Nuclear Power Plant

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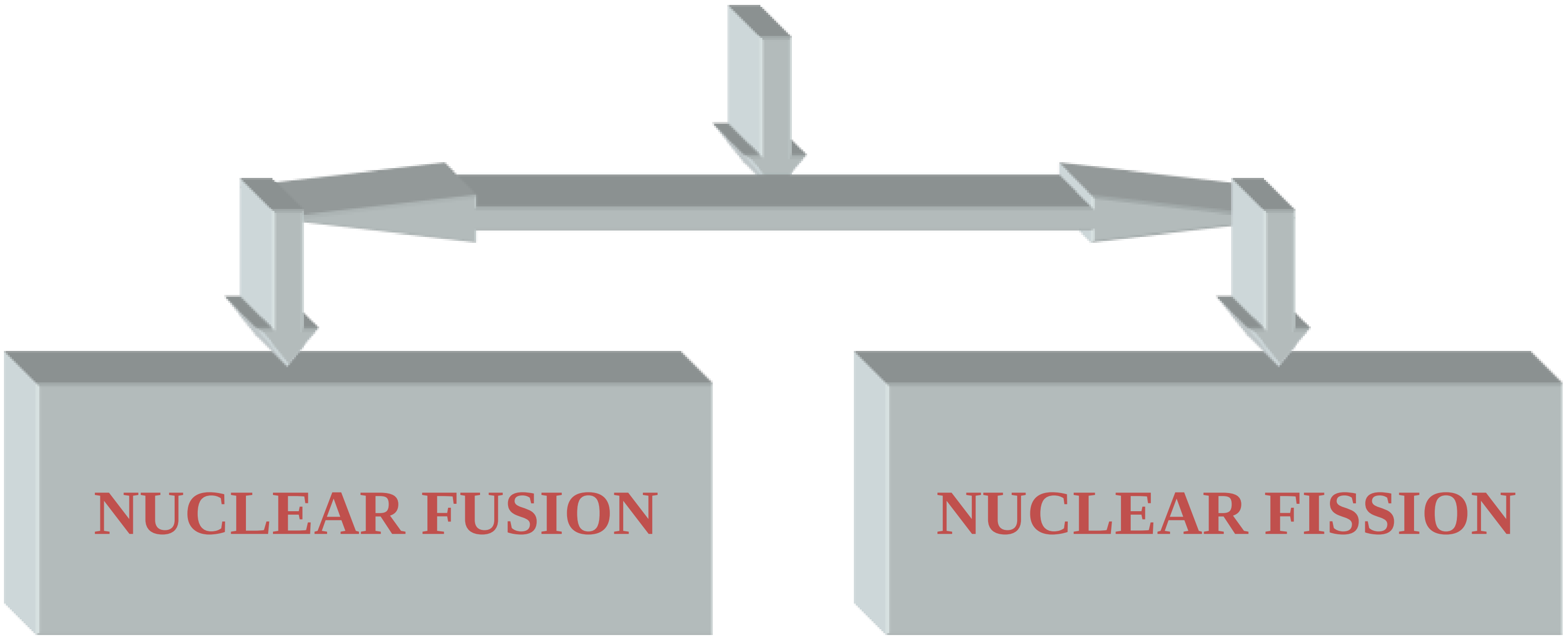
NUCLEAR POWER PLANT

- **Cheap & abundant power is essential**
- **Industrialization & living standard creates Pressure on conventional sources.**
- **Fission of 1 Kg of Uraniun=3100 Ton of coal & 1700 Kg of oil.**
- **Total amount of uraniun & thorium in earth crust = 10^{12T} at 5 Km depth**
- **Nuclear power is cheaper than 50% conventional resources.**
- **Clean source, no combustion products & no ash.**
- **First NPP is commissioned in chicago University.**
- **First NPP 5 MW in USSR in 1954.In USA 1956.**
- **In INDIA Uranium is about 32000 T & thorium 500,000 T sufficient for thousand of years.**

Nuclear power station.

Generation of heat in nuclear power reactor.

