Nuclear Reactors

A **nuclear reactor** is a device for initiating and controlling a sustained nuclear chain.

A **moderator** substance must be used to surround the nuclear fuel and slow down any emitted neutrons.

Deuterium turns out to be a good moderator component because it tends to slow down neutrons without absorbing them. In practice, the simplest way to utilize large amounts of deuterium is in the form of "heavy water," in which deuterium takes the place of the hydrogen atoms in water molecules.

Graphite (^{12}C) is also a common moderator material and was used in the first nuclear reactor, constructed by Enrico Fermi in 1942.

In order to sustain the chain reaction while avoiding a potentially catastrophic sudden release of energy, the reaction must also be maintained at a critical level ($K = 1$).

Enrico Fermi and his research team at the University of Chicago generated the first controlled chain reaction in 1942. In a racquet court on the university campus, Fermi assembled a nuclear "pile" of graphite bricks surrounding small pieces of uranium. Cadmium control rods were used to regulate the rate of reaction. On December 2, 1942, by measuring the neutron output at various points in the pile, Fermi's team concluded that the nuclear chain reaction had in fact been self-sustaining.

Power Plant Operation

Nuclear power plants use the energy released by fission reactions to heat water to boiling, producing steam that drives a turbine connected to an electric generator.

Nuclear fuel tends to be enriched uranium containing 3–4 percent ^{235}U. The core is contained within a reactor vessel made of thick steel, which is located within a heavily reinforced concrete containment structure. A coolant (usually water, or sometimes liquid sodium) is pumped through the core, where it absorbs thermal energy from the fission reactions.

Heavy water reactors, commonly employed in Canada, use heavy water as a moderator substance. Although heavy water is more expensive to obtain than ordinary water, it is so effective at slowing neutrons that heavy water reactors are able to achieve criticality with natural, unenriched uranium fuel. Thus the added expense of heavy water is offset by the lack of expense for fuel enrichment.

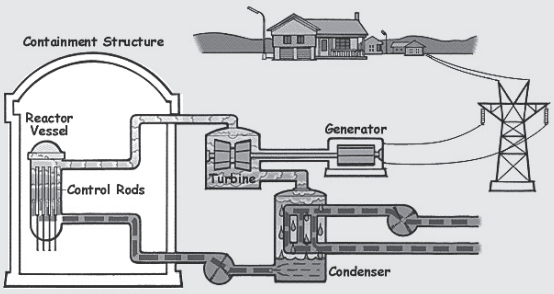
In a *boiling water reactor*, water acts as a moderator, coolant, and source of steam to drive the turbine. A *pressurized water reactor* contains a primary loop of water that serves as reactor coolant, which in turn heats a secondary loop that generates steam.

The first generation of electricity from a nuclear reactor source took place in 1951 at the EBR-I reactor in Arco, Idaho. The reactor powered a string of four light bulbs.

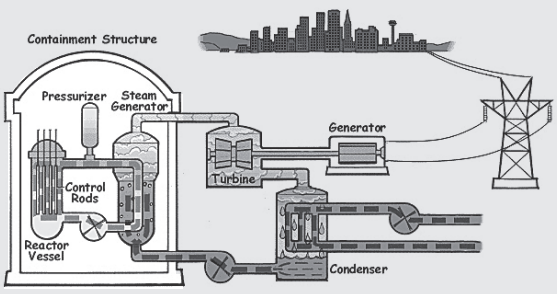
In 1954, the first nuclear power plant connected to a power grid began operation in the Soviet Union.

As of 2015, 438 nuclear reactors are generating power in thirty countries around the world. Nuclear power accounted for 10.9 percent of the world's electricity production in 2012.[3]

Nuclear Power Reactor Designs



Boiling Water Reactor



Pressurized Water Reactor