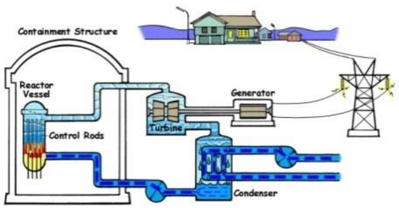
بسم الله الرحمن الرحيم

Thermal Power Stations II



جامعة كفر الشيخ
Kafrelsheikh University

Faculty of Engineering
Mechanical Engineering Dept.

Lecture (2)

on

Nuclear Power Stations

By

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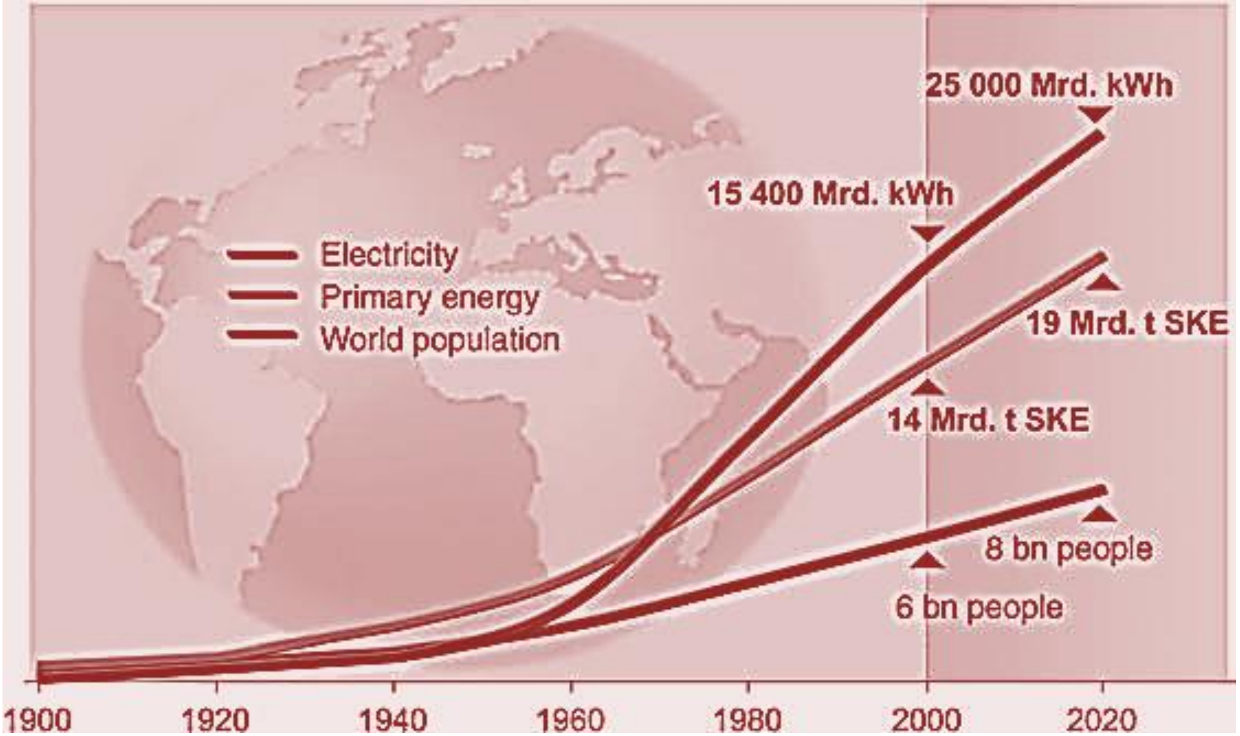
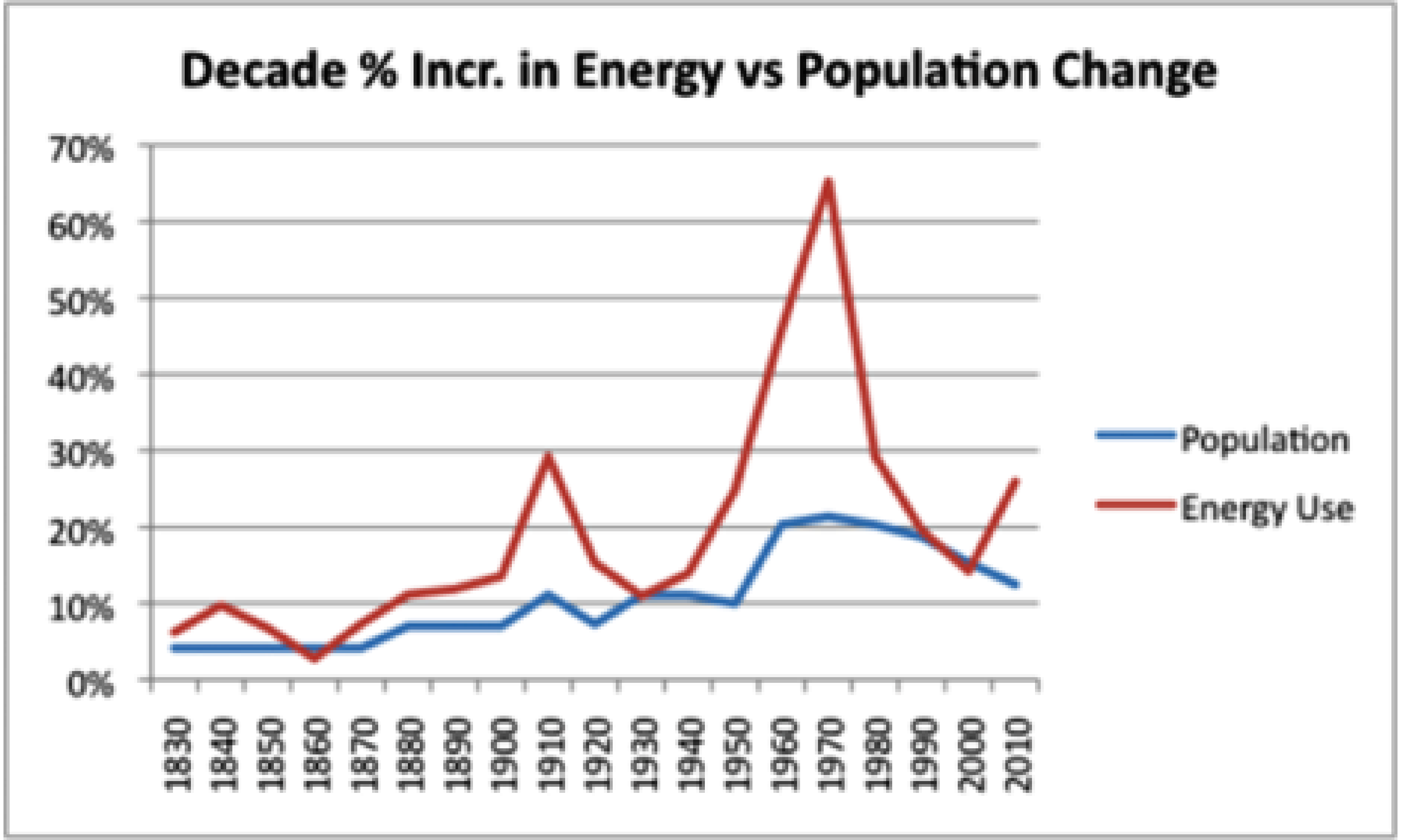
2015 - 2016

