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Development of Innovative Nuclear Systems

October 9, 2019

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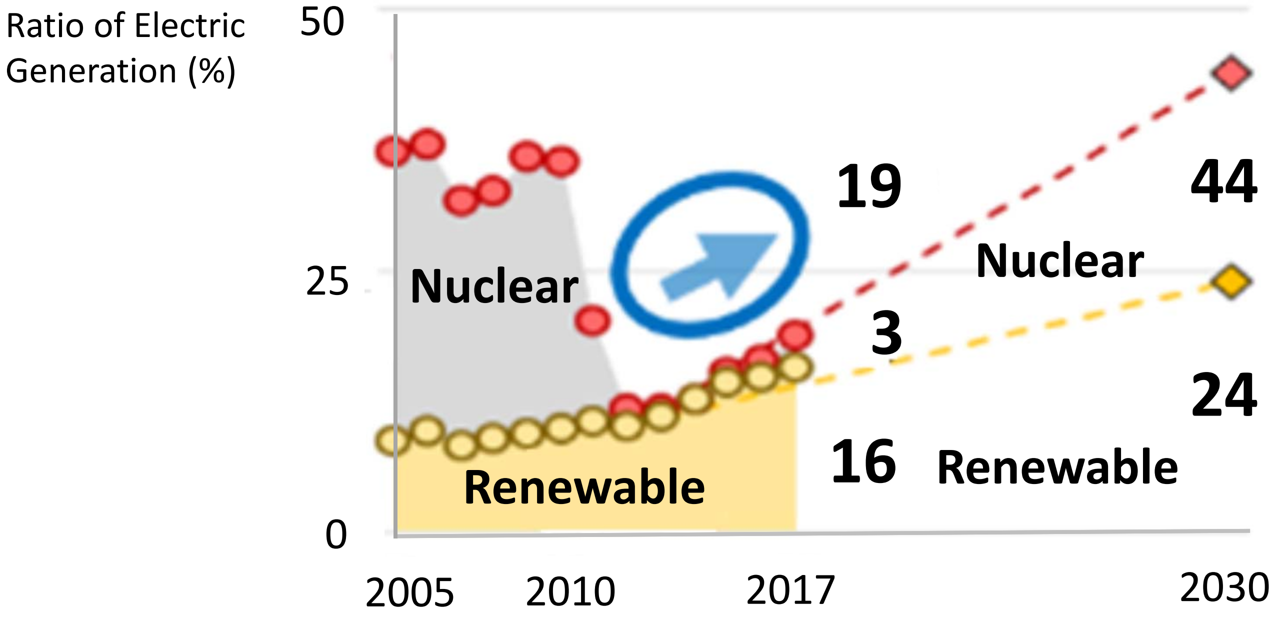
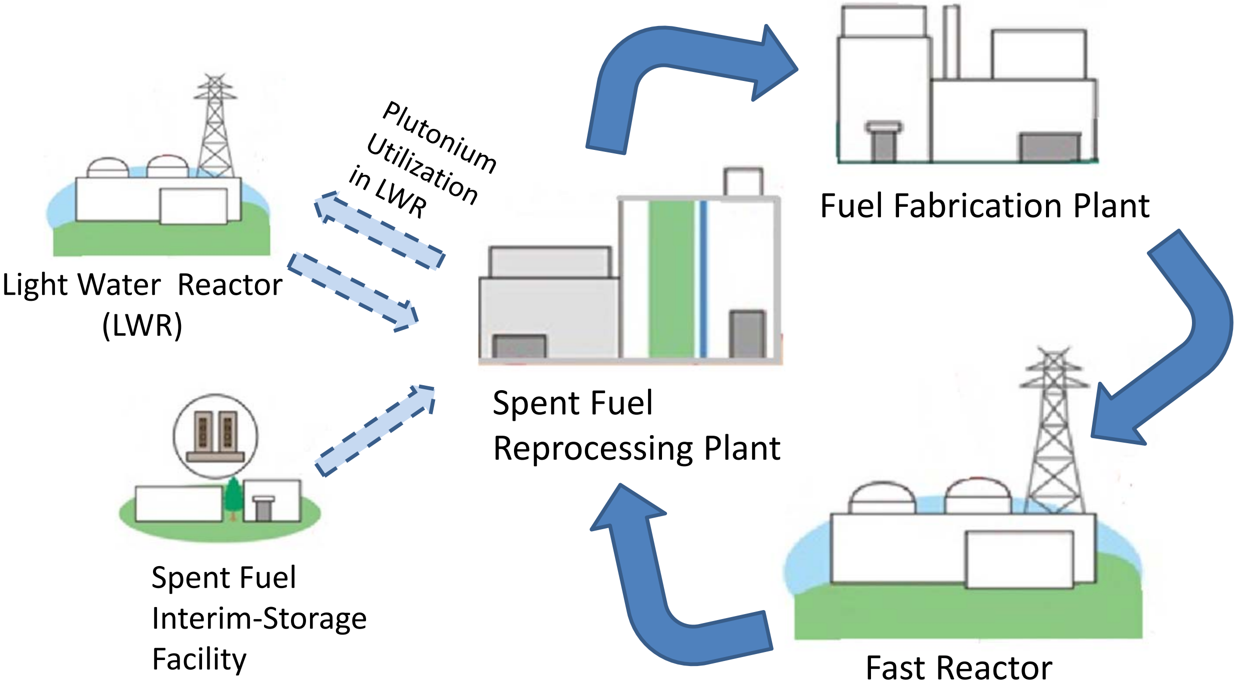
Non-Fossil fuel in Japan



