Chemical Engineering 412

Introductory Nuclear Engineering

Lecture 19

Nuclear Power Plants I

Nuclear Power Plants: LWRs

Spiritual Thought

"Jesus uses an unfathomable measurement here because His Atonement is an unfathomable gift given at an incomprehensible cost. That, it seems to me, is at least part of the meaning behind Jesus's charge to be perfect. We may not be able to demonstrate yet the 10,000-talent perfection the Father and the Son have achieved, but it is *not* too much for Them to ask us to be a little more godlike in little things, that we speak and act, love and forgive, repent and improve at least at the 100-pence level of perfection, which it is clearly within our ability to do."

Jeffery R. Holland

PRIS

The Database on Nuclear Power Reactors

The Power Reactor Information System (PRIS), developed and maintained by the IAEA for over four decades, is a comprehensive database focusing on nuclear power plants worldwide. PRIS contains information on power reactors in operation, under construction, or those being... READ MORE »

Registered User ENTRY | How to Register

Select Country

Select Reactor

2017: Nuclear Power Reactors in the...

2017: Operating Experience with NPP...

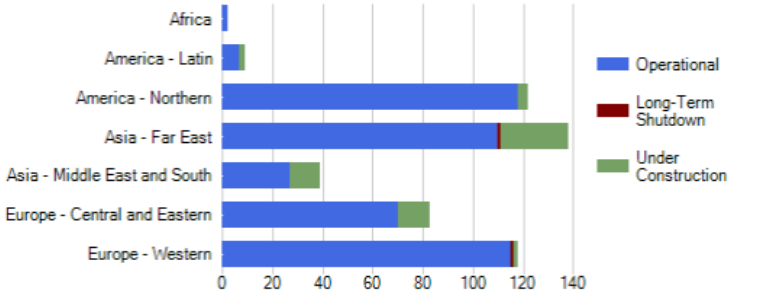
PRIS-WEDAS User's Manual

OVERVIEW

Current Status:

449	NUCLEAR POWER REACTORS IN OPERATION
392 116	MW_e TOTAL NET INSTALLED CAPACITY
2	NUCLEAR POWER REACTORS IN LONG-TERM SHUTDOWN
60	NUCLEAR POWER REACTORS UNDER CONSTRUCTION
17185	REACTOR-YEARS OF OPERATION

Regional Distribution of Nuclear Power Plants (Click on the chart for more statistics)



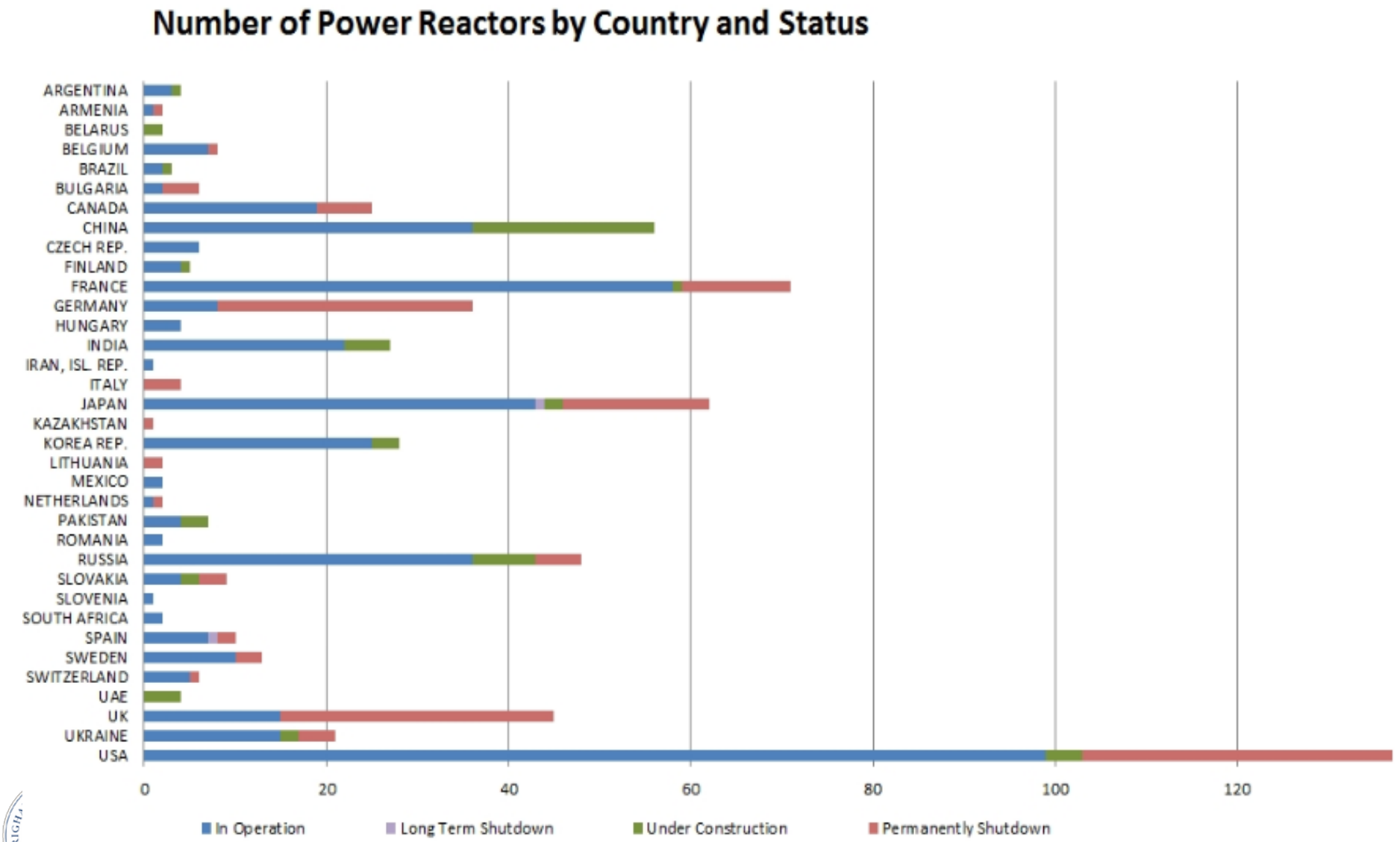
HIGHLIGHTS

NPP Status Changes (2017)

