

ENERGY AND ENERGY TRANSFORMATIONS

The scientific definition of energy is ‘the ability to do work’.

The four most common forms of energy are:

- **chemical** - potential or stored energy stored in chemicals, released when the chemicals react.
- **electrical** - energy of charged particles, transferred when they travel from place to place.
- **mechanical** - energy possessed by an object because of its motion or its potential to move.
- **thermal** - kinetic energy of a substance



KINETIC ENERGY	POTENTIAL ENERGY
<p>Kinetic energy is motion—of waves, electrons, atoms, molecules, substances, and objects.</p>	<p>Potential energy is stored energy and the energy of position—gravitational energy.</p>
<p>Electrical Energy is the movement of electrical charges. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrical charges moving through a wire is called electricity. Lightning is another example of electrical energy.</p> <p>Radiant Energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.</p> <p>Thermal Energy, or heat, is the internal energy in substances—the vibration and movement of the atoms and molecules within substances. Geothermal energy is an example of thermal energy.</p> <p>Motion Energy is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to Newton’s Laws of Motion. Wind is an example of motion energy.</p> <p>Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate—the energy is transferred through the substance in a wave.</p>	<p>Chemical Energy is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.</p> <p>Stored Mechanical Energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.</p> <p>Nuclear Energy is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of hydrogen atoms in a process called fusion. Scientists are working on creating fusion energy on earth, so that someday there might be fusion power plants.</p> <p>Gravitational Energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.</p>

LAW of CONSERVATION of ENERGY

Energy can neither be created nor destroyed but it can be transformed from one form to another

Energy Conversions

Energy can be changed from one form into other forms. This is called energy conversion. People have invented ingenious ways of converting one form of energy into other useful forms. Throwing a rock transforms chemical energy in your body into mechanical energy. Starting a fire is a way of converting chemical energy into light and heat. A steam engine is a more complex machine. It converts heat energy into motion. In an electric generator, motion is converted into electrical energy. In all energy conversions, the useful energy output is always less than the energy input, with some energy being wasted as heat.

INPUT Energy	Mechanical Device	OUTPUT Energy
Thermal	Thermocouple	Electrical
Thermal	Steam Engine	Mechanical
Thermal		Chemical
Electrical	Toaster, Heater	Thermal
Electrical	Blender, Motor	Mechanical
Electrical	Rechargeable Battery	Chemical
Mechanical	Any mechanical device that creates friction	Thermal
Mechanical	Van de Graff Generator Wind Turbine	Electrical
Chemical	Gas Heater/Stove	Thermal
Chemical	Flashlight (Battery)	Electrical
Chemical		Mechanical
Light	Solar Panel	Electrical
Sound	Piezoelectric lighter	Electrical
Gravitational Potential Energy	Hydroelectric (Waterfall) Turbine	Mechanical Kinetic Energy

The human body is like a machine designed to convert the chemical energy contained in food into mechanical energy evidenced by movement of our limbs. Food gives up its chemical energy to produce heat energy (body temperature) and mechanical energy (muscle power). Batteries turn chemical energy directly into electrical energy. Chemical energy in wood and fossil fuels turns into heat and light energy when it is burned. One of the many ways we can make electrical energy is through one-step conversions, such as mechanical to electrical. For this, you need a machine called a generator. You can use your mechanical energy (muscle power) to turn the crank connected to an electrical generator to make electricity. A windmill captures the mechanical energy of wind to turn a generator. Falling water can turn a waterwheel which is connected to a generator.

Electricity and Heat

A thermocouple is a device that can convert thermal energy into electrical energy. It consists of two different metals (bimetal) joined together that conduct heat at slightly different rates. When heated, the difference in conduction results in electricity flowing from one metal to the other.

The basic principle of the thermocouple was discovered by Thomas Johann Seebeck in 1821, and was named the **Seebeck Effect**. Thermocouples are useful for measuring temperatures in areas that are difficult to access or too hot for a regular liquid-filled thermometer. Ovens and heaters do the opposite. They convert electrical energy into thermal energy.