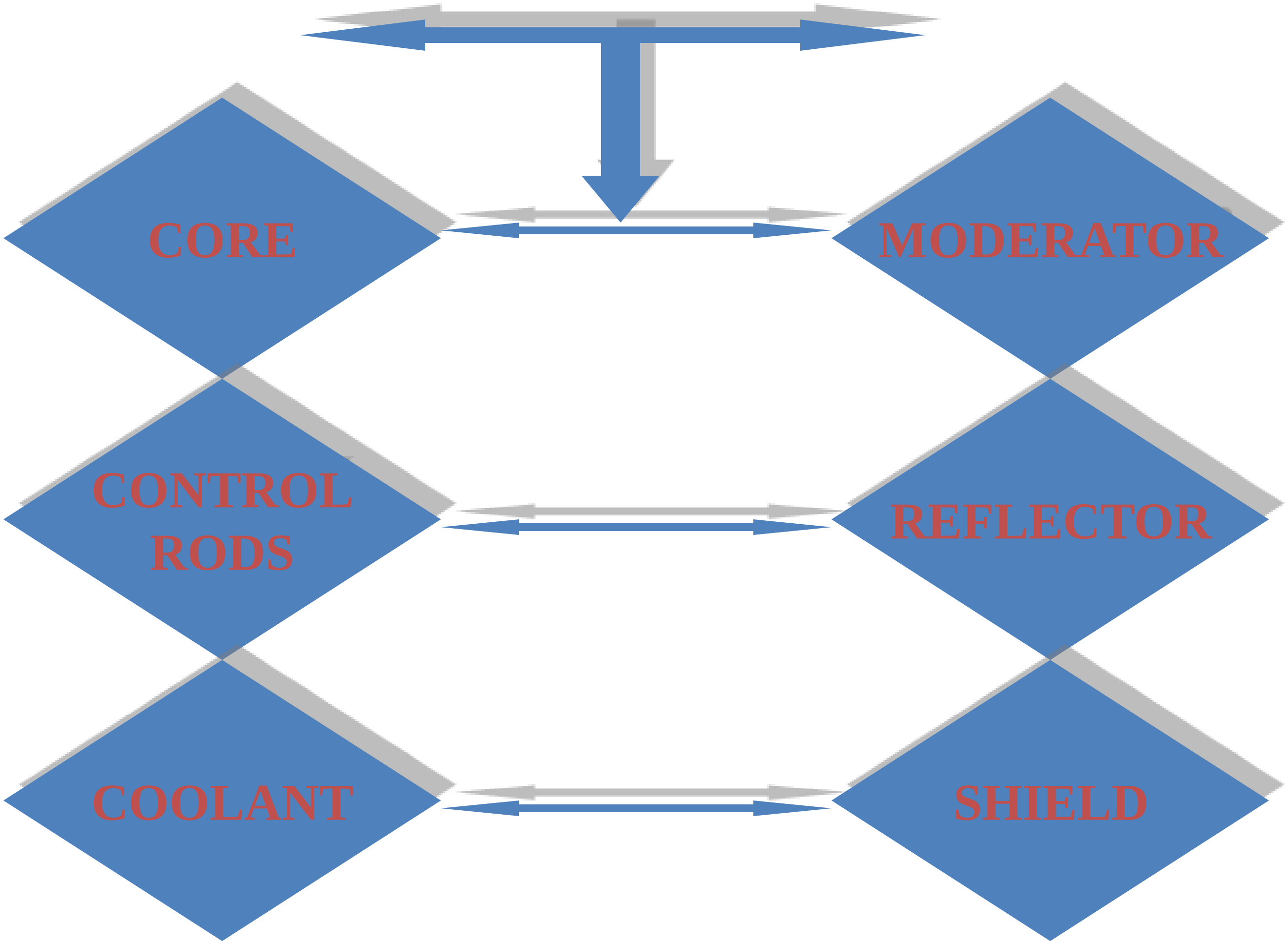


Nuclear power station.