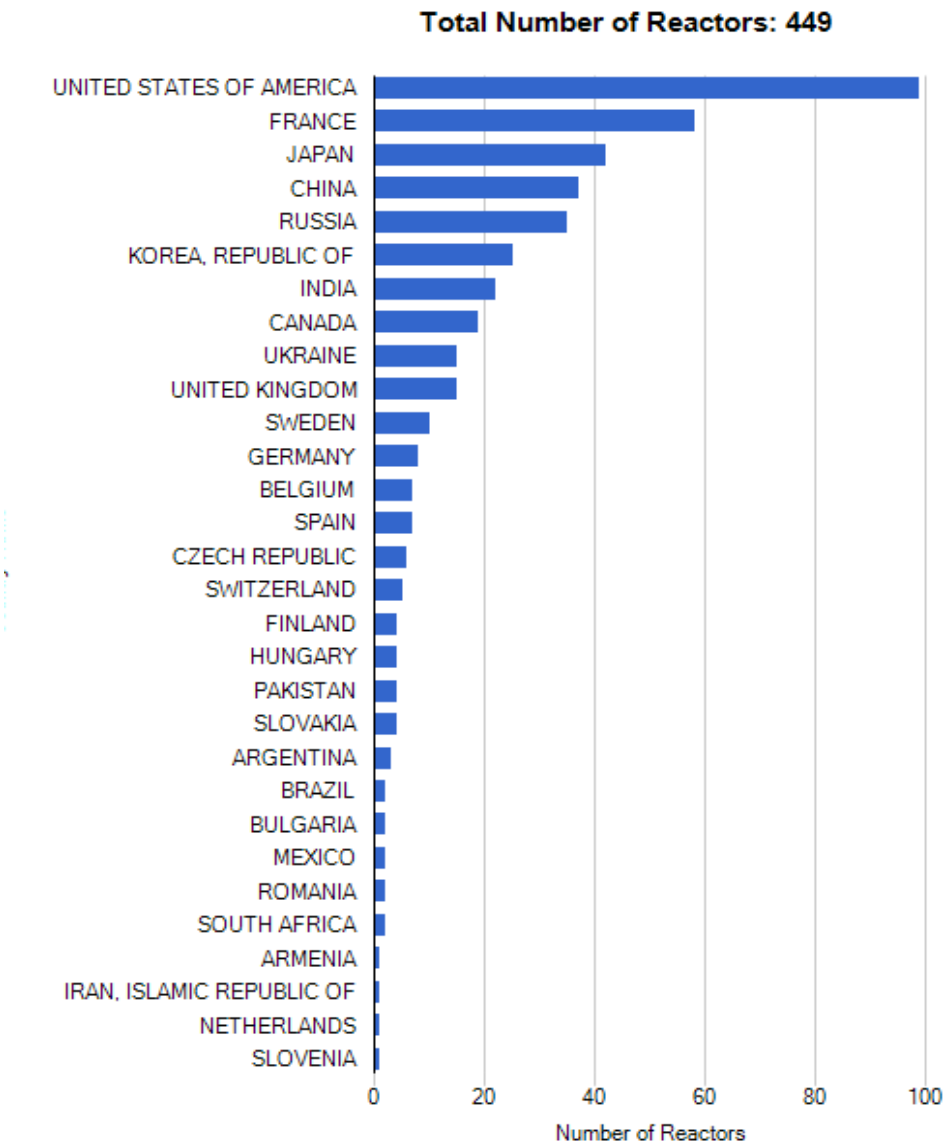
Year: 2017

New connections to the grid	
YANGJIANG-4	(1000 MW(e), PWR, CHINA) on 8 January
Miscellaneous	
TAKAHAMA-3	Reconnected to the grid on 9th June
TAKAHAMA-4	Reconnected to the grid on 22nd May
The 2017 edition of "Operating Experience with NPPs" has been published on 1 June	
The 2017 edition of "Nuclear Power Reactors in the World" has been published on 17 May	
NPP statistics for 2016 have been released on 12 April	