Source: FY2018 Annual Report on Energy (Energy White Paper 2019)
https://www.enecho.meti.go.jp/en/

Fast Reactor Fuel Cycle



Potential of Innovative Nuclear Systems

Hybrid systems

Reliable Grid : Load following, Heat Storage

Heat Usage for Hydrogen Production & Water Desalination (Gen-4)

Sustainability

Effective Use of Uranium Resources(Gen-4)

Minimize Radioactive Waste and Burden (Gen-4)

Cost Competitive

R&Ds on Innovative Systems

Cost Challenges based on recent Gen-3+ experiences

Suitable Scale for Market Needs (SMR)

Safety

Passive Features of Feedbacks

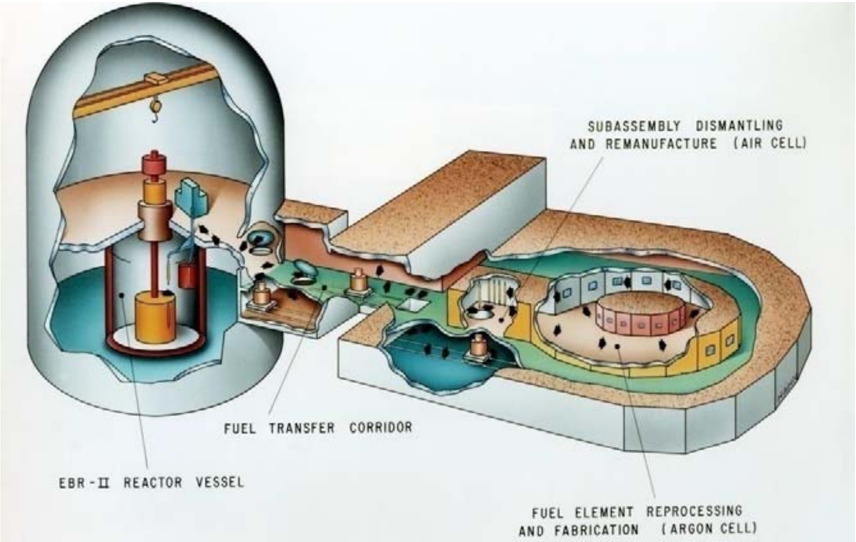
Passive Shut down Systems

Passive Decay Heat Removals : Natural Circulations, etc.

Safety Design Criteria for International Safety Standards

Technical Feasibility of an Integral Fast Reactor (IFR)

- ✓ The concept of an integral fast reactor (IFR) consists of reprocessing the fuel debris, fabricating TRU fuel, burning it in a small MF-SFR and recycling the spent fuel by reprocessing
- ✓ Amount of heavy metals (HM), such as uranium, contained in fuel debris: Approx. 250tons and **<u>TRU elements account for approximate 1.9tons</u>**.
- ✓ Configuration
  - A Metallic Fuel(MF)-SFR with inherent safety features (reactor output: 190MWt)
  - Application of a MF pyro-processing method that makes debris processing possible.