A thermo-electric generator is a device based on a thermocouple that converts heat directly into electricity without moving parts. Several thermocouples connected in a series is called a thermopile. Thermopiles are extremely reliable, low-maintenance devices and are often used in remote locations for emergency power generation.

Electricity to Motion

The piezoelectric effect produces sound by converting electricity into motion (vibrations). When a piezoelectric crystal, such as quartz, or Rochelle salt is connected to a potential difference, the crystal expands or contracts slightly. Material touching the crystal experiences pressure, creating sound waves or vibrations.

Motion to Electricity

A barbeque spark lighter uses the piezoelectric effect in reverse. When a crystal or Rochelle salt is compressed or pulled, a potential difference is built up on the opposite sides of the crystal. Conductors then take this through a circuit to produce electric energy (a spark).

Electricity to Light

An incandescent resistance filament (load) glows white-hot when electricity is passed through it. In fluorescent tubes a gas glows brightly and when crystals are struck together they can produce light. LED's (light-emitting diodes) are solid –state components that use a fraction of the power. When connected to a semiconductor chip in the right direction, they will produce light and last for many years.

Light to Electricity

Solar panels, containing photovoltaic cells can convert light into electrical energy. The photovoltaic (PV) cells, or solar cells, are made of semiconductor materials, such as silicon. When light is present, the material, breaking electrons loose – allowing them to flow freely, absorbs some. This current is drawn off by metal contacts on the top and bottom of the cell and then used in devices such as calculators, heater, or emergency telephones. Individual solar cells are combined in modules, to form arrays to produce larger amounts of electric current.

Certain animals, namely, the electric eel, can produce electric shock, to kill or stun prey. They have a special organ that contains specialized muscle cells called electroplaques. Each cell produces a small amount of electricity. When all the cells work together, a large amount of electricity is produced and used to help the eel survive. This type of electricity is like static electricity, which builds up and then discharges.

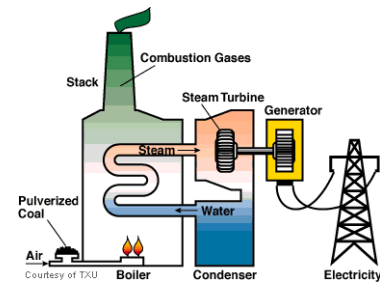
ELECTRICAL PRODUCTION

The US ranks 15th in electrical energy consumption worldwide. To generate the amount of electricity needed for consumers is a massive undertaking and can affect the environment.

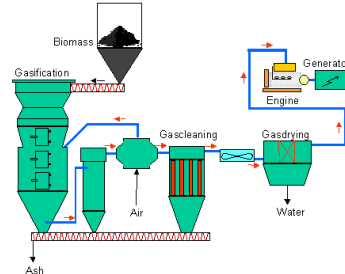
Energy from Burning Fuels

Fuel oil, natural gas, and coal are used in large **thermo-electric** generating plants to produce roughly 25% of America's electrical energy needs.

Coal is mined, crushed into a powder, blown into a combustion chamber and burned to release heat. This heat boils water and superheats the resulting steam to a high temperature and pressure, which then turns a turbine. The turbine shaft rotates large electromagnetic coils in the generator to produce electricity.



These fossil fuels are **non-renewable** resources – eventually they will be gone.



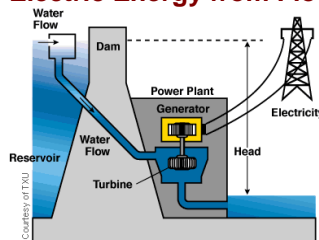
Biomass, solid material from living things, is also burned to power these thermo-electric generators.

Biomass is a **renewable** resource.

