Energy and Power in Electric Circuits

To know what power is and how to calculate the power of an electrical circuit
To know how to calculate the energy transferred in an electrical circuit
To be able to derive further equations or use a series of equations to find the answer

Power

Power is a measure of how quickly something can transfer energy. Power is linked to energy by the equation:

$$\boxed{Power = \frac{Energy}{time}}$$

Power is measured in Watts, W
Energy is measured in Joules, J
Time is measured in seconds, s

New Equations

New equations can be derived for energy and power.

Energy

$V = \frac{E}{Q}$ can be rearranged into $E = VQ$ and we know that $Q = It$ so combining these equations we get a new one to calculate the energy in an electric circuit:

$E = VQ$ <---------------------- $Q = It$ so $\boxed{E = VIt}$ (1)

Power

If we look at the top equation, to work out power we divide energy by time:

$\frac{E}{t} = \frac{VIt}{t}$ which cancels out to become $\boxed{P = VI}$ (2)

If we substitute $V = IR$ into the last equation we get another equation for power:

$P = IV$ <----------------------$V = IR$ so $\boxed{P = I^2R}$ (3)

We can also rearrange $V = IR$ into $I = \frac{V}{R}$ and substitute this into $P = VI$ to get our last equation for power:

$P = VI$ <---------------------- $I = \frac{V}{R}$ so $\boxed{P = \frac{V^2}{R}}$ (4)

Energy again

Two more equations for energy can be derived from the equation at the top and equations 3 and 4
Energy = Power x time

$Pt = I^2Rt$ Equation 3 becomes $\boxed{E = I^2Rt}$ (5)

$Pt = \frac{V^2}{R}t$ Equation 4 becomes $\boxed{E = \frac{V^2}{R}t}$ (6)

Fuses

Electrical devices connected to the Mains supply by a three-pin plug have a fuse as part of their circuit. This is a thin piece of wire that melts if the current through it exceeds its maximum tolerance. The common fuses used are 3A, 5A and 13A. A 100W light bulb connected to the UK Mains would have a 240V potential difference across it. Using $P = IV$ we can see that the current would be 0.42A so a 2A fuse would be the best to use.

Applications

The starter motor of a motor car needs to transfer a lot of energy very quickly, meaning its needs a high power. Millions of Joules are required in seconds; since the voltage of the battery is unchanging we need current in the region of 160A which is enormous.
The power lines that are held by pylons and form part of the National Grid are very thick and carry electricity that has a very high voltage. Increasing the voltage lowers the current so if we look at the equation $E = I^2Rt$ we can see that this lowers the energy transferred to the surroundings.