The Demand for Energy

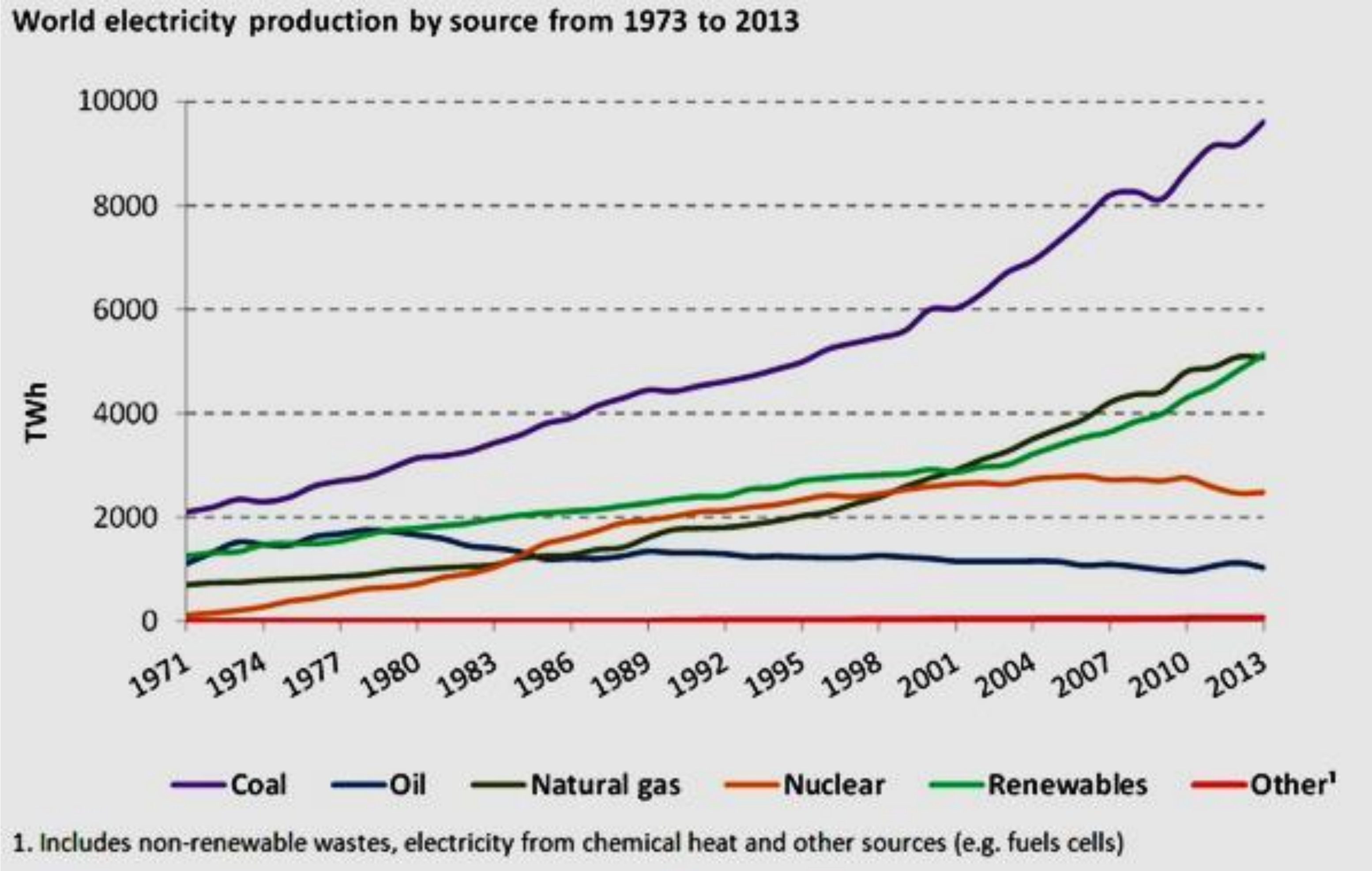
Between 2000 and 2020, world population is set to increase from six to eight billion (33%), but the demand for energy is forecast to rise at nearly twice the rate, by around 62%.