Fossil Fuels Affect Land and Air

Coal is mined in **open pits**, are an eyesore, and disturb topsoil and vegetation. **Underground** mines produce 'tailings' which accumulate near the mine. Water seeps through these tailings and becomes acidic and contaminated. Fossil fuel reserves are decreasing, but with less reliance on these fuels we will be able to see a decrease in pollution. The burning of these fuels creates contaminants such as visible particles and invisible gases (SO_2 is one such gas). **Electrostatic precipitators** can remove most of the solid particles, but not the gases. Sulfur dioxide can be reduced by using **scrubbers** – which spray a water solution through the gas, making sulfuric acid, which is then collected and sold. Another gas produced is carbon dioxide CO_2 which is a greenhouse gas. Producing more of this naturally occurring gas helps the atmosphere trap more heat, leading to global warming. Some generating plants are switching to natural gas which burns a little cleaner. Finding ways to lower our dependence on fossil fuels and finding alternative fuel sources is a decision that will determine much of what our future environment will be like.

Electric Energy from Flowing Rivers



Hydro-electric plants use falling water (gravity), and pressure to generate electricity. Large dams raise the water above the power plant (which is usually built inside the dam), near the base.

A channel, called a **penstock**, directs the water (at high pressure) to a **turbine**. The turbine then converts mechanical energy to electrical energy.

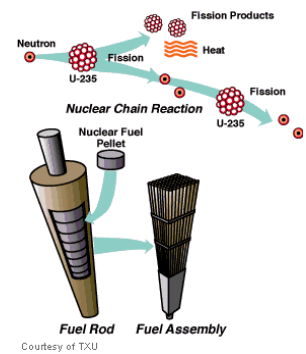
Although these hydro-electric plants appear to be doing no harm to the environment, the reservoir they have to create behind the dam, destroys habitat and displaces whoever lived in the area prior to the reservoir being created. When the submerged vegetation is decomposed, bacteria take up the oxygen supply in the water, methane gas can be produced, and aquatic species – such as fish, are affected when the oxygen levels drop. Other species take over and a new ecosystem can be created.

Energy from Atomic Reactions

Bombarding uranium atoms with tiny particles, called neutrons cause the uranium to split into two smaller atoms.

This is called **nuclear fission**.

The process creates a huge amount of energy which is used to generate electricity in a **thermonuclear** plant.



Heating the Environment

All thermonuclear and thermo-electric-generating plants release thermal energy into the environment. 43% of the water used in the cooling process enters the environment. **Thermal pollution** occurs when this heated water is not cooled before it re-enters the water system. This overheated water can upset the life cycles of organisms in the water and be fatal because they cannot tolerate the sudden temperature change. The heated water also contains less oxygen. To reduce this type of pollution, plants are required to have holding ponds or towers which hold the water until it returns to normal levels.

Cogeneration

Cogeneration is the dual generation of electrical and thermal energy. Cogeneration systems usually are associated with industries, or commercial complexes. A cogeneration plant provides electricity and heat or steam to the industry and may even sell excess electricity to the local or regional power grid. Cogeneration plants produce about 8 percent of all energy in the U.S. Implementation of this type of energy generation is left up to individual states, resulting in little or nothing being done in many parts of the country.

Alternative Energy Sources



Wind - this energy is harnessed by large propeller-type blades, which turn a shaft - connected to a generator.



Sunlight - Solar cells (made from silicon) enable the energy from the sun to be transformed (photoelectric effect) into electricity.



Geothermal - Heat from the Earth's core can also be used to generate electricity. This geothermal energy (hot water and steam) is channeled through pipes to drive turbines - connected to generators, which produce the electricity.



Tides - moving water can power turbines, which then run generators. When the tide comes in, the water is trapped in large reservoirs and then allowed to flow out past turbines.

Renewable resources like these alternative sources of energy can be replenished over and over again. Tree harvesting can also be renewed, but it takes a much longer period of time to renew this resource. They can also negatively affect the environment: Dams, wind farms and solar cell arrays can destroy large areas of ecological habitat; Tidal power plants can disrupt the habitat of fish and other marine life.