ENERGY, FOSSIL FUELS and ALTERNATIVE ENERGY SOURCES

- **Fossil fuel resources, which took millions of years to form, may be essentially exhausted in just a few hundred years.**
- **The decisions we make today will affect energy use for generations.**

- **Should we choose complex, centralized energy production methods, or simpler and widely dispersed methods, or a combination of the two?**
- **Which energy sources should be emphasized?**
- **Which uses of energy should be emphasized for increased efficiency?**
- **How can we develop a sustainable energy policy?**

There are no easy answers.

ENERGY SOURCES AND CONSUMPTION

- People living in industrialized countries make up a relatively small percentage of the world's population but consume a disproportionate share of the total energy consumed in the world.
- For example, the United States, with only 5% of the world's population, uses approximately 20% of the total energy consumed in the world. There is a direct relationship between a country's standard of living (as measured by gross national product) and energy consumption per capita.

FOSSIL FUELS AND ALTERNATIVE ENERGY SOURCES

PETROLEUM, NATURAL GAS, AND COAL

- Because they originated from plant and animal material that existed millions of years ago, they are called fossil fuels.
- They are forms of stored solar energy that are part of our geologic resource base, and they are essentially nonrenewable.

- Other sources of energy—**GEOTHERMAL, NUCLEAR, HYDROPOWER, AND SOLAR,** among others—are referred to as **ALTERNATIVE ENERGY SOURCES** because they may serve as alternatives to fossil fuels in the future. Some of them, such as solar and wind, are not depleted by consumption and are known as **RENEWABLE ENERGY SOURCES**.

- The shift to alternative energy sources may be gradual as fossil fuels continue to be used, or it could be accelerated by concern about potential environmental effects of burning fossil fuels.
- Regardless of which path we take, one thing is certain:
- **Fossil fuels are finite.** It took millions of years to form them, but they will be depleted in only a few hundred years of human history.

ENERGY CONSERVATION, INCREASED EFFICIENCY, AND COGENERATION

- Conservation of energy refers simply to using less energy and adjusting our energy needs
- Increased energy efficiency involves designing equipment to yield more energy output from a given amount of energy input (first-law efficiency) or better matches between energy source and end use (second-law efficiency).
- Cogeneration includes a number of processes designed to capture and use waste heat, rather than simply releasing it into the atmosphere, water, or other parts of the environment as a thermal pollutant - that is, to use it a second time, at a lower temperature, but possibly to use it in more than one way as well.

- Energy conservation, energy efficiency, and cogeneration are all interlinked.
- For example, when big, coal-burning power stations produce electricity, they may release large amounts of heat into the atmosphere. **Cogeneration**, by using that waste heat, can increase the overall efficiency of a typical power plant from 33% to as much as 75%, effectively reducing losses from 67 to 25%.

- **Industrial Energy**

The rate of increase in energy use (consumption) leveled off in the early 1970s. Nevertheless, industrial production of goods (automobiles, appliances, etc.) continued to grow significantly.

SUSTAINABLE-ENERGY POLICY

A visionary path for energy policy was suggested more than 30 years ago by Amory Lovins. That path focuses on energy alternatives that emphasize energy quality and are renewable, flexible, and environmentally more benign than those of the business-as-usual path. As defined by Lovins, these alternatives have the following characteristics:

- They rely heavily on renewable energy resources, such as sunlight, wind, and biomass (wood and other plant material).
- They are diverse and are tailored for maximum effectiveness under specific circumstances.
- They are flexible, accessible, and understandable to many people.
- They are matched in energy quality, geographic distribution, and scale to end-use needs, increasing second-law efficiency.

- **Integrated, Sustainable Energy Management**

The concept of integrated energy management recognizes that NO SINGLE ENERGY SOURCE CAN PROVIDE ALL THE ENERGY REQUIRED BY THE VARIOUS COUNTRIES OF THE WORLD. Furthermore, the mix of technologies and sources of energy will involve both fossil fuels and alternative, renewable sources. A basic goal of integrated energy management is to move toward sustainable energy development that is implemented at the local level. Sustainable energy development would have the following characteristics:

- It would provide reliable sources of energy.
- It would not destroy or seriously harm our global, regional, or local environments.
- It would help ensure that future generations inherit a quality environment with a fair share of the Earth's resources.

ALTERNATIVE ENERGY AND THE ENVIRONMENT

Introduction to Alternative Energy Sources

The primary energy sources today are fossil fuels—they supply approximately 90% of the energy consumed by people. All other sources are considered **alternative energy** and are divided into **renewable energy** and **nonrenewable energy**. Nonrenewable alternative energy sources include nuclear energy and deep-earth geothermal energy (the energy from the Earth's geological processes). This kind of geothermal energy is considered nonrenewable for the most part because heat can be extracted from Earth faster than it is naturally replenished— that is, output exceeds input. **Nuclear energy** is nonrenewable because it requires a mineral fuel mined from Earth. The **renewable energy sources** are solar; freshwater (hydro); wind; ocean; low-density, near-surface geothermal is simply solar energy stored by soil and rock near the surface. It is widespread and easily obtained and is renewed by the sun.

