An easy way to Physics: 09 Electric Energy, Electric Power, and Resistance

Electric Energy

Negative and positive electric charges attract each other. If we want to separate them, we must put in energy, and the charges then have electric energy. If these charges come together again, they lose their electric energy and set free other types of energy, like mechanical energy or heat or even light. In the household, we get electrons with electrical energy from batteries, from dynamos or from the electric net. We bring these electrons with energy to places, where the energy is needed, like a refrigerator, a motor, a lamp, computer, fan. The electrons give away their energy and go back without energy. For the transport of electrical energy we, therefore, need 2 wires: One wire for the electrons with energy, and the other one for electrons, that gave away their energy. The currents in these 2 wires are always equal. In a bicycle you need 1 wire only, because the electrons without energy can go back through the steel frame of the bicycle.

Voltage

The voltage U between the 2 points A and B says, how much energy an electron gives away, when it moves from A to B. In the household, the electrons have no energy when they leave the house. Thus we can say: The voltage is the energy carried by an electron. The unit for the voltage is 1 V [Volt] = 1 J / C.

Electric Power

If the voltage U gives the energy per electron and if the current I gives the number of electrons per second passing at a certain place, then the product $P = U \cdot I$ gives the energy per second passing at this point. P is called the electric power. Its unit is 1 W [Watt] = 1 V · 1 A

If a constant power flows during the time t, the electric energy $E_{el} = P \cdot t$. Its unit is the 1 J [Joule] = 1 W · 1 s = 1 V · A · s

Resistance

If you have a voltage U between the two points A and B, and you connect A and B with a metallic wire, then a current I flows. In many cases you have: Double U => double I, U · 3 => I · 3, U · 4 => I · 4. In all these cases, the quotient $U/I = R$ is constant. This quantity is called the resistance and it is measured in 1 Ω [Ohm]. This resistance depends on the material of the wire, its diameter and its length. If a current I flows through this wire, then you will measure a voltage $U = I \cdot R$. between the ends of this wire. In the resistance the electrons lose electric energy. The power lost by the electrons in the resistance is $P = U \cdot I = I \cdot U = I \cdot I \cdot R = U \cdot U / R$.
The energy lost by the electrons is transformed into heat. If a strong current flows through the human body, the body cells in the way of the current are killed and burned, even so much, that they become coal, and toxic substances are produced.

The human body has an electrical resistance of about 1000 Ω between both hands or hand and foot. A voltage of 50 V causes an electric current of 50 mA flowing through the heart. That current destroys the electric coordination between the cells of the heart muscle, the heart can't pump blood anymore and you will die. The voltage of 230 V in household electricity is deadly.

If electrons go through resistance R_1 first and then through resistance R_2, the current I through both resistances is the same. The electrons lose a part of their energy in R_1 and another part in R_2, that means total energy loss per electron $U = U_1 + U_2 = I \cdot R_1 + I \cdot R_2 = I \cdot (R_1 + R_2)$. Both resistances together act the same way as one resistance $R = R_1 + R_2$. An additional resistance decreases the current.

If the same voltage U is put to several resistances R_1, R_2, R_3 (as it is in the household: Everywhere there is the same voltage of 230 V), then through each resistance flows a current determined by the resistance: $I_1 = U/R_1$, $I_2 = U/R_2$. The total current is then the sum of both currents: $I = I_1 + I_2 = U/R_1 + U/R_2 = U \cdot (1/R_1 + 1/R_2)$. This combination of resistances acts like resistance $R = 1 / (1/R_1 + 1/R_2)$. If we add a resistance, the current becomes bigger.