What is Energy?

Energy is the ability to do work. Your body uses energy when you jog, ride your skateboard or bicycle, or play games. A car uses energy when it takes us from one place to another. Energy provides much more than movement, though. It can also provide light, heat, and sound. In a large concert hall, all three of these forms of energy would be present. Energy is contained in all kinds of matter and can be converted from one form to another.

Work and Power

In our daily lives, we usually think of work as a job where people go to earn a living or sometimes as a task to be completed. In engineering and physics, however, work has a very different meaning. We define work as the transfer of energy from one physical system to another. Work causes movement (including movement caused by motors). Work is done only if the "push" actually moves the object. Work is directly related to energy and is often the visible result you see. Usually you cannot see energy, but you can see the result of energy when it does work.

We measure work by how far an object moved and how much force it took to move it (figure 1). Mathematically, we calculate work by multiplying the force times the distance the object traveled (work = force X distance). The formula is: W = F X d.

We use the term power to describe how much work has been or could be done in a certain amount of time. Power is the mathematical description of how much work is done. We calculate power by dividing work by time (power = work/time). The formula is: P = W/t

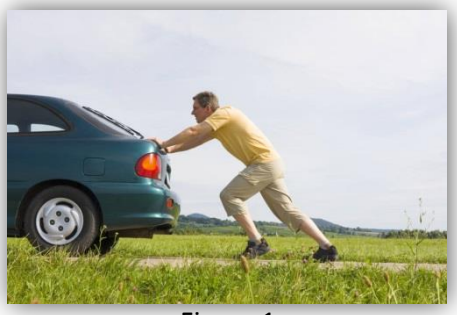

Figure 1

Horsepower is one common unit for measuring mechanical power in the US customary system of measurement. This unit is based on the fact that an average horse could lift a 550lbs weight one foot in one second. If you were to experiment with some weights (under adult supervision by a trained professional), you would find that an average teenager in good condition can produce on about .1-.2 horsepower for several minutes.

Why Study Energy?

Learning about energy is important because it is incorporated into the design of so many devices and products we use today. We would not be able to use any of the wonderful technological devices that we now enjoy without energy. Energy literally powers almost everything we depend on for both survival and recreation. Sources of energy are an important part of our economy and national security.

Some sources of energy are in limited supply and may be depleted in the near future if carelessly wasted. The conservation of energy into more usable forms of energy or power often produces negative consequences such as pollution. We should not waste energy; we should conserve it and use it wisely. Responsible citizens should understand not only the importance of conserving energy, but also that using energy sometimes has negative impacts.

Sources of Energy

We can classify energy sources as exhaustible, renewable, or inexhaustible. We explain each source in the following sections. The sun is the greatest source of energy, and many forms of energy we use today can be traced back to the sun. For example, fossil fuels (oil, coal, and natural gas) are the result of plants and animals such as dinosaurs that lived long ago. They depended on the sun for their survival, just as we do today.

Exhaustible Energy:

Fossil fuels are the primary sources of exhaustible energy. We call them exhaustible because we cannot replace them when they are used up - at least not for a million years. Thus, this source of energy is in limited

supply. Our readily available supply of oil could potentially be used up in your lifetime (current estimates are about 40 years) if we do not practice energy conservation.

Exhaustible energy sources currently provide more than 85% of all the energy consumed in the United States. We depend on foreign countries to provide most of our oil, and these countries could reduce or eliminate our supply of oil at any time. This poses a potential threat to national security. We use oil not only as an energy source, but also as a critical component in making plastics. A reduction in the supply of oil could have a disastrous effect on our economy and on our ability to protect ourselves.

We convert fossil fuels into usable energy through combustion, or burning. Burning fossil fuels produce air pollution. The resultants of this air pollution include acid rain, which kills plants and forests; lung cancer in humans; and the destruction of the ozone layer, which protects our planet from the sun's rays.

Renewable Energy:

Renewable energy is energy that can be replaced. Examples of renewable energy sources include ethanol, hydrogen, and biomass. Generally, these energy sources are less pollution than nonrenewable energy sources. Renewable energy sources will become increasingly important in the future. Renewable energy sources are vital to our economy and our national security. We can use plants such as corn, soy beans, seaweed, and sugarcane to make ethanol (a substitute for gasoline). We call this type of energy biomass. The term also refers to living or recently dead biological material that can be used as fuel.

