GEN IV International Forum

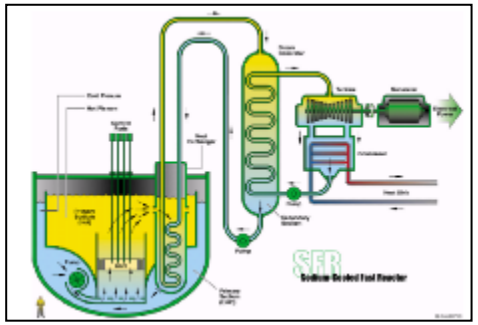
Expertise | Collaboration | Excellence

Generation-IV Reactor Systems and International Cooperation through GIF

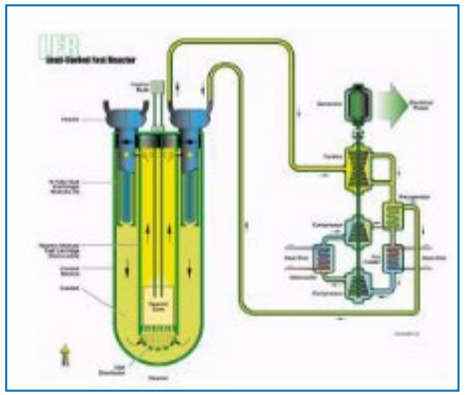
Hideki Kamide

GIF Chair

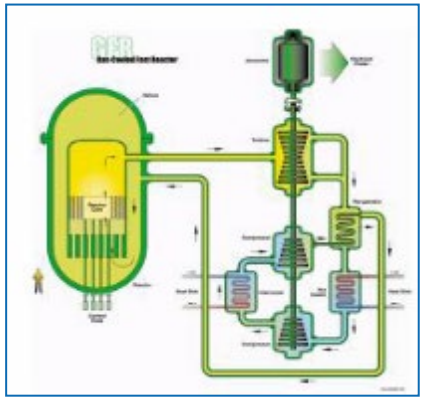
Generation-IV Reactor Systems



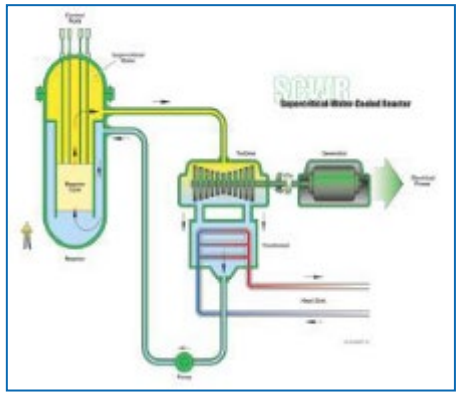
Sodium-cooled Fast Reactor (SFR)



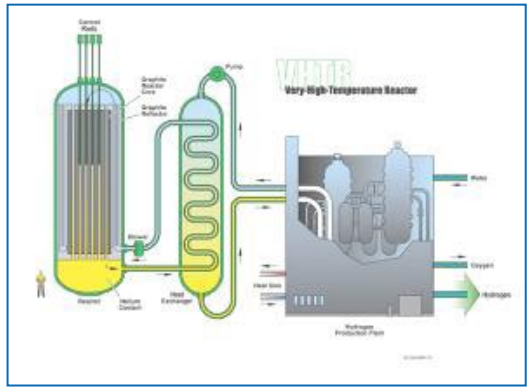
Lead-cooled Fast Reactor (LFR)



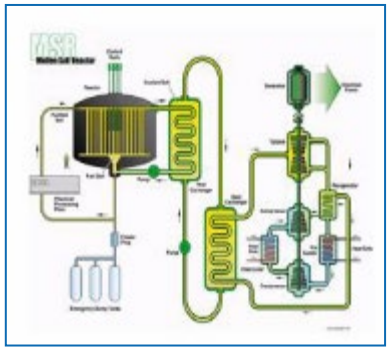
Gas-cooled Fast Reactor (GFR)



Supercritical Water cooled Reactor (SCWR)



Very High Temperature Reactor (VHTR)



Molten Salt Reactor (MSR)

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Comparison of Gen-IV Reactor Systems

