

NUCL 402 Engineering of Nuclear Power Systems

Lecture 1: Introduction

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Introduction- Energy Sources

<i>Source</i>	<i>Advantages</i>	<i>Disadvantages</i>
<i>Coal</i>	Inexpensive, Easy to recover (in U.S. and Russia)	Pollution, Requires extensive transportation system
<i>Nuclear</i>	Inexpensive Fuel Concentrated Energy source Compact Waste No greenhouse or acid rain effects	Larger capital cost Long-term high level waste storage Potential nuclear proliferation
<i>Hydroelectric</i>	Inexpensive to operate	Very limited source Environmental damage
<i>Gas / Oil</i>	Good distribution system Easy to obtain Better as space heating energy	Very limited availability Global warming Expensive for energy generation
<i>Renewable Wind, Solar, Biomass, Hydrogen</i>	Free if available	Limited areas, Need expensive energy storage Some environmental effects



Nuclear, Wind, Tidal, Hydro, Thermal (Coal/Gas)

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Nuclear Power Reactors

- ✓ Most nuclear electricity is generated using just two kinds of reactors which were developed in the 1950s and improved since.
- ✓ New designs are coming forward and some are in operation as the first generation reactors come to the end of their operating lives.
- ✓ Over 16% of the world's electricity is produced from nuclear energy, more than from all sources worldwide in 1960.

Nuclear Plants in Commercial Operation

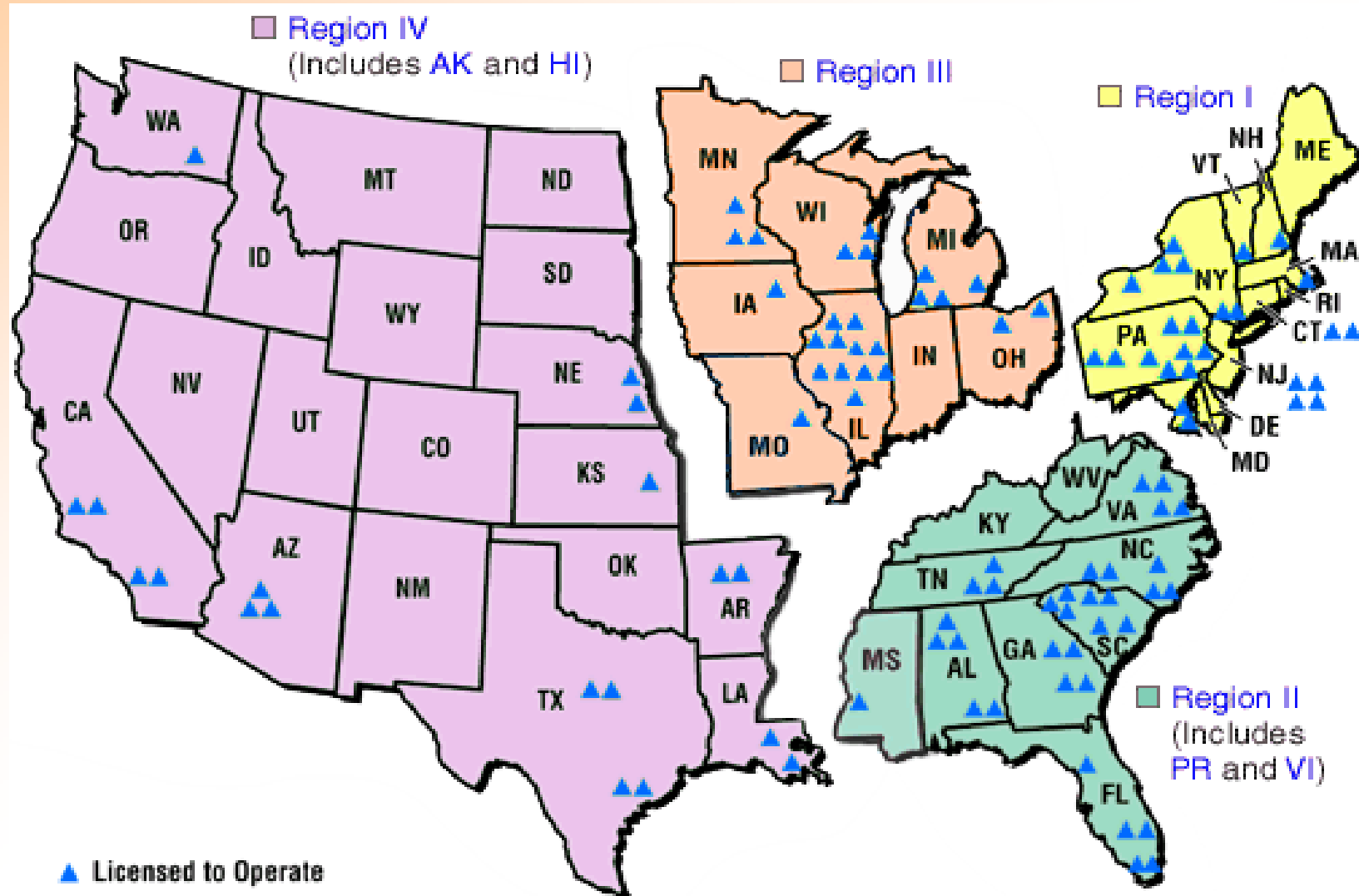
Reactor type	Main Countries	Number	GWe	Fuel	Coolant	Moderator
Pressurised Water Reactor (PWR)	US, France, Japan, Russia	264	250.5	enriched UO_2	water	water
Boiling Water Reactor (BWR)	US, Japan, Sweden	94	86.4	enriched UO_2	water	water
Pressurised Heavy Water Reactor 'CANDU' (PHWR)	Canada	43	23.6	natural UO_2	heavy water	heavy water
Gas-cooled Reactor (AGR & Magnox)	UK	18	10.8	natural U (metal), enriched UO_2	CO_2	graphite
Light Water Graphite Reactor (RBMK)	Russia	12	12.3	enriched UO_2	water	graphite
Fast Neutron Reactor (FBR)	Japan, France, Russia	4	1.0	PuO_2 and UO_2	liquid sodium	none
other	Russia	4	0.05	enriched UO_2	water	graphite
	TOTAL	439	384.6			

