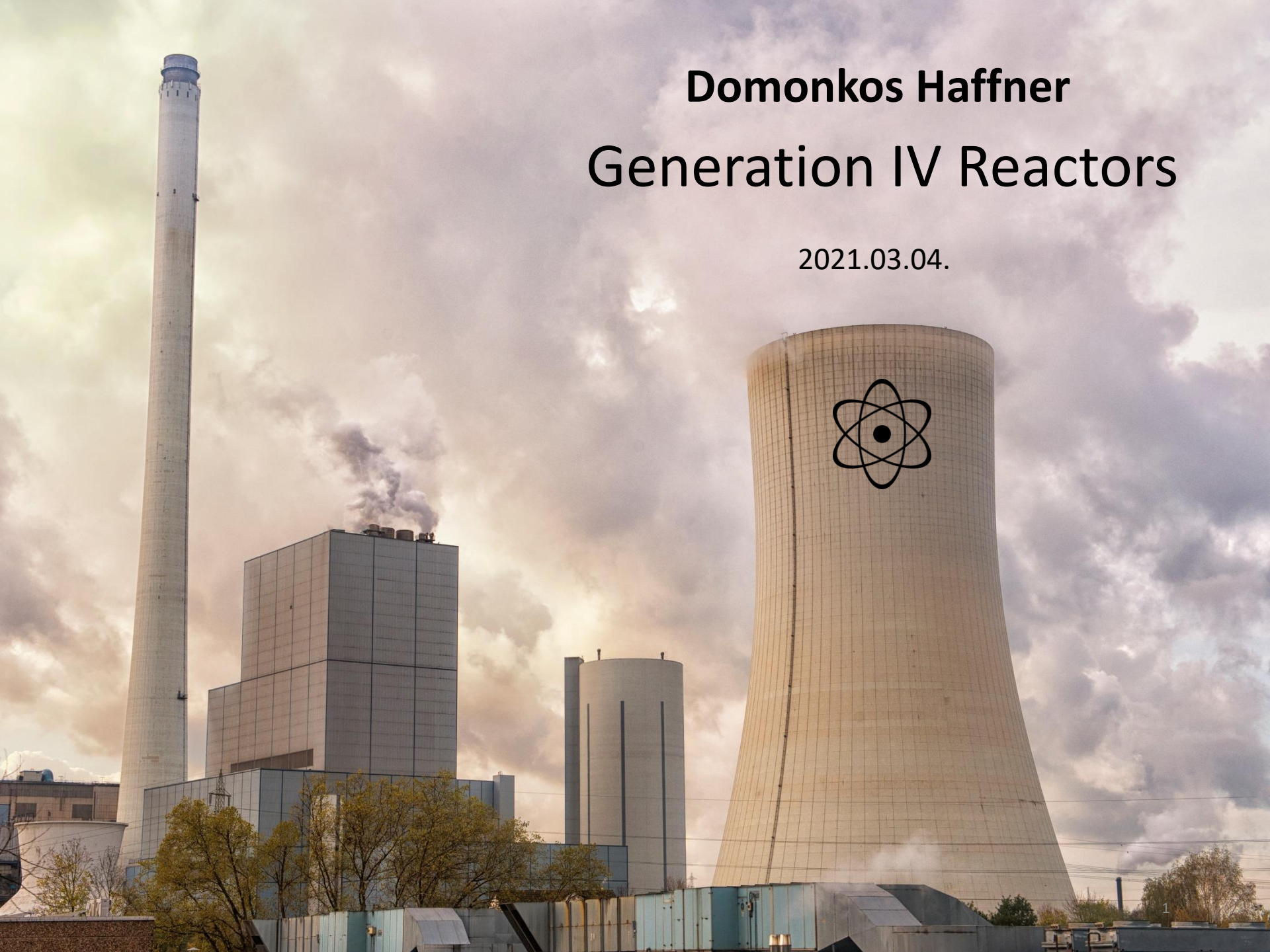


Domonkos Haffner

Generation IV Reactors

2021.03.04.