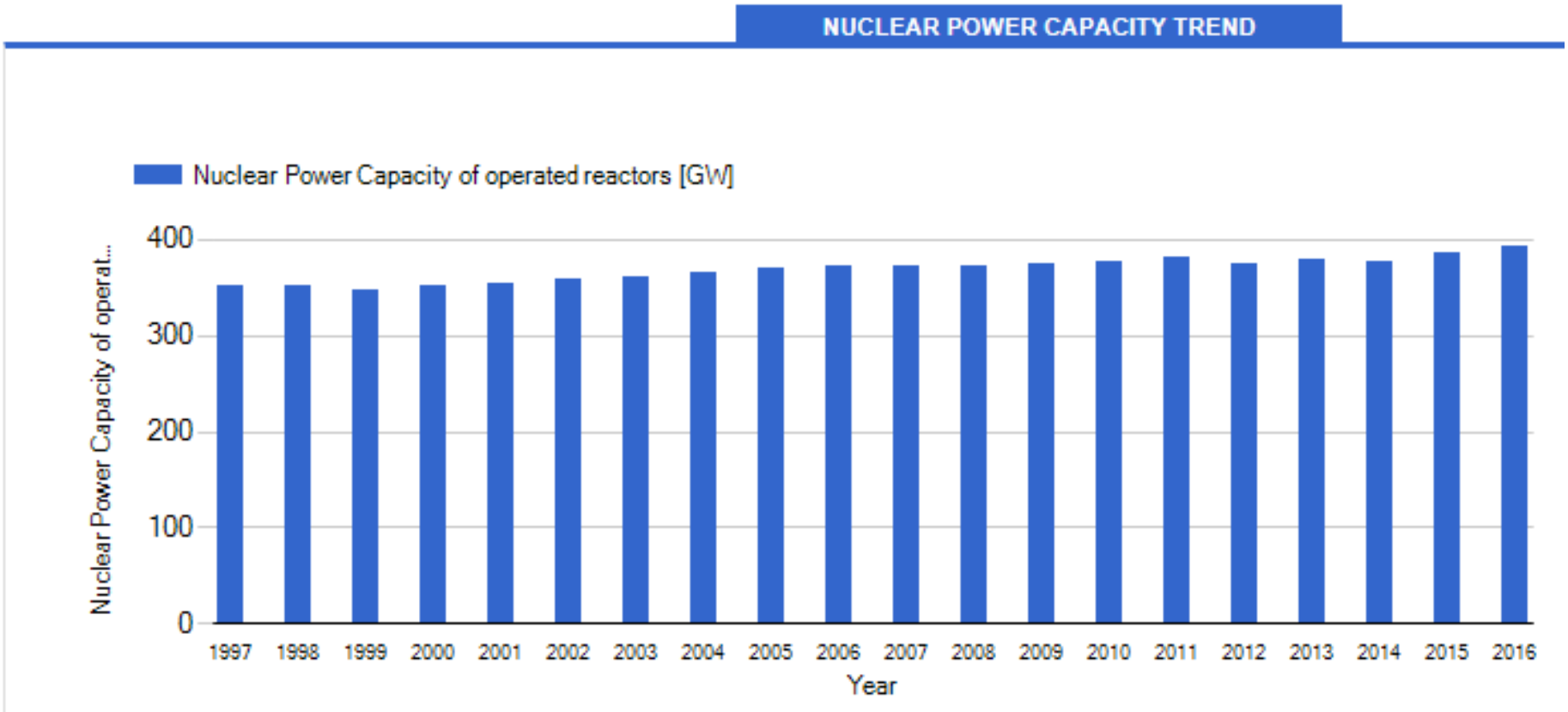
Current Reactors



Worldwide Reactor Count

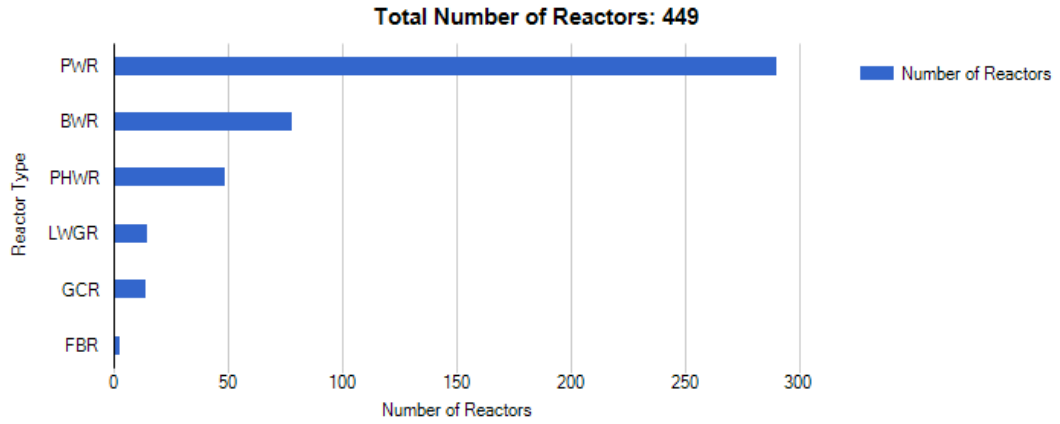


Unit Capacity



Reactor Types and Capacities

OPERATIONAL REACTORS



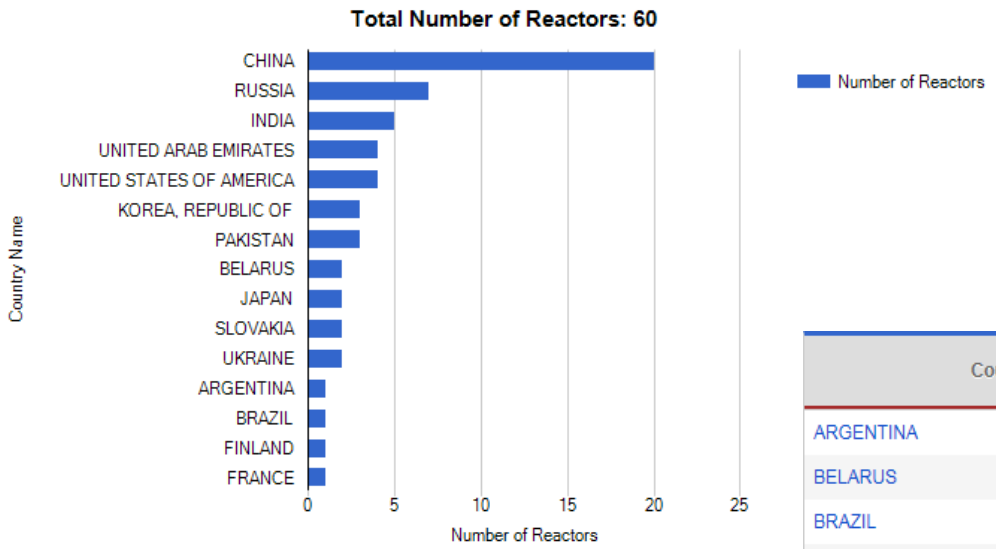
Reactor Type ▲	Reactor Type Descriptive Name	Number of Reactors	Total Net Electrical Capacity [MW]
BWR	Boiling Light-Water-Cooled and Moderated Reactor	78	75323
FBR	Fast Breeder Reactor	3	1369
GCR	Gas-Cooled, Graphite-Moderated Reactor	14	7720
LWGR	Light-Water-Cooled, Graphite-Moderated Reactor	15	10219
PHWR	Pressurized Heavy-Water-Moderated and Cooled Reactor	49	24629
PWR	Pressurized Light-Water-Moderated and Cooled Reactor	290	272856
Total		**449**	**392116**

