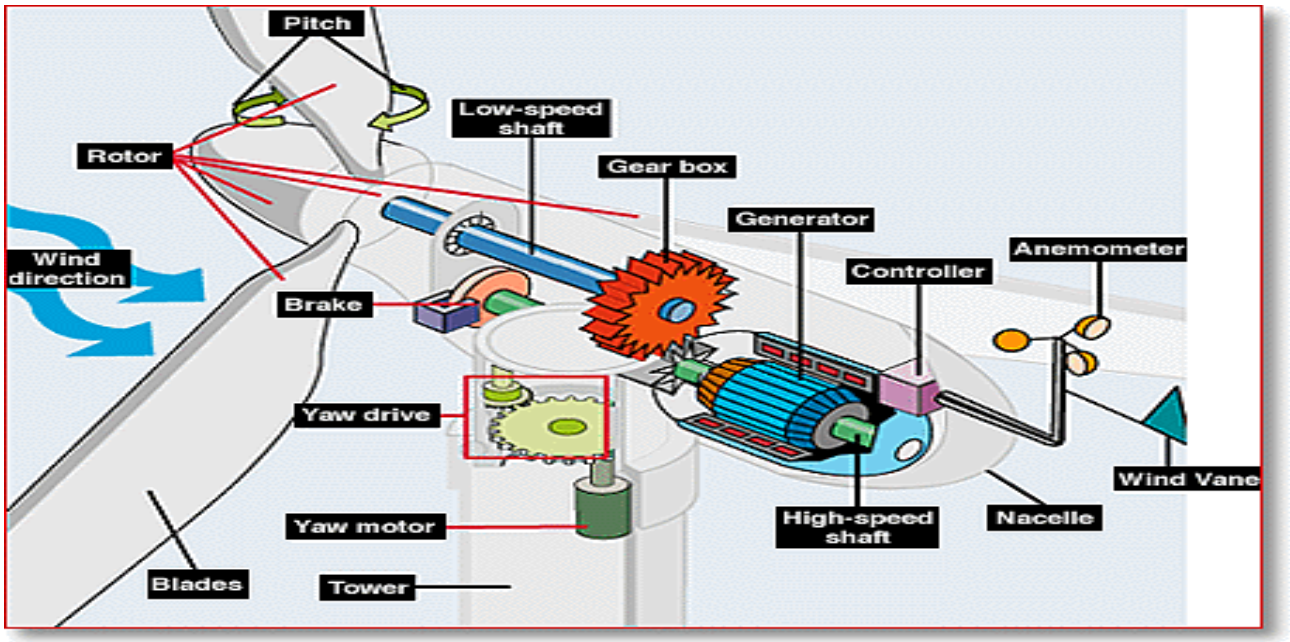
***4.2.4*: *Ocean energy*:** The world's oceans are a vast and practically untapped source of energy. There are a few operating wave and tidal power plants around the world, and several experimental ocean thermal energy conversion (OTEC) plants have been built. A small wave power plant in Norway captures water from waves in a dam and lets the water out through a turbine. A 240-megawatt tidal power facility on the Rance River in France produces electricity as tidal flows move back and forth through turbines located at the mouth of the river. In Hawaii, a small OTEC plan was built which uses the temperature of warm surface water to evaporate cold seawater in a vacuum to produce steam that turns a turbine and generator.

***4.2.5*: *Solar energy systems*:** The simplest uses of solar energy are for drying crops, and heating buildings and water. Solar-heated homes and solar water heaters can be found in nearly every country around the world. Crops can be simply laid in the sun to dry, or more collectors that are sophisticated can be used to heat air to dry food stored on drying racks. Solar water heaters use collectors to heat water that is stored in a tank for later use. Homes can be heated by using a masonry floor to absorb sunshine coming through windows, or by using solar collectors to heat a large tank of water than can be distributed for heating at night. Concentrated sunlight can be used to produce high-temperature heat and electricity. Nine concentrating solar parabolic trough power plants, with a combined generation capacity of 354 megawatts, are located in the Mojave Desert in California. (A