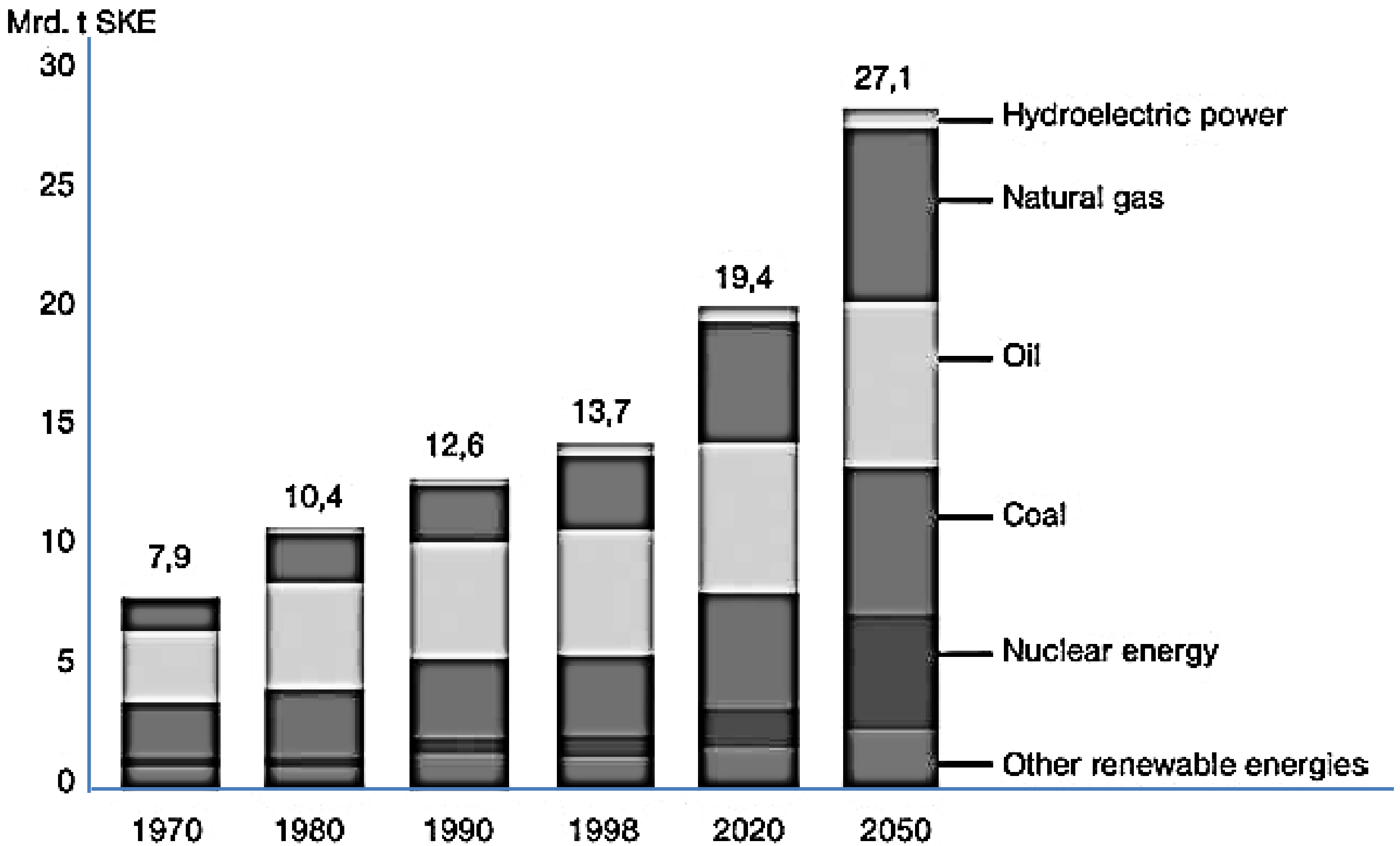
The Demand for Energy



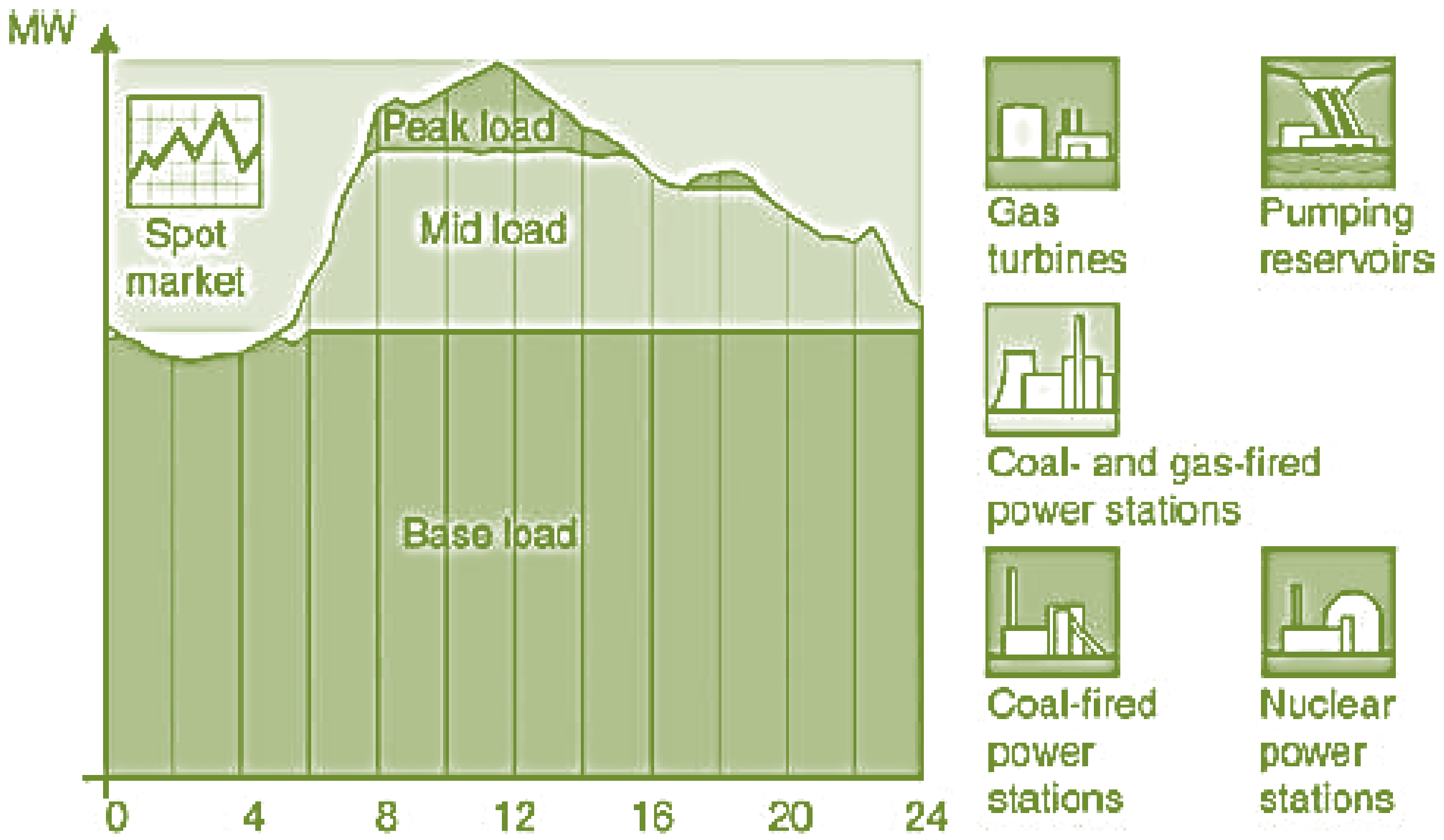
The Demand for Energy



Electricity Generation

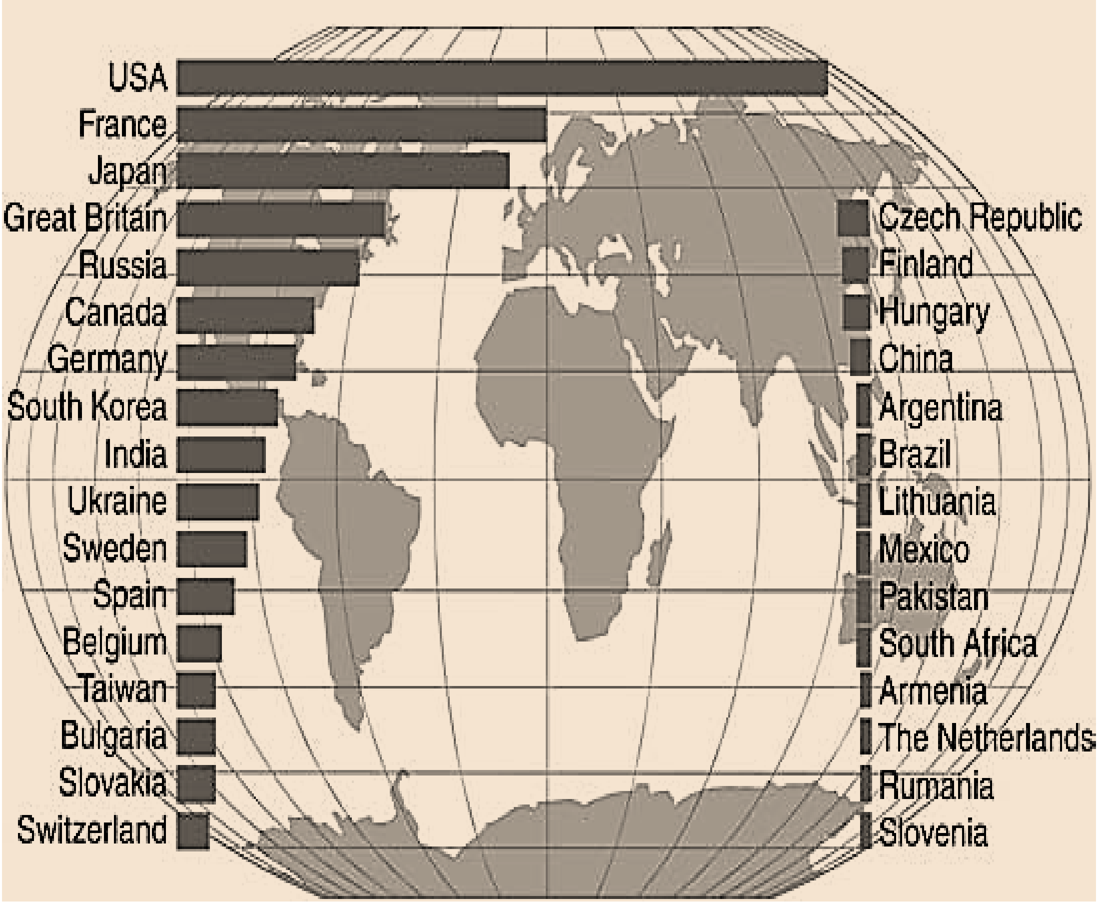


Electricity Generation



Importance of Nuclear Energy

At autumn 2009, as well as the 437 nuclear power plants already in operation, another 53 new nuclear power blocks were under construction, and another 76 new blocks were planned. The new blocks currently being built or planned mostly have (electricity) outputs from 1000 to 1600MW.



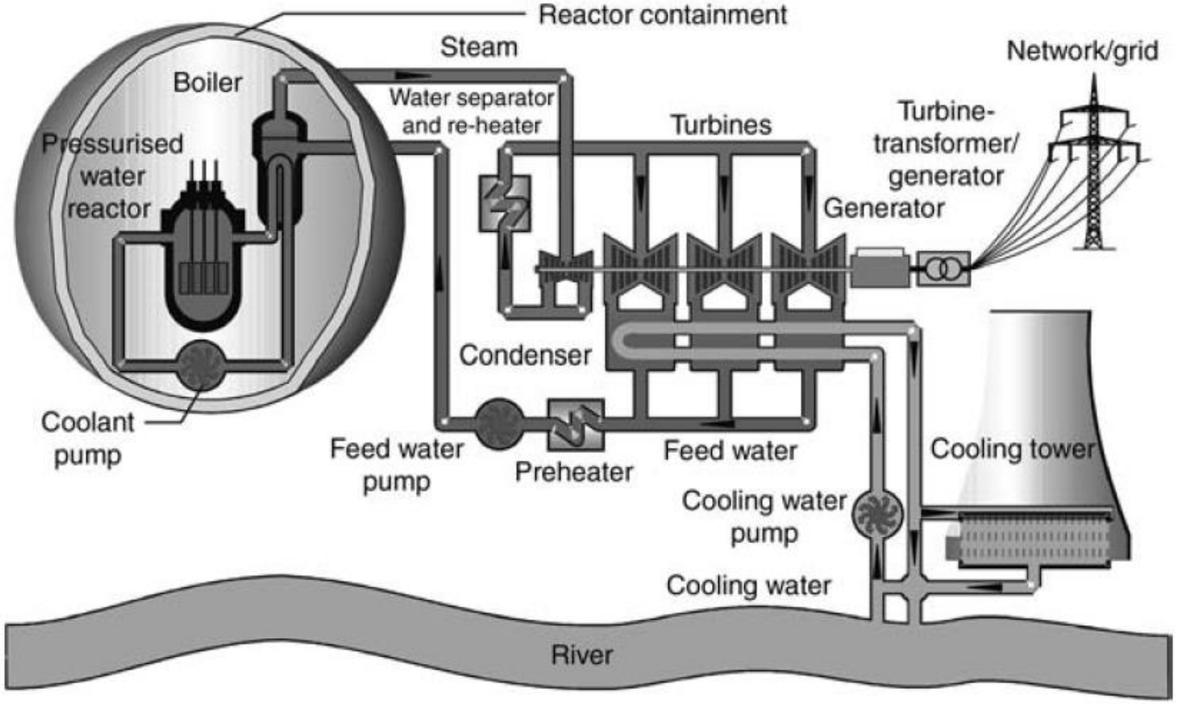
Importance of Nuclear Energy

Nuclear energy now provides around 15% of the electricity generated worldwide. It avoids around 2.5 bn tonnes of CO_2 emissions, so it makes a major contribution towards a sustainable electricity supply which achieves the goals in terms of economics, capability and the environment to a large extent.

