Section 2: Sources of Energy

Types of Energy[1]

All the things we use every day to meet our needs and wants are provided through the use of natural resources.Natural resources are either renewable or nonrenewable.

Renewable resources are materials that can be replaced through natural and/or human processes.

Nonrenewable resources exist in fixed amounts within Earth and once they're used up, they are gone forever or it takes the planet an extreme amount of time to make them.

Energy is derived from natural resources. We use energy to light, heat, and cool our homes, offices, and factories. Energy powers the machines of industry and transportation. We depend on energy to help us manufacture the clothing we wear, the food we eat, the buildings in which we live and work, and even the systems we use to communicate.

For generations, our society has been enjoying the benefits of plentiful, inexpensive, and easily available energy—fossil fuels. But these fuels, such as coal, oil, and natural gas, are finite. As supplies have decreased and become more expensive to extract, the search has intensified for alternative energy sources (i.e., sources of energy other than fossil fuels).

Past studies and evidence suggest that every year about 28 to 30 million tons (25.4 to 27.2 million metric tons) of carbon go into the formation of new fossil sediments, yet humans are currently using about 6 to 8 billion tons (5.4 to 7.2 billion metric tons) of carbon per year. The rate of consumption is over 200 times the rate of deposition. Because of this, fossil fuels are limited and nonrenewable.

The most obvious and virtually limitless energy source is the natural fusion reactor which Earth revolves around in space—the sun. In terms of humankind's residence on Earth, the sun is an object that will last forever. It continuously radiates energy that makes life on our planet possible. Although Earth intercepts only a small fraction of the total energy emitted by the sun, the amount received is thousands of times the present energy requirement of the world's human population.

SECTION 2: Activities

- **Activity 6:** Solar Circuits (PG 45)
- **Activity 7:** Solar Oven (PG 49)
- **Activity 8:** Exploring Wind Energy (PG 51)

Other renewable energy sources include wind energy, hydroelectric energy, biomass energy, geothermal energy, and various forms of energy derived from the ocean. New ways and ideas to harness or use these renewable energy sources are continually being researched and developed.

Solar Electricity[2]

Solar cells, also called photovoltaic (PV) cells , convert sunlight directly into electricity. Solar cells are often used to power calculators and watches. They are made of semiconducting materials similar to those used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is called the PV effect.

Solar cells are typically combined into modules that hold about 40 cells. About 10 of these modules are mounted in PV arrays that can measure up to several meters on a side. These flat-plate PV arrays can be mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day. About 10 to 20 PV arrays can provide enough power for a household. For large electric utility or industrial applications, hundreds of arrays can be interconnected to form a single, large solar-electric system.

Thin-film solar cells use layers of semiconductor materials only a few micrometers thick. Thin-film technology has made it possible for solar cells to double as rooftop shingles, roof tiles, building facades, or the glazing for skylights or atria. The solar-cell version of items such as shingles offer the same protection and durability as ordinary asphalt shingles.

Some solar cells are designed to operate with concentrated sunlight. These cells are built into concentrating collectors that use a lens to focus the sunlight onto the cells. This approach has advantages and disadvantages compared with flat-plate PV arrays. The main idea is to use very little of the expensive semiconducting PV material while collecting as much sunlight as possible. But because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the world. Some concentrating collectors are designed to be mounted on simple tracking devices but most require sophisticated tracking devices, which further limit their use to electric utilities, industries, and large buildings.

The performance of a solar cell is measured in terms of its efficiency at turning sunlight into electricity. Only sunlight of certain intensities will work efficiently to create electricity, and most of the sunlight is reflected or absorbed by the materials that make up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%, which means that only about 15% of the sunlight striking the cell generates electricity. Photovoltaic arrays are large and expensive because of the low efficiency of solar cells. Improving solar cell efficiencies while holding down the cost per cell is an important goal of the PV industry. The industry has already come a long way. In the 1950s, the first solar cells had efficiencies of less than 4%.

Passive Solar[3]

Step outside on a hot and sunny summer day, and you'll feel the power of solar heat and light. Today many buildings are designed to take advantage of this natural resource through the use of passive solar heating and daylighting.

The south side of a building always receives the most sunlight. Therefore, buildings designed for passive solar heating usually have large, south-facing windows. Materials that absorb and store the sun's heat can be built into the sunlit floors and walls. The floors and walls will then heat up during the day and slowly release heat at night, when the heat is needed most. This passive solar design feature is called direct gain. Other passive solar heating design features include sunspaces and Trombe walls. A sunspace (which is much like a greenhouse) is built on the south side of a building. As sunlight passes through glass or other glazing, it warms the sunspace. Proper ventilation allows the heat to circulate into the building. Another passive solar feature is a Trombe wall, which is a thick, south-facing wall that is painted black and made of a material that absorbs a lot of heat. A pane of glass or plastic glazing, installed a few inches in front of the wall, helps hold in the heat. The wall heats up slowly during the day. Then as it cools gradually during the night, it gives off its heat inside the building.

