ELECTRICAL
ENERGY STORAGE

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We've been talking about electrical energy quite a lot, but let's today discuss where and how we actually store this otherwise ephemeral stuff.

Before we dive into electricity let's have a think about how energy, mechanical energy because it's easy to visualise, works. Take a rain water tank at home connected via a hose to a garden sprinkler; the type that rotates to evenly water the lawn. If the rainwater tank is full the sprinkler spins quite rapidly; less so as the tank empties.

What is happening? The answer is that the potential energy due to the height of the water in the tank is converted into work done and kinetic energy expended by the rotating water turbine. We say potential or static energy because while the tank is at rest and no water is flowing the water has the potential to do work and expend energy whilst it's not actually doing any work. When full the tank has, by virtue of the height if the water, greater potential to do work than when the level falls. The tank stores more potential energy when its full; less when empty.

Kinetic energy is the work done and energy expended by motion. It suggests energy of a dynamic nature. Incidentally what we have demonstrated in the water tank and sprinkler example is the exact model of a hydroelectric system.

Back to electrical energy storage methods.

The first obvious one is a battery where by chemical reactions, electrical energy is stored in the chemistry of the battery. Like with the water tank the energy is stored as potential energy or here as chemical potential energy; waiting in the battery to do work by forcing a flow of electrons through an outside element such as a light bulb for that potential energy to be converted electrical energy and then to light energy and heat energy in the light bulb.

Note that the light bulb doesn't store energy, it dissipates energy and converts energy from one form to another; light and heat.

The next electrical storage element we will look at, consists of two metallic plates placed close to each other but not touching. Its called a capacitor.

If we connect its two leads to our battery, electrons will flow briefly until they encounter the air gap when they will stop but accumulate on the plate waiting for an opportunity to cross to the other plate and find their way back to the opposite pole of the battery.

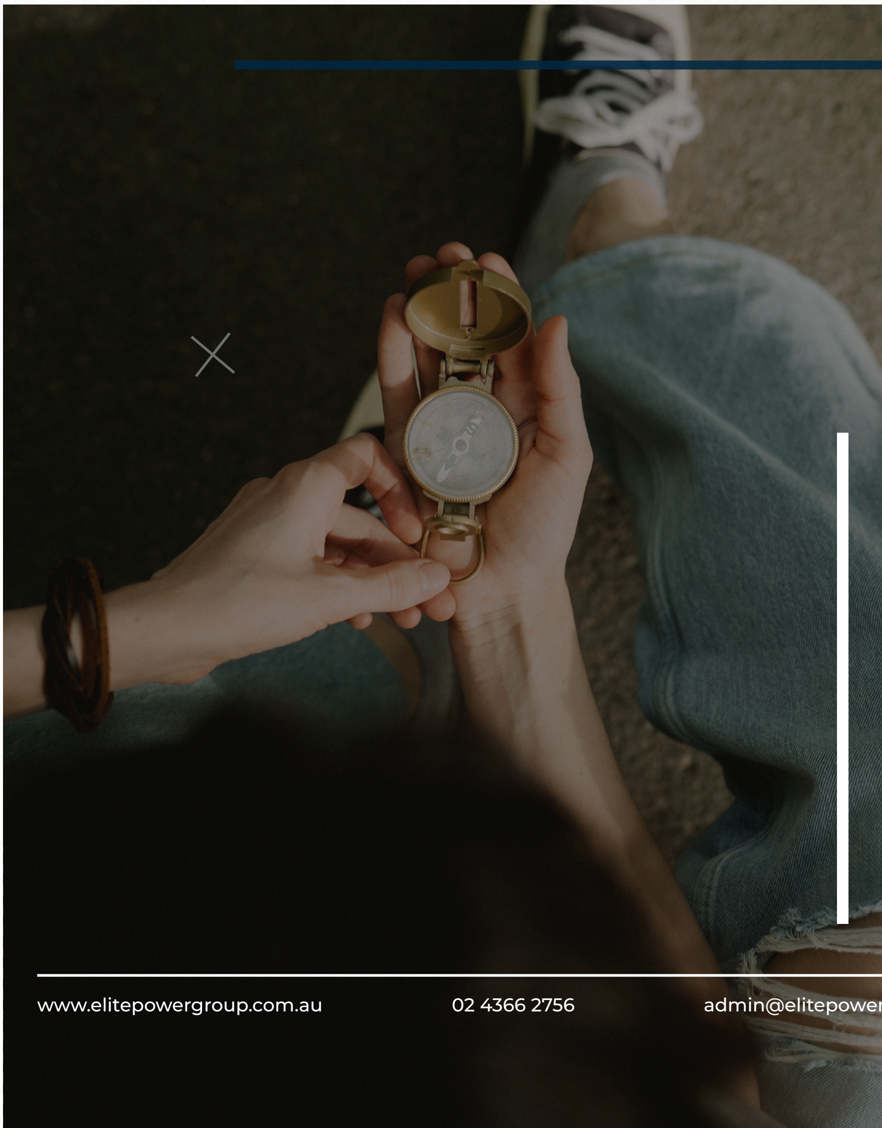
We say that the brief flow of electrons represents a small amount of kinetic energy expended to be stored as potential energy in the capacitor. The fact that the capacitor has stored some energy can be demonstrated by removing the connection to the battery and placing our light bulb across the leads instead. The bulb will flash briefly as it dissipates this potential or electrostatic energy. Electrostatic infers that the energy is stored in the static field across the metallic plates. Rubbing a plastic ruler across some synthetic cloth and placing it near our skin demonstrates the effect of static charge. We have loaded up the ruler with electrons, or removed an equal number of electrons and the resultant electric field attracts the mobile hairs which have no charge on our arm causing them to stand up in attraction to an oppositely charged ruler. The ruler is one plate of the capacitor our arm the other.

A capacitor is a fundamental electrical energy storage component. The air in our example has the general name dielectric and factors such as the plate area, distance between the plates and dielectric material dictate the energy storage capability of the capacitor. The energy is stored as potential energy in the electric field between the capacitor plates. Discharging the capacitor by placing a conductor between the plates results in current lowing and the potential energy being converted to kinetic energy by way of heat.
Let’s move to the other storage element in electricity; the inductor.

An inductor is simply the effect of a current flowing through a piece of wire. The current results in a magnetic field in the form of concentric "lines of force." Place a compass in the vicinity and the field can be visualised. Another way to visualise the field is to poke the wire through a piece of paper covered in iron filings. The filings will form into concentric circles mimicking the magnetic field. Remove the current and the field will collapse. If we could measure the current in the wire as the field collapsed we would find that it flows in the opposite direction to the current that established the field. This is called "back electromotive force" (back EMF.)

Lets wind the wire several hundred times around a bobbin with or without a ferromagnetic core; usually but not always, steel. Using a simple AA 1.5 volt battery to create a magnetic field our compass will be strongly deflected; much more than in the simple case described earlier. This magnification of the magnetic field is due to the winding process. Now with our fingers touching the end of the coil if we remove the battery we will feel a very slight electric shock. This is caused by the collapsing magnetic field "inducing" in the hundreds of turns of wire small individual voltages which all add up to a brief voltage pulse that we notice as a tingle or shock from the back EMF.

The potential energy stored in the static magnetic field is converted into kinetic energy as the field collapses.



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