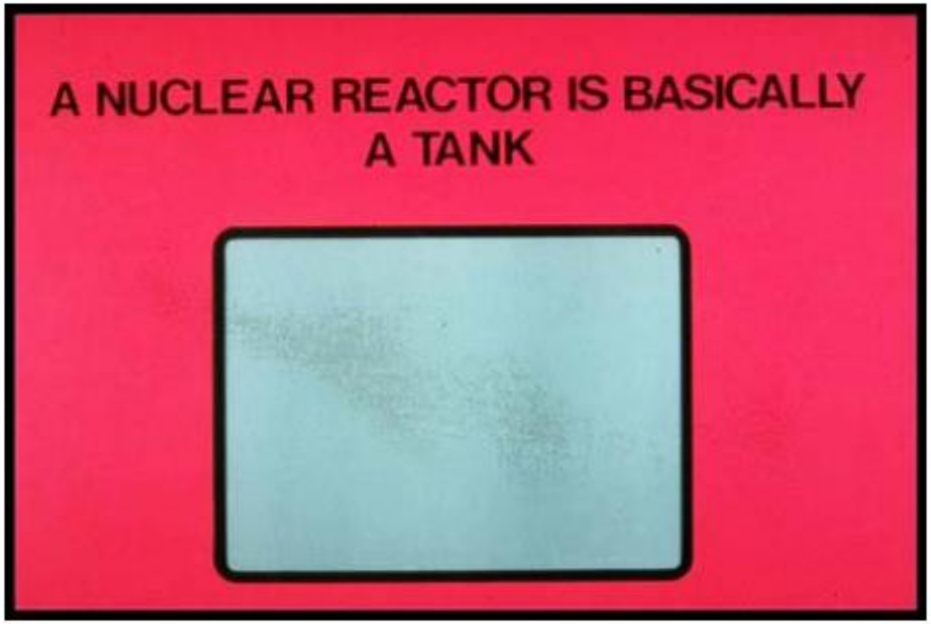
Just how important nuclear energy is can also be seen from how economical it is in generating electricity. Building new nuclear power plants is relatively expensive in terms of capital costs, but the fuel costs involved (uranium), including disposal, are so low that the total cost (including disposal and end stage planning) of generating electricity is around 3–4 Euro cents per kWh. This means that nuclear power is not affected by volatile fuel prices and guarantees a reliable supply, as the uranium deposits

Generating Electricity by nuclear power plants

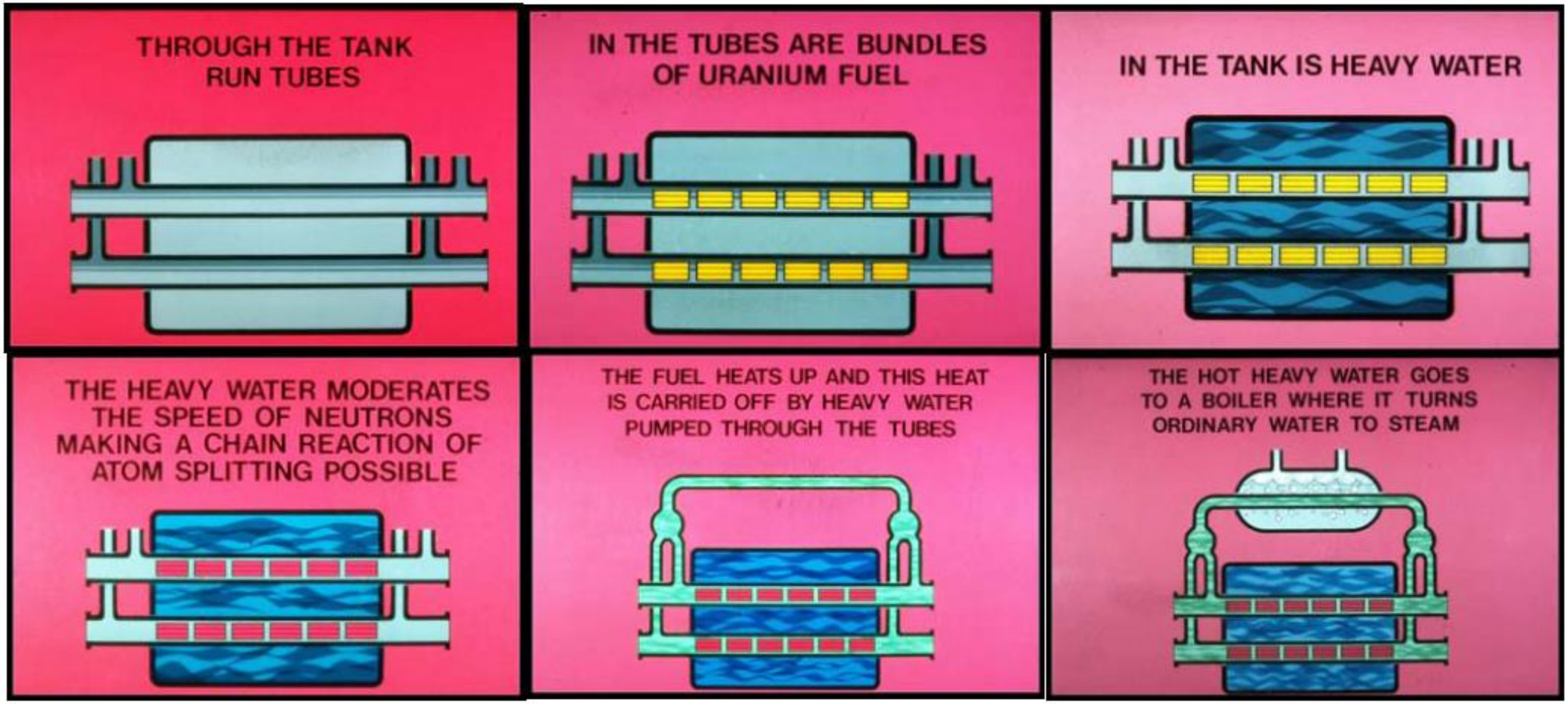
Basically, nuclear power plants work in the same way as coal- and gas-fired plants, converting heat to electricity. Whereas fossil-fuel-fired power plants run on energy media such as oil, lignite or hard coal, nuclear power plants use the heat given off when atomic nuclei split.