GWe = capacity in thousands of megawatts (gross)

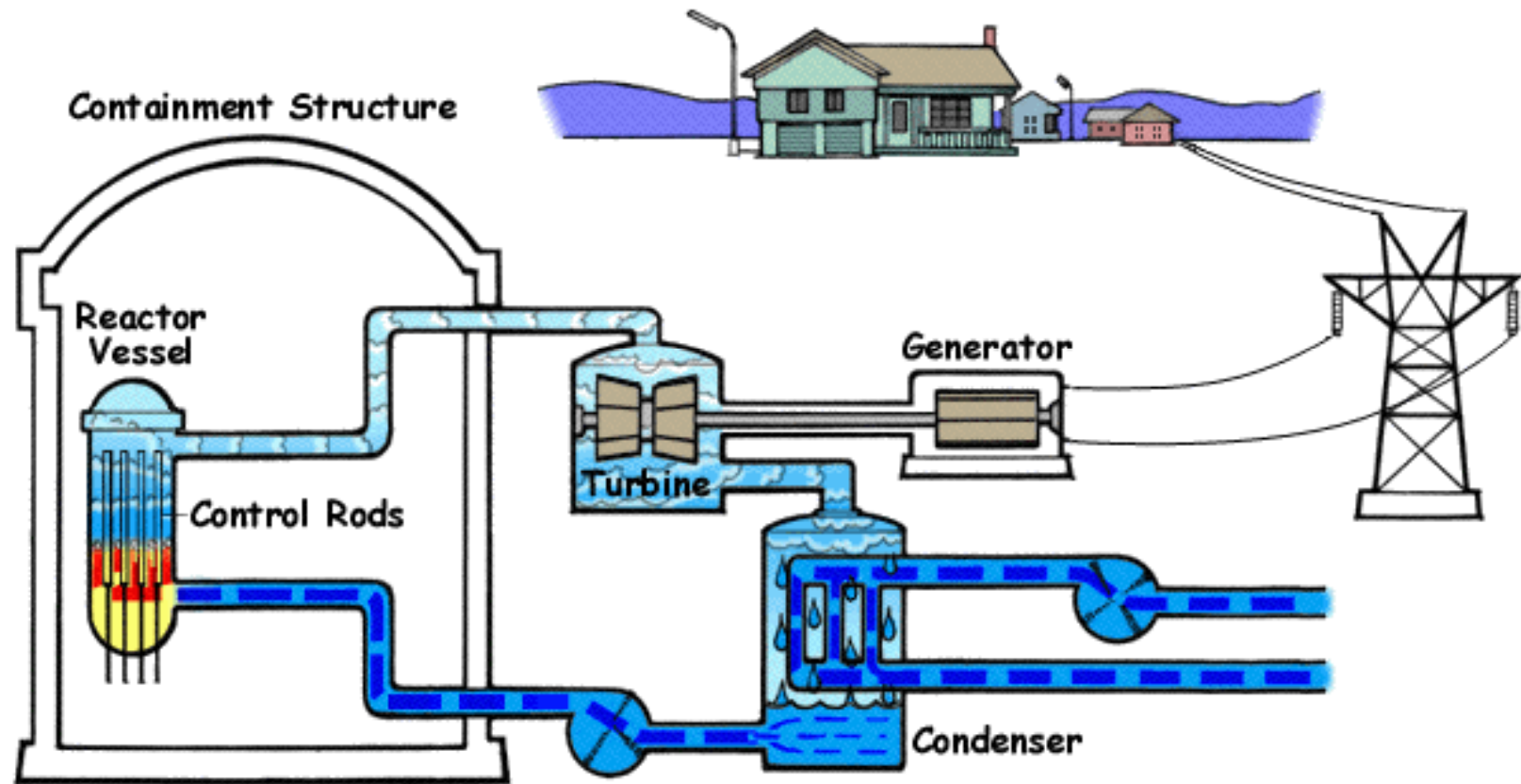
Source: Nuclear Engineering International Handbook 2007