LONG-TERM SHUTDOWN REACTORS

Reactor Type ▲	Reactor Type Descriptive Name	Number of Reactors	Total Net Electrical Capacity [MW]
BWR	Boiling Light-Water-Cooled and Moderated Reactor	1	446
FBR	Fast Breeder Reactor	1	246
Total		**2**	**692**

Construction and Capacity

UNDER CONSTRUCTION REACTORS



The total Number of Reactors includes also 2 reactors in Taiwan, China

Country	Number of Reactors	Total Net Electrical Capacity [MW]
ARGENTINA	1	25
BELARUS	2	2218
BRAZIL	1	1245
CHINA	20	20936
FINLAND	1	1600
FRANCE	1	1630
INDIA	5	2990
JAPAN	2	2653
KOREA, REPUBLIC OF	3	4020
PAKISTAN	3	2343
RUSSIA	7	5520
SLOVAKIA	2	880
UKRAINE	2	2070
UNITED ARAB EMIRATES	4	5380
UNITED STATES OF AMERICA	4	4468
Total	**60**	**60578**

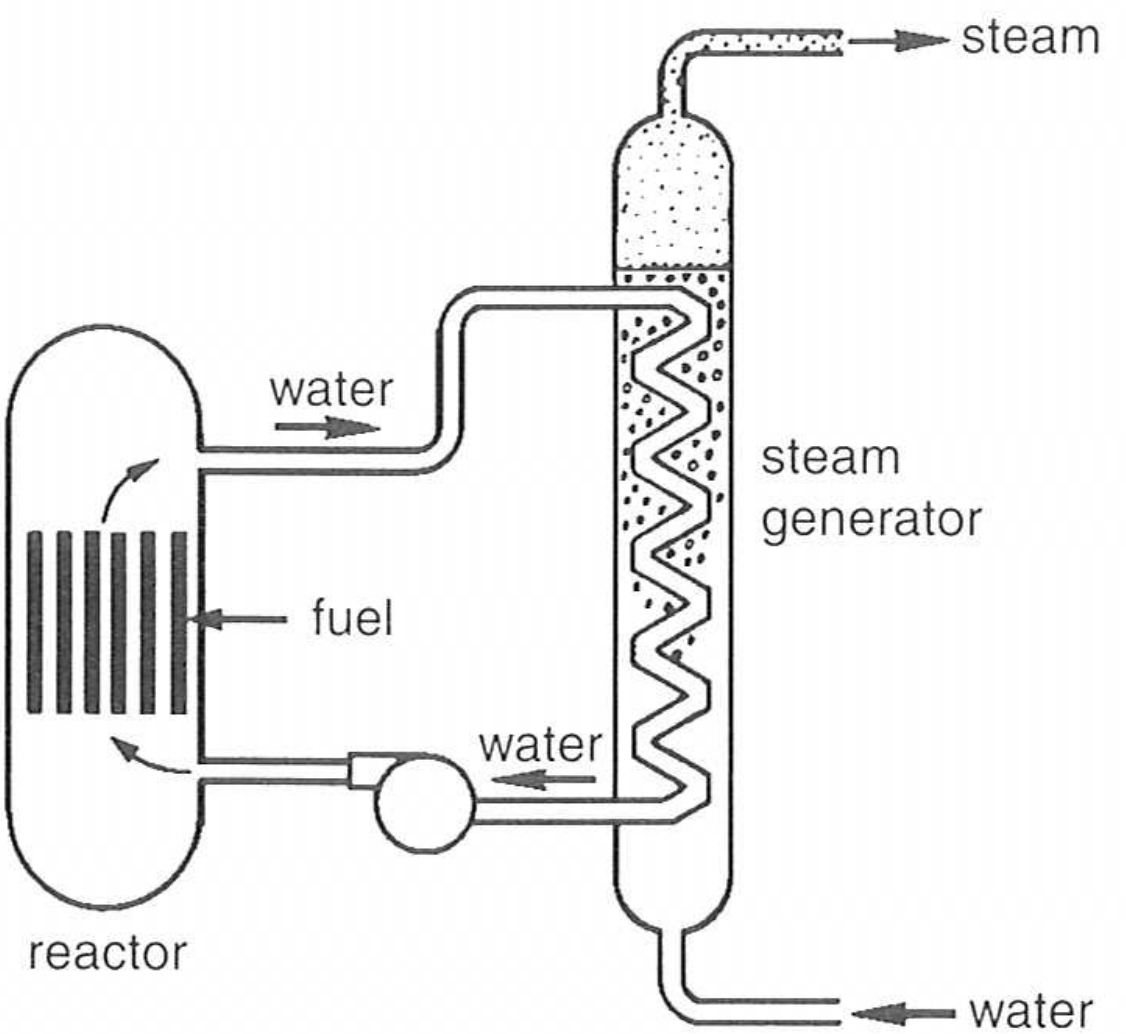
US Power Plants

100 plants in 31 states operated by 30 utilities with combined capacity and generation of 98.6 GW and 800 GWh, respectively, with average capacity factors slightly over 90%. 5 reactors under construction on 3 sites.