The total energy we may be able to extract from alternative energy sources is enormous. For example, the estimated recoverable energy from solar energy is about 75 times as much as all the people of the world use each year. The estimated recoverable energy from wind alone is comparable to current global energy consumption.

SOLAR ENERGY

- The total amount of solar energy reaching Earth’s surface is tremendous.

- For example, on a global scale, ten weeks of solar energy is roughly equal to the energy stored in all known reserves of coal, oil, and natural gas on Earth. Solar energy is absorbed at Earth’s surface at an average rate of 90,000 terawatts (1 TW equals 1012 W), which is about 7,000 times the total global demand for energy.

Solar energy may be used by passive or active solar systems. Passive solar energy systems do not use mechanical pumps or other active technologies to move air or water. Instead, they typically use architectural designs that enhance the absorption of solar energy.

- **Active Solar Energy**
- **Solar Collectors**
- **Photovoltaics**
- **Solar thermal generators**

SOLAR ENERGY AND THE ENVIRONMENT

- The use of solar energy generally has a relatively low impact on the environment, but there are some environmental concerns. One concern is the large variety of metals, glass, plastics, and fluids used in the manufacture and use of solar equipment. Some of these substances may cause environmental problems through production and by accidental release of toxic materials.

WATER POWER

Water power is a form of stored solar energy that has been successfully harnessed since at least the time of the Roman Empire. Waterwheels that convert water power to mechanical energy were turning in Western Europe in the Middle Ages.

Today, hydroelectric power plants use the water stored behind dams. In the United States, hydroelectric plants generate about 80,000 MW of electricity—about 10% of the total electricity produced in the nation.

Hydropower can also be used to store energy produced by other means, through the process of pump storage. During times when demand for power is low, excess electricity produced from oil, coal, or nuclear plants is used to pump water uphill to a higher reservoir (high pool). When demand for electricity is high (on hot summer days, for instance), the stored water flows back down to a low pool through generators to help provide energy. The advantage of pump storage lies in the timing of energy production and use.

WATER POWER AND THE ENVIRONMENT

Water power is clean power in that it requires no burning of fuel, does not pollute the atmosphere, produces no radioactive or other waste, and is efficient. BUT

- Large dams and reservoirs flood large tracts of land that could have had other uses. For example, towns and agricultural lands may be lost.
- Dams block the migration of some fish, such as salmon, and the dams and reservoirs greatly alter habitats for many kinds of fish.
- Dams trap sediment that would otherwise reach the sea and eventually replenish the sand on beaches.
- Reservoirs with large surface areas increase evaporation of water compared to pre-dam conditions. In arid regions, evaporative loss of water from reservoirs is more significant than in more humid regions.
- For a variety of reasons, many people do not want to turn wild rivers into a series of lakes.

OCEAN ENERGY

A lot of energy is involved in the motion of waves, currents, and tides in oceans but it's not easy to harness this energy. The most successful development of energy from the ocean has been tidal power.

WIND POWER

Wind power, like solar power, has evolved over a long time. From early Chinese and Persian civilizations to the present, wind has propelled ships and has driven windmills to grind grain and pump water. In the past, thousands of windmills in the western United States were used to pump water for ranches. More recently, wind has been used to generate electricity. The trouble is, wind tends to be highly variable in time, place, and intensity. Winds are produced when differential heating of Earth's surface creates air masses with differing heat contents and densities.

Wind Power and the Environment Wind energy does have a few disadvantages:

- Wind turbines can kill birds. (Birds of prey, such as hawks and falcons, are particularly vulnerable.)
- Wind turbines and wind farms may degrade an area's scenery.
- However, although wind farms must often compete with other land uses, in many cases wind turbines can share land used for farms, military bases, and other facilities. Everything considered, wind energy has a relatively low environmental impact.

BIOFUELS

- Biofuel is energy recovered from biomass (organic matter). We can divide biofuels into three groups: firewood, organic wastes, and crops grown to be converted into liquid fuels.

Biofuels and Human History

- Biomass is the oldest fuel used by humans. Our Pleistocene ancestors burned wood in caves to keep warm and cook food. Biofuels remained a major source of energy throughout most of the history of civilization. When North America was first settled, there was more wood fuel than could be used. Forests often were cleared for agriculture by girdling trees (cutting through the bark all the way around the base of a tree) to kill them and then burning the forests.