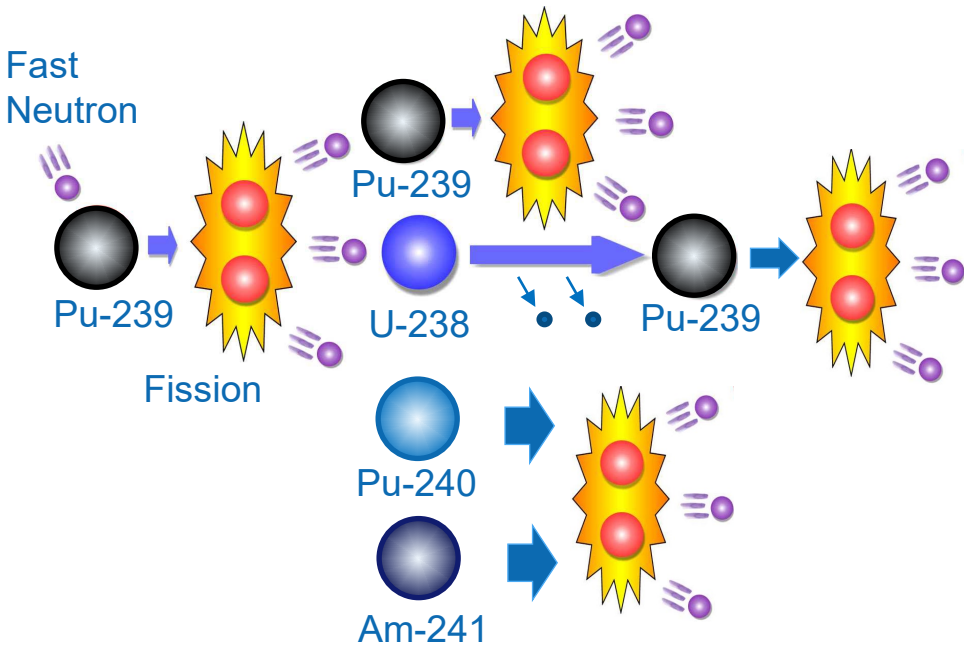
System	Neutron Spectrum	Coolant	Outlet temp. (°C)	Fuel cycle
Sodium-cooled Fast Reactor (SFR)	Fast	Sodium	500-550	Closed
Lead-cooled Fast Reactor (LFR)	Fast	Lead	480-570	Closed
Gas-cooled Fast Reactor (GFR)	Fast	Helium	850	Closed
Molten Salt Reactor (MSR)	Thermal/ Fast	Fluoride/Chloride salts	700-800	Open/ Closed
Supercritical Water-cooled Reactor (SCWR)	Thermal/ Fast	Water	510-625	Open/ Closed
Very High Temperature Reactor (VHTR)	Thermal	Helium	900-1000	Open

GIF Goals for Generation-IV Reactor Systems

- Sustainability
  - Long term fuel supply
  - Minimize waste and long term stewardship burden
- Safety & Reliability
  - Very low likelihood and degree of core damage
  - Eliminate need for offsite emergency response
- Economics
  - Life cycle cost advantage over other energy sources
  - Financial risk comparable to other energy projects
- Proliferation Resistance & Physical Protection
  - Unattractive materials diversion pathway
  - Enhanced physical protection against terrorism

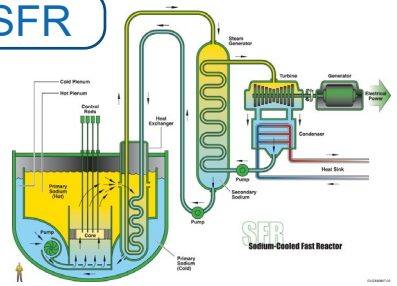
Efficient Uranium use and MA burning by Fast Reactors