US Sites Under Construction

Site	Technology	MWe gross	Proponent or utility	Construction start	Loan guarantee; start operation
Watts Bar 2, TN	Westinghouse PWR	1218 (1177 net)	Tennessee Valley Authority	2007 re-start (1983 original)	on line Dec 2015
Vogtle 3, GA	Westinghouse AP1000	1200 (1117 net)	Southern Nuclear Operating Company	March 2013	has loan g'tee, late 2017
Vogtle 4, GA	Westinghouse AP1000	1200 (1117 net)	Southern Nuclear Operating Company	Nov 2013	has loan g'tee, late 2017
V.C.Summer 2, SC	Westinghouse AP1000	1200 (1117 net)	South Carolina Electric & Gas	CANCELLED!	short list loan g'tee, end 2017
V. C. Summer 3, SC	AP1000	1200	South Carolina Electric & Gas	CANCELLED!	short list loan guarantee; early 2019
Subtotal 'under construction': 5 units (6018 MWe gross, 5645 MWe net)					

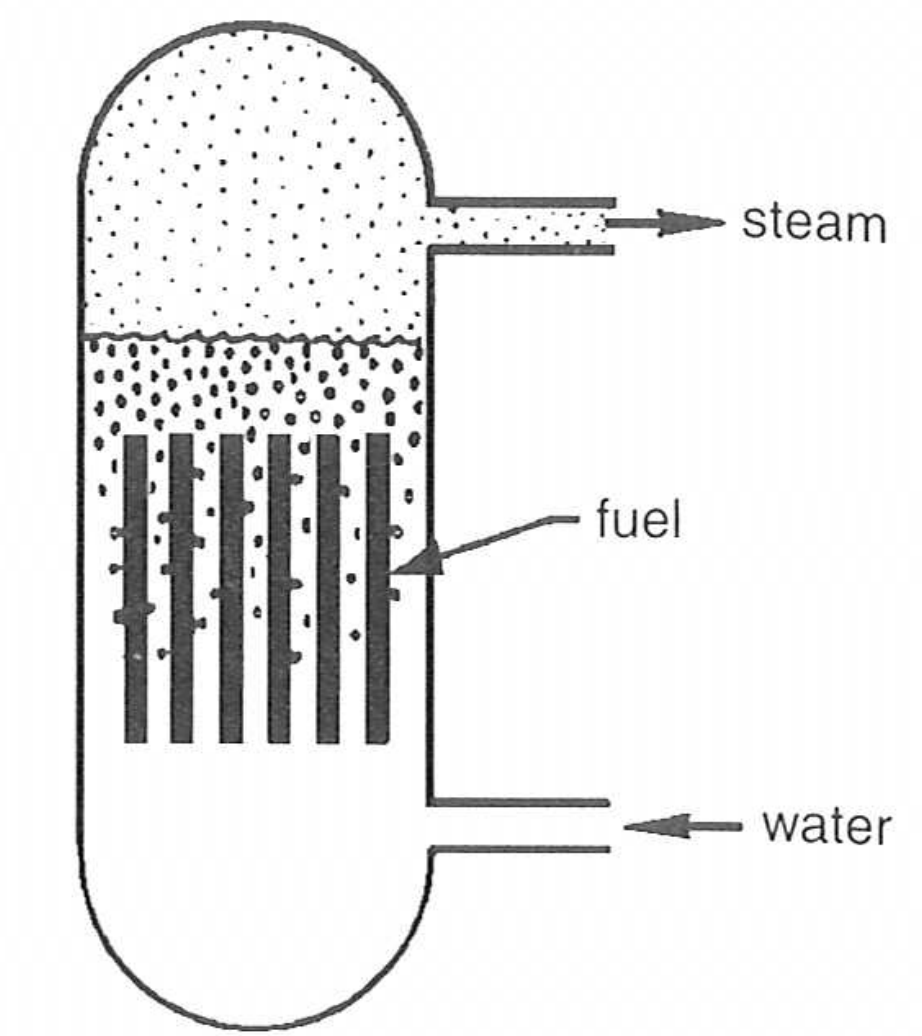
Pressurized Water Reactor (PWR)



Pressurized Water Reactor (PWR)

- Most widely used reactor worldwide.
- Water never boils in the core (which is pressurized – typically 150-200 atm).
- Heat exchanged in a second lower-pressure loop to generate turbine steam.
- Minimizes equipment exposure to ionizing radiation and radioactive waste production.

