nationalgrid

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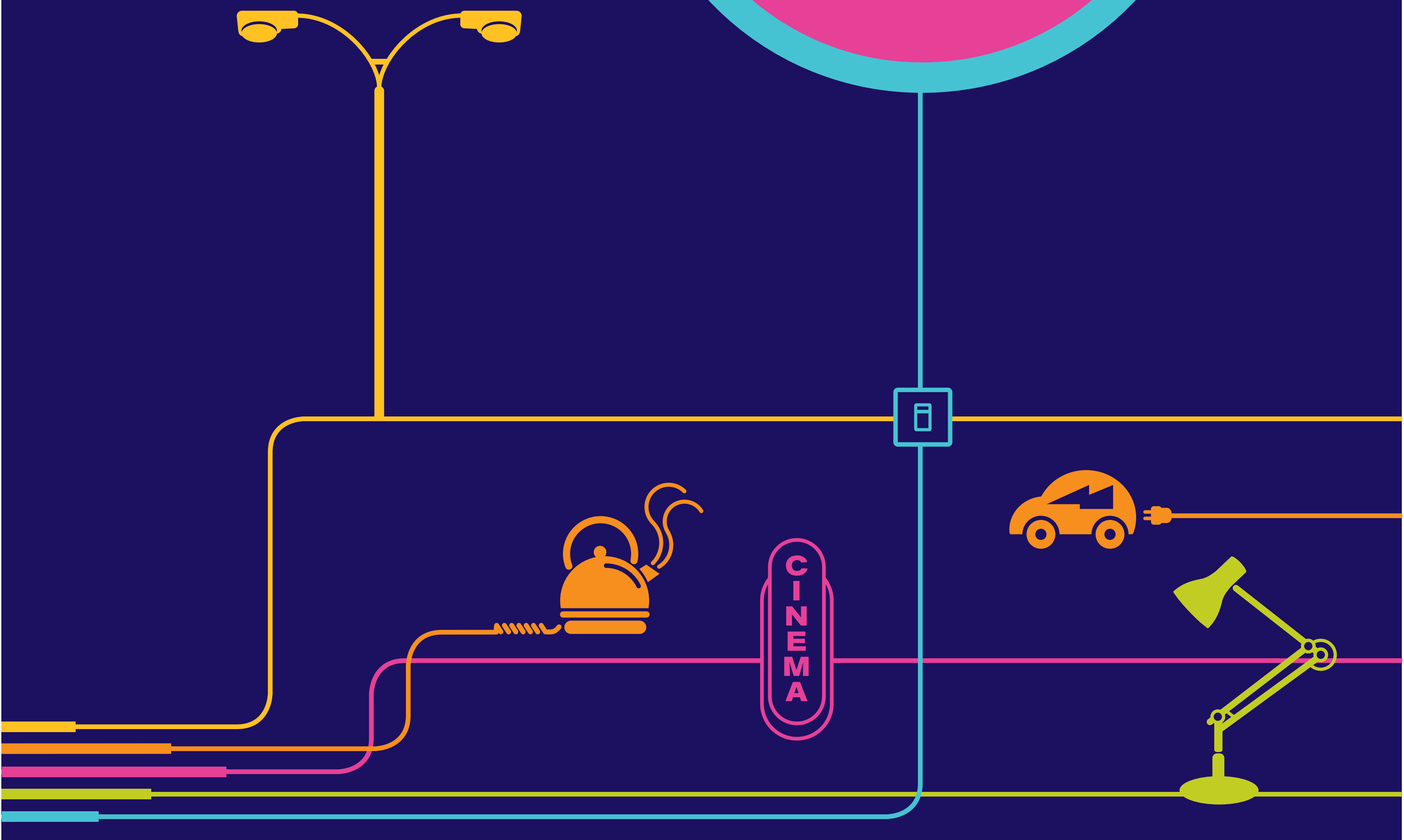
Electricity Transmission National Grid Assets