- Fast neutron reactors



Minor Actinide (MA): Am, Np,,,,
long term radio activities

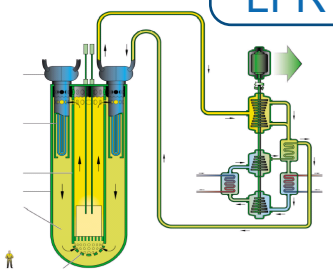
SFR



Na
Mass No. 23
$T_{boiling}$ 883°C

Sodium cooled Fast Reactor

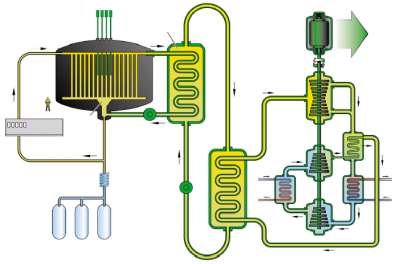
LFR



Pb
206-208
1,737°C

Lead cooled Fast Reactor

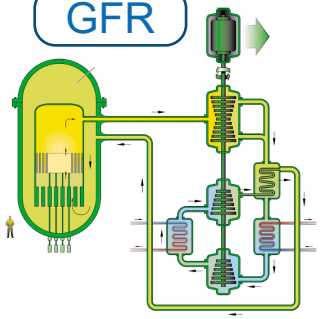
MSR



Fluoride or
Chloride salt
F: 19
Cl: 35 or 37

Molten Salt Reactor

GFR



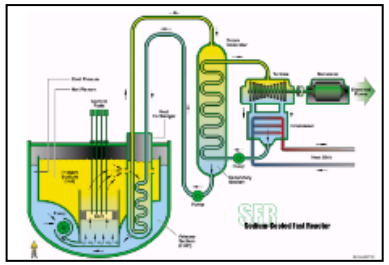
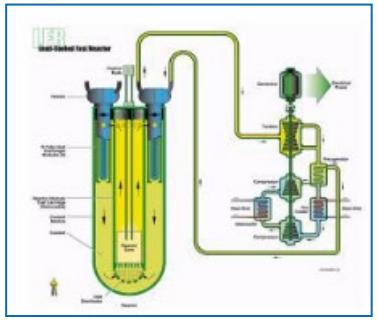
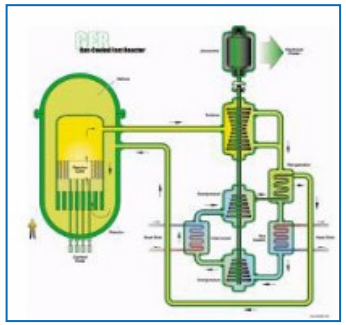
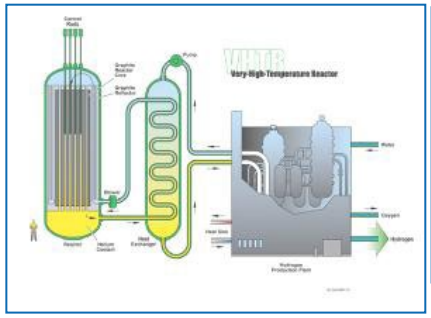
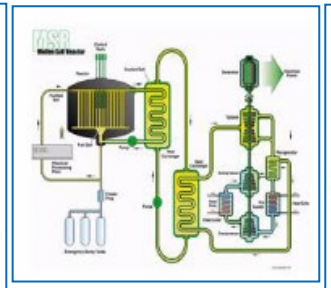
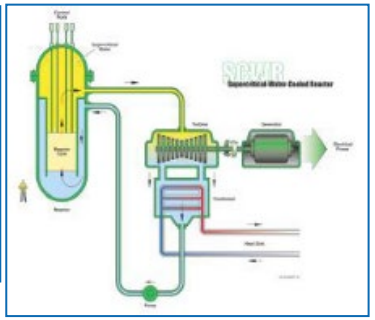
He
4

Gas cooled Fast Reactor

Coolant: Heavy nuclide and High boiling point or Gas; No phase change

Non-electric Application of Nuclear Heat

Reactor Types

SFR, LFR, GFR
VHTR, SCWR, MSR

x

Reactor Size

Power Reactor
SMR
Micro Reactor

x

Applications

- ✓ Cogeneration application
- ✓ Hydrogen production
- ✓ Seawater Desalination
- ✓ Process heat
- ✓ Synthetic Fuel and Chemicals
- ✓ Cooling application