megawatt is 1 million watts, or 1,000 kilowatts.) The U.S. Department of Energy built and tested a ten-megawatt solar thermal central receiver power plant near Barstow, California, which operated successfully for about seven years. Another type of concentrating solar thermal power system is a parabolic dish. Systems with a capacity of up to twenty-five kilowatts have been developed. Photovoltaic (PV) systems are based on solar electric cells, which convert sunlight directly to electricity. They can be used to power hand calculators or in large systems on buildings. Many PV systems are installed in remote areas where power lines are expensive or unfeasible, although the number of systems connected to electricity transmission systems is increasing, and range in size from 1 to several kilowatts on houses, to systems over one hundred kilowatts on large buildings. PV systems are very suitable for use in developing countries where people have no electricity from electric power lines.

***4.2.6*: *Wind energy systems*:** Water-pumping and grain-milling windmills have evolved into electric power turbines. There are now tens of thousands of wind turbines operating around the world. They range in size from tiny turbines on the back of sailboats to very large units that can produce as much as 2 to 3 megawatts of electricity, with 100-foot (30-meter) blades. They can be installed on land and in shallow water in coastal areas. Since long time windmills are used to mill wheat and pump, water. Modern windmills are called wind turbines. They transform the energy in the wind into mechanical power, which can then be used to produce electricity. Wind turbines can be used singly or in clusters called wind farms and are usually about 60 m high. Small wind turbines called wind chargers are used to charge batteries and can be used by unelectrified homes, boats etc., to power television and other domestic appliances and so on. For the economical harnessing of wind power a wind velocity of about 7 m/sec. is required which is the major limitation of this system. However, the conversion of wind energy into electricity has increased to 6315 (1/1/07) MW that is more than half of the total production by renewables. It is under sincere considerations even in Rajasthan. 2 MW wind

project started in Jaisalmer on 14th August 1999. Rajasthan State Power Corporation Ltd. Plans to construct a new 1- billion rupee 25 MW Wind farm in the district of Jaisalmer. The development is one of the 28 planned state government wind projects expected to generate 444.25 MW of electricity. As per the officials, the state government is also considering other sites at Devgarh, Harhnath, Jaisalmer, kohdal, Mohangarh and Phalodi for the potential establishment of wind farms by private developments. The following photograph shows the wind farm (a collection of aerogenerators for the production of electricity).



U.S. ENERGY CONSUMPTION AND ELECTRICITY GENERATION, 1999

Energy Source	(Quads*)	(%Total)	(Bill. kWh**)	(%Total)
Total	96	85	3,641	
Coal/Coal Coke	22	23	1,891	52
Petroleum	38	39	116	3
Natural Gas	22	23	546	15
Nuclear	8	8	674	19
Renewables (Total)	7.2	7.5	419	12
Hydro	3.5	3.6	339	9.4
Biomass/Biofuels	3.2	3.3	58	1.6
Geothermal	0.4	0.4	17	0.46
Solar	0.07	0.07	0.85	0.02
Wind	0.05	0.05	4.5	0.12

*A quad is quadrillion British Thermal Units (BTUs), and is the equivalent of about 180 million barrels of crude oil.
**Bill. kWh = a billion kilowatt-hours; One kilowatt-hour (kWh) is the equivalent of running a 100-watt lightbulb for 10 hours.
Note: values are rounded.

SOURCE: Energy Information Administration, U.S. Department of Energy.

4.3: The Future for Renewable Energy

Renewable energy has many advantages that will help to maintain and expand its place in world energy supply:

• Renewable energy resources are enormous-hundreds of times beyond the needs of world energy consumption in 2000.

• Advances in technologies are reducing manufacturing costs and increasing system efficiencies, thereby reducing the cost of energy from renewable resources.

• Negative environmental and health impacts of renewable energy use are much fewer than those of fossil fuels and nuclear power.