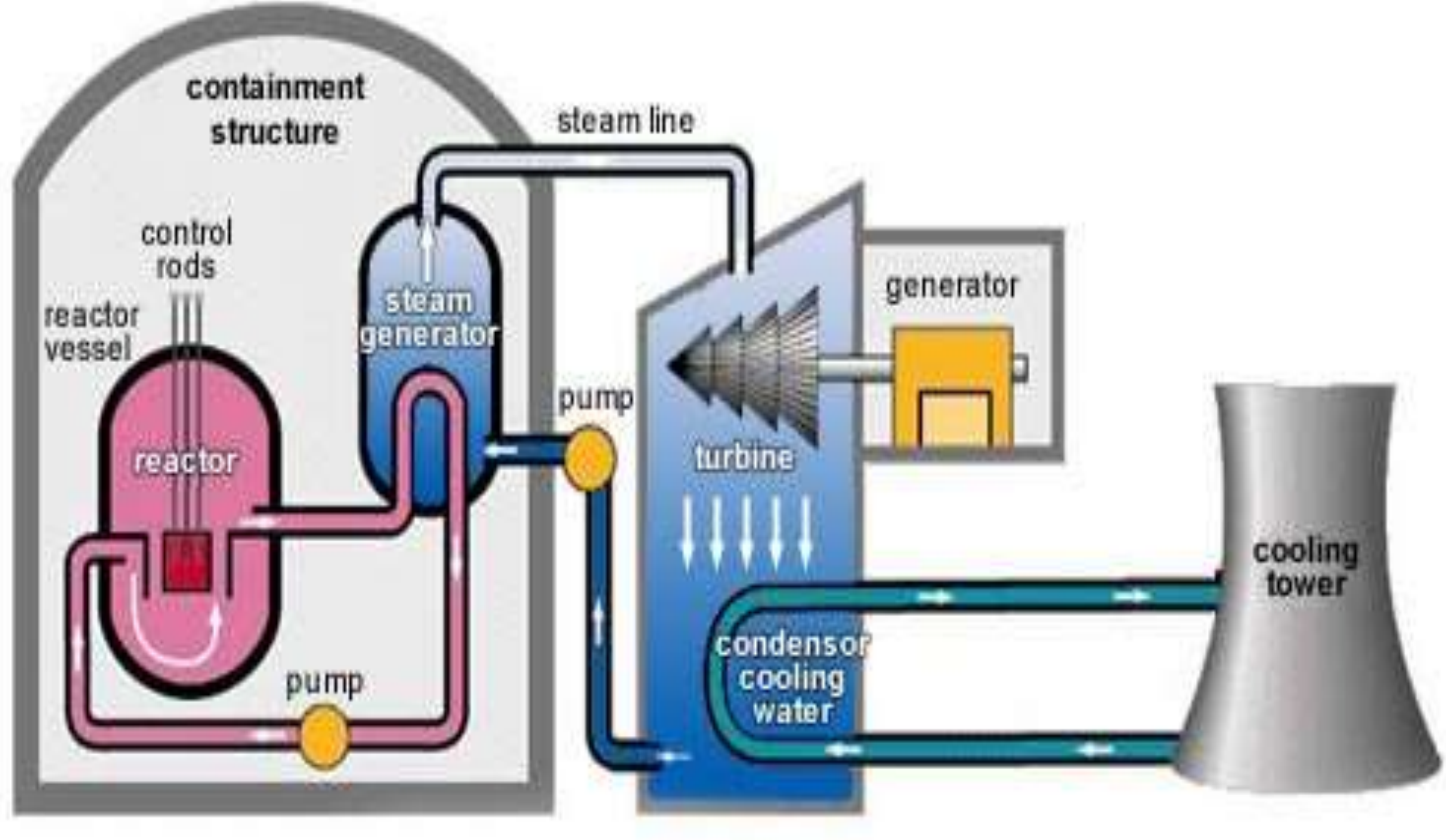
Fuels used in Reactor.

Nuclear power station.

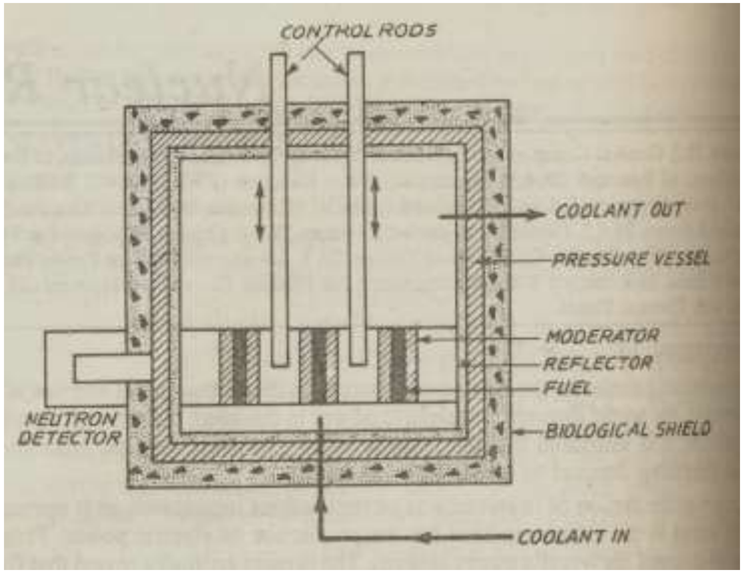
Main element of nuclear reactor.



Working diagram of Nuclear power station.