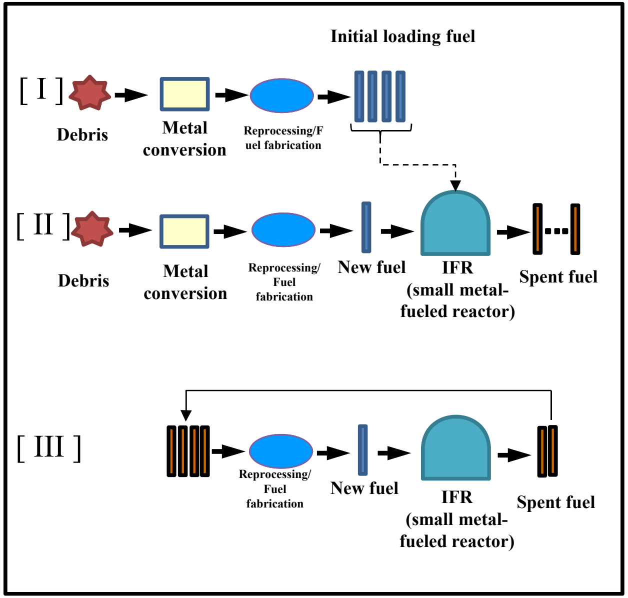


Concept diagram of an IFR that combines a fast reactor with a fuel recycling facility
(Example: Argonne National Laboratory Experimental-Breeder Reactor EBR-II and fuel cycle facility (FCF))

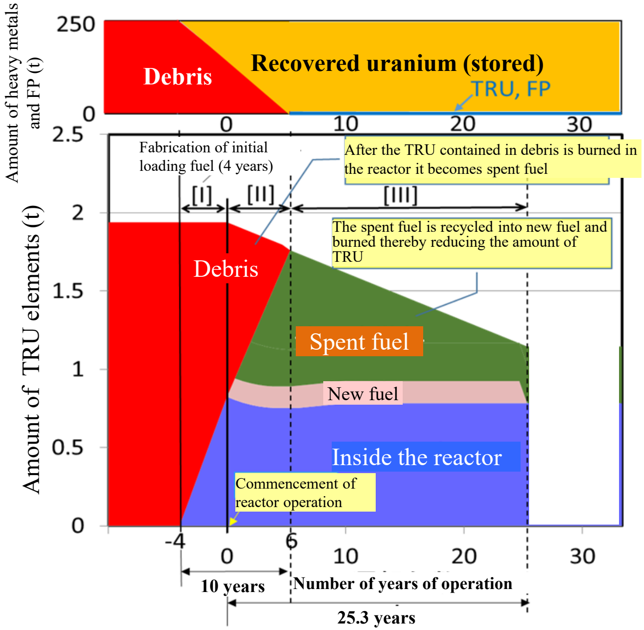
(Source：Y. I. Chang, “Integral fast reactor – a next-generation reactor concept,” in Panel on future of nuclear Great Lakes symposium on smart grid and the new energy economy, Sept. 24-26, 2012.)

Debris Processing Scheme and TRU Reductions

- The amount of fuel debris could be processed within 10 years.
- In 25 years after the launching the IFR, the 1.9 tons of TRU present in the debris will be reduced to a total of 1.2 tons in the reactor and in the spent fuel. Because of the shortage of TRU required to fabricate fuel, it will be necessary to procure TRU from breeder reactor core or external sources in order to continue operation of the reactor.