• Many renewable energy technologies can produce energy at the point of use, allowing homeowners, businesses, and industry to produce their own power.

• There is strong support for renewable energy from people around the world.

• Many governments have programs that support renewable energy use to limit the emission of greenhouse gases and thereby reduce the threat of global warming.

As fossil fuels such as oil and natural gas become scarce, they will become more expensive. Some experts believe that demand for oil will exceed production capability within the next twenty years. Using energy conservatively and

efficiently, no matter how it is produced or where it comes from, is the most economical way to consume energy. Simply turning off lights and computers when they are not in use can save an individual household or business money and reduce the environmental impact associated with producing electricity.

4.4: Electricity from renewable energy

Each renewable energy source has tradeoffs. One renewable source may produce little or no pollution, but have other adverse environmental and social effects. As you read, keep in mind that no one technology can do it all - there is ‘‘no magic bullet.” A mix of sources will be needed and the task may take many decades. As a Royal Dutch Shell spokesperson remarked, it will be a ‘‘messy transition.”

Hydroelectric dams

A dam appears to have many advantages. It generates little air pollution and depletes few non-renewable resources. It generates needed electricity, is expected to prevent floods, and is used to provide irrigation water. Nevertheless, a large dam* floods agricultural land drives many people from their homes, deprives downstream wildlife of water or the water temperature which they need, deprives downstream recreational users, interferes with fish migration, and disrupts ecosystems and wildlife habitats both up- and downstream. Although dam builders expect the dams to improve flood control, sometimes changes in water flow lead to less frequent but more catastrophic floods. Using the dam as a source of irrigation water can waterlog the land on which it is used and saturate it with salt. Dams also have safety concerns. Their lifetimes are limited by a build-up of silt. In addition, dams are not pollution free: decomposing organic matter in dam reservoirs generates methane; and reservoir bacteria are unusually active in converting elemental mercury to methylmercury

