

Energy is the ability to do work. Energy is a scalar quantity, having no direction in space. It comes in different forms - heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy. Energy is in everything. We use energy to do everything we do, from making a jump shot to baking our favorite cookies to sending astronauts into space - energy is there, making sure we have the power to do it all. There are two types of energy - stored energy (*potential*) and working energy (*kinetic*). For example, the food you eat contains chemical energy, and your body stores this energy until you release it when you work or play.

Forms of energy – All forms of energy fall under two categories:

Potential:

Potential energy is stored energy and the energy of position (gravitational)

Chemical energy – Chemical energy is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane and coal are examples of stored chemical energy.

Nuclear energy – Nuclear energy is the energy stored in the nucleus of an atom – the energy that holds the nucleus together. The nucleus of a uranium atom is an example of nuclear energy.

Stored mechanical 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.

Gravitation energy – Gravitational energy is the energy of place or position. Water in a reservoir behind a hydropower dam is an example of gravitational potential energy. When the water is released to spin the turbines, it becomes motion energy.

Kinetic:

Kinetic energy is motion – the motion of waves, electrons, atoms, molecules and substances

Radiant 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 – Thermal energy (or heat) is the internal energy in substances – the vibration and movement of atoms and molecules within substances. Geothermal energy is an example of thermal energy.

Motion – The movement of objects or substances from one place to another is motion. Wind and hydropower are examples of motion.

Sound – Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

Electrical energy – Electrical energy is the movement of electrons. Lightning and electricity are examples of electrical energy.

Heat Transfer Mechanisms

Heat transfer mechanisms can be grouped into 3 broad categories:

Conduction:

Regions with greater molecular kinetic energy will pass their thermal energy to regions with less molecular energy through direct molecular collisions, a process known as conduction. In metals, a significant portion of the transported thermal energy is also carried by conduction-band electrons.

Convection:

When heat conducts into a static fluid it leads to a local volumetric expansion. As a result of gravity-induced pressure gradients, the expanded fluid parcel becomes buoyant and displaces, thereby transporting heat by fluid motion (i.e. convection) in addition to conduction. Such heat-induced fluid motion in initially static fluids is known as *free convection*.

For cases where the fluid is already in motion, heat conducted into the fluid will be transported away chiefly by fluid convection. These cases, known as *forced convection*, require a pressure gradient to drive the fluid motion, as opposed to a gravity gradient to induce motion through buoyancy.

Radiation:

All materials radiate thermal energy in amounts determined by their temperature, where the energy is carried by photons of light in the infrared and visible portions of the electromagnetic spectrum. When temperatures are uniform, the radiative flux between objects is in equilibrium and no net thermal energy is exchanged. The balance is upset when temperatures are not uniform, and thermal energy is transported from surfaces of higher to surfaces of lower temperature.

Transformations of energy

One form of energy can often be easily transformed into another with the help of a device—for instance, a battery, from chemical energy to electrical energy; a dam: gravitational potential energy to kinetic energy of moving water (and the blades of a turbine) and ultimately to electric energy through an electrical generator. Similarly, in the case of a chemical explosion, chemical potential energy is transformed to kinetic energy and thermal energy in a very short time.

Energy can be converted into matter and vice versa. The equation $E = m \cdot c^2$, derived independently by Albert Einstein and Henri Poincaré quantifies the relationship between mass and rest energy. Since c^2 is very large relative to ordinary human scales, the conversion of mass to other forms of energy can liberate giant amounts of energy, as can be seen in nuclear reactors and nuclear weapons. Conversely, the mass equivalent of a unit of energy is very small, which is why loss of energy from most systems is difficult to measure by weight, unless the energy loss is very large.

Energy conversion is any process of converting energy from one form to another. Energy found in fossil fuels, solar radiation, or nuclear fuels needs to be converted into other energy forms such as electrical, propulsive, or heating to be useful. Often, machines are used to convert energy from one form to another. The efficiency of a machine characterizes how well (how efficiently) it can perform such a conversion.

Energy may be converted so that it may be used by other machines, or else to provide some service to society (such as *heat*, *light*, or *motion*). For example, an internal combustion engine converts the potential chemical energy in gasoline and oxygen into the propulsive energy that moves a vehicle. A solar cell converts solar radiation into electrical energy that can then be used to light a bulb or power a computer. The generic name for a device which converts energy from one form to another is transducer.

Energy conversion machines:

- Fuel cells
- Geothermal power
- Heat engines, such as the internal combustion engine used in cars or the steam engine
- Hydroelectric dams
- Jet engine
- Nuclear reactor
- Nuclear fusion
- Ocean thermal power
- Solar cells
- Solar thermal
- Steam engine
- Wave power
- Windmills
- Piezoelectrics
- Dielectric materials

Heat equation

The heat equation is an important partial differential equation which describes the variation of temperature in a given region over time.

When we consider surrounding with some properties (non-insulated thermodynamic system), where is possible heat transfer by every form of heat transfer (conduction, convection, radiation) and every this form can be changed, then following differential equation is definition of this unsteady process:

$$\frac{\partial}{\partial t}(w_u + w_k + w_p + w_r) + \text{div}(\mathbf{q}_v + \mathbf{q}_k + \mathbf{q}_r) = q_z \quad [\text{W}\cdot\text{m}^{-3}] \quad (1)$$

Where the first term of (1) represents time dependence of particular energy forms in surrounding, that is expressed by its energy volume densities:

• internal energy density $w_u = \mathbf{r} \cdot \mathbf{c} \cdot \mathbf{J} \quad [\text{J}\cdot\text{m}^{-3}] \quad (2)$

• kinetic energy density $w_k = \frac{1}{2} \cdot \mathbf{r} \cdot \mathbf{v}^2 \quad (3)$

• potential energy density $w_p = \sum_{i=1}^n \mathbf{r}_i \cdot w_{pi} \quad (4)$

• radiant energy density $w_r \quad [\text{J}\cdot\text{m}^{-3}] \quad (5)$

The second term represents energy fluxes into or from surrounding by conduction, convection and radiation, expressed by their densities.

And the third term q_z [$\text{W}\cdot\text{m}^{-3}$] is power density of internal source, if it exists in surrounding.

Equation (1) represents energetic balance of surrounding that is in interaction with surrounding (law of conservation of energy in thermodynamic non-insulated system). This equation is also known as a general differential equation of energy propagation in various surroundings.