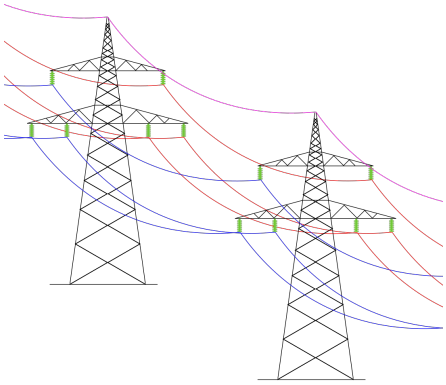
2.7 The National Grid

The National Grid is a UK network of electrical cables and transformers which link power stations to consumers of electricity (e.g. homes, factories).



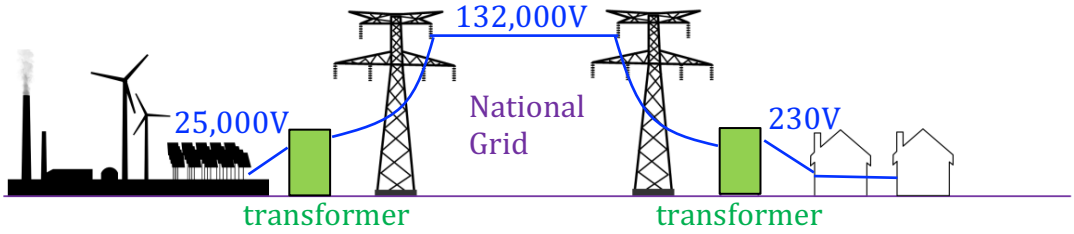
(1) Large power stations are often built well away from centres of population. Give at least two reasons why this is the case.

(2) Wind farms are often sited well away from centres of population. Give at least two reasons why this is the case.

A big advantage to having a network which links electricity generators and consumers, is that supply can more easily be matched to demand. For example, wind turbines produce electricity when it's windy. With a network of generators, when it is windy, other electricity generators (e.g. as gas-fired power stations) can reduce their input, and vice versa.

One disadvantage of the national grid is that there is energy wasted (through heat loss to the surroundings) when electric currents flow through cables. The longer the cables are, the greater the energy loss. The challenge is to reduce these losses.

Consider the following:

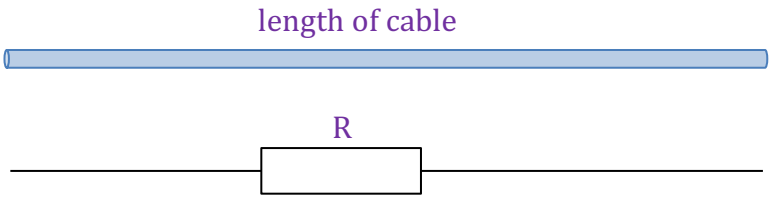


Electricity is generated, on the left (e.g. power station, wind turbine, solar photovoltaic, etc). The voltage is stepped up to 132,000V or more, using a transformer, before it is sent around the National Grid. The voltage is then stepped down to 230V, using a transformer, for distribution to homes.

The reason for stepping up the voltage to very high voltages is to reduce energy losses in the National Grid cables through heating.

To understand why large voltages reduce energy loss, we need to look at the equations for electrical power.

If we consider that a length of cable has a resistance. We can think of the length of cable as a resistor.



The power loss in the cable is given by:

$$P = I^2 \times R$$

Where I=current, R=resistance of the length of wire.

(3) Looking at this equation, what two things can be done to reduce the power loss?

To reduce the resistance, cables can be made thicker. To reduce the current, the voltage needs to be increased (stepped up).

To understand why, consider the equation for power transmitted:

$$P = I \times V$$

Where I=current, V=voltage.

Let us say that we want to transmit 3000W of power. We could do it like this:

$$P = 300A \times 10V$$

Or like this:

$$P = 30A \times 100V$$

Or like this:

$$P = 3A \times 1000V$$

Or any other combination.

The thing to recognise is the bigger the voltage, the smaller the current. To minimise power loss in the cables we need to minimise the current, which means maximising the voltage.

(4) Why do overhead the cables in the National Grid need to be carried high above the ground, using pylons?

(5) Transmission cables have a resistance of 1Ω *per kilometre. They are used to supply a town 10km away. Work out the power loss in the transmission cables for a current of (i)0.03A, and ii)0.30A.*

(6) Explain which current (in the previous question) would minimise energy loss, and how this current could be achieved.