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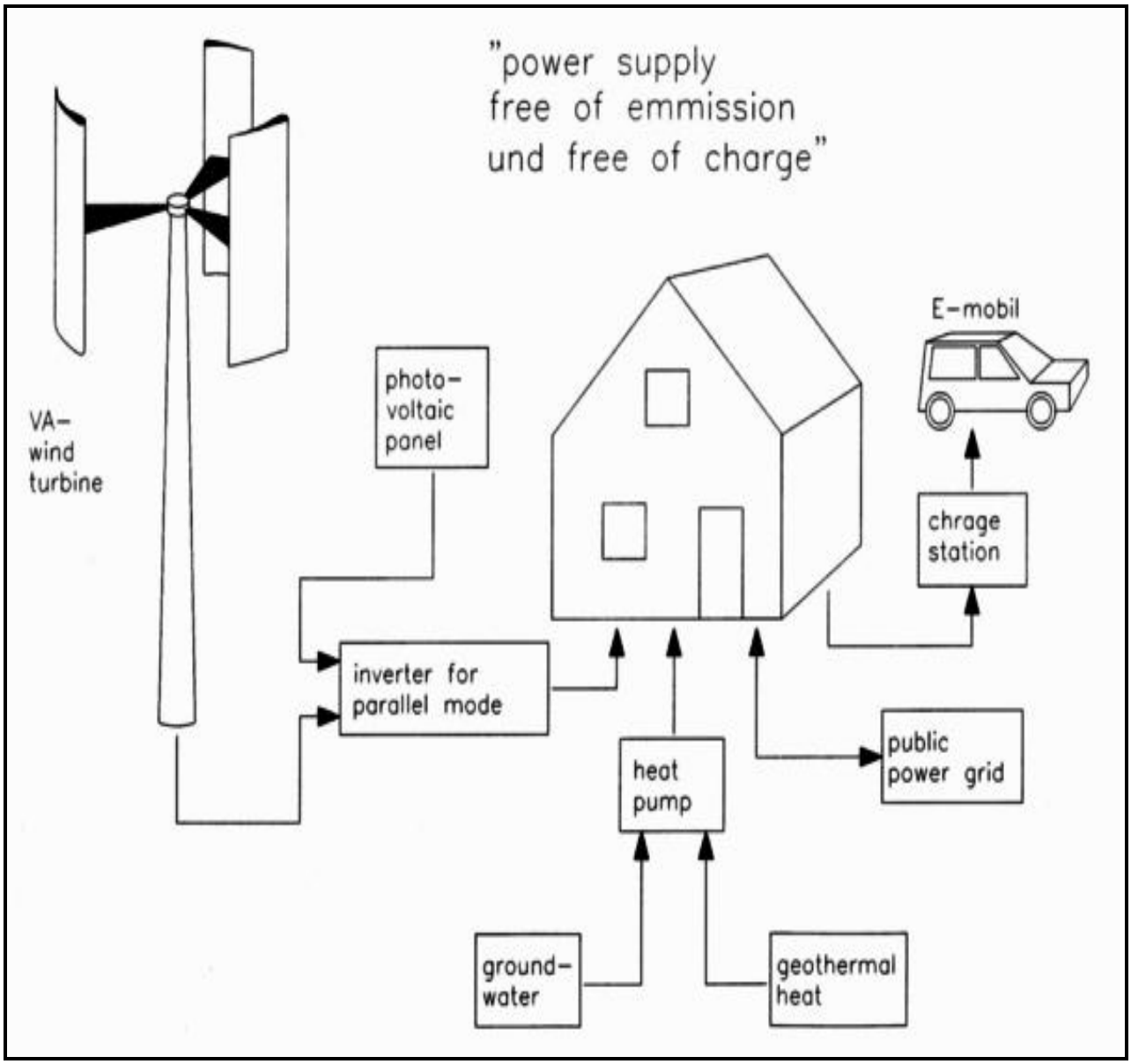
* *A large dam is one more than 15 m high or one with reservoirs holding more than 3 million m3 of water. There are over 45 000 large dams in the world. China, which already has a great many of these, is building the biggest dam of all, the Three Gorges Dam on the Yangtze River. It will displace 2 million people.*

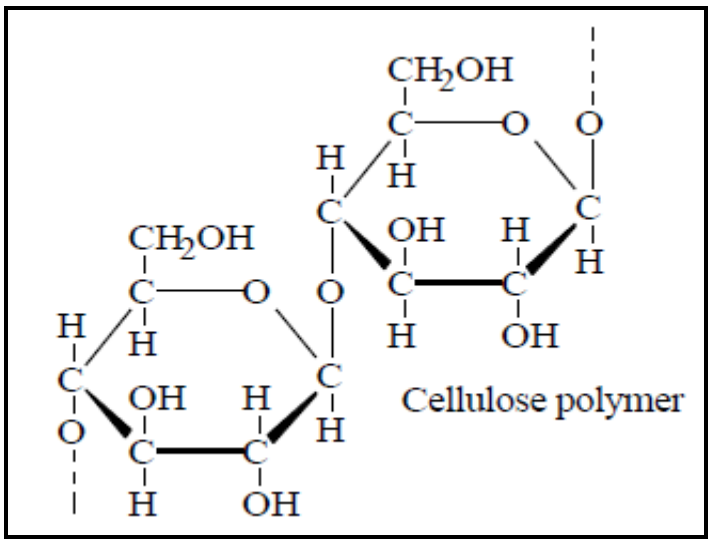
Dams also often lead to angry confrontations over water use, even if the river flows only within one country. Powerful local people may take all the benefits. Dams on international rivers can cause severe tensions.

In 2000, the World Commission on Dams presented a decision-making framework to guide future dam construction. Their approach is based on more than financial considerations, and analyzes factors such as why a new dam is needed, and whether another option could meet the same goal. It analyzes the various effects the dam will have, makes recommendations to assure that its benefits would be shared and not appropriated by a few individuals, and recommends provisions for people whose livelihoods and homes are destroyed. *Small* dams, depending on the characteristics of each, avoid the worst of these problems.