NUCLEAR REACTOR



1. **FUEL:**

- $_{92}U^{235}$:- **Naturally available.**
- $_{94}U^{233}$:- & $_{92}Pu^{239}$ **are formed during nuclear reaction of** $_{92}U^{238}$
- **Fuel is placed in such a way that heat production within reactor is uniform.**
- **Fuel rod coated with Al ,SS, Zirconium to prevent oxidation.**

NUCLEAR REACTOR

2) MODERATOR:

- **Reduces the K.E. of fast neutron 13200 Km/s to 2200 m/s .**
- **Slowing down of neutrons is effectively done by light elements**

  H_2,D_2,N_2,O_2,C & Be
- **Graphite, heavy water, Beryllium can be used as moderator with natural uranium.**
- **Ordinary water is used as moderator with enriched uranium only.**
- **Moderator should be light, as slowing down action is more effective in elastic collision with light elements.**
- **Must have resistance to corrosion, machinability, high melting point,**
- **Good conductor.**
- **Should not decomposed due to nuclear radiation.**
- **High chemical stability.**

NUCLEAR REACTOR

2) REFLECTOR:

- **Necessary to conserve neutrons to reduce consumption of fissile material.**
- **Neutrons may be absorbed by fuel itself, moderator, coolant,structural material.**
- **H2O,D2O,Carbon are used as reflector.**
- **Properties are low absorption & high reflection.**
- **Necessary to provide cooling the reflector as it gets heated due to collision of neutrons.**

NUCLEAR REACTOR

2) COOLANT:

H_2O,Heavy water,Na,CO_2,He

- **Transfer the heat produced in reactor.**
- **Must not absorb the neutrons.**
- **High chemical & radiation stability.**
- **Non corrosive.**
- **High boiling point & low melting point (solids).**
- **Non oxidizing & non toxic.**

NUCLEAR REACTOR

2) CONTROL RODS:

Boron, Cadmium, Indium.

Control is necessary to fulfill following functions:-

- **To start the nuclear reactor.**
- **Chain reaction should be maintained at steady rate.**
- **To shut down the reactor.**
- **To prevent the melting of fuel rod. disintegration of coolant, destruction of reactor.**