Generation IV International Forum

- Original members: Argentina, Brazil, Canada, France, Japan, South Korea, South Africa, UK, USA
- Later joined: Switzerland, China, Russia, Australia, EU

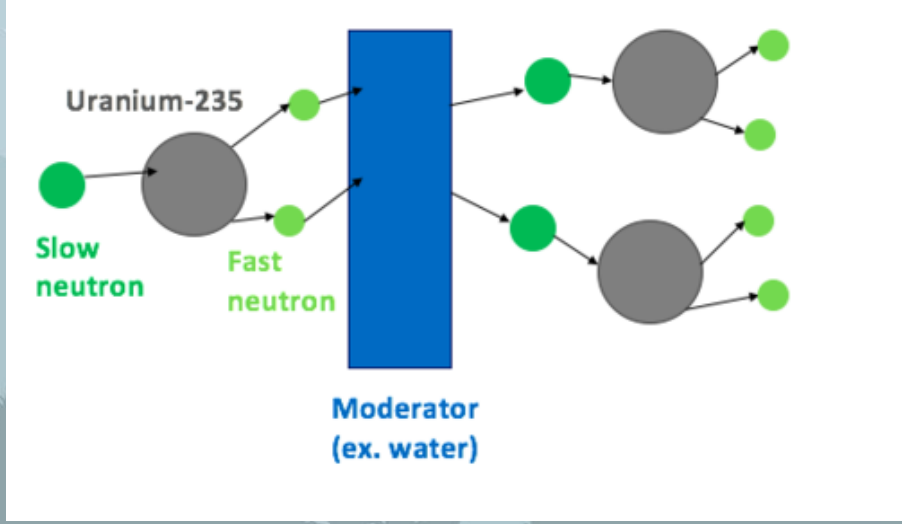
- US Department of Energy in 2000
- Goal is to share R&D
- 6 reactor technologies
- 2005 – joint research

Overview of the Reactors

- Open or closed fuel cycle

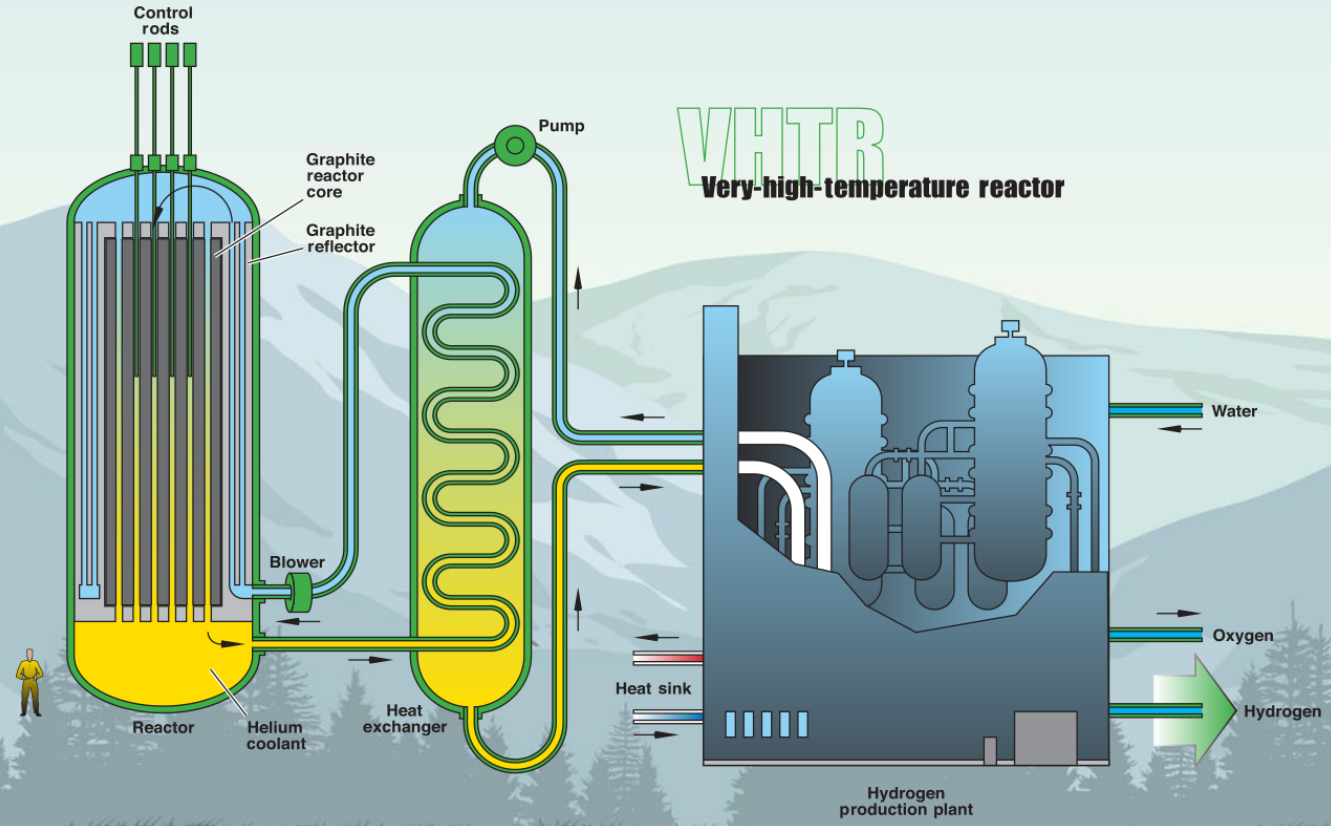
- Fast reactors
- Epithermal reactor
- Slow neutron reactors