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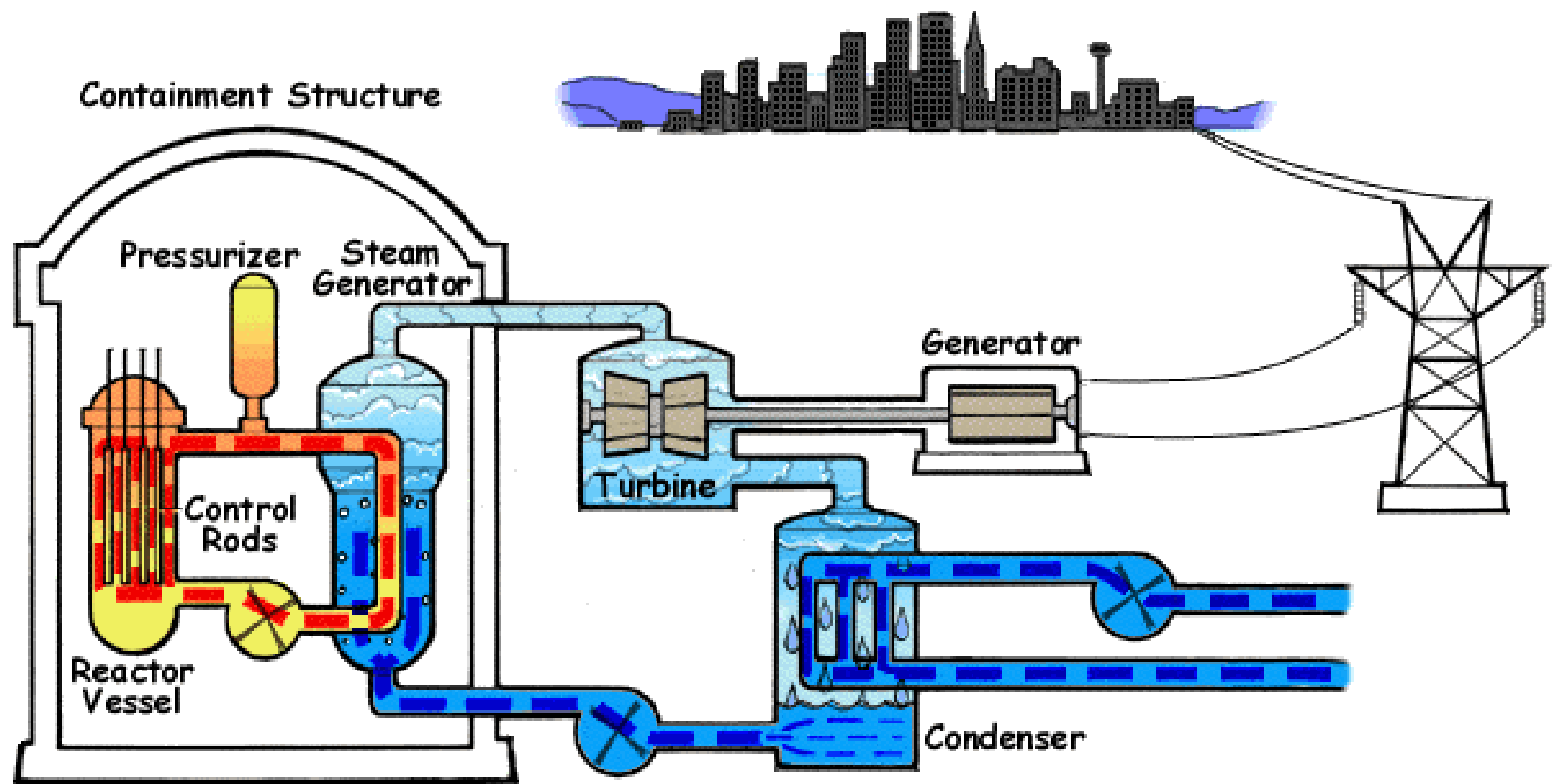
Locations of Operating Nuclear Power Reactors in US (104 as of now)



