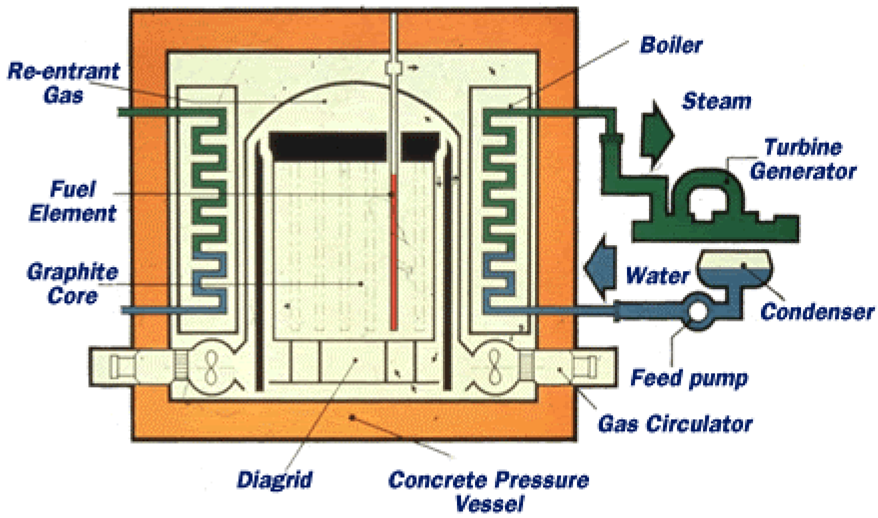
How an AGR power station works

Nuclear Power

Coal, oil and nuclear power stations produce electricity in basically the same way – they use fuel to raise steam that turns a turbine to generate an electric current. In an advanced gas-cooled (AGR) station a controlled chain reaction generates heat which turns water into steam. The steam then powers turbines which, in turn, drive the electrical generators.

Advanced Gas-cooled Reactor (**AGR**)



The Reactor

At the heart of the reactor is a graphite core called the moderator. Running vertically through this core are tubes containing uranium called fuel channels. The moderator has a vital role to play as it slows down the neutrons released by the fuel so that they will interact with other uranium atoms and sustain the chain reaction.

The Pre-stressed Pressure Vessel

Each reactor is encased in a concrete pressure vessel which acts as a barrier against radiation from the reactor and as a container for the carbon dioxide coolant gas. The walls vary in thickness from 3.8 metres to 6 metres and are pre-stressed by heavy steel wires wound from top to bottom and around the reactor.

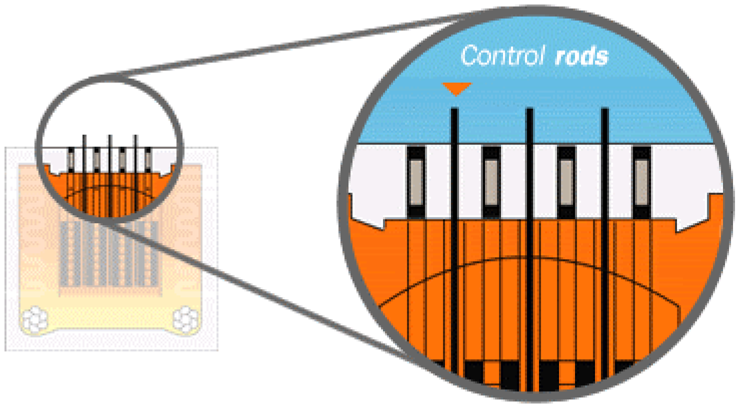
Each of the fuel channels in the graphite core continues upwards in a steel tube called a standpipe, sealed at the top, which links to the top surface of the pressure vessel, known as the pile cap.

The Fuel

The fuel elements of an AGR are comprised of 36 pins containing small pellets containing uranium built into a graphite sleeve. Seven or eight fuel elements are fixed together vertically by a tie bar which passes through the centre of the elements to form a fuel stringer. A plug unit is attached to the top of the stringer to form a complete fuel assembly. An assembly is placed into each of the standpipes, so that the fuel elements are positioned within the graphite core's fuel channels and are then sealed in by the plug unit.