- Cooling by water, He, Pb, Sodium salt, etc..



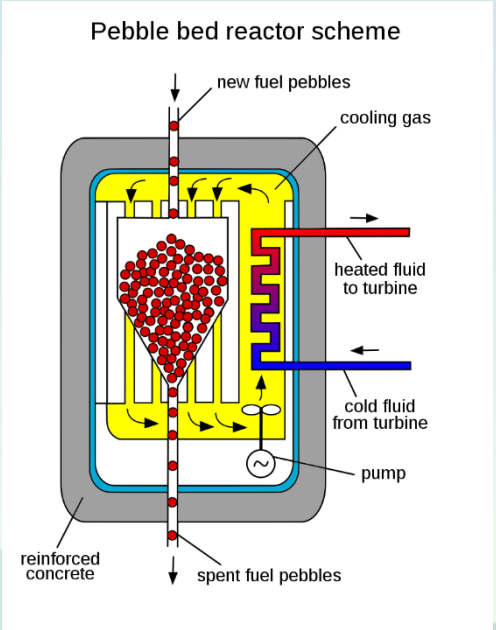
Very-high-temperature reactor (VHTR)

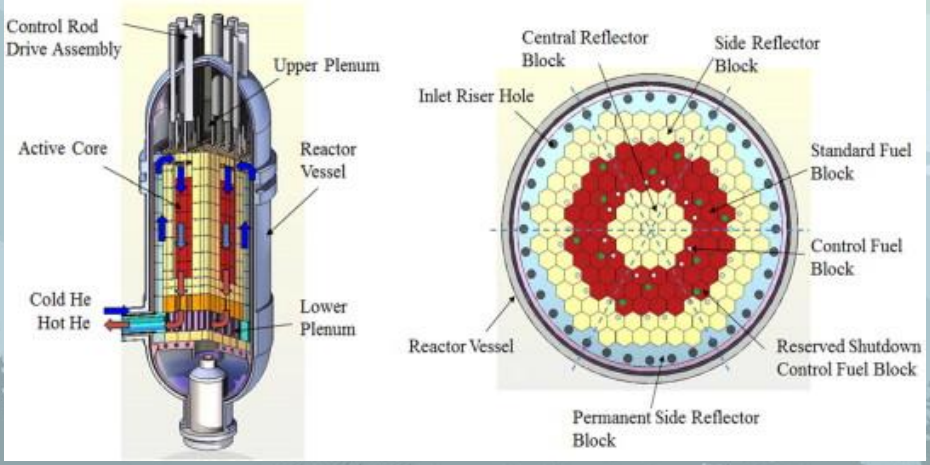
- Only a concept
- First VHTR was planned in South Africa
- Outlet temperature of 1000 ˚C
- Graphite moderated core
- Uranium fuel cycle
- He or Molten salt as coolant



