

BEYOND

SMART CITIES

ENERGY SAVINGS PERFORMANCE AND
MEASUREMENT & VERIFICATION
ONLINE TRAINING COURSE

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BASICS OF ENERGY AND ITS VARIOUS FORMS
FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN

Electricity basics - DC & AC
currents

Electricity tariff

Load management and
Maximum demand control

Power factor

INTRODUCTION

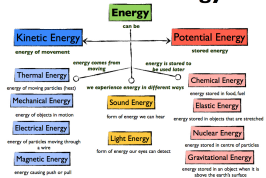
Energy is the ability to do work and work is the transfer of energy from one form to another. In practical terms, energy is what we use to manipulate the world around us, whether by exciting our muscles, by using electricity, or by using mechanical devices such as automobiles. Energy comes in different forms heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy.

Electricity is the flow of electrons generated by converting a primary resource, like coal, wind, nuclear, or solar into energy. Electricity is what carries energy to your home, and it's what helps power your lights and appliances.

VARIOUS FORMS OF ENERGY

There are two types of energy stored (potential) energy and working (kinetic) energy. For example, the food we eat contains chemical energy, and our body stores this energy until we release it when we work or play.

Forms of Energy



Potential Energy : Potential energy is stored energy and the energy of position (gravitational). It exists in various forms.

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.

VARIOUS FORMS OF 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.

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

Kinetic Energy : Kinetic energy is energy in motion the motion of waves, electrons, atoms, molecules and substances. It exists in various forms.

VARIOUS FORMS OF ENERGY +

✓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 :

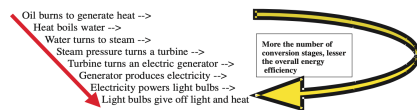
Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves.

✓Electrical Energy:

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

ENERGY CONVERSION

Energy is defined as "the ability to do work." In this sense, examples of work include moving something, lifting something, warming something, or lighting something. The following is an example of the transformation of different types of energy into heat and power.



It is difficult to imagine spending an entire day without using energy. We use energy to light our cities and homes, to power machinery in factories, cook our food, play music, and operate our TV.

GRADES OF ENERGY

High-Grade Energy :

✓Electrical and chemical energy are high grade energy, because the energy is concentrated in a small space. Even a small amount of electrical and chemical energy can do a great amount of work. The molecules or particles that store these forms of energy are highly ordered and compact and thus considered as high grade energy.

✓High grade energy like electricity is better used for high grade applications like melting of metals rather than simply heating of water.

GRADES OF ENERGY

Low-Grade Energy :

- ✓ Heat is low-grade energy. Heat can still be used to do work (example of a heater boiling water), but it rapidly dissipates.
- ✓ The molecules, in which this kind of energy is stored (air and water molecules), are more randomly distributed than the molecules of carbon in a coal.
- ✓ This disordered state of the molecules and the dissipated energy are classified as low grade energy.

ELECTRICAL ENERGY BASICS

Electric current is divided into two types: Directional Current (DC) and Alternating Current (AC).

✓ **Directional (Direct) :**
Current A non-varying, unidirectional electric current (Example: Current produced by batteries)

Characteristics:

- ✓ Direction of the flow of positive and negative charges does not change with time
- ✓ Direction of current (direction of flow for positive charges) is constant with time
- ✓ Potential difference (voltage) between two points of the circuit does not change polarity with time

ELECTRICAL ENERGY BASICS+

✓ **Alternating Current:**
A current which reverses in regularly recurring intervals of time and which has alternately positive and negative values, and occurring a specified number of times per second. (Example: Household electricity produced by generators, Electricity supplied by utilities.)

Characteristics:

- ✓ Direction of the current reverses periodically with time
- ✓ Voltage (tension) between two points of the circuit changes polarity with time.
- ✓ In 50 cycle AC, current reverses direction 100 times a second (two times during one cycle)

ELECTRICAL ENERGY BASICS+

✓Ampere (A)

Current is the rate of flow of charge. The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires, which are 1 metre apart in a vacuum.

✓Voltage (V)

The volt is the International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance.

$$1000 \text{ V} = 1 \text{ kiloVolts (kV)}$$

ELECTRICAL ENERGY BASICS+

✓Resistance

Resistance is a measure of the opposition to current flow in an electrical circuit. Resistance is measured in ohms, symbolized by the Greek letter omega (Ω).

✓Ohm' Law

Ohm's law states that the current through a conductor is directly proportional to the potential difference across it, provided the temperature and other external conditions remain constant.

✓Frequency

The supply frequency tells us the cycles at which alternating current changes. The unit of frequency is hertz (Hz :cycles per second).

ELECTRICAL ENERGY BASICS+

✓Kilovolt Ampere (kVA)

It is the product of kilovolts and amperes. This measures the electrical load on a circuit or system. It is also called the apparent power.

$$\text{For a single phase electrical circuit, Apparent power (kVA)} = \frac{\text{Voltage} \times \text{Amperes}}{1000}$$

$$\text{For a three phase electrical circuit, Apparent power (kVA)} = \frac{\sqrt{3} \times \text{Voltage} \times \text{Amperes}}{1000}$$

✓kVAr (Reactive Power)

kVAr is the reactive power. Reactive power is the portion of apparent power that does no work. This type of power must be supplied to all types of magnetic equipment, such as motors, transformers etc. Larger the magnetizing requirement, larger the kVAr.

ELECTRICAL ENERGY BASICS+

✓ **Kilowatt (kW) (Active Power)** : kW is the active power or the work-producing part of apparent power.

$$\text{For single phase, Power (kW)} = \frac{\text{Voltage} \times \text{Amperes} \times \text{Power factor}}{1000}$$

$$\text{For Three phase, Power (kW)} = \frac{1.732 \times \text{Voltage} \times \text{Amperes} \times \text{Power factor}}{1000}$$

$$\text{Power Factor (Cos}\phi\text{)} = \frac{\text{Active Power (kW)}}{\text{Apparent Power (kVA)}}$$

$$= \frac{\text{kW}}{\sqrt{(\text{kW})^2 + (\text{kVAr})^2}}$$

$$= 1.0 \text{ (when kVAr} = 0\text{)}$$

✓ **Power Factor**
Power Factor (PF) is the ratio between the active power (kW) and apparent power (kVA).

ELECTRICAL ENERGY BASICS+

✓ When current lags the voltage like in inductive loads, it is called lagging power factor and when current leads the voltage like in capacitive loads, it is called leading power factor.

✓ Inductive loads such as induction motors, transformers, discharge lamp, etc. absorb comparatively more lagging reactive power (kVAr) and hence, their power factor is poor.

✓ Lower the power factor; electrical network is loaded with more current. It would be advisable to have highest power factor (close to 1) so that network carries only active power which does real work. PF improvement is done by installing capacitors near the load centers, which improve power factor from the point of installation back to the generating station.

ELECTRICAL ENERGY BASICS+

✓ **Kilowatt-hour (kWh)** Kilowatt-hour is the energy consumed by 1000 Watts in one hour. If 1kW (1000 watts) of a electrical equipment is operated for 1 hour, it would consume 1 kWh of energy (1 unit of electricity).
For a company, it is the amount of electrical units in kWh recorded in the plant over a month for billing purpose. The company is charged / billed based on kWh consumption.