IAEA Source

Matrix of 6 x 3 x 6

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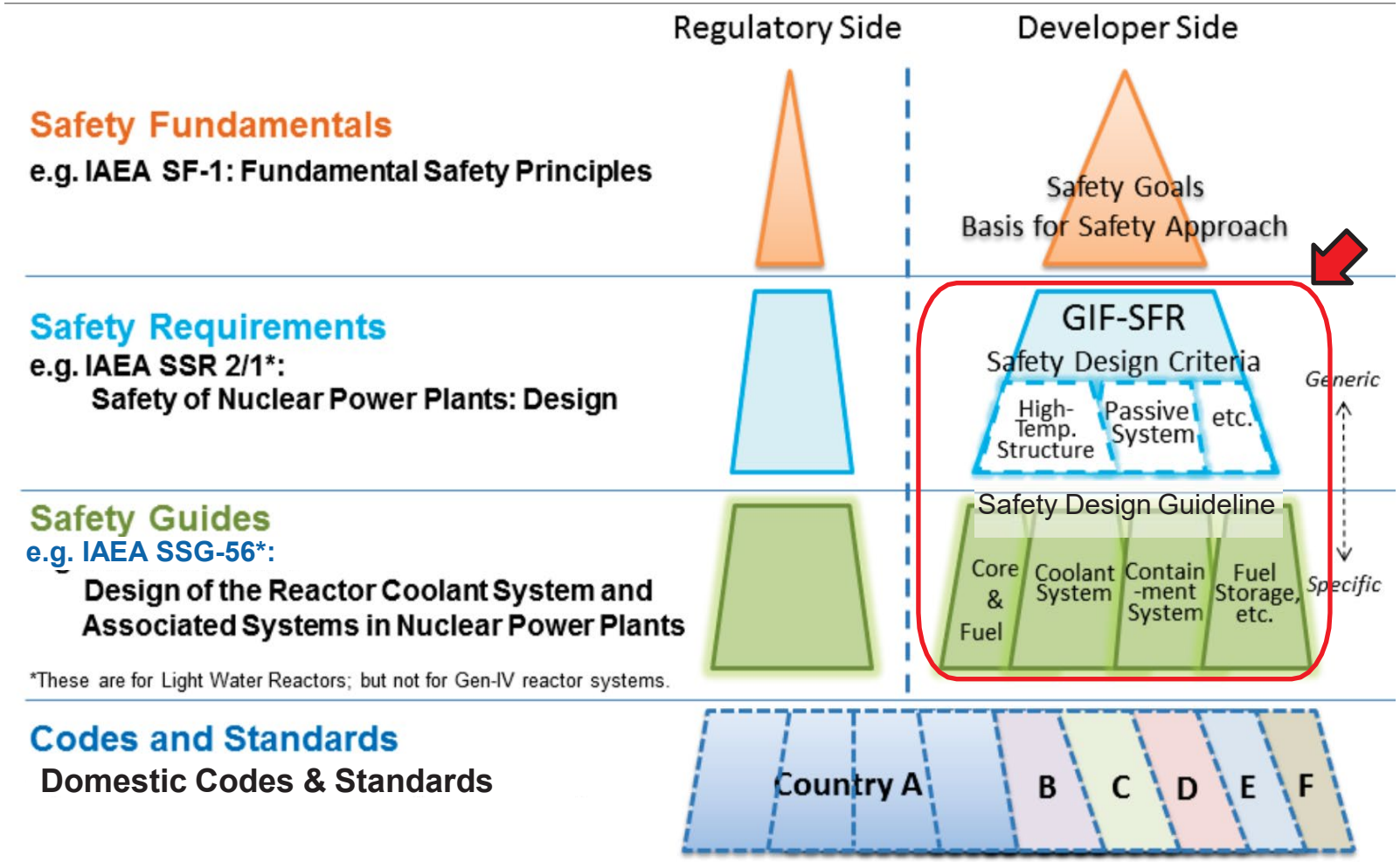
Safety Design of Gen-IV reactors and World Standardization

Safety Design Criteria and Guideline of Sodium cooled Fast Reactor



- SFR Safety Design Criteria (SDC) development was proposed at GIF Policy Group in 2010
  - Realization of enhanced safety designs common to SFR systems,
  - Preparation for the forthcoming licensing in the near future
- SDC was formulated in 2013, external review and update
  - IAEA
  - OECD/NEA WGSAR
  - Regulatory bodies in SFR developing countries
- Safety design guidelines (SDG) for GIF SFR started in 2013.

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Safety document development for GIF reactor systems

- SDC/SDG are extended to the other reactor systems.

	White Paper on ISAM Implement.	System Safety Assessment	Safety Design Criteria/Guidelines*
SFR	Completed	Completed https://www.gen-4.org/gif/jcms/c_9366/risk-safety	SDC-Completed 1st SDG-Completed 2nd SDG-under review
VHTR	Completed	Completed	GIF is observing IAEA-CRP for SDC
LFR	Completed	Completed	SDC-under preparation SDC Report submitted to IAEA for review in 2021
SCWR	Completed	Completed	Not needed
GFR	Completed	Completed	SDC-under preparation
MSR	Under preparation	Under preparation	Under planning

* https://www.gen-4.org/gif/jcms/c_93020/safety-design-criteria

Advanced Manufacturing and Material Engineering (AMME)

- AMME is a key for cooperation with Industry (SMR Vendors…)
  - Innovation for Safety and Economy of construction, operation, and maintenance, inspections. AI is also significant issue
- Advanced Manufacturing Workshop held at NEA in Feb. 2020
- AMME-TF is launched in GIF
  - Requirements Capture
    - Given the rapid change in advanced manufacturing, this group will work to identify the needs of the community.
  - Qualification, Demonstration and Deployment
    - New approaches and methods for qualification are key to the deployment of advanced manufacturing. The first focus is to identify these commonalities in qualification across different reactor systems.
  - Design and Modelling
    - Meeting the need to capture and share processes and methodologies for ensuring product quality by a) collecting experience, b) sharing, and c) benchmarks (including data driven AI approaches).

Workshop

Small Group discussions

Summary

- Generation-IV Reactor Systems in GIF
  - SFR, LFR, GFR, MSR, VHTR, SCWR
  - GIF Goals; Sustainability, Safety and Reliability, Economy, PRPP (Security)
- Safety design criteria and Guide lines
  - SFR and extended to Other reactor systems
  - Cooperation with IAEA, OECD/NEA , and Regulatory bodies in each country
- New Activities
  - Non-electric Application of Nuclear Heat for Carbon Neutral
  - Advanced Manufacturing and Material Engineering with Private Sectors