Very-high-temperature reactor (VHTR)

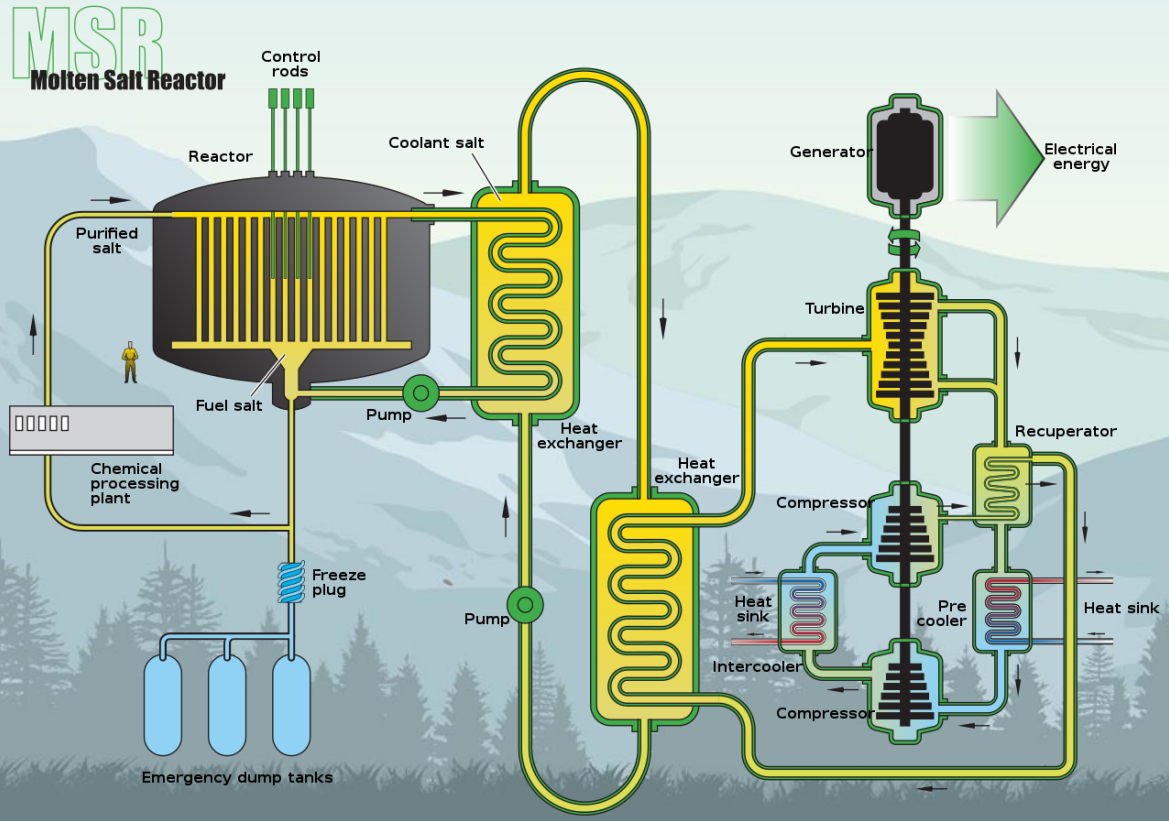
- Design can be prismatic block or pebble bed reactor
- Prismatic block: hexagonal graphite block in a cylindrical pressure vessel
- Pebble bed: spherical graphite fuel elements are the moderators.