Generating Electricity by nuclear power plants



Generating Electricity by nuclear power plants

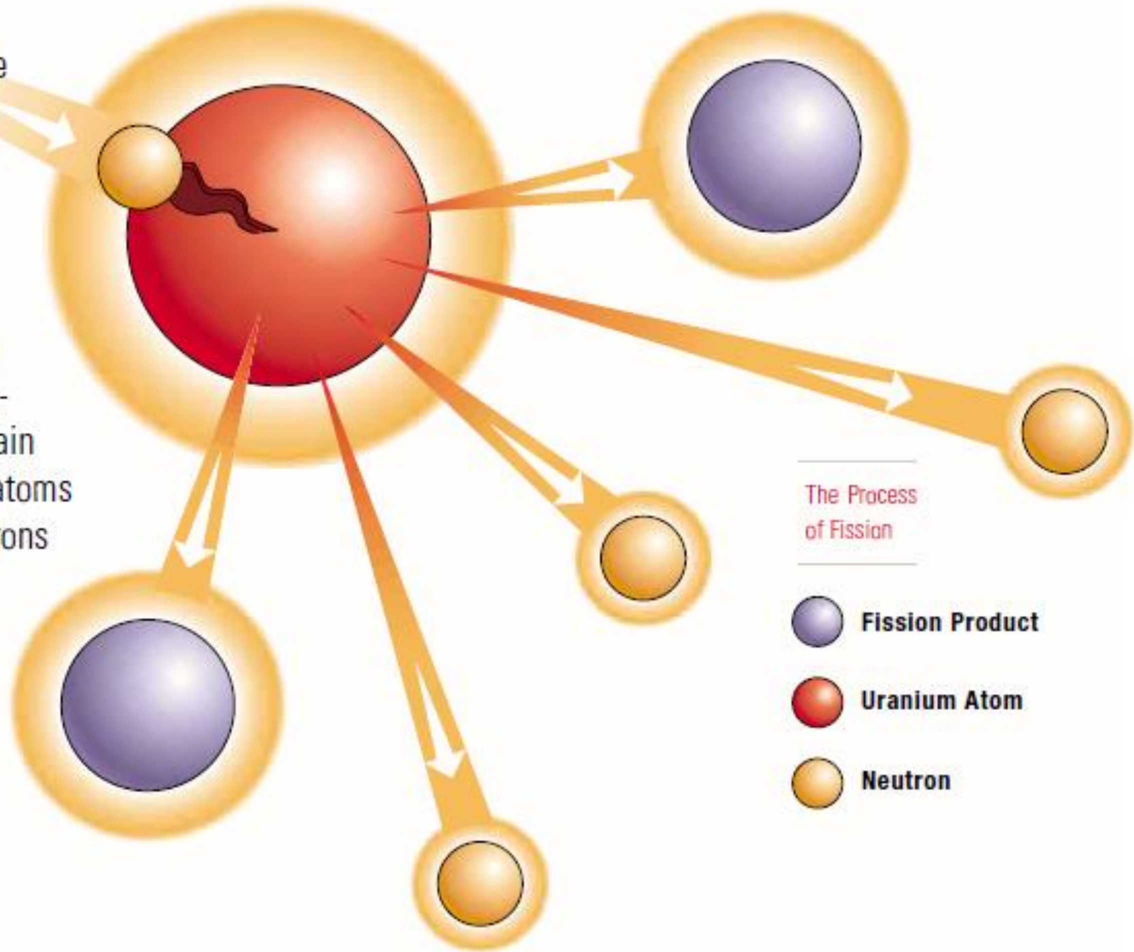


Generating Electricity by nuclear power plants

Fission makes Heat

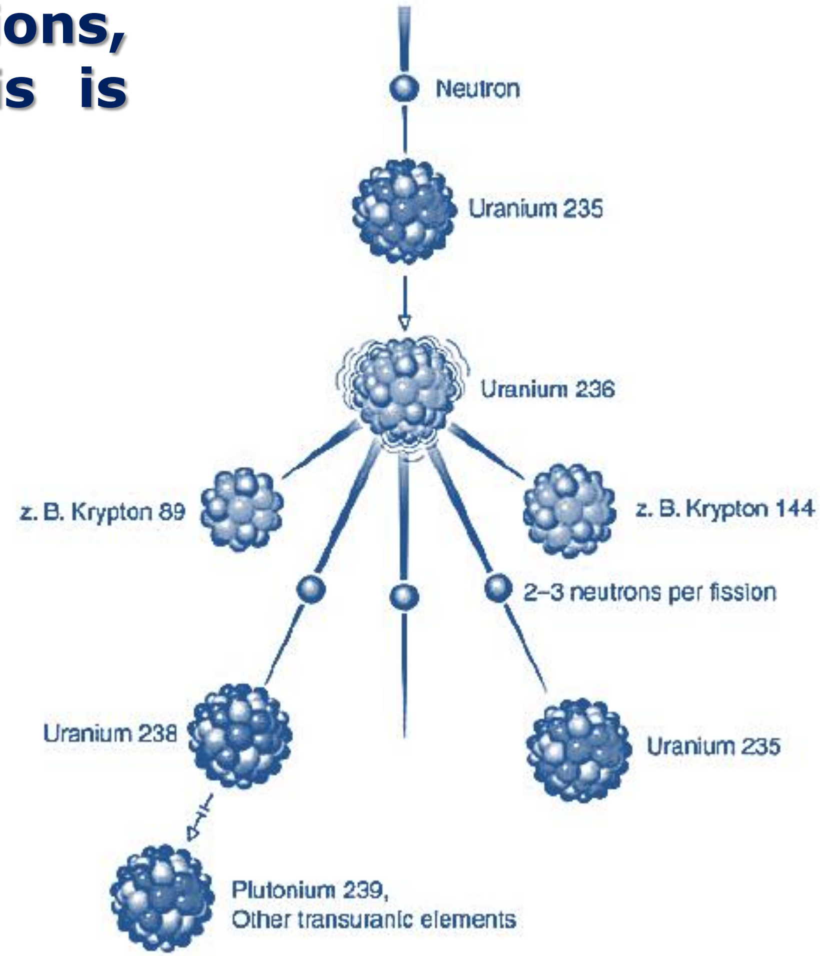
When a neutron (a tiny sub-atomic particle that is one of the components of almost all atoms) strikes an atom of uranium, the uranium atom splits into two lighter atoms (which are called fission products) and releases heat at the same time. The fissioning process also releases from one to three more neutrons that can split other uranium atoms. This is the beginning of a "chain reaction" in which more and more uranium atoms are split, releasing more and more neutrons (and heat).

In a power reactor, the chain reaction is tightly controlled to produce only the amount of heat needed to generate a specific amount of electricity.



Generating Electricity by nuclear power plants

Trigger more fission reactions, and so on and so on… This is called a chain reaction.

