Introduction to Energy

What is Energy?

Energy makes change; it does things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work.

Forms of Energy

Energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.

POTENTIAL ENERGY

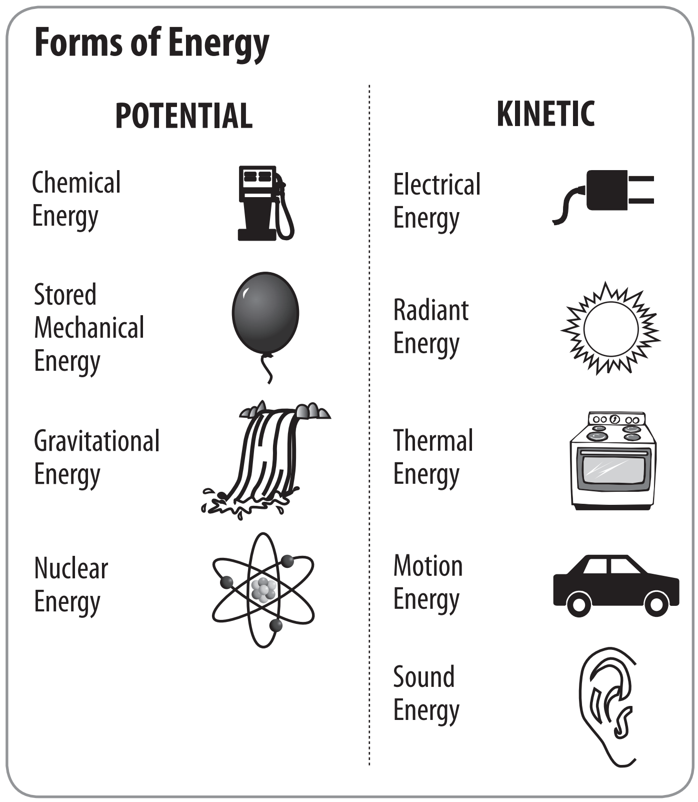
Potential energy is stored energy and the energy of position, or gravitational energy. There are several forms of potential energy.

- **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.
- **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.
- **Nuclear energy** is energy stored in the nucleus of an atom; it is 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**.
- **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.

KINETIC ENERGY

Kinetic energy is motion; it is the motion of waves, electrons, atoms, molecules, substances, and objects.

- **Electrical energy** is the movement of electrons. 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. Electrons moving through a wire is called circuit electricity. Lightning is another example of electrical energy.
- **Radiant energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Solar energy is an example of radiant energy.
- **Thermal energy**, or heat, is the internal energy in substances; it is the vibration and movement of the atoms and molecules within substances. The more thermal energy in a substance, the faster the atoms and molecules vibrate and move. Geothermal energy is an example of thermal energy.
- **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.
- **Sound energy** 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 longitudinal wave.



Conservation of Energy

To scientists, **conservation of energy** is not saving energy. The law of conservation of energy says that energy is neither created nor destroyed. When we use energy, it doesn't disappear. We change it from one form of energy into another.

A car engine burns gasoline, converting the chemical energy in gasoline into motion energy. Solar cells change radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe stays the same.

Efficiency

Efficiency is the amount of useful energy you get from a system. A perfect, energy efficient machine would change all the energy put in it into useful work—a technological impossibility today. Converting one form of energy into another form always involves a loss of usable energy.

Most energy transformations are not very efficient. The human body is a good example. Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think.

Your body isn't very efficient at converting food into useful work. Your body's overall efficiency is about 15 percent most of the time. The rest of the energy is transformed into heat. You can really feel that heat when you exercise!

Sources of Energy

We use many different energy sources to do work for us. They are classified into two groups—renewable and nonrenewable.

In the United States, most of our energy comes from **nonrenewable** energy sources. Coal, petroleum, natural gas, propane, and uranium are nonrenewable energy sources. They are used to make electricity, heat our homes, move our cars, and manufacture all kinds of products. These energy sources are called nonrenewable because their supplies are limited. Petroleum, for example, was formed millions of years ago from the remains of ancient sea plants and animals. We can't make more crude oil deposits in a short time.