Molten-salt reactor (MSR)

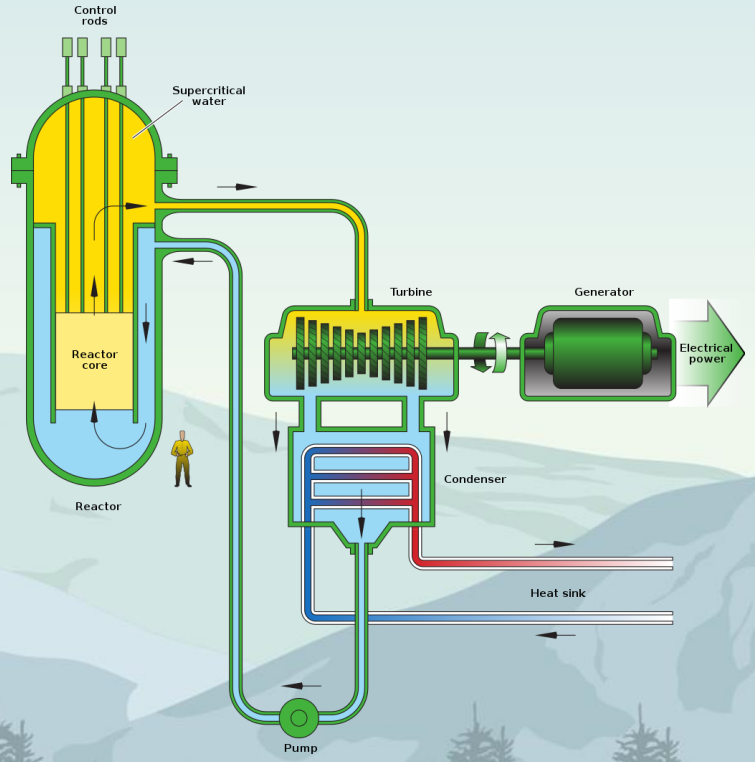
- The primary coolant / fuel is a molten salt mixture
- ThF_4 or UF_4
- Operation at around atmospheric pressure
- MSR reactors do not produce dangerous and radioactive fission gases
- High temperature -> high electricity generating efficiency



Supercritical-water-cooled reactor (SCWR)

- LWR operating at supercritical pressure
- The reactor outlet coolant is supercritical water
- Light water is used as a neutron moderator and coolant

- Advantages: excellent heat transfer property, good fuel economy, less residual heat
- Disadvantages: high pressure causes mechanical- and thermal stress