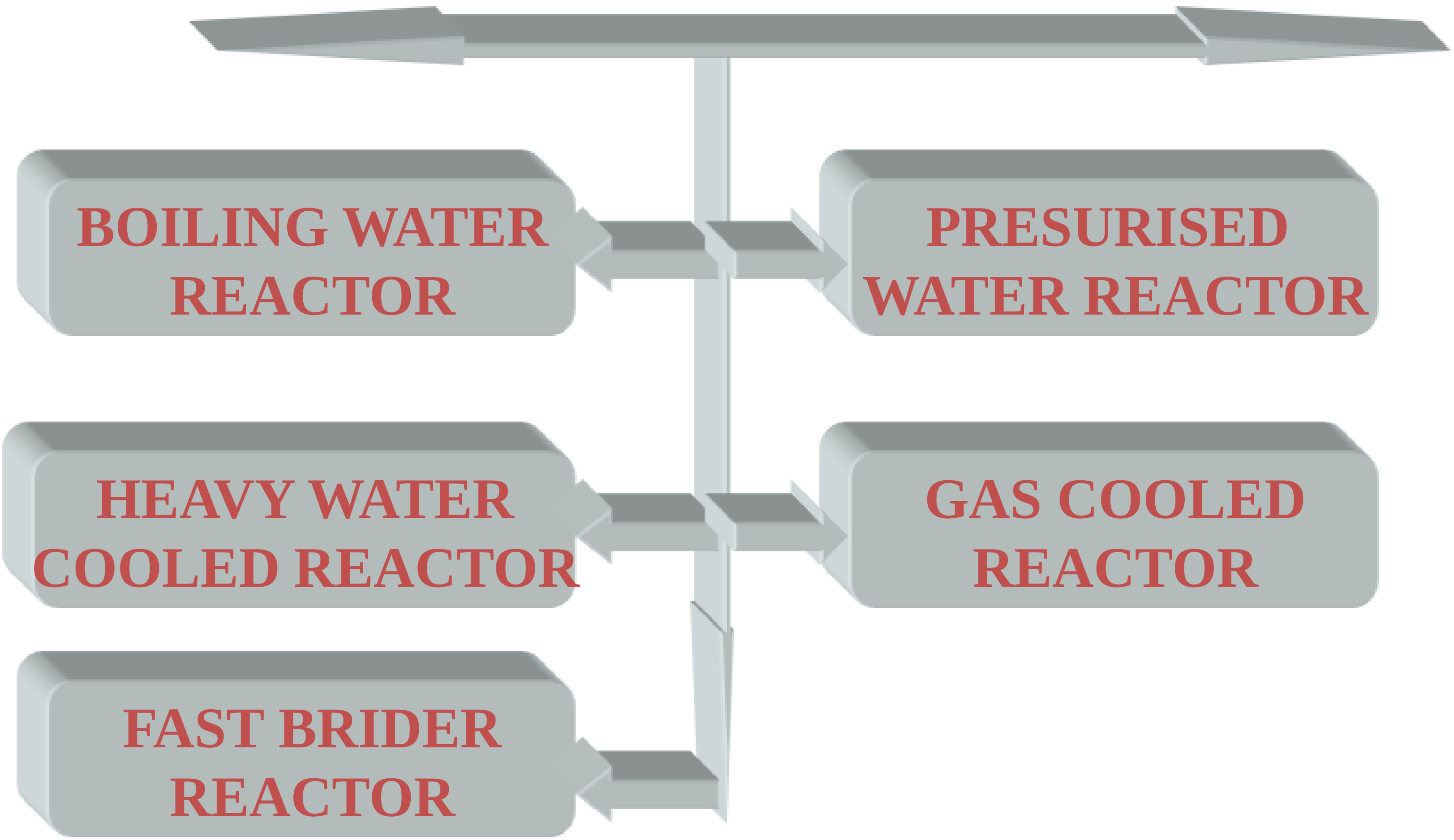
NUCLEAR REACTOR

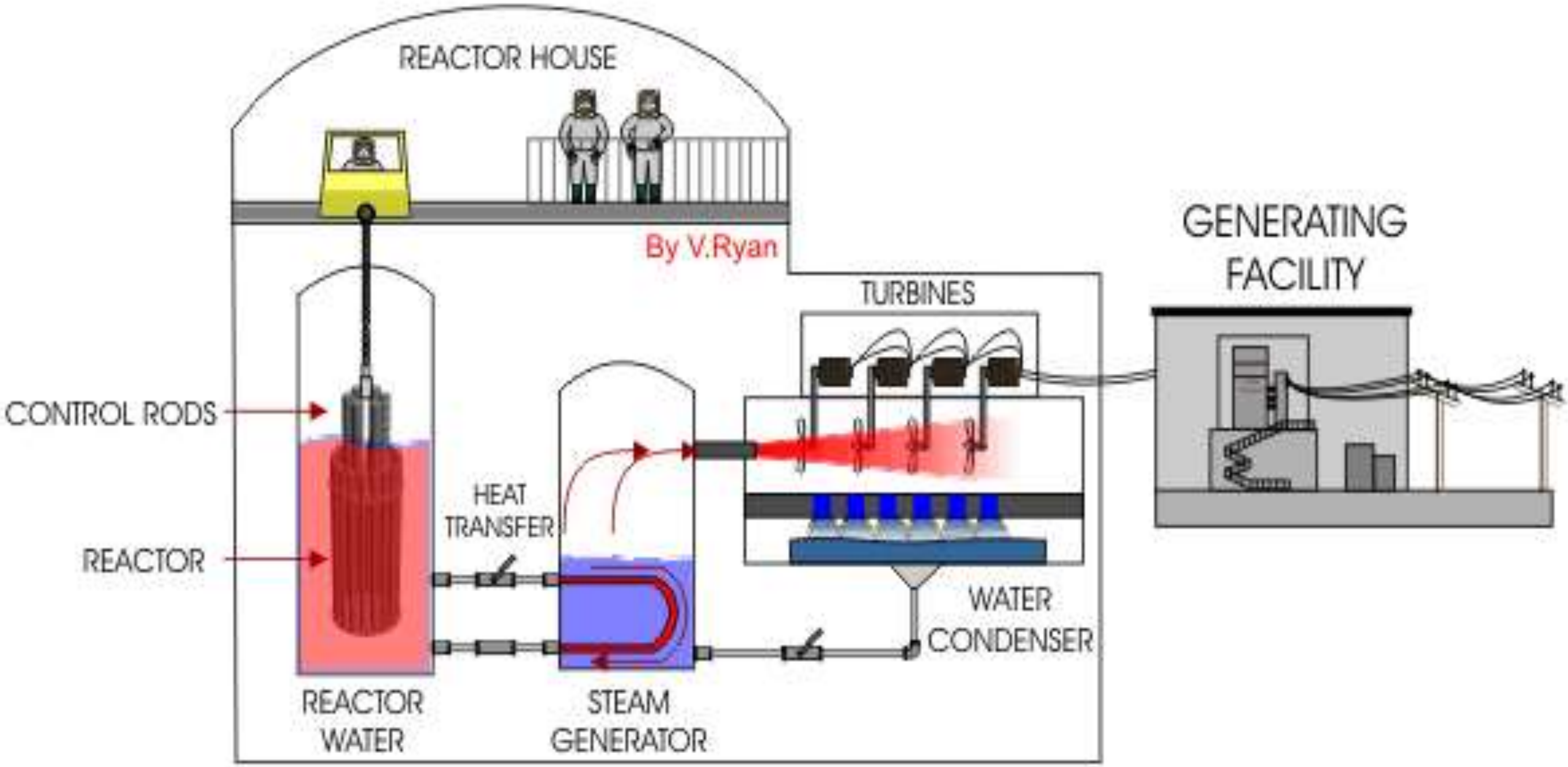
2) Shielding:

- **Reactor core is source of intense radiations, harmfull to human life.**
- **ά,β,γ & fast neutrons absorbed before.**
- **Concrete & steel structure.**
- **Inner portion 50 to 60 cm thick steel plate.**
- **Concrete few meters thick.**
- **Cooled by circulation of water.**

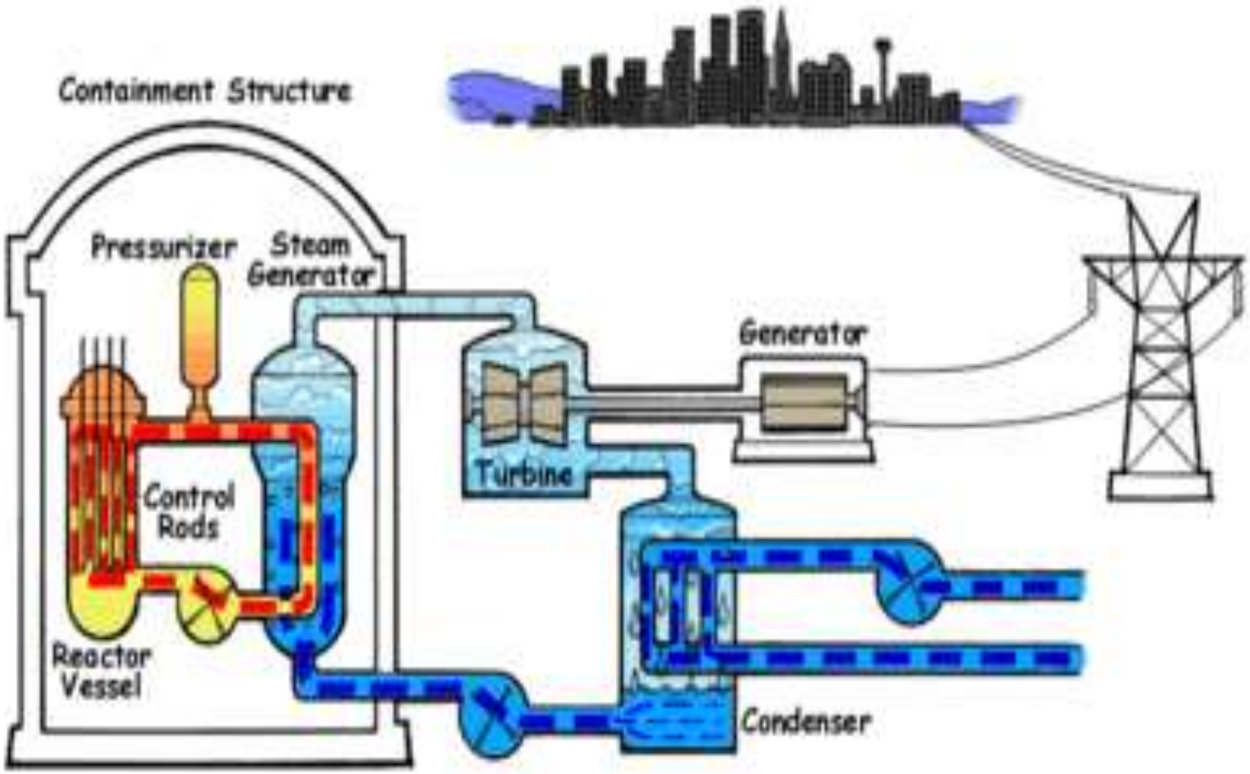
Nuclear power station.

Types of nuclear reactor.