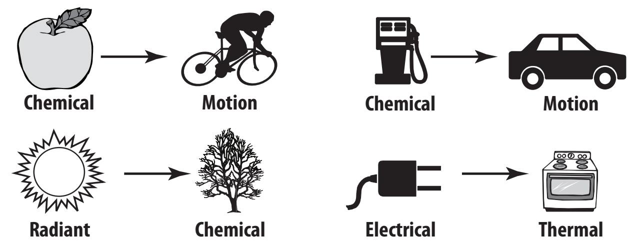
Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Electricity

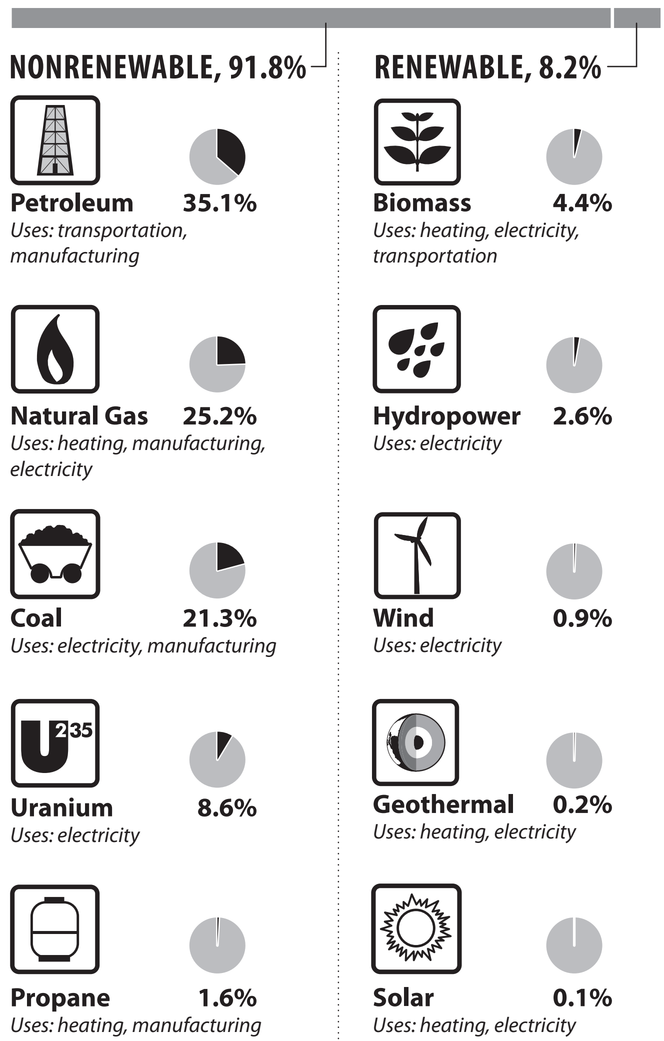
Electricity is different from the other energy sources because it is a secondary source of energy. We must use another energy source to produce electricity. In the U.S., coal is the number one energy source used for generating electricity.

Electricity is sometimes called an **energy carrier** because it is an efficient and safe way to move energy from one place to another, and it can be used for so many tasks. As we use more technology, the demand for electricity grows.

Energy Transformations



U.S. Energy Consumption by Source, 2010



Data: Energy Information Administration

Physical and Chemical Properties

All substances have properties that we can use to identify them. For example we can identify a person by their face, their voice, height, finger prints, DNA etc.. The more of these properties that we can identify, the better we know the person. In a similar way matter has properties - and there are many of them. There are two basic types of properties that we can associate with matter. These properties are called **Physical** properties and **Chemical** properties:

Physical properties:	Properties that do not change the chemical nature of matter
Chemical properties:	Properties that do change tha chemical nature of matter

Examples of physical properties are: colour, smell, freezing point, boiling point, melting point, infra-red spectrum, attraction (paramagnetic) or repulsion (diamagnetic) to magnets, opacity, viscosity and density. There are many more examples. Note that measuring each of these properties will not alter the basic nature of the substance.

Examples of chemical properties are: heat of combustion, reactivity with water, PH, and electromotive force.

The more properties we can identify for a substance, the better we know the nature of that substance. These properties can then help us model the substance and thus understand how this substance will behave under various conditions.