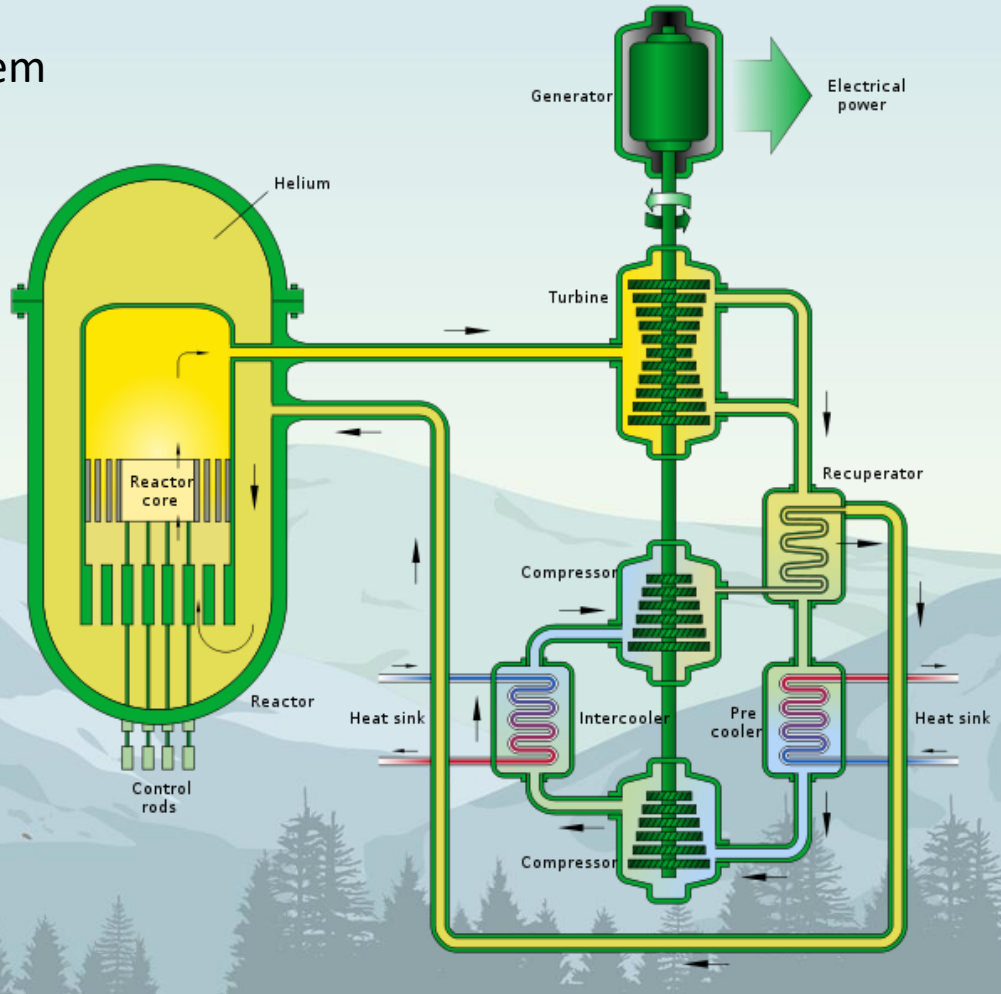


Gas-cooled fast reactor (GFR)

- He- or carbon dioxide-cooled system
- Outlet temperature of 850 C
- Electricity + breeding

- No moderator is needed
- Thorium

- Central or Eastern Europe
- 2018



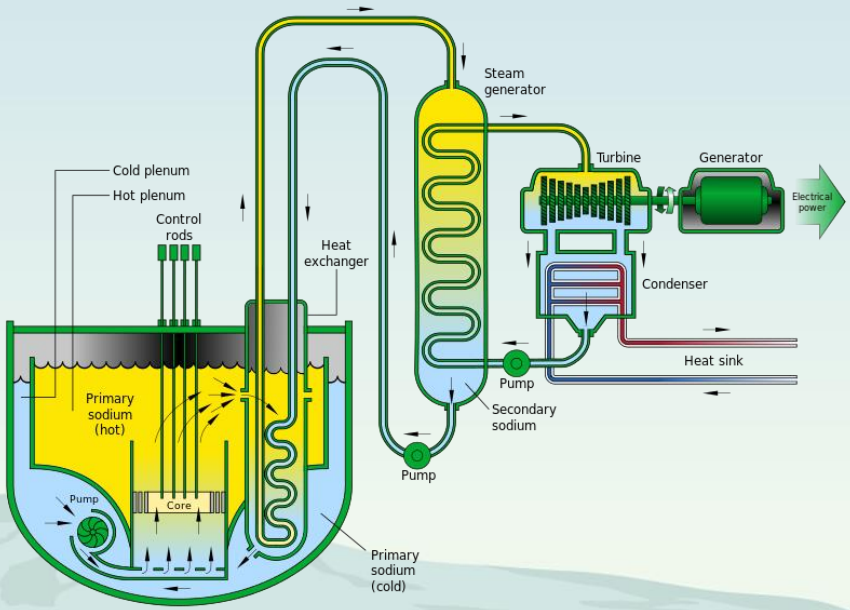
Sodium-cooled fast reactor (SFR)