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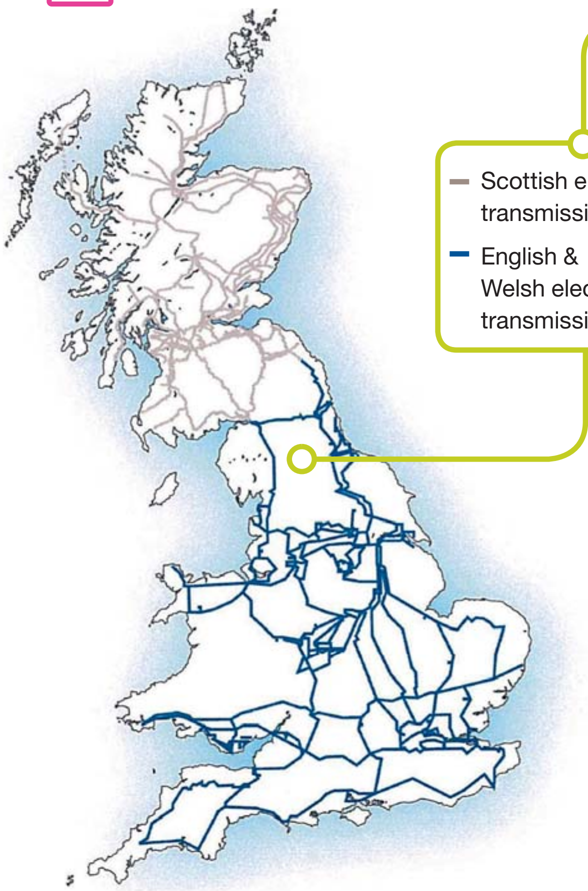
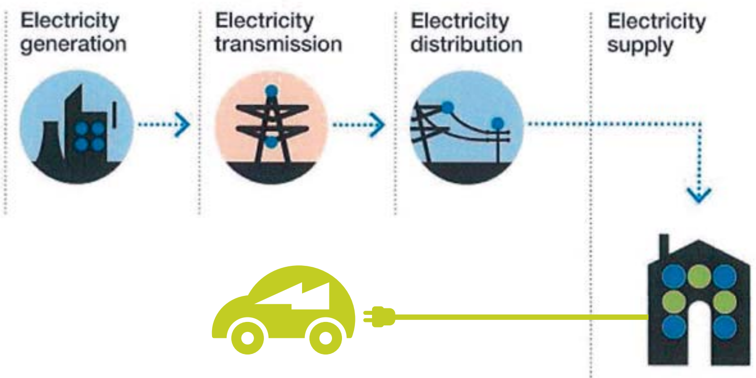


Scottish electricity transmission system

English & Welsh electricity transmission system

UK Transmission

CINEMA



The vast majority of our network operates at high voltages of 400,000 and 275,000 Volts (also written as 400 and 275 kV.)

High voltages are used for the bulk transfer of electricity because this reduces the amount of energy lost during transmission.

Distribution networks operate at 132 kV and below, and take electricity all the way to domestic properties at 230 Volts.

Substations and circuits

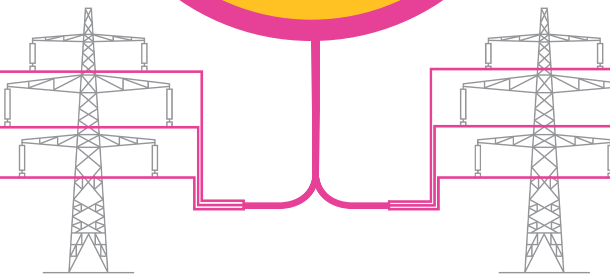
The building blocks of a transmission network

Electricity is carried by conductors. A transmission network transports electricity over long distances (from suppliers to demand) via the conducting wires carried on overhead lines or the conductors inside underground or undersea cables.

A substation is a common connecting point for overhead lines and cables (which together form electrical circuits). Generators (power stations) and interconnectors from other countries connect and supply energy to the transmission network at substations, while large demand customers and distribution network operators may also connect at substations to extract energy from the network.

A substation can be thought of as an assembly of equipment that allows the routing and control of electricity across the network.

As of 2011, National Grid Electricity Transmission owns and operates just less than 500 high voltage substations across England and Wales.



Aerial view of a large outdoor, air-insulated substation

Insulation

Insulation – different types

Just like domestic wiring, all high voltage conductors must be insulated to prevent the electricity 'escaping' (flowing away into the earth). The insulation can be solid (e.g. glass, porcelain, resin), liquid (e.g. oil) or gas (e.g. air, sulphur hexafluoride (SF_6), nitrogen).