4.5: Wood-A Major Renewable Resource:

Fortunately, one of the major natural resources in the world, wood, is a renewable resource. Production of wood and wood products is the fifth largest industry in the United States, and forests cover one-third of the United States surface area. Wood ranks first worldwide as a raw material for the manufacture of other products, including lumber, plywood, particleboard, cellophane, rayon, paper, methanol, plastics, and turpentine. Chemically, wood is a complicated substance consisting of long cells having thick walls composed of polysaccharides such as cellulose.



The polysaccharides in cell walls account for approximately three-fourths of *solid wood*, wood from which extractable materials have been removed by an alcohol-benzene mixture. Wood typically contains a few tenths of a percent of ash (mineral residue left from the combustion of wood). A wide variety of organic compounds can be extracted from wood by water, alcohol-benzene, ether, and steam distillation. These compounds include tannins, pigments, sugars, starch, cyclitols, gums, mucilages, pectins, galactans, terpenes, hydrocarbons, acids, esters, fats, fatty acids, aldehydes, resins, sterols, and waxes. Substantial amounts of methanol (sometimes called *wood alcohol*) are obtained from wood, particularly when it is pyrolyzed. Methanol, once a major source of liquid fuel, is now being used to a limited extent as an ingredient of some gasoline blends a major use of wood is in paper manufacture. The widespread use of paper is a mark of an industrialized

society. The manufacture of paper is a highly advanced technology. Paper consists essentially of cellulosic fibers tightly pressed together. The lignin fraction must first be removed from the wood, leaving the cellulosic fraction. Both the sulfite and alkaline processes for accomplishing this separation have resulted in severe water and air pollution problems, now significantly alleviated through the application of advanced treatment technologies. Wood fibers and particles can be used for making fiberboard, paper-base laminates (layers of paper held together by a resin and formed into the desired structures at high temperatures and pressures), particleboard (consisting of wood particles bonded together by a phenol formaldehyde or urea-formaldehyde resin), and nonwoven textile substitutes consisting of wood fibers held together by adhesives. Chemical processing of wood enables the manufacture of many useful products, including methanol and sugar. Both of these substances are potential major products from the 60 million metric tons of wood wastes produced in the U.S. each year.

4.6: The Energy Problem:

Since the 1973-1974 “energy crisis,” much has been said and written, many learned predictions have gone awry, and some concrete action has even taken place. Catastrophic economic disruption, people “freezing in the dark,” and freeways given over to bicycles (perhaps a good idea) have not occurred. Nevertheless, uncertainties over petroleum availability and price and disruptions such as the 1990 Gulf War have caused energy to be one of the major problems of modern times. In the U.S. concern over energy supplies and measures taken to ensure alternate supplies reached a peak in the late 1970s. Significant programs on applied energy research were undertaken in the areas of renewable energy sources, efficiency, and fossil fuels. The financing of these efforts reached a peak around 1980, and then dwindled significantly after that date. By the year 2000, an abundance of fossil energy had resulted in a false sense of security regarding energy sources. The solutions to energy problems are strongly tied to environmental considerations. For example, a massive shift of the energy base to

coal in nations that now rely largely on petroleum for energy would involve much more strip mining, potential production of acid mine water, use of scrubbers, and release of greenhouse gases (carbon dioxide from coal combustion and methane from coal mining). Similar examples could be cited for most other energy alternatives. Dealing with the energy problem requires a heavy reliance on technology, which is discussed in numerous places in this book. Computerized control of transportation and manufacturing processes enables much more efficient utilization of energy. New and improved materials enable higher peak temperatures and therefore greater extraction of usable energy in thermal energy conversion processes. Innovative manufacturing processes have greatly lowered the costs of photovoltaic cells used to convert sunlight directly to energy.