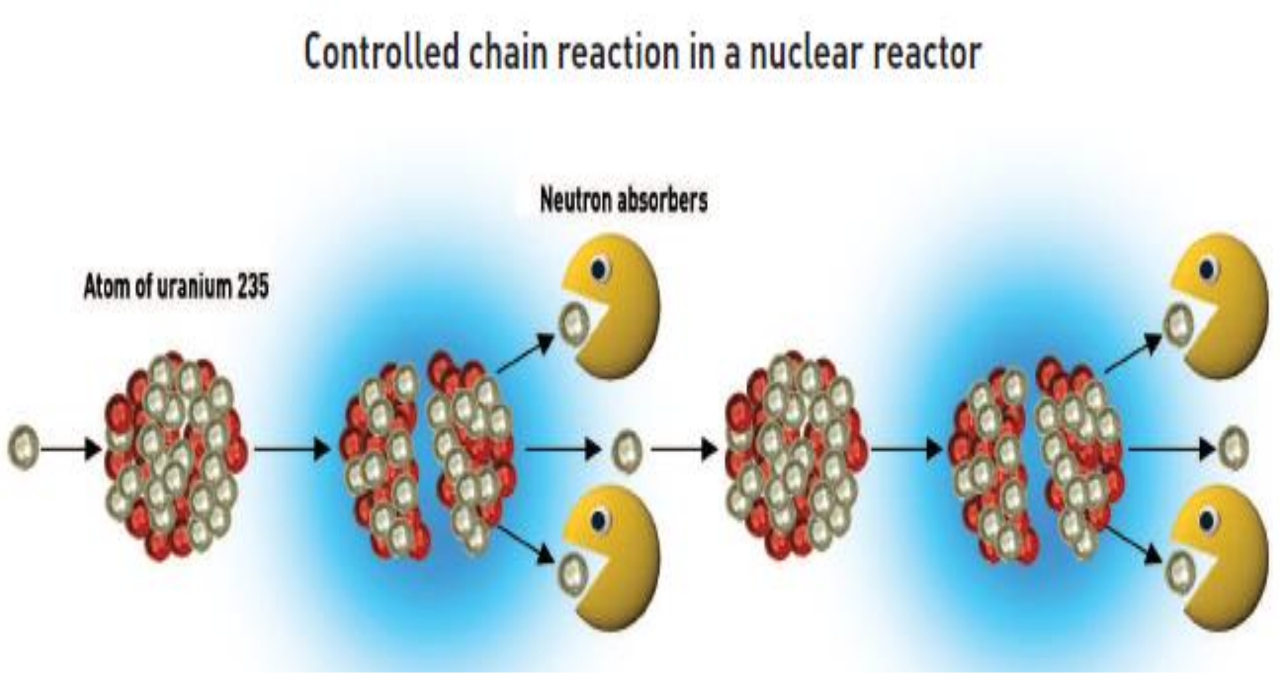


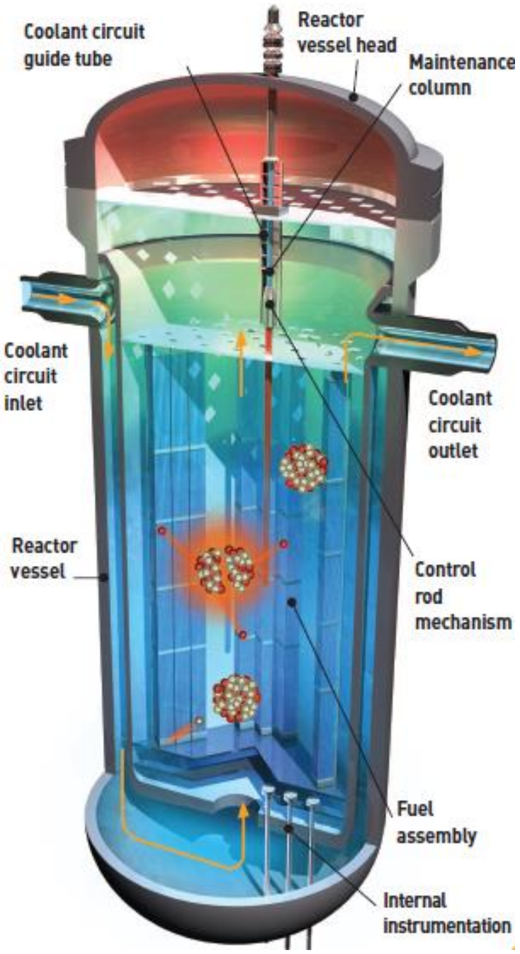
Generating Electricity by nuclear power plants

Chain Reaction Control

In a nuclear reactor, the chain reaction is controlled in order to maintain a constant rate of fission reactions. Of the two or three neutrons liberated during a fission reaction, only one triggers a new reaction and the others are simply captured. The system is in equilibrium. One fission reaction leads to one new fission reaction, which leads to one more, and so on. In an uncontrolled chain reaction, one fission reaction could lead to two, which could lead to four, then eight, etc. In a controlled chain reaction ,the quantity of heat liberated per second in the mass of uranium is completely under control.

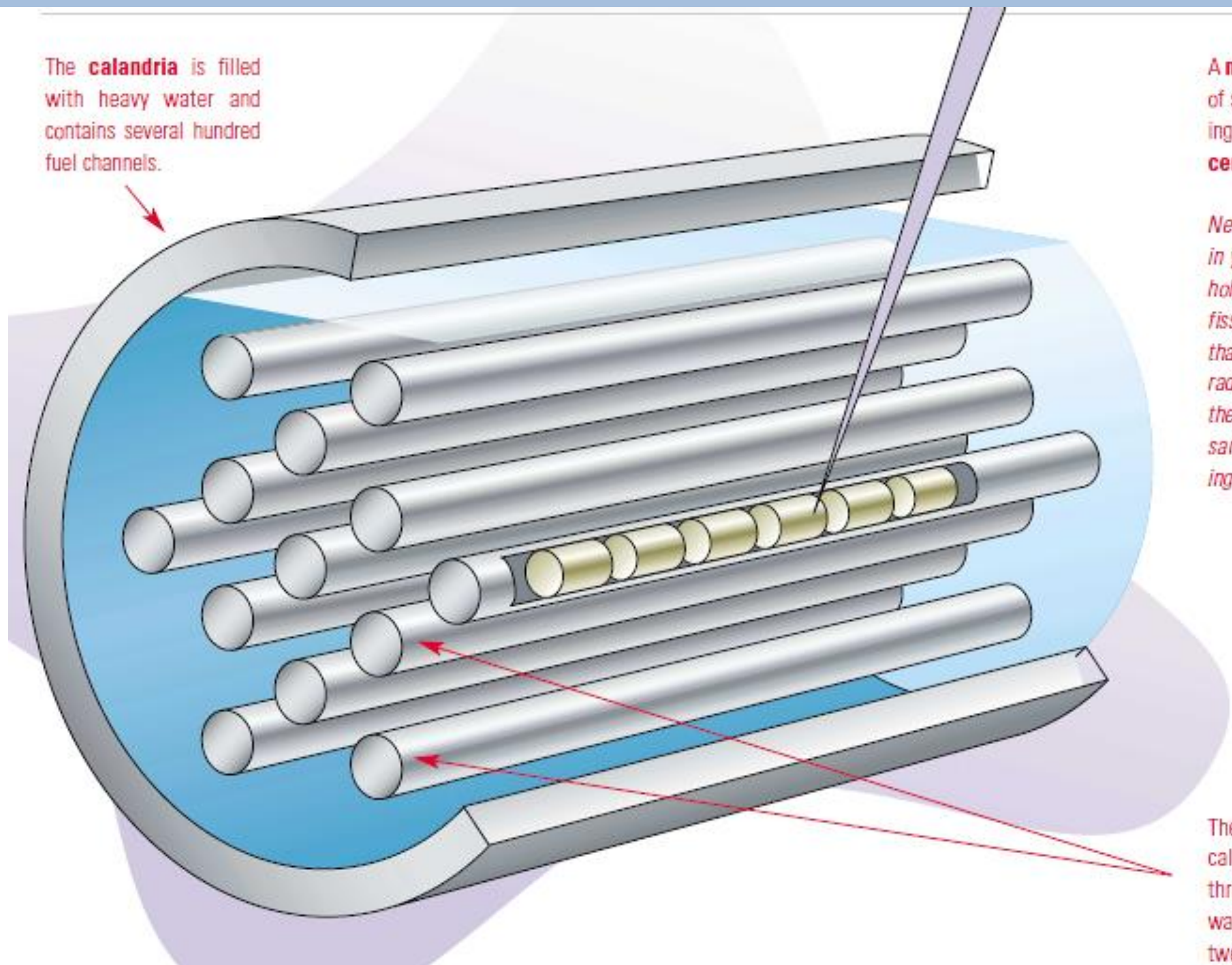
Generating Electricity by nuclear power plants





Generating Electricity by nuclear power plants

The **calandria** is filled with heavy water and contains several hundred fuel channels.