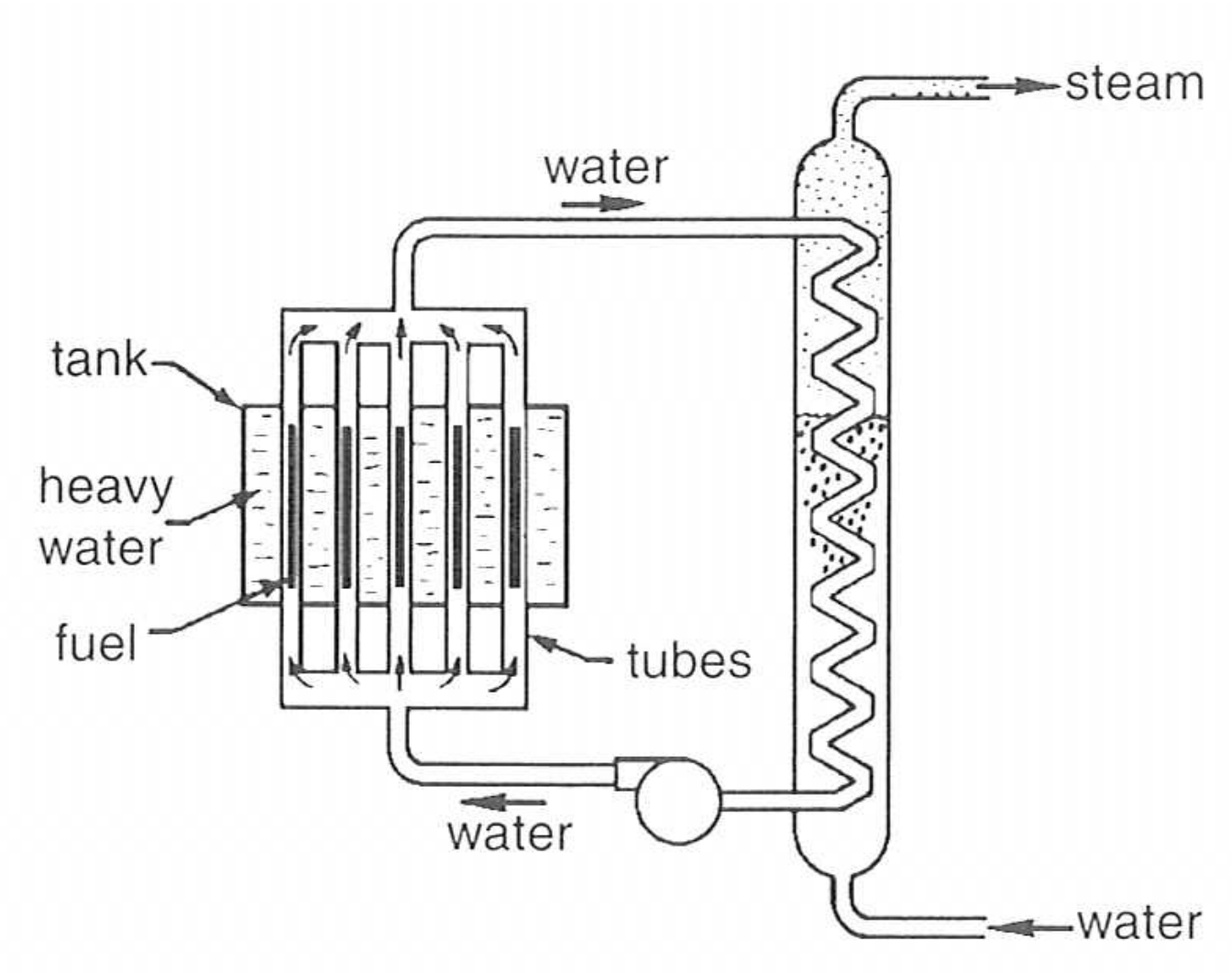
Boiling Water Reactor (BWR)



Boiler Water Reactor (BWR)

- Water boils directly in the core.
- Steam passes directly to turbine.
- After turbine, steam recondenses and returns to reactor.
- Large variations in heat transfer coefficients on the fuel rods.
- Turbine exposed to radioactive products from fluid, complicating maintenance and decommissioning.

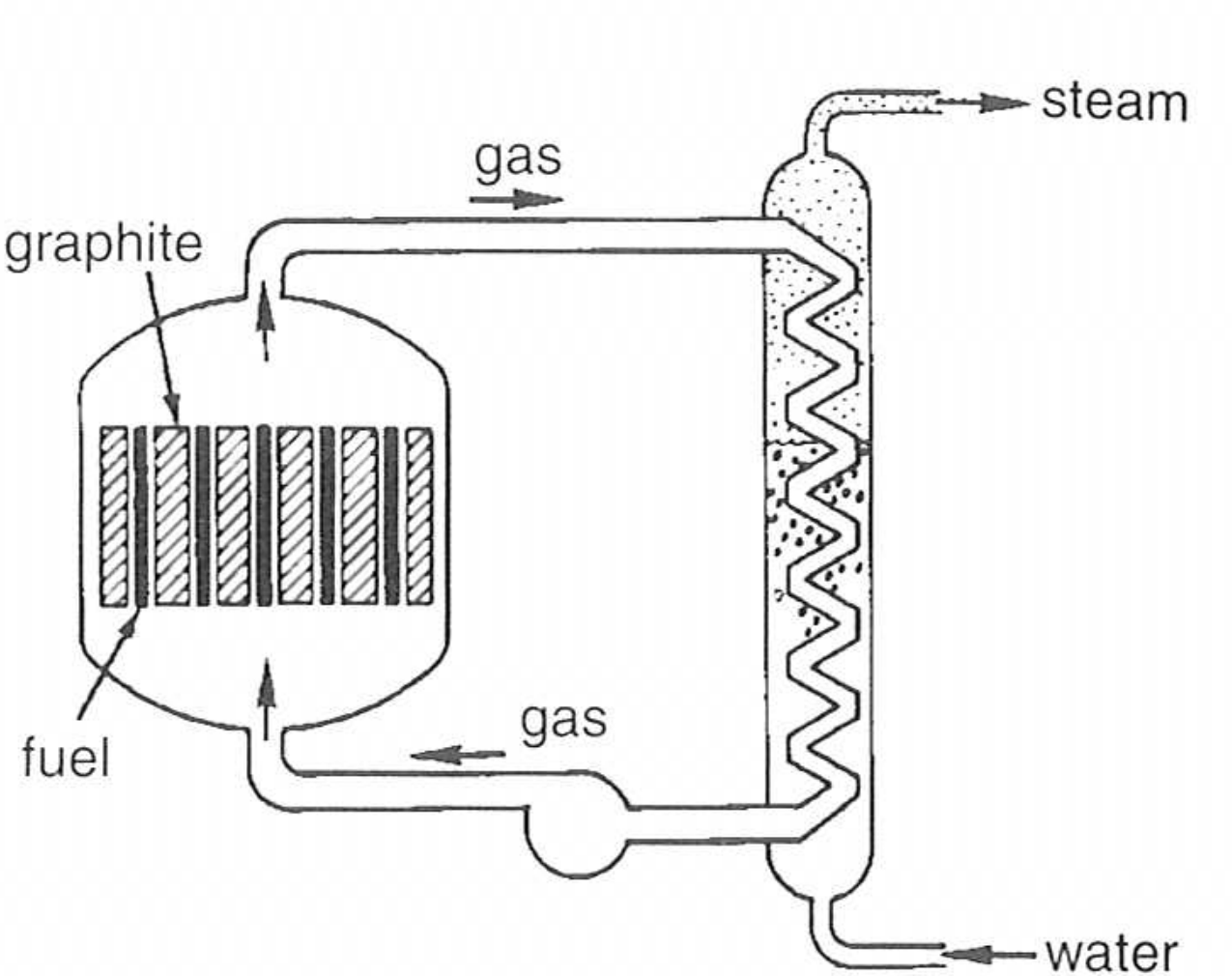
Heavy Water Reactor (PHWR)