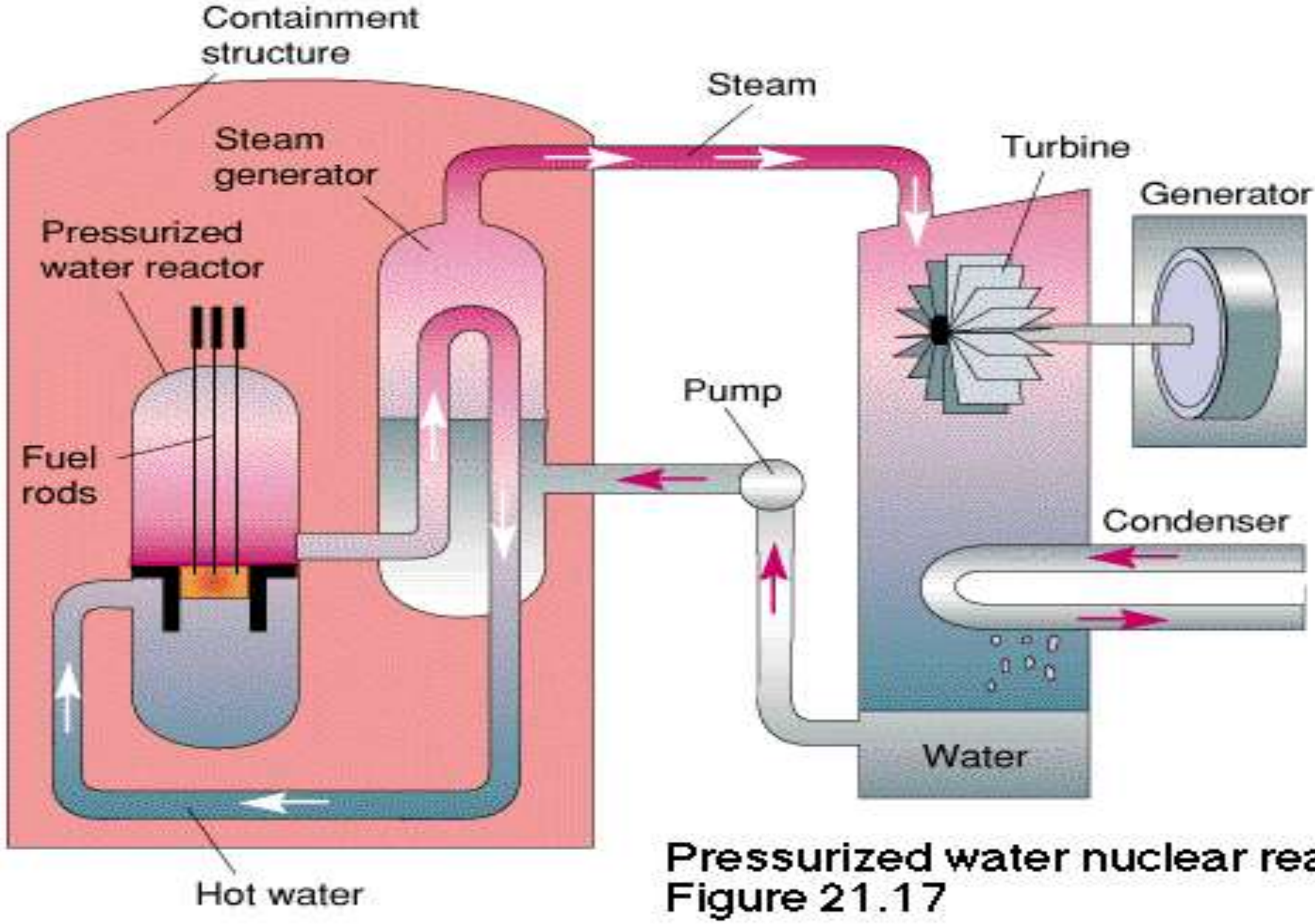

REACTOR HOUSE
By V.Ryan
GENERATING
FACILITY
TURBINES
CONTROL RODS
HEAT
TRANSFER
REACTOR
WATER
CONDENSER
REACTOR
WATER
STEAM
GENERATOR

Pressurized water nuclear reactor



Nuclear power station.

Pressurized water nuclear reactor.



Pressurized water nuclear reactor.
Figure 21.17

Pressurized water nuclear reactor
(Kota,Narora,Kakrapar,kaiga)

Coolant & Moderator : Water

Fuel: Enriched Uranium thin rod or pallets.200 fuel rods & 24 control rods, cladding of stainless steel 20 to 35 cm.

Pressure:100 to 130 bar

Developed by USA in 1957. O/P=231 MW, ή= 20.4 %

Limitation: Critical temp. of water 374°C.

Pressure maintained at 155 bar.(above 85.93 bar to supress boiling)

Pressure Equalizer: For load variation or change in nuclear reactivity.

First PWR in world:

Shippingport USA 1957

Out Put : 231 MW Efficiency : 29.4 %.