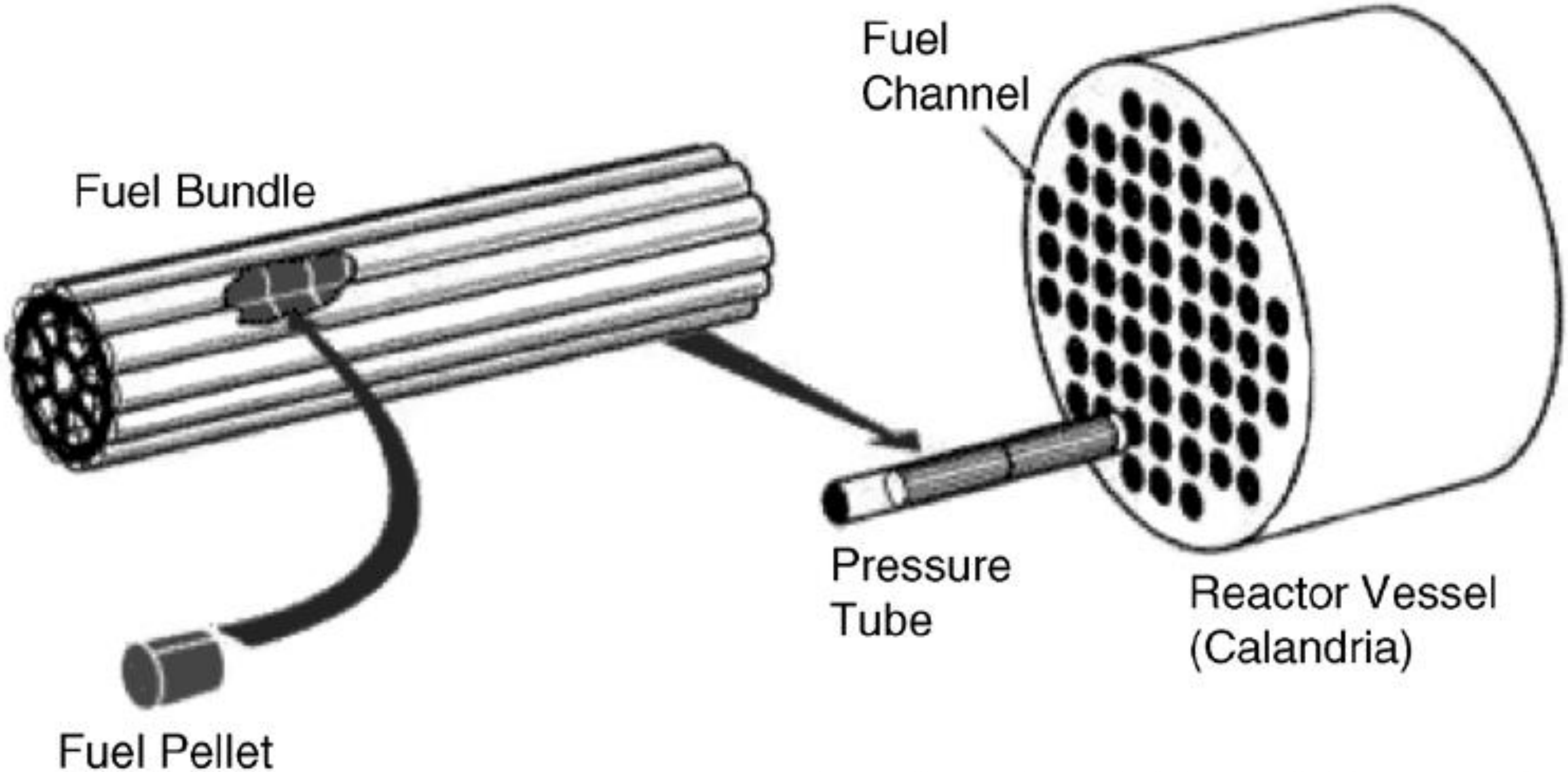


A **nuclear fuel bundle** is made up of several metal tubes, each housing uranium fuel in the form of **ceramic pellets**.

New fuel bundles are safe to hold in your hands - just as it is safe to hold a piece of uranium ore. It's the fission process inside the reactor that makes the used fuel more radioactive. One fuel bundle like the one you see above makes the same amount of electicity as burning 400 tonnes of coal.

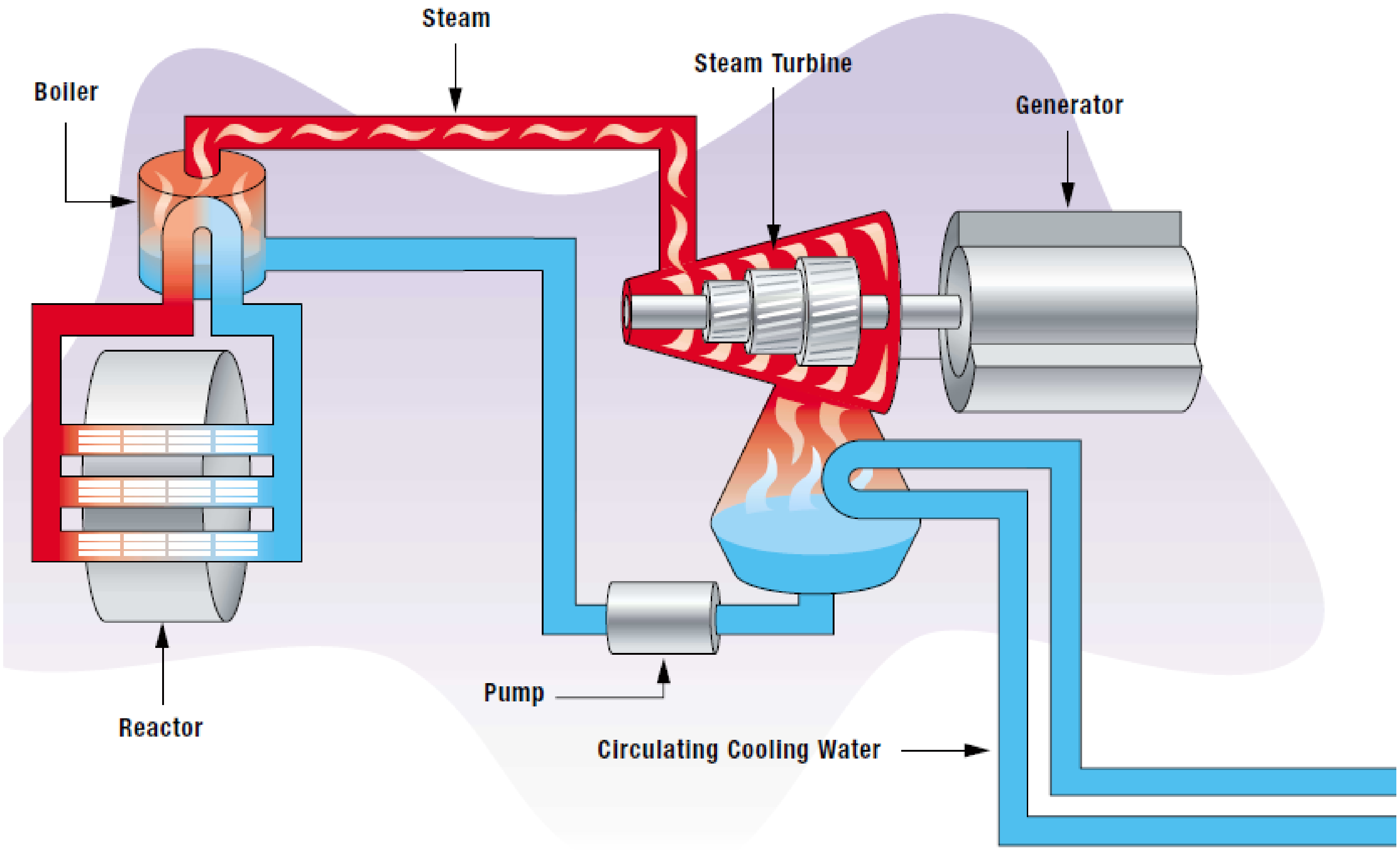
The fuel bundles rest in tubes called **fuel channels** that run through a large tank of heavy water. Each fuel channel contains twelve or thirteen fuel bundles.

Generating Electricity by nuclear power plants



Fuel Bundle and Fuel Channel Relationship.

Generating Electricity by nuclear power plants



Reactor Designs

Many kinds of nuclear reactors have been developed since the discovery of uranium's nuclear decay in 1938. These can be divided into generations, in the order in which they were developed, as follows:

Generation I

The initial prototypes built between 1957 and 1963.

Generation II

Commercially viable reactors built from the mid 1960s onwards.