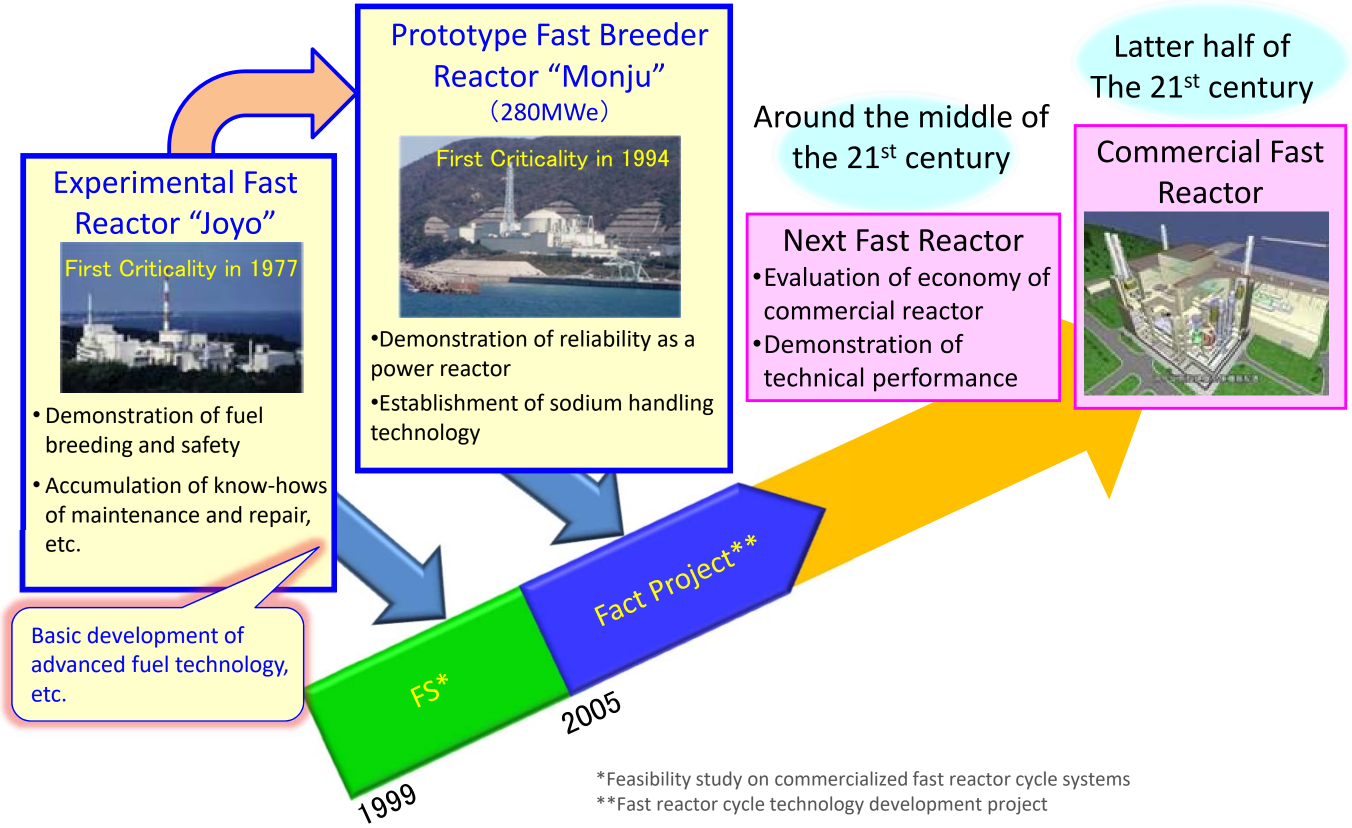


Concept diagram of debris processing scheme



IFR operation and TRU reductions

Current development plan of fast reactor in Japan



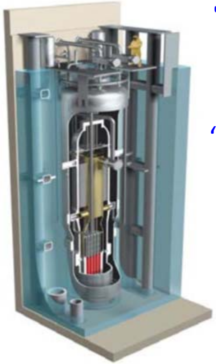
*Feasibility study on commercialized fast reactor cycle systems
**Fast reactor cycle technology development project

