JAEA's Efforts for Reduction of Radioactive Wastes

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Contents

Significance and Necessity Of the Nuclear Fuel Cycle

- Activities in reprocessing spent fuels and utilizing the nuclear fuel cycle **further enhance nuclear power characteristics** of being excellent in supply stability
  - **Enhancing the energy security of Japan**
  - **Reducing waste generation and potential hazard of HLW**

The Nuclear Fuel Cycle Policy

Strategic Energy Plan (Apr. 2014)

- **To promote nuclear fuel cycle** that reprocesses spent fuels and effectively utilizes the plutonium recovered as **a basic policy** of Japan for **reduction of the volume and radiotoxicity of radioactive wastes**

The 5th Science and Technology Basic Plan (Jan. 2016)

- **To address the establishment of innovative technologies,** ex. nuclear fusion, and **the nuclear fuel cycle technologies, being important for future**

Business Outline of JAEA

R&D related to dealing with the Fukushima Daiichi NPS accident 【Sector of Fukushima R&D】

Decommissioning etc.

Environmental Recovery

Make concentrated efforts maximizing JAEA's ability

R&D on fast reactor *【Sector of Fast Reactor R&D】*

Monju

R&D for establishment of demonstrated technologies of fast reactors

R&D on reprocessing, fuel fabrication and treatment/ disposal of radioactive wastes

【Sector of Decommissioning and Radioactive Waste Management】

Reprocessing/fuel fabrication

Technologies for HLW disposal

Volume/radiotoxicity reduction

Decommissioning

R&D for safety improvement of nuclear use and activities contributing to non-proliferation/nuclear security

Technical assistance for nuclear safety regulatory administration through safety research

【Sector of Nuclear Safety Research and Emergency Preparedness】

Enhancement of industry/academia/government cooperation and activities to secure reliability from society

Technology Transfer, Innovation

Nuclear Operator Support

International Cooperation

Basic & Foundation Research, Development of Human Resources

【Sector of Nuclear Science Research】

Basic Foundation Research to Support Nuclear Use

Advanced Nuclear Science Research

R&D of HTGR

Development of Human Resources / Promotion of Utilization of Shared Facilities

Quantum Beam Research

J-PARC

R&D on nuclear fusion 【Sector of Fusion R&D】

Promotion of ITER plan

R&D expanding BA activities

R&Ds for the establishment of nuclear fuel cycle are underway in 3 sectors

R&D in JAEA for reduction of the volume and radiotoxicity of radioactive wastes (1/2)

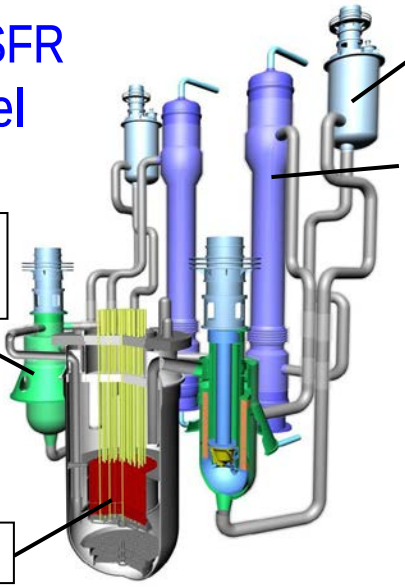
Fast Reactor (FR) Cycle Type

- Partitioning and transmutation technology using nuclear power generation reactors
- Recycle MA together with Pu
- Conduct nuclear transmutation of Minor Actinides (MA) in a nuclear power reactor (Fast Reactor(FR))
- MA content in fuel: up to 3 - 5%
- Major candidate: Sodium-cooled Fast Reactor (SFR) with the MOX fuel

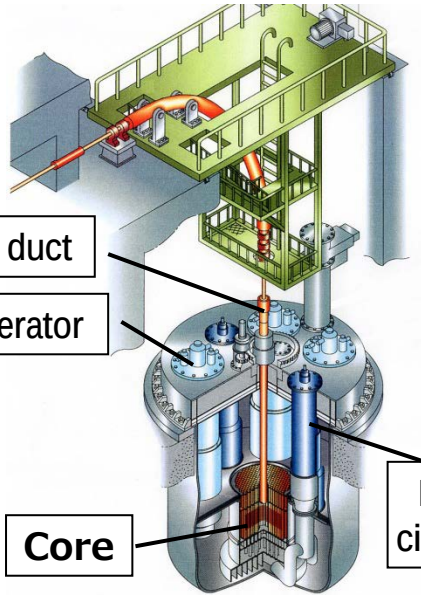
Accelerator-Driven System (ADS) Type (Hierarchical Type)

- Incorporate a transmutation cycle to a nuclear power generation cycle
- Confine MAs in a compact cycle
- Transmutation dedicated system (accelerator-driven system: ADS etc.)
- MA content in fuel: 50 % or more (fuel without uranium)
- Major candidate: Lead-cooled Fast Reactor (ADS) with the nitride-fuel

Concept of SFR with MOX fuel



Concept of ADS with nitride fuel



R&D in JAEA for reduction of the volume and radiotoxicity of radioactive wastes (2/2)

Research field of nuclear transmutation technologies using FR

- Validate core design methodology using data obtained from performance tests of Monju, etc.
- Core design study
- Obtain irradiation behavior data of MOX fuel in a homogeneous MA cycle
- Research long-life core materials
- Implement collaborative irradiation tests of MA bearing MOX fuel in Joyo with US and France

【Sector of Fast Reactor R&D】

Research of common basic technologies for MA partitioning and transmutation

- Evaluate technical feasibility on MA partitioning and recovery
- Evaluate technical feasibility on MA fuel fabrication
- Start small-scale MA cycle demonstration tests

Research field of nuclear transmutation technologies using ADS

- Work on the construction of Transmutation Experimental Facility (TEF) in J-PARC
- Aim to start the construction of TEF in the middle of the third mid- and long term target period
- Conduct ADS conceptual design study, target window material evaluation, development of pyro-reprocessing technology for MA fuel, etc. and accelerate ADS development with international cooperation

【Sector of Nuclear Science Research】

As two fields have many research items in common (ex. MA partitioning technology, MA fuel technology, two sectors are implementing R&Ds in cooperation

R&D Facilities for reduction of the volume and radiotoxicity of radioactive wastes

Plutonium Fuel Development Facility (PFDF)

Prototype Fast Breeder Reactor (Monju)

Japan Proton Accelerator Research Complex (J-PARC)

Material Monitoring Facility (MMF)

Monju

Fuel assemblies

Fuel assembles containing MA fuel pins (Planned)

Irradiated fuel assemblies

Plutonium Fuel Production Facility (PFPF)

Tokai Pu Facilities

Oarai Fuel & material facilities

Test fuel pins

Fuel assemblies Test fuel pins

Irradiated fuel assemblies (incl re-loaded)

Fuel for irradiation

Fuel Monitoring Facility (FMF)

Alpha-Gamma Facility (AGF)

Joyo

Plutonium Conversion Development Facility (PCDF)

Experimental Fast Reactor (Joyo)

Tokai Cycle Facilities

Chemical Processing Facility (CPF)

Nuclear Fuel Cycle Safety Engineering Research Facility (NUCEF-BECKEY)