Generation III

Advanced reactors, generating much more power and with much more concern about safety, built since the early 1980s. (Chernobyl Nuclear Power Plant 26/04/1986)

Reactor Designs

Generation III+

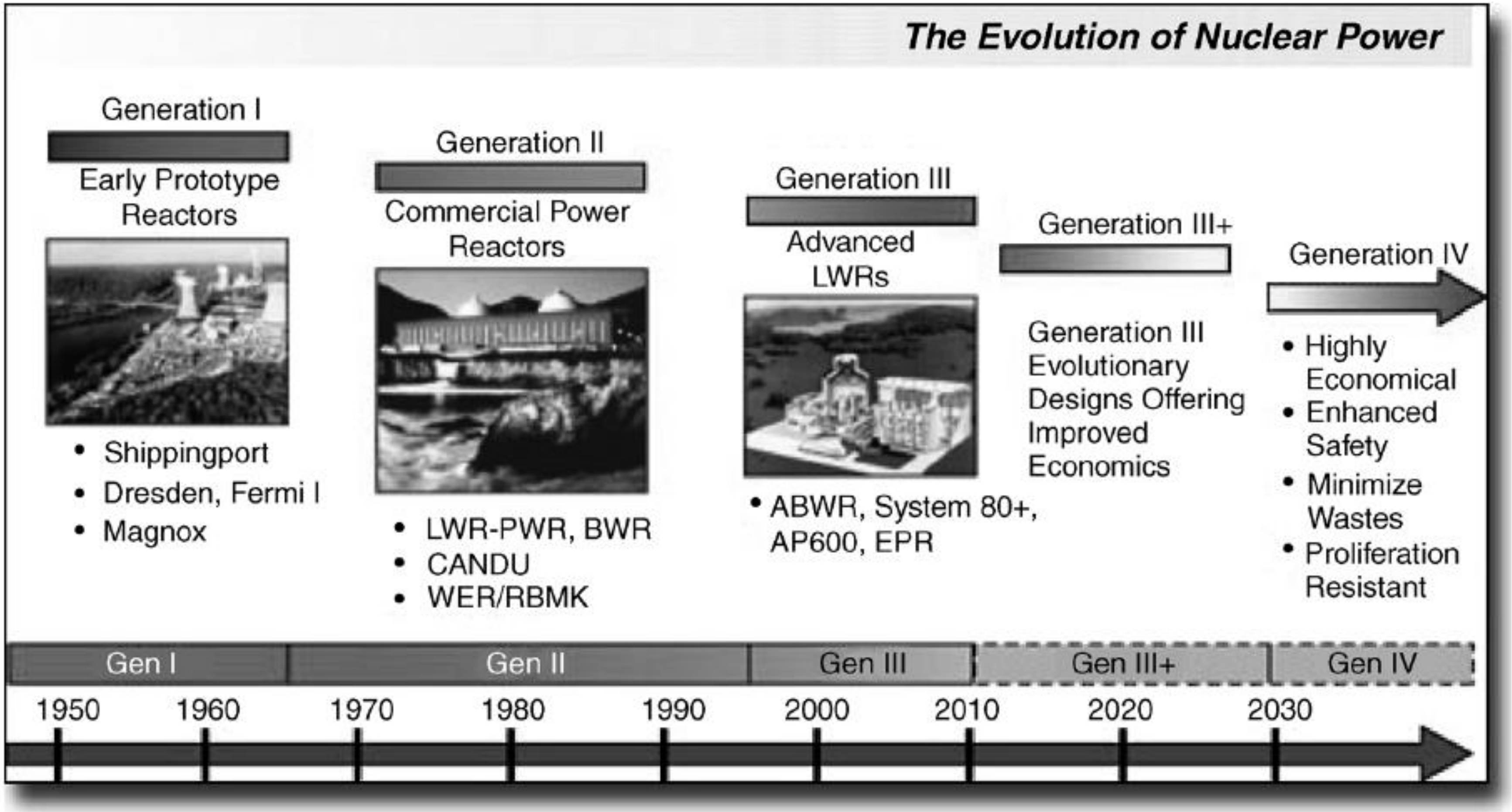
The next generation of reactors, with structural safeguards against meltdown and/or passive safety features.

Generation IV

The reactors of the future, highly efficient, with advanced safety features and producing little spent nuclear fuel, but not expected to come on stream until 2030 at the earliest.

(Fukushima Nuclear Power Plant 11/03/2011)

Reactor Designs



Reactor Designs

The types of nuclear reactor that have been developed, there are only a few that can be used in commercial operation. The different types can be broken down by the following aspects:

Fuel

e.g. natural uranium, enriched uranium, plutonium, thorium; whether they use clad or unclad solid fuels (cladding materials are zirconium, aluminum, magnesium or magnesium oxide – Magnox); fuel elements may be rods, plates, tubes or pellets.

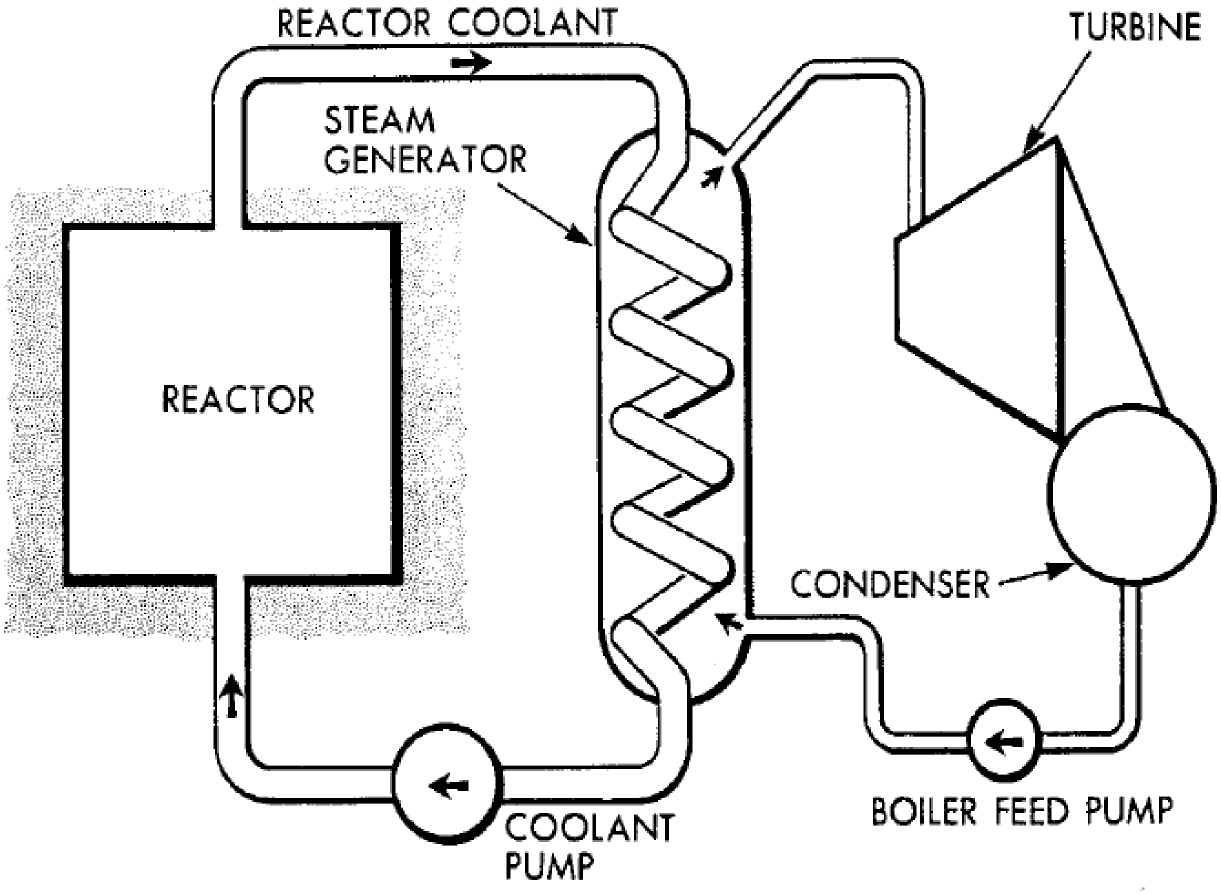
Neutron energy

Thermal reactors (moderated neutrons, using moderators such as graphite, light water H_2O or heavy water D_2O) and fast reactors (without moderating the neutrons).

Coolant: Carrier of heat

light water H_2O, heavy water D_2O, gas (air, but mainly carbon dioxide and helium).

Reactor Designs



Reactor Designs

Moderator	Coolant	Reactor type
Light water (H_2O)	Light water (H_2O)	PWR – pressurised water reactor
Boiling light water (H_2O)	Boiling light water (H_2O)	BWR – boiling water reactor
Heavy water (D_2O)	Light water (H_2O)	Advanced CANDU
Heavy water (D_2O)	Heavy water (D_2O)	CANDU – Canadian deuterium uranium reactor
Graphite	Helium (He)	HTGR – high temperature gas-cooled reactor
Graphite	Carbon dioxide (CO_2)	AGR – advanced gas-cooled reactor
Graphite	Light water (H_2O)	RBMk – graphite moderated pressure tube reactor

Thank you