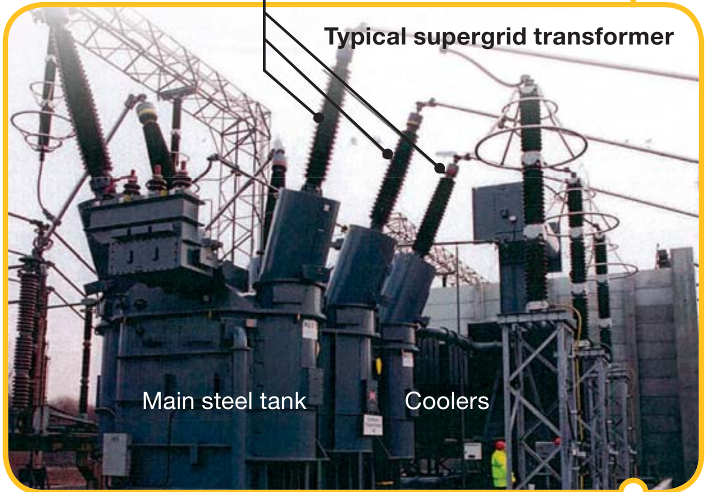
Solid insulation is generally used where it is required to physically support conductors whereas fluid insulation is used to isolate conductors and prevent electricity 'flashing over' (jumping) to neighbouring metallic structures which are in turn connected to earth.

Air is used as insulation in many of our substations; it is free and self-replenishing. This works well in non-polluted environments but, because it is not the best insulator, large separations between equipment are required (e.g. 3.6 metres at 400 kV) and hence air-insulated substations (AIS) take up a relatively large area. In industrial or coastal locations, conducting airborne particles such as salt fog from the sea may cause electrical short circuits. In these locations, we can protect our assets by moving them indoors; we may also choose to use gas-insulated substations (GIS). These use SF_6 gas, which is an excellent insulator, allowing separations to be reduced and bringing benefits where space is constrained. However, GIS is more expensive than AIS, and SF_6 is a potent greenhouse gas (23,900 more potent than carbon dioxide).

Outdoor air-insulated substation

Indoor gas-insulated substation (under construction)

Substation assets

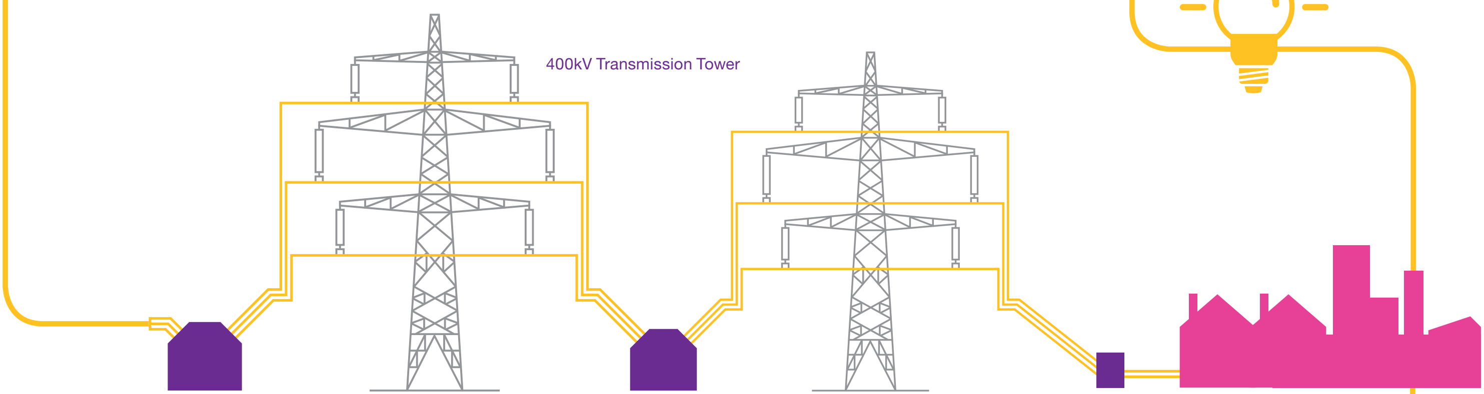


Transformers

Transformers enable the efficient transmission of electricity by increasing the voltage and reducing the current in circuits, hence reducing electrical losses. Supergrid transformers are used at the generator connection to increase voltage and at the substation to reduce it again for onward distribution to customers.