Physical and Chemical Properties of Matter

We are all surrounded by matter on a daily basis. Anything that we use, touch, eat, etc. is an example of matter. Matter can be defined or described as anything that takes up space, and it is composed of miniscule particles called atoms. It must display the two properties of mass and inertia.

Introduction

The different types of matter can be distinguished through two components: composition and properties. The composition of matter refers to the different components of matter along with their relative proportions. The properties of matter refer to the qualities/attributes that distinguish one sample of matter from another. These properties are generally grouped into two categories: physical or chemical.

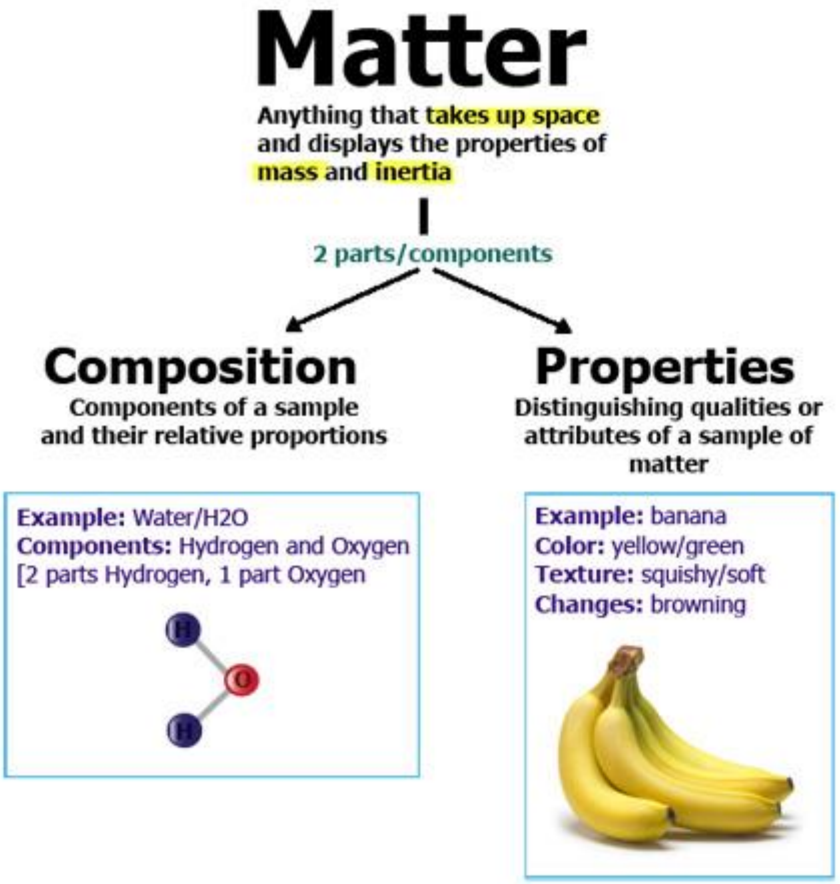


Figure 1: Visual With Examples. Content from S.M.

Physical (Properties and Changes)

Physical Property

A physical property is one that is displayed without any change in composition. (Intensive or Extensive)

1. **Intensive**: A physical property that will be the same regardless of the amount of matter.

- Density: m/v
- Colour: The pigment or shade
- Conductivity: electricity to flow through the substance
- Malleability: if a substance can be flattened
- Lustre: how shiny the substance looks

2. **Extensive**: A physical property that will change if the amount of matter changes.

- Mass: how much matter in the sample
- Volume: How much space the sample takes up
- Length: How long the sample is

Physical Change

Change in which the matter's physical appearance is altered, but composition remains unchanged. (Change in state of matter)

- Three main states of matter are: Solid, Liquid, Gas
  - Solid is distinguished by a fixed structure. Its shape and volume do not change. In a solid, atoms are tightly packed together in a fixed arrangement.
  - Liquid is distinguished by its malleable shape (is able to form into the shape of its container), but constant volume. In a liquid, atoms are close together but not in a fixed arrangement.
  - Gas is made up of atoms that are separate. However, unlike solid & liquid, a gas has no fixed shape and volume.

Example: When liquid water (H_2O) freezes into a solid state (ice) -- It appears different/changed; However, the composition is still: 11.19% hydrogen and 88.81% oxygen by mass.

