Energy and Power

In physics, *energy* is a property of objects, transferable among them via fundamental interactions, which can be converted in form but not created or destroyed. Energy can be used to do ***work*** or can be expelled into the environment in the form of ***heat***. The joule (J) is the SI unit of energy, based on the amount transferred to an object by the mechanical work of moving it 1 meter against a force of 1 newton.

Power is the rate at which energy is transferred. It is thus the time derivative of energy. We usually denote it with the symbol, *p*.

$$p = \frac{dw}{dt}\ (W)$$

The unit of power is a Watt, which is equivalent to a Joule per second (J/s).

Note the previously given definitions of current and voltage:

$$v = \frac{dw}{dq}\ (V)$$
$$i = \frac{dq}{dt}\ (A)$$

Note that if you multiply the two:

$$v \cdot i = \frac{dw}{dq} \cdot \frac{dq}{dt} = \frac{dw}{dt}(W)$$

Thus, we see that

$$p = v \cdot i$$

Thus, multiplying the instantaneous voltage across a device with the instantaneous current gives us the instantaneous power being consumed or supplied by that device.

Passive Sign Convention

By convention, when trying to determine if a device or component (or sub-circuit) is consuming or supplying power (i.e. if power is flowing into or out of the device), we first define a voltage and current as per the figure below (i.e. we define a current i which enters the (+) side of the voltage, v.

Once these values are found, then we calculate

$$p = v \cdot i$$

If **p > 0** then power is being delivered to the device
If **p < 0** then power is being supplied by the device