Transformers also limit the amount of current that flows if there is a fault to a level that will not cause damage and can be turned off by a circuit breaker.

A transformer has an iron core and paper-insulated copper windings inside a steel tank filled with oil. A typical NGET transformer reduces the voltage from 400 kV to 132 kV and transfer energy at a power of 240,000 kW (enough power to supply 120,000 typical kettles). The main part of the transformer is about 8 metres long, 5 metres wide and 5 metres high (not including the terminals or coolers) and weighs almost 300 tonnes including 100,000 litres of oil. Transformers have an efficiency of 99.8% under normal operating conditions.



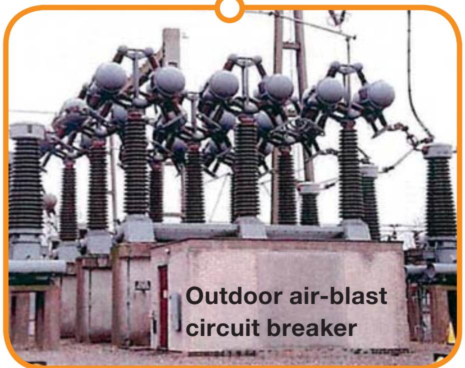
Circuit breakers

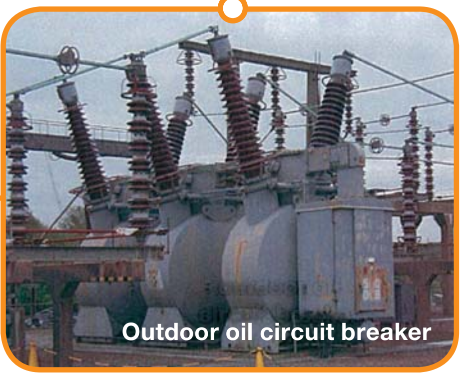
Circuit breakers are high voltage switching devices that are used to switch circuits 'on' or 'off' under both normal and fault conditions. Switching under normal operating conditions controls the flow of electricity across the network.

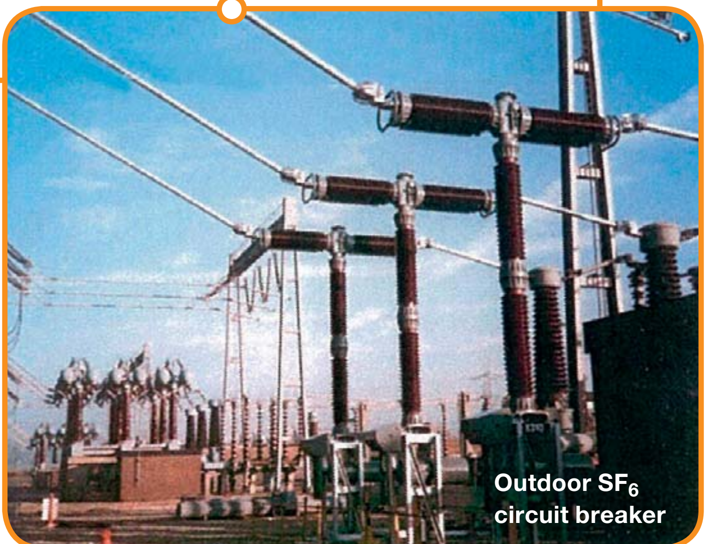
If a fault occurs on the network, it is important that the fault is disconnected and isolated from the rest of network to ensure the safety of staff and the public, limit the damage caused and maintain a secure electricity supply. To achieve this, circuit breakers must operate extremely quickly to disconnect up to 63,000 Amps in about a tenth of a second.

As of 2011, we have nearly 3,000 circuit breakers at different voltages on the England and Wales electricity transmission system. The older types use oil or air for switching, while modern circuit breakers use gas (SF_6).

As SF_6 is such a potent greenhouse gas, we are working with our suppliers to investigate technologies that reduce the mass of gas used – or even remove the need for SF_6 gas altogether.