Heavy Water Reactor

- Heavy water (deuterium- or tritium-based water) passes through pressurized fuel tubes surrounded by a non-pressurized heavy water bath.
- Operates on natural uranium
- Avoids pressurized reactor vessel (major expense).
- Steam generated in second loop.
- Basis of the CANDU (Canadian) reactor designs.
- Variant is the heavy-water-moderated, light-water-cooled reactor (HWLWR) that uses light water in the fuel tubes and no heat exchanger.

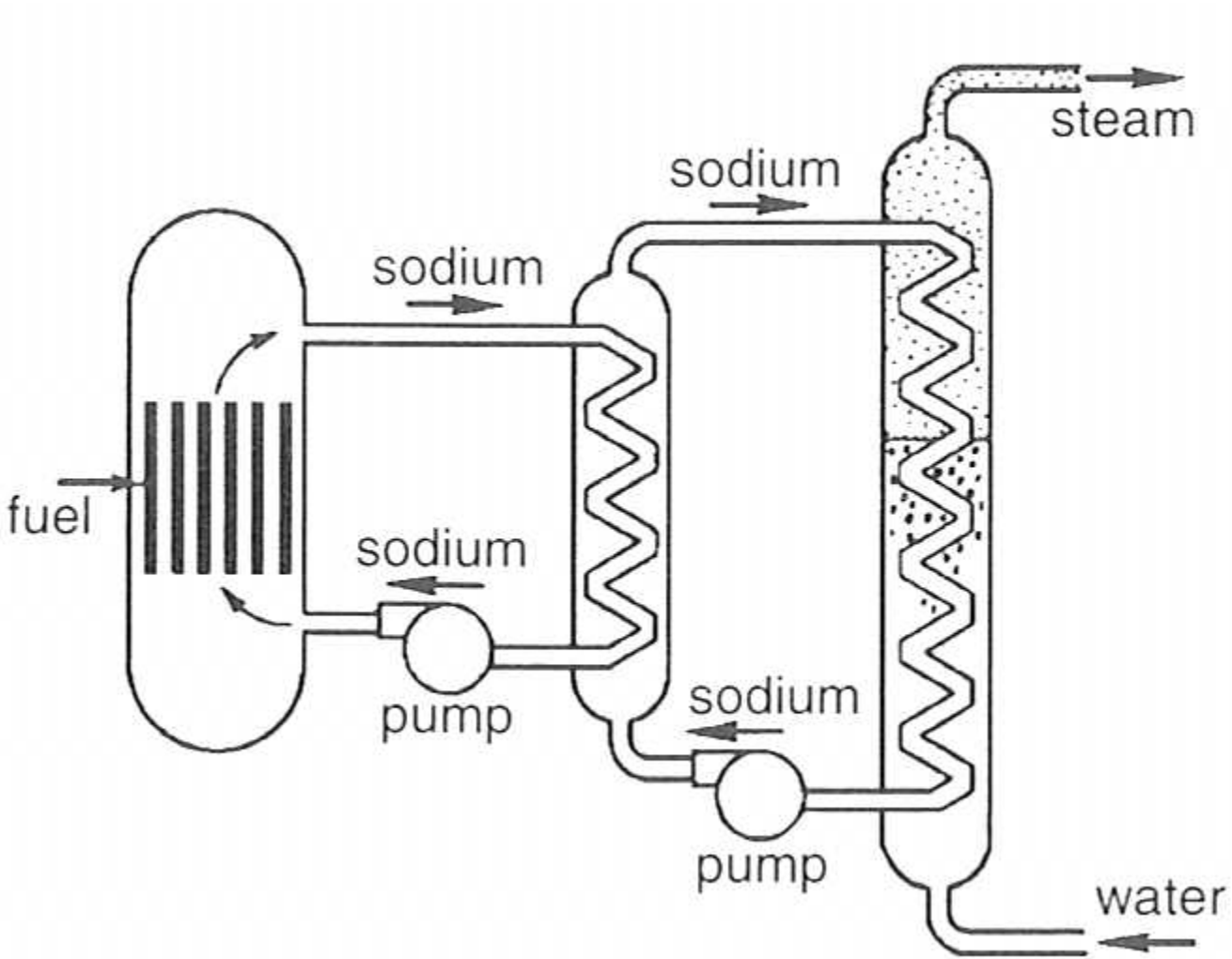
Gas-cooled Reactor (GCR)



Gas-cooled Reactor (GCR, HTGR)

- Gas (He or CO_2) used as coolant.
- Graphite typically used as moderator.
- Graphite (which remains solid) and gas need not be pressurized
  - No expensive pressure vessel
  - No Blowdown in accident
- Gas heats steam in secondary loop.
- In a gas-cooled reactor (GCR), gas passes through holes in graphite moderator.
- In a high-temperature gas-cooled reactor (HTGR), fuel channels and gas channels are drilled in graphite core.