The Control Rods

The graphite core also contains channels for boron steel control rods, which can be raised and lowered by electric motors to control the reactor power by absorbing neutrons and stopping them splitting atoms. In the event of a power failure or a need to shut the reactor down, gravity makes these rods drop fully into the core, shutting down the reactor. When they are partially raised, the neutrons become free to cause `fission' in the uranium atoms and release more neutrons. When the reaction becomes self-sustaining, the reactor is said to be 'critical'.



The Boilers

Within the pressure vessel the boilers are connected to the inlet and outlet of the reactor by ducts. At the bottom of each boiler are large gas circulators which pump high-pressure carbon dioxide coolant gas through the graphite core and up the fuel channels, where the gas picks up the heat generated by the nuclear reaction.

The gas – now very hot – is routed through the top of the boiler back down to the gas circulator. As it passes through, it gives up its heat to the water in the boiler, forming superheated high-pressure steam which is piped away to drive the turbine.

The Turbine

The superheated steam from the boilers is first piped to the high-pressure turbine where nozzles direct it onto the blades causing the turbine to rotate. The steam then returns to the boilers to be re-heated before passing to the intermediate-pressure turbine and from there to its final energy-making destination, the low-pressure turbines.

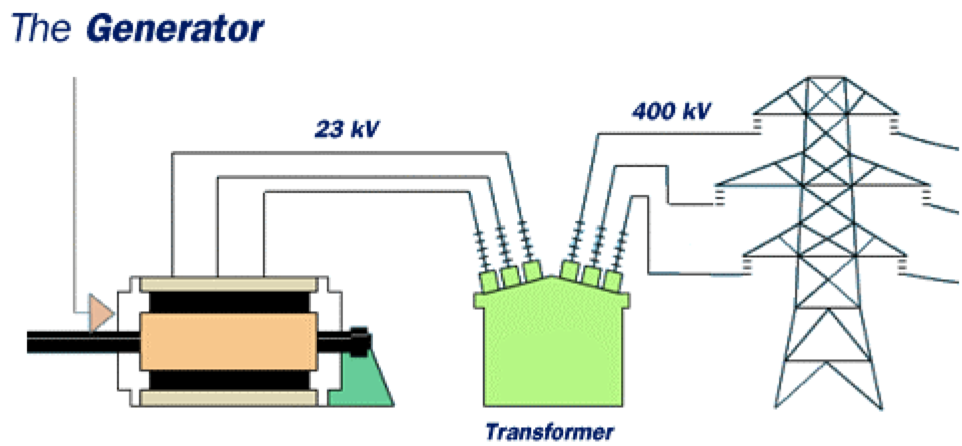
The Condenser

Having exhausted all its useful energy, the steam passes into a condenser where it turns back into water before being returned to the boiler. The condenser works by directing the steam over the surface of thousands of tubes containing cold filtered water pumped through from the sea by circulating water pumps. When the cooling is complete the water, its temperature raised by just a few degrees Celsius, is returned to the sea.

The condensed water, must be cleaned and heated before returning to the boilers. First, the water travels through a chemical plant to remove impurities and then through heaters where it is mixed with warm steam from the turbine to increase its temperature. Next, it is pumped into a large vessel called a de-aerator to remove any gases before the feed pump sends it back into the boilers.

The Generator

The turbines drive a generator which consists of a large hydrogen cooled electro-magnet, called the rotor, which revolves at 3000 revolutions per minute inside the stator – a water-cooled electrical winding. Electricity is produced in the windings of the stator, at 23kV by the revolving magnetic field of the rotor.



Refuelling

After approximately five years the fuel in the reactor can no longer maintain the chain reaction efficiently and must be replaced. To do this, a refuelling machine removes and replaces fuel assemblies. These assemblies are then dismantled into individual parts. Most of the components are reused, but the fuel elements are sent to the cooling ponds.

Cooling Ponds

The used elements are then stored in cooling ponds of water for a minimum of 90 days. This allows any short-lived radioactivity to decay before the elements are packed into special shielded flasks over 30cm thick. These flasks are carried by rail to Sellafield in Cumbria for reprocessing of the fuel.

Fuel Transport

There has never been a fuel flask accident involving the release of radioactivity. Their safety was demonstrated in July 1984 at Old Dalby testing track, when a nuclear flask was placed in the path of an on-coming locomotive and three carriages travelling at 100mph. The flask remained wholly intact and pressure tight, sustaining nothing more than a little shallow denting and superficial damage to its cooling fins. The locomotive was not so fortunate – it was written off.