- Several reactors have been built
- TerraPower

- Coolant: sodium
- Only has one stable isotope: ^{23}Na

- Pool- or Loop type design

- Advantages: sodium is weak neutron moderator -> good for fast reactors, high temp. causes high efficiency



- Disadvantages: sodium is chemically very reactive -> 1995 Monju power plant accident

- Operational reactors: 5 currently around the world

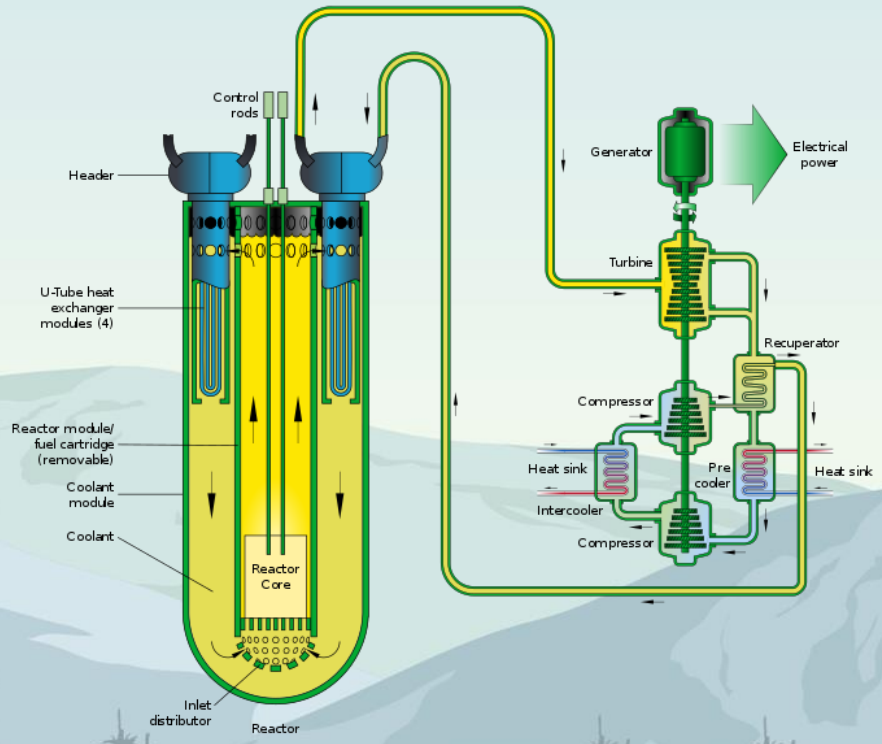
Lead-cooled fast reactor (LFR)

- Molten lead or lead-bismuth coolant
- Neutrons are slowed less by the heavy nucleis
- Outlet temperature: around 500-600˚C

- The concept is very similar to the SFR

- Advantages: safe, can’t cause explosion, lead is good shield against gamma-rays
- Disadvantages: very heavy materials, bismuth is rare, thus expensive, polonium

- Russia has a couple reactors like this



Advantages of Generation IV reactors

- Less radioactive waste
- Same amount of fuel but 100-300 times more energy
- More types of fuel
- Improved safety

- CO_2 emission only when construction the reactor and mining the materials

- U.S. research laboratory director: ”Fabrication, construction, operation, and maintenance of new reactors will face a steep learning curve: advanced technologies will have a heightened risk of accidents and mistakes. The technology may be proven, but people are not.”

System	Neutron Spectrum	Coolant	Temperature [C]	Fuel Cycle	Size [MW]
VHTR	Thermal	He	900-100	Open	250-300
MSR	Fast or Thermal	Fluoride or chloride salts	700-800	Closed	250, 1000
SCWR	Fast or Thermal	Water	510-625	Open or Closed	300-700, 1000-1500
GFR	Fast	He	850	Closed	1200
SFR	Fast	Sodium	550	Closed	30-150, 300-1500, 1000-2000
LFR	Fast	Lead	480-800	Closed	20-180, 300-1200, 600-1000

Thank you for your attention!