- With other fuels reaching a limit in abundance and production, there is renewed interest in using natural organic materials for fuel. More than 1 billion people in the world today still use wood as their primary source of energy for heat and cooking.

In recent years, however, biofuels have become controversial. Do biofuels offer a net benefit or disbenefit? In brief:

- Using wastes as a fuel is a good way to dispose of them. Making them takes more energy than they yield—but on the other hand, they reduce the amount of energy we must obtain from other sources.
- Firewood that regenerates naturally or in plantations that require little energy input will remain an important energy source in developing nations and locally in industrialized nations.
- Despite pressure from some agricultural corporations and some governments to promote crops grown solely for conversion into liquid fuels (called agrifuels), at present these are poor sources of energy. Most scientific research shows that producing agrifuels takes more energy than they yield. In some cases, there appears to be a net benefit, but the energy produced per unit of land area is low, much lower than can be obtained from solar and wind.

BIOFUELS AND THE ENVIRONMENT

The conversion of farmland from food crops to biofuels appears to be one of the main reasons that food prices have risen rapidly worldwide, and that worldwide food production no longer exceeds demand. It also has environmental effects.

Biofuel agriculture competes for water with all other uses, and the main biofuel crops require heavy use of artificial fertilizers and pesticides.

Biofuels are supposed to reduce the production of greenhouse gases, but when natural vegetation is removed to grow biofuel crops, the opposite may be the case.

The environmental organization Friends of the Earth says that as much as 8% of the world's annual CO2 emissions can be attributed to draining and deforesting peatlands in Southeast Asia to create palm plantations.

The use of biofuels can pollute the air and degrade the land. Under certain weather conditions, woodsmoke from many campfires or chimneys in narrow valleys can lead to air pollution.

The use of biomass as fuel places pressure on an already heavily used resource. A worldwide shortage of firewood is adversely affecting natural areas and endangered species.

Biofuels do have some potential benefits. One is that certain kinds of crops, such as nuts produced by trees, may provide a net energy benefit in environments that are otherwise not suited to the growth of food crops. But this is not commonly the case.

Another environmental plus is that combustion of biofuels generally releases fewer pollutants, such as sulfur dioxide and nitrogen oxides, than does combustion of coal and gasoline.

GEOTHERMAL ENERGY

- There are two kinds of geothermal energy: deep-earth, high-density; and shallow-earth, low-density. The first makes use of energy within the Earth. The second is a form of solar energy: When the sun warms the surface soils, water, and rocks, some of this heat energy is gradually transmitted down into the ground.
- The first kind of geothermal energy—deep-earth, high-density—is natural heat from the interior of the Earth. It is mined and then used to heat buildings and generate electricity. The idea of harnessing Earth's internal heat goes back more than a century.

- **Geothermal Energy and the Environment**

Deep-earth, high-density, geothermal energy development produces considerable thermal pollution from its hot wastewaters, which may be saline and highly corrosive. Other environmental problems associated with this kind of geothermal energy use include onsite noise, emissions of gas, and disturbance of the land at drilling sites, disposal sites, roads and pipelines, and power plants.

The use of deep-earth, high-density geothermal energy releases almost 90% less carbon dioxide and sulfur dioxide than burning coal releases to produce the same amount of electricity. Furthermore, development of geothermal energy does not require large-scale transportation of raw materials or refining of chemicals, as development of fossil fuels does. Nor does geothermal energy produce the atmospheric pollutants associated with burning fossil fuels or the radioactive waste associated with nuclear energy. Even so, deep-earth, high-density geothermal power is not always popular.

WHAT IS NUCLEAR ENERGY?

- Nuclear energy is the energy contained in an atom's nucleus. Two nuclear processes can be used to release that energy to do work: fission and fusion. Nuclear fission is the splitting of atomic nuclei, and nuclear fusion is the fusing, or combining, of atomic nuclei. A by-product of both fission and fusion is the release of enormous amounts of energy.

- Nuclear energy for commercial use is produced by splitting atoms in nuclear reactors, which are devices that produce controlled nuclear fission. In the United States, almost all of these reactors use a form of uranium oxide as fuel. Nuclear fusion, despite decades of research to try to develop it, remains only a theoretical possibility.

Nuclear Energy and the Environment

- The nuclear fuel cycle begins with the mining and processing of uranium, its transportation to a power plant, its use in controlled fission, and the disposal of radioactive waste. Ideally, the cycle should also include the reprocessing of spent nuclear fuel, and it must include the decommissioning of power plants. Since much of a nuclear power plant becomes radioactive over time from exposure to radioisotopes, disposal of radioactive wastes eventually involves much more than the original fuel. Throughout this cycle, radiation can enter and affect the environment.