The shippigport cycle is modifided by inclusion of

Oil fired superheater and economiser

At turbine inlet steam conditions are

25.5 bar & 538ºC

Pressurized water nuclear reactor (Kota,Narora,Kakrapar,kaiga)

Advantages:

1) Water is used as coolant, moderator, reflector
2) Complete freedom for inspection.
3) Reduce Fuel cost extracting more energy per unit weight of fuel.
4) Compact in size.

Disadvantages:

1) High capital cost, Pressure Equalizer .
2) Corrosion is more cause of high pressure & temp.
3) Shut Down period: for fuel charging requires three months.
4) γ radiations affect pressure vessel.

Boiling water nuclear reactor

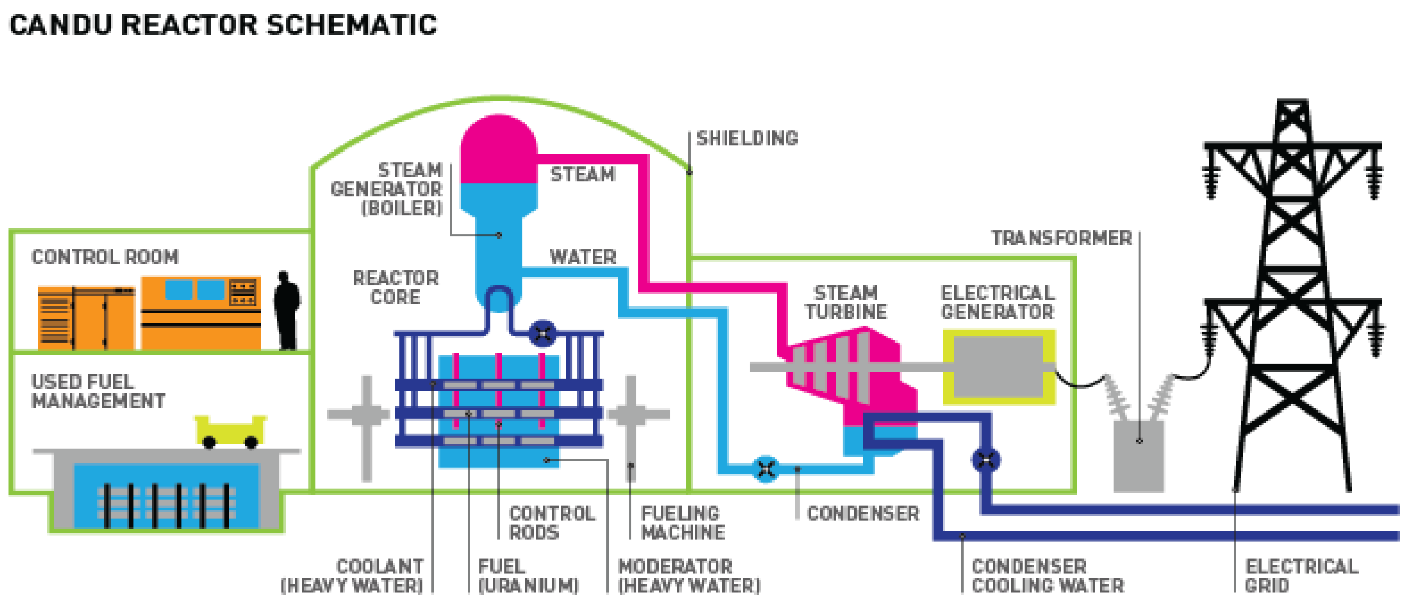
Advantages:

1) Reactor vessel is smaller : Boiling of Water inside.
2) Cost is less :Does not require pressriser,circulating pump, pipes.
3) Metal surface temperature is lower than PWR.
4) BWR is more stable.
5) ή= 30.00 % is higher.

Disadvantages:

1) Cannot meet sudden change in power requirement.
2) Shielding of turbine & piping is necessary.
3) Size is large: Power density is 50 % of PWR.
4) Possibility of fuel burnout. Surface heat flux beyond 140cm2/kcal/hr

Canadian Deuterium Uranium Reactor CANDU



Coolant & Moderator : Heavy Water

Fuel: Natural Uranium , No control rods, control of reactor achieved by varying moderator level.

ή= 29.00 %

Canadian Deuterium Uranium Reactor CANDU

Advantages:

1) Fuel need not to be enriched.
2) Reactor vessel may be built to withstand low pressure as compared to PWR & BWR. Only fuel tubes are designed to withstand high pressure.
3) No control rods are required.
4) Construction period is shorter.

Disadvantages:

1) Cost of heavy water is high Rs. 500/kg.
2) Power density is low 9.7 kW/lit. Size is large.
3) Leakage through fuel tube.

Top view Nuclear power station.