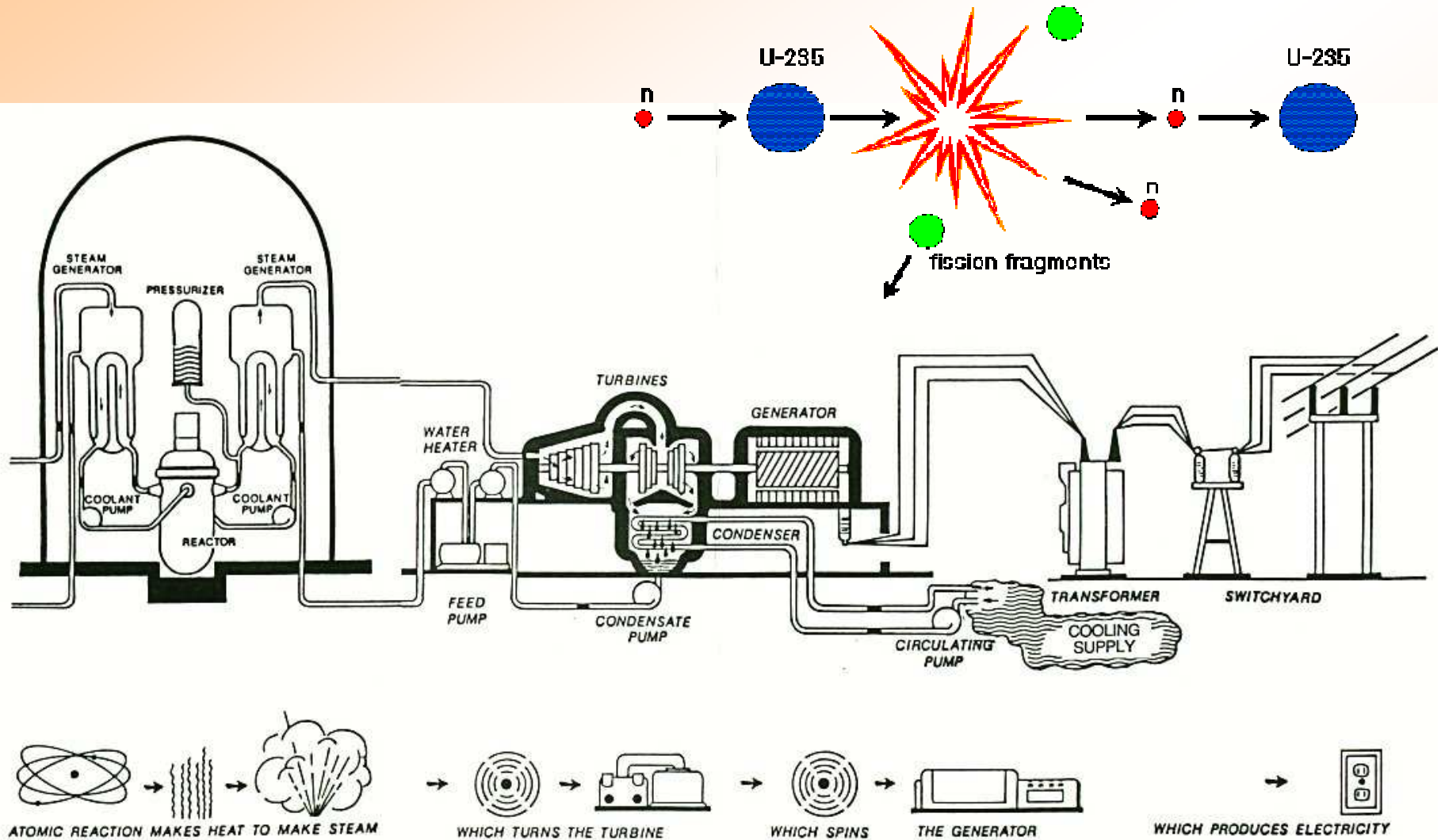
BWR



PWR



Processes in Power Production



Reactor Components

Fuel. Pellets of (UO_2) in tubes, fuel rods, assemblies in the reactor core.

Moderator. Neutrons thermalization, water, water or graphite.

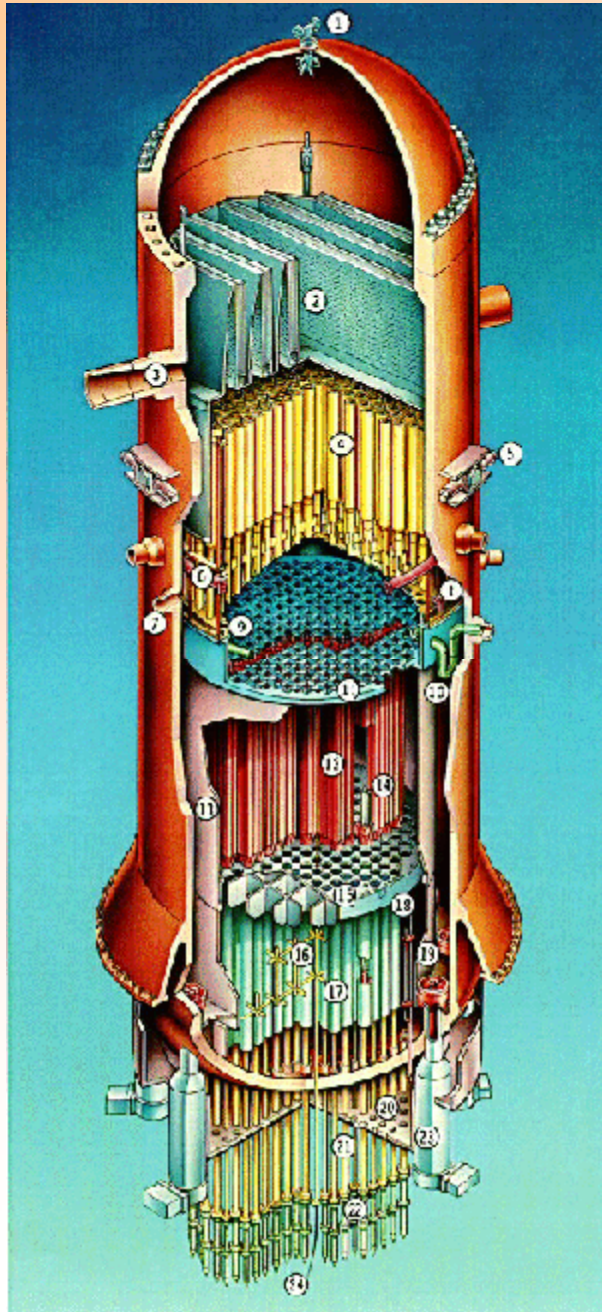
Control rods. Neutron-absorbing material , cadmium, hafnium or boron

Coolant. A liquid or gas circulating through the core, water, LM, CO_2 , He,

Pressure vessel or pressure tubes. steel vessel containing the reactor core and moderator/coolant,

Steam generator. Cooling system where the heat from the reactor

Containment. The structure around the reactor core which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any malfunction inside. It is typically a metre-thick concrete and steel structure.



✓ Reactor is an Amazing Engineering Feat

- ✓ Fission process and controlled reaction
- ✓ Cooling of the core under normal and abnormal conditions
- ✓ Radiation protection and shielding
- ✓ Refueling and waste handling
- ✓ Maintenance and power generation
- ✓ Safety and accident mitigation
- ✓ etc