"Nuclear Energy x Innovation Promotion" (NEXIP) Initiative

- Japanese METI launched in 2019 the *Nuclear Energy x Innovation Promotion (NEXIP)* initiative supporting private sectors to develop nuclear technologies which enhance Safety, Economy and Maneuverability of nuclear power plant
- Two categories of technologies will be subsidized:
  1. Innovative nuclear technologies to meet social requirements
     - Feasibility study on innovative reactor technologies which enhance the Safety and Economy
     - Obliged to attain at least one feature among Maneuverability, Multipurpose uses, Effective use of resources, Reduction of radioactive waste, and others
  2. Technologies enhancing the safety of NPP
     - Development of innovative elemental technologies which enhance the Safety of commercial NPP (light water reactor)

Technologies studied in "NEXIP" Initiative

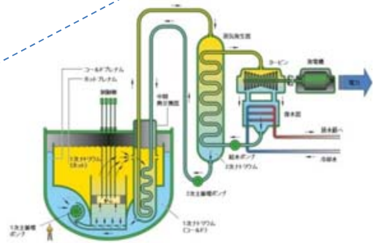
Small Modular Reactor (SMR)



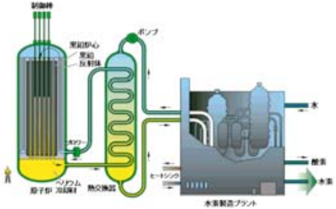
"NuScale" Design and others

Generation-4 Reactors

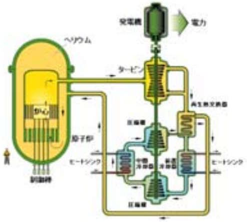
6 reactor types selected by GIF



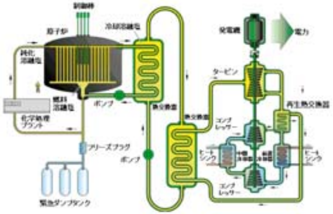
Sodium-cooled Fast Reactor (SFR)



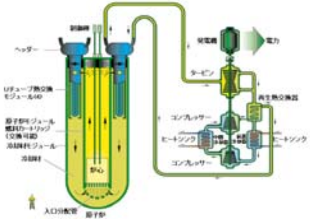
Very High Temperature Reactor (VHTR)



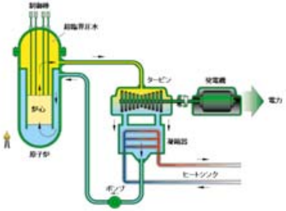
Gas-cooled Fast Reactor (GFR



Molten Salt Reactor (MSR)