Outdoor air-blast circuit breaker


Outdoor oil circuit breaker


Outdoor SF_6 circuit breaker

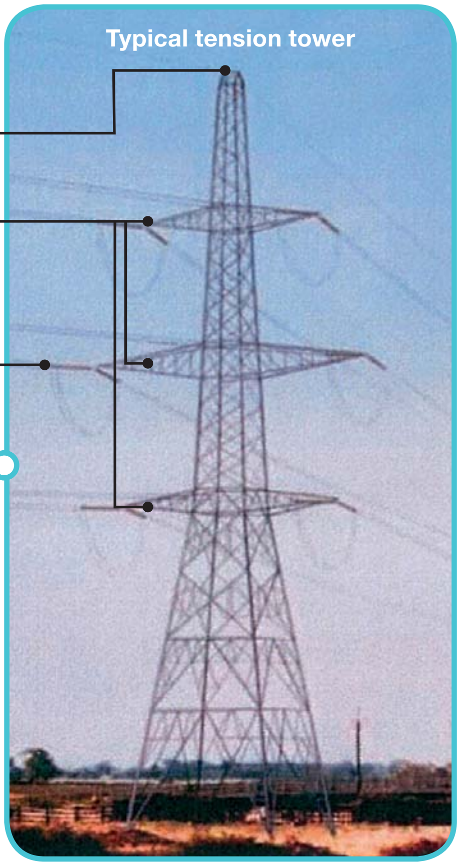
Overhead line assets

Conductors and towers (pylons)

Overhead line conductors are layered wires made of aluminium with a steel core for strength or aluminium alloy.

There are two types of transmission tower – tension and suspension. They are typically 40 to 50 metres tall, and perform the same task of keeping conductors a safe distance from the ground (earth). Suspension towers are lighter structures used where overhead lines run in a straight line, while tension towers are stronger to allow changes of direction.

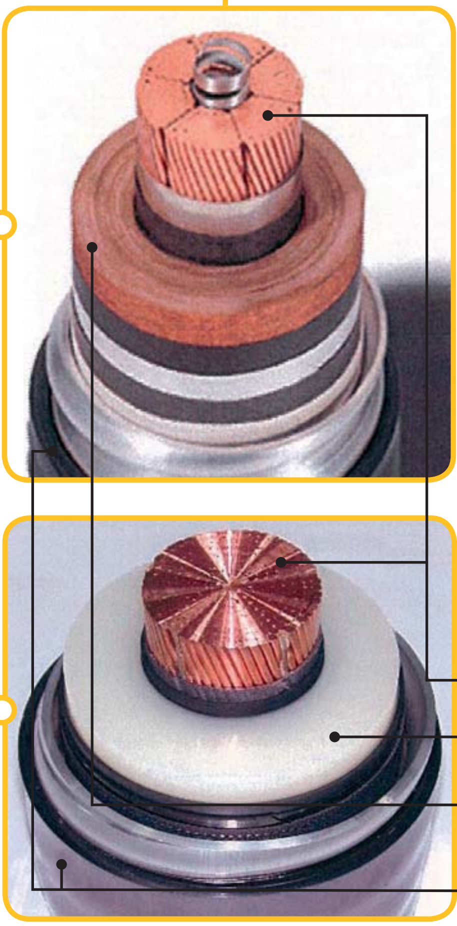
Different tower designs are used depending on the voltage of the circuits being carried and the amount of power that we need to transfer (which affects the number and size of conductors carried). As of 2011 we have circa 22,000 towers, the vast majority of which carry two electrical circuits over 7,000 route km of overhead lines.



Underground cable assets

Glass, porcelain or polymeric insulator strings are used to support the conductors and prevent the electricity flowing to earth via the steel (and therefore conducting) tower.

Spacer dampers prevent bundled conductors clashing in the wind and also reduce wind-induced vibrations (and hence protect the conductors from physical damage).



Cables can be directly-buried in the ground, laid in troughs or run through special tunnels.

The electricity flows through the conducting copper wires. Insulation was traditionally provided by wrapping the conductors in paper tapes soaked with oil. The technology has subsequently developed to use solid crossed-linked polyethylene (XLPE) insulation. This removes the risk of oil leaks contaminating the ground through which cables run, and potentially polluting adjacent water courses.

As of 2011, we have over 600 route km of high voltage cable circuits on the transmission network plus many shorter lengths connecting assets within substations.

nationalgrid

Education & Skills
National Grid
National Grid House
Warwick Technology Park
Gallows Hill
Warwick
CV34 6DA

www.nationalgrideducation.com

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