Many of the passive solar heating design features also provide daylighting, which is simply the use of natural sunlight to brighten up a building's interior. To lighten up north-facing rooms and upper levels, a clerestory—a row of windows near the peak of the roof—is often used along with an open floor plan inside that allows the light to bounce throughout the building.

Of course, too much solar heating and day lighting can be a problem during the hot summer months. Fortunately, there are many design features that help keep passive solar buildings cool in the summer. For instance, overhangs can be designed to shade windows when the sun is high in the summer. Sunspaces can be closed off from the rest of the building. And a building can be designed to use fresh-air ventilation in the summer.

Advantages and Disadvantages of Solar Energy

Advantages of Solar[4]

- Photovoltaic (PV) technology is highly reliable and needs little maintenance. Many panels are warranted 20 years or more.
- Photovoltaic technology costs little to build and operate. As it costs increasingly less to produce and use, PV becomes more affordable and available.
- Few power-generation technologies have as little impact on the environment as solar energy. As it quietly generates electricity from light, PV produces no air pollution or hazardous waste. It doesn't require liquid or gaseous fuels to be transported or combusted. And because its energy source (sunlight) is free and abundant, solar-electric systems can guarantee access to electric power.
- Photovoltaic technology is produced domestically, which helps strengthen the U.S. economy and reduce our trade deficit.
- As a domestic source of electricity, solar contributes to the nation's energy security.

- As a relatively young, high-tech industry, the solar industry helps to create jobs and strengthen the economy.
- Photovoltaics are modular and thus flexible in terms of size and applications.
- Solar energy helps meet the demand and capacity challenges facing energy service providers.

Disadvantages of Solar

- Currently, there is a limited supply of materials to produce solar modules. This limited supply keeps the price of PV high.
- There is limited manufacturing of PV in relation to the growing demand for the technology.
- There are limited tax credits and incentives available to help offset the high cost of PV.
- Wide-spread use of solar power requires a shift in the fundamental structure of the U.S. energy supply.

Wind as Energy[5]

Wind is a form of kinetic energy created in part by the sun. About 2% of the sun's energy that reaches Earth is converted to wind energy. The atmosphere is heated during the day by the sun, and at night it cools by losing its heat to space. Wind is the reaction of the atmosphere to the heating and cooling cycles, as well as the Earth's rotation. Heat causes low pressure areas, and the cool of the night results in high pressure areas. This process creates wind as air flows from high pressure areas into low pressure areas. Wind flow patterns are modified by Earth's terrain, bodies of water, and vegetation. Humans use this wind flow, or motion energy, for many purposes such as sailing, flying a kite, and even generating electricity.

Wind energy has been used for hundreds of years. The windmills of Europe and Asia converted the kinetic energy of the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water), or a generator can convert this mechanical power into electricity.

So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Wind energy offers many advantages, which explains why it is one of the fastest-growing energy sources in the world. Research efforts are aimed at addressing the challenges to greater use of wind energy.

Advantages and Disadvantages of Wind Energy[6]

Advantages of Wind Energy

- Wind energy is fueled by the wind, so it's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas. Wind turbines don't produce atmospheric emissions that cause acid rain or greenhouse gasses.
- Wind energy is a domestic source of energy, produced in the United States. The nation's wind supply is abundant.
- Wind energy relies on the renewable power of the wind, which can't be used up.
- Wind energy is one of the lowest-priced renewable energy technologies available today, costing between four and six cents per kilowatt-hour, depending upon the wind resource and project financing of the particular project.
- Wind turbines can be built on farms or ranches, thus benefiting the economy in rural areas, where most of the best wind sites are found. Farmers and ranchers can continue to work the land because the wind turbines use only a fraction of the land. Wind power-plant owners make rent payments to the farmer or rancher for the use of the land.

Disadvantages of Wind Energy

- Wind power must compete with conventional generation sources on a cost basis. Depending on how energetic a wind site is, the wind farm may or may not be cost competitive. Even though the cost of wind power has decreased dramatically in the past 10 years, the technology requires a higher initial investment than fossil-fueled generators.
- The major challenge to using wind as a source of power is that the wind is intermittent and it does not always blow when electricity is needed. Wind energy cannot be stored (unless batteries are used), and not all winds can be harnessed to meet the timing of electricity demands.
- Good wind sites are often located in remote locations, far from cities where the electricity is needed.
- Wind resource development may compete with other uses for the land, and those alternative uses may be more highly valued than electricity generation.
- Although wind power plants have relatively little impact on the environment compared to other conventional power plants, there is some concern over the noise produced by the rotor blades, aesthetic (visual) impacts, and the impact on wildlife (such as birds and bats) that are sometimes killed by wind rotors. Most of these problems can be resolved or greatly reduced through technological development or by properly situating wind plants.

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1 Text for *Types of Energy* was adopted from the National Energy Foundation.
2 Text for *Solar Electricity* was adopted from National Renewable Energy Laboratory.
3 Text for *Passive Solar* was adopted from the National Renewable Energy Laboratory.
4 Text for *Advantages of Solar* was adopted from the Department of Energy.
5 Text for *Wind Energy* was adapted from National Energy Foundation.
6 Text from *Advantages and Disadvantages of Wind Energy* was adapted from the Department of Energy.