Hydrogen fuel can be used to power cars as an alternative to fossil fuels. Hydrogen fuel is generated by separating water into hydrogen and oxygen through a process called electrolysis. Solar or wind energy can generate the electricity needed for electrolysis.

Inexhaustible Energy:

Inexhaustible energy is an energy source that cannot be used up, for example, solar, wind, water, and geothermal. The sources are absolutely critical to our future and the Earth's environment. The responsible use and management of natural resources is called sustainability. Sustainability means that we design engineering solutions with our future and the environment in mind.

The sun is the ultimate source of all renewable energy on Earth. We can capture solar energy, energy from the sun, in many different ways. We use a very small amount of the available solar energy that reaches Earth. Many houses take advantage of passive solar heating, in which the sun's energy passes through windows and is absorbed by stone, slate, or other materials in the house. This heat is drawn out of the air when the temperatures are cooler. This is not a new process, as humans have used this principle for thousands of years.

Active solar heating is more efficient and involves a liquid circulating through tubes. The tubes are typically encased in a box under glass and mounted on a roof. As the liquid is heated, it circulates through the pipes to heat the water or the entire house.

A photovoltaic cell (figure 2) is a device that converts the sun's energy into electricity. We can group photovoltaic cells together in an array. The cells are grouped together because individual cells do not produce enough electricity to be useful. We can combine one or more arrays with batteries to store the electricity generated by the photovoltaic cells. We use photovoltaic to power emergency phones along highways, satellites, the International Space Station, private house, and even solar cars!


Figure 2

Wind is another inexhaustible energy source. Humans have used wind energy for thousands of years. You have probably see windmills on farms that were used to draw water from the ground. We can also use wind power to power large generators that create electricity. A turbine is a device that produces electricity from rotary motion. The wind possesses mechanical energy by virtue of motion. The generator produces an electrical current. Often dozens or even hundreds of large wind turbines are placed together on wind farms, which are located in places with strong and frequent winds (figure 3).

Figure 3

The United States receives only 1% of its total electricity from wind. Denmark, Spain, and Germany on the other hand, are approaching 10% of their electrical energy from wind. Using more wind energy would benefit the environment because wind does not produce any pollution or hazardous waste. It is also readily available without mining or drilling, is not radioactive, and does not require the transportations of dangerous substances.

Water is another energy source that people have been using for thousands of years. Water turned large waterwheels to power machines and tools during the Industrial Revolution. Before that, waterwheels powered mills to crush corn and grains into meal. Today we use the force of falling water to turn giant turbines to create electricity, similar to how wind turns turbines. We called electricity generated from water hydroelectricity.

Hydroelectric power plants are located inside dams. Dams serve three valuable purposes: 1- They control flooding to protect people and farms, 2- They produce hydroelectricity, and 3- the reservoirs behind the dams provide recreational areas for boating and fishing.

Hydroelectricity is produced by using the force of falling water. The dam raises the level or the water and actually increases the water's potential energy. The water falls with greater force through pipes in the dam to turn turbines and power the giant generators (figure 4).

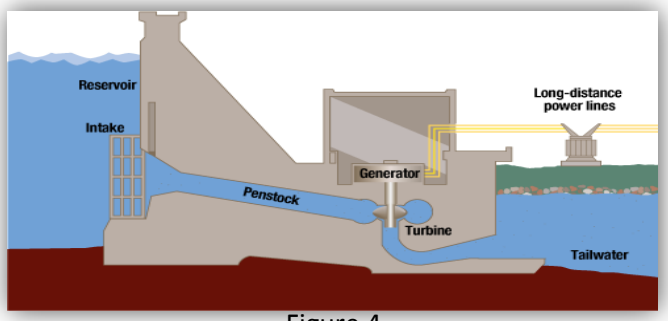

Figure 4

Geothermal energy is the energy stored in the Earth in the form of heat. A layer of rock, called the mantle, lies deep within the Earth. The molten outer core superheats the mantle. Any water that seeps into the mantle turns to steam which increases its volume and pressure. This eventually causes the steam to escape through cracks in the Earth. We find this steam and hot water in geysers and natural hot springs. We can use this steam to heat houses and buildings.

Iceland is a world leader in using geothermal energy to heat houses, businesses, and government buildings. We do not have to wait for water to naturally seep into the mantle to produce steam. We can pump water deep into the Earth through pipes, turning it into steam that can rise to the surface through another set of pipes. We can also use the superheated steam to power large steam turbine generators to produce electricity.