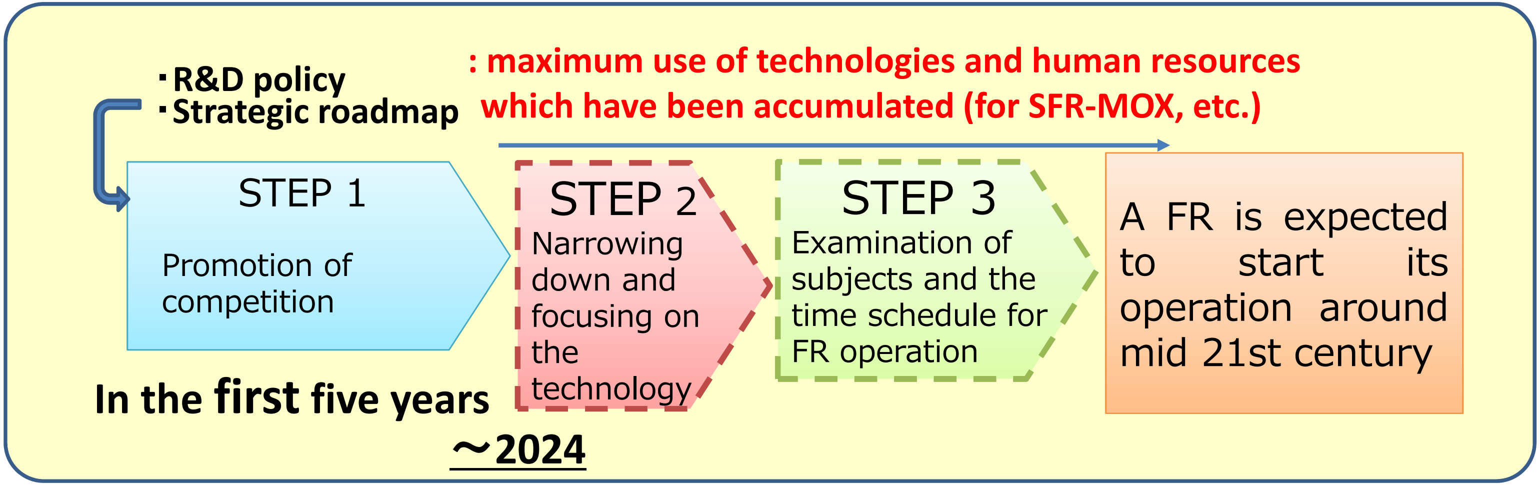


Lead-cooled Fast Reactor (LFR)



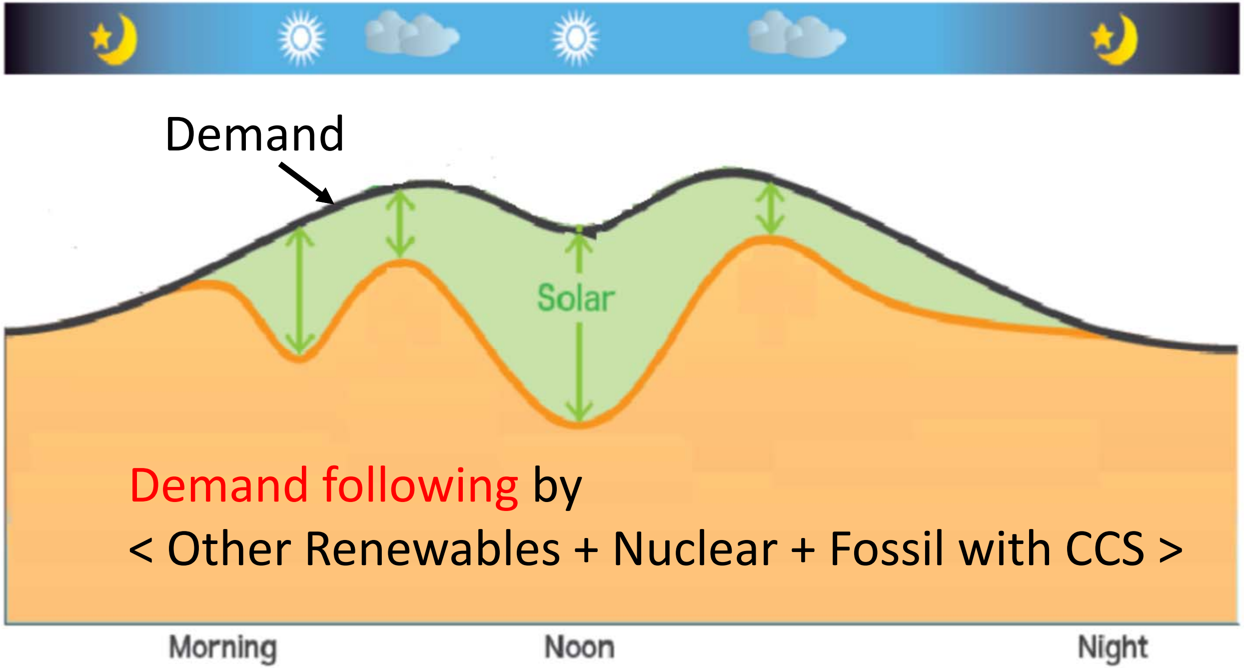
Supercritical Water Reactor (SCWR)

Steps of "NEXIP" Initiative



- After 2020, the scope of varieties of technologies will be narrowed

Balancing Demand and Supply of Electricity



Conclusion

- From the viewpoint of global warming, expansion of non-fossil power resources including nuclear power is indispensable.
- Innovative nuclear systems such as Gen-4 systems and Small Modular Reactors (SMRs) have potential features on sustainability, Safety and so on.
- In Japan, Nuclear Energy X Innovative Promotion (NEXIP) Initiative was launched supporting private sectors to develop nuclear innovative technologies. After 2020, the scope of varieties of technologies will be narrowed in about 5 years.
- Harmonization of renewable energy is expected to be an important characteristics for future nuclear energy.

Thank You for Your Attention!