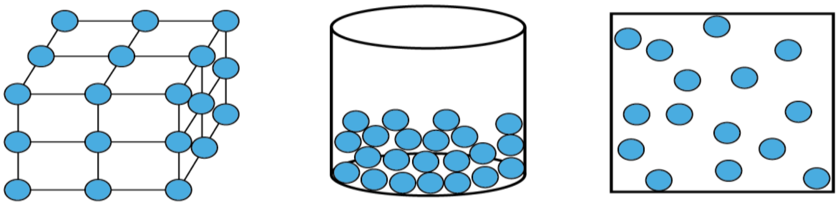


Figure 2: States of Matter

Chemical (Properties and Changes)

Chemical Property: Any characteristic that gives a sample of matter the ability/inability to undergo a change that alters its composition.

Examples: Alkali metals react with water; Paper's ability to burn.

Chemical Change: Change in which one or more kinds of matter are transformed to new kinds of matter with altered compositions.

(Or Chemical Reaction):
Examples:

- Magnesium + Oxygen → Magnesium Oxide or $2\ Mg + O_2 \rightarrow 2\ MgO$
- Iron + Oxygen → Iron Oxide/ Rust or $2\ Fe + 3\ O_2 \rightarrow Fe_2O_3$

[*With higher knowledge of these different properties and changes, we receive a better understanding of the nature of different samples of matter that exist. Using the components of composition and properties, we have the ability to distinguish one sample of matter from the others.*]

Example Problems

1. Milk turns sour. This is a ________________

- Chemical Change
- Physical Change
- Chemical Property
- Physical Property
- None of the above

2. HCl being a strong acid is a __________, Wood sawed in two is ___________

- Chemical Change, Physical Change
- Physical Change, Chemical Change
- Chemical Property, Physical Change
- Physical Property, Chemical Change
- None of the above

3. $CuSO_4$ is dissolved in water

- Chemical Change
- Physical Change
- Chemical Property
- Physical Property
- None of the above

4. Aluminium Phosphate has a density of 2.566 g/cm3

- Chemical Change
- Physical Change
- Chemical Property
- Physical Property
- None of the above

5. Which of the following are examples of matter?

- A Dog
- Carbon Dioxide
- Ice Cubes
- copper (II) nitrate
- A Moving Car

6. The formation of gas bubbles is a sign of what type of change?

7. True or False: Bread rising is a physical property.

8. True or False: Dicing potatoes is a physical change.

9. Is sunlight matter?

10. The mass of lead is a _____________property.

~~Answers:1)chemical change 2)chemical property, physical change 3) physical change 4)physical property 5)All of the above 6) chemical 7) False 8) True 9) No 10) physical property~~

Physical and Chemical Properties

Physical properties are those that can be observed without changing the identity of the substance. The general properties of matter such as colour, density, hardness, are examples of physical properties. Properties that describe how a substance changes into a completely different substance are called chemical properties. Flammability and corrosion/oxidation resistance are examples of chemical properties.

Question: What is the difference B/w a Chemical property & Physical property?

A **Physical property**; is an aspect of matter that can be observed or measured without changing it. Examples of this property include: Colour, Molecular weight & volume.

A **Chemical property**: may only be observed by changing the chemical identity of a substance. This property measures the potential for undergoing a chemical change. Examples of this property include: reactivity, flammability & oxidation states.

The difference between a physical and chemical property is straightforward until the phase of the material is considered. When a material changes from a solid to a liquid to a vapour it seems like them become a difference substance. However, when a material melts, solidifies, vaporizes, condenses or sublimes, only the state of the substance changes. Consider ice, liquid water, and water vapour, they are all simply H_2O. Phase is a physical property of matter and matter can exist in four phases – solid, liquid, gas and plasma.

Some of the more important physical and chemical properties from an engineering material standpoint will be discussed in the following sections.

- Phase Transformation Temperatures
- Density
- Specific Gravity
- Thermal Conductivity
- Linear Coefficient of Thermal Expansion
- Electrical Conductivity and Resistivity
- Magnetic Permeability
- Corrosion Resistance

Resource: Prof. N. De Leon
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