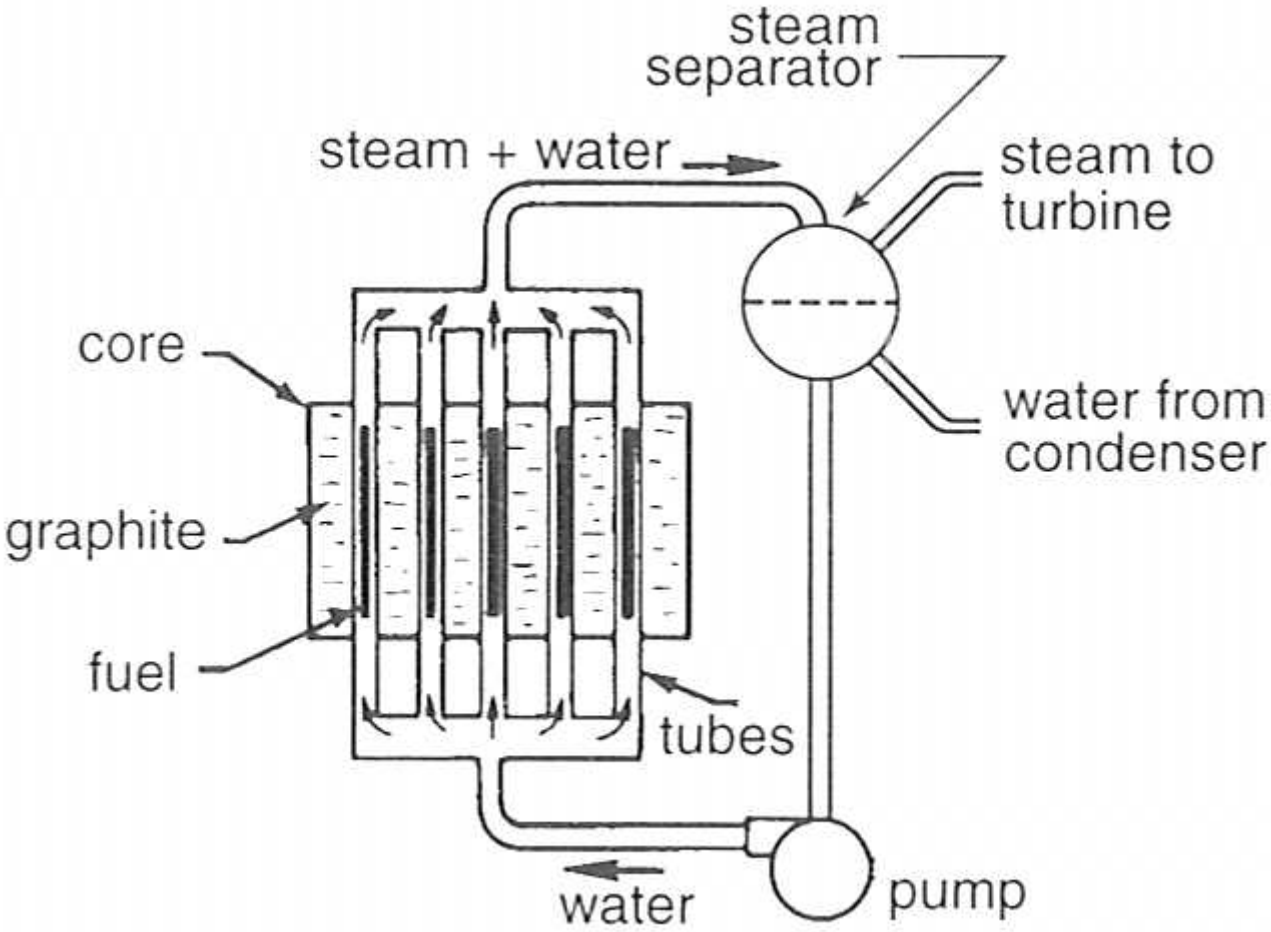
Liquid-metal fast breeder reactor



Liquid Metal Fast Breeder Reactor (LMFBR)

- Fast-neutron-based reactor scheme.
- No moderator (no light elements).
- Na or K-Na molten metal used as coolant.
- No pressurization, very high heat transfer coefficients.
- Na becomes radioactive and Na and K react violently with water (moderately with air).
- Second Na heat exchanger isolates Na/K coolant in core from turbine steam.
- New fuel to consumed fuel ratio raises from 0.6-0.8 in typical reactors to over 1 if designed as a breeder reactor.
- One in commercial operation (in Russia), though they are aggressively pursuing new designs.

Light-water-cooled graphite moderated reactor (LGR)



Light-water-cooled graphite moderated reactor (LGR)

- Soviet-designed reactor, called RBMK (reactory bolshoi moshchnosti kanalnye – high-powered pressure-tube reactor).
- Fuel in fuel pressurized fuel channels in graphite block.
- Steam passes directly to turbine.
- Fuel can be exchanged without reactor shutdown.
- Capable of operation on natural uranium.
- All systems since Chernobyl use higher (2.4%) uranium enrichment.