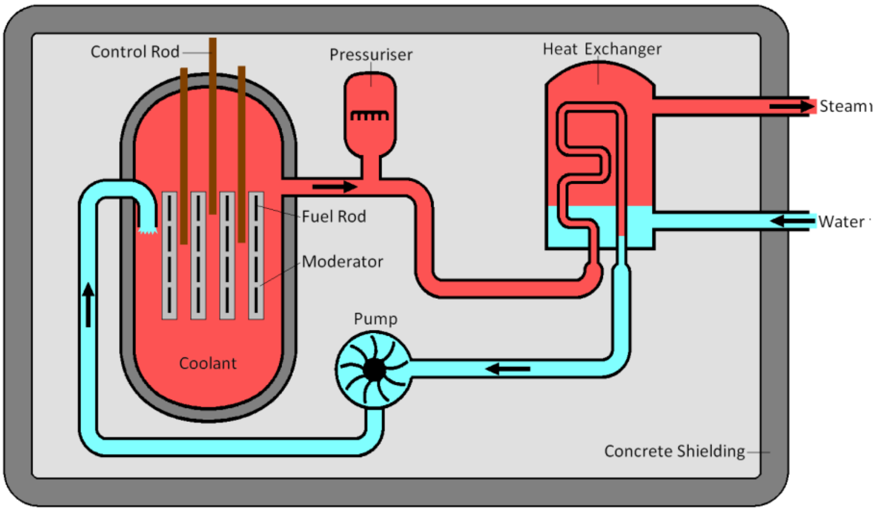
<u>Nuclear Reactors</u>

To be able to explain how a nuclear reactor produces electricity
To be able to explain the roles of the fuel rods, moderator, coolant and control rods
To be able to give examples of the materials use for each of the above

Making Electricity

This is a typical nuclear fission reactor. A nuclear power station is similar to a power station powered by the combustion of fossil fuels or biomass. In such a station the fuel is burnt in a boiler, the heat this produces it uses to heat water into steam in the pipes that cover the roof and walls of the boiler. This steam is used to turn a turbine which is connected to a generator that produces electricity (see GCSE Physics 3 and A2 Unit 4). Steam enters the cooling towers where is it condensed into water to be used again. In a nuclear fission reactor the heat is produced in a different way.



Components of a Nuclear Reactor

Fuel Rods

This is where nuclear fission reactions happen. They are made or Uranium and there are hundreds of them spread out in a grid like pattern.

Natural Uranium is a mixture of different isotope. The most common are U^{238} which accounts for 99.28% and U^{235} which accounts for only 0.72% of it. 238 will only undergo fission when exposed to very high-energy neutrons whilst 235 will undergo fission much more easily. The Uranium that is used in fuel rods has a higher percentage of 235 and is said to be ***enriched***. This is so more fission reactions may take place.

Moderator

Role: The neutrons that are given out from nuclear fission are travelling too fast to cause another fission process. They are released at 1×10^7 m/s and must be slowed to 2×10^3 m/s, losing 99.99975% of their kinetic energy. The neutrons collide with the atoms of the moderator which turns the kinetic energy into heat. Neutrons that are travelling slow enough to cause a fission process are called ***thermal neutrons***, this is because they have the same amount of kinetic energy as the atoms of the moderator (about 0.025 eV at 20°C).

Factors affecting the choice of materials: Must have a low mass number to absorb more kinetic energy with each collision and a low tendency to absorb neutrons so it doesn't hinder the chain reaction.

Typical materials: graphite and water.

Coolant

Role: Heat is carried from the moderator to the heat exchanger by the coolant. The pressuriser and the pump move the hot coolant to the heat exchanger, here hot coolant touches pipes carrying cold water. Heat flows from hot coolant to cold water turning the water into steam and cooling the coolant. The steam then leaves the reactor (and will turn a turbine) as the coolant return to the reactor.

Factors affecting the choice of materials: Must be able to carry large amounts of heat (L11 The Specifics), must be gas or liquid, non-corrosive, non-flammable and a poor neutron absorber (less likely to become radioactive).

Typical materials: carbon dioxide and water.

Control rods

Role: For the reactor to transfer energy at a constant rate each nuclear fission reaction must lead to one more fission reaction. Since each reaction gives out two or more we must remove some of the extra neutrons. The control rods absorb neutrons, reducing the amount of nuclear fission processes occurring and making the power output constant. They can be lowered further into the fuel rods to absorb more neutrons and further reduce the amount of fission occurring. Some neutrons leave the reactor without interacting, some travel too fast while other are absorbed by U^{238} nuclei. If we need more neutrons we can raise the control rods.

Factors affecting the choice of materials: Ability to absorb neutrons and a high melting point.
Typical materials: boron and cadmium.