ENERGY/WORK/POWER

Energy is the potential to do work. Work is the ability to displace an object a certain distance. Power is the work done in a set time.

There are two states of energy

- **Kinetic energy:** energy possessed by an object in motion = ½ x Mass x Velocity^2

- **Potential Energy:** stored energy.

Forms of energy – sources of potential energy

- **Chemical energy**: is stored in the bonds of atoms and molecules.

- **Electrical energy**: is carried by moving electrons in an electric conductor.

- **Radiant energy:** electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves.

- **Mechanical energy:** stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

- **Nuclear energy:** stored in the nucleus of an atom—the energy that holds the nucleus together.

- **Thermal energy:** or heat, is the vibration and movement of the atoms and molecules within substances.

Work

Work = Force x Displacement x Cos of the angle between the force and displacement. (W = F x D x Cos)

Note: The cosine is the angle between the force and the displacement. If the angle is 0 degrees you can delete this part of the equation.

Reference:

$\cos 90^0 = 0$ $\cos 0^0 = 1$ $\cos 180^0 = 1$ $\cos 45^0 = .707$

Power

Power = Work/Time (P=W/T)

Power = Force x (Displacement/Time) x Cos of the angle between the force and displacement.
P = (F) (D/T) (Cos og the angle). If the angle is 0 degrees the equation is simplified to: P = F x (D/T).

Note: Average Velocity = Displacement/Time
Velocity: The speed of something in a given direction; both magnitude and direction are required to define it. Velocity is measured in meters per second. Therefore:
Power = Force x Velocity x Cos

With velocity a change in speed, direction, or both, then the object has a changing velocity and is undergoing acceleration. Acceleration is the rate at which the velocity of an object changes over time (A = V/T).

Electrical Power

Power-- Alternating Current (ac) Electrical
Power (ac) = Volts (V) x Current (I) x Cos of the angle between V and I.

Power-- Direct Current (dc) Electrical. In a DC circuit the angle between V and I is 0 and therefore it can be ignored.
Power (dc) = V x I

Joule (metric work) defined:
Joule/ Second = Watts
1 J / 1 Sec = 1 Watt

Terms to know

Watt

At the time the term horsepower was created, horses did most of the work for humans. To make a Watt meaningful to humans the term horsepower was created.

1 horsepower (hp) is equal to 746 Watts. Looked at another way a 1 hp system can move a 550lb object, 1 foot, in 1 second.

Energy Density
The formula for energy density is determined by the taking the total of energy stored in a system and dividing by its weight or volume.

Energy is expressed in joules (1 J / 1 Sec = 1 Watt). Weight is measured in grams (and their multiples). Volume is measured in cubic centimeters, liters (dm3) or cubic meters.

Common energy density measurements include:

- Joules per gram (J/g)
- Joules per cubic centimeter (J/cm3)
- Megajoules per liter (MJ/L)
- Megajoules per kilogram (MJ/kg)
- Gigajoules per ton (GJ/t)
- Gigajoules per cubic meter (GJ/m3)

Note: Energy should not be measure in calories. The US is the only country that is still using the outdated, non-metric, BTU measurement.

Examples of the energy density of commonly used food and fuels.

By weight:

- Carrots: 1.7 J/g
- Granola bar: 17 J/g
- Air-dry wood: 17 MJ/kg
- Coal: 22-25 MJ/kg
- Refined oil products: 42 MJ/kg

By volume:

- Hydrogen gas: 0.01 MJ/L
- Jet fuel (kerosene): 33 MJ/L
- Crude oil: 35 GJ/m3

Power Density Comparison Chart

Power Source	Power Density (W/m2)	
	Low	High
Natural Gas	200	2000
Coal	100	1000
Solar (PV)	4	9
Solar (CSP)	4	10
Wind	0.5	1.5
Biomass	0.5	0.6

FYI:

Solar power (PV) has a very low power density. If 10% of the electricity generated in the US were to be produced by large PV plants, the area required would be about 5,500 km^2.

Wind power has a power density that is lower than solar. If 10% of the US electricity generated were to be produced by large wind farms their area would cover an area approximately the size of New Hampshire.

Conversion Loss

Every time energy is converted from potential energy to kinetic energy, energy is lost. A 100% conversion is impossible. A system with a high conversion rate is considered to be highly efficient and is said to be a “green” technology.

Example: In a car combustion is used to convert the chemical energy into thermal energy. Pistons convert the thermal energy to the mechanical work that turns the wheels. The conversion process is approximately 35% efficient. Most of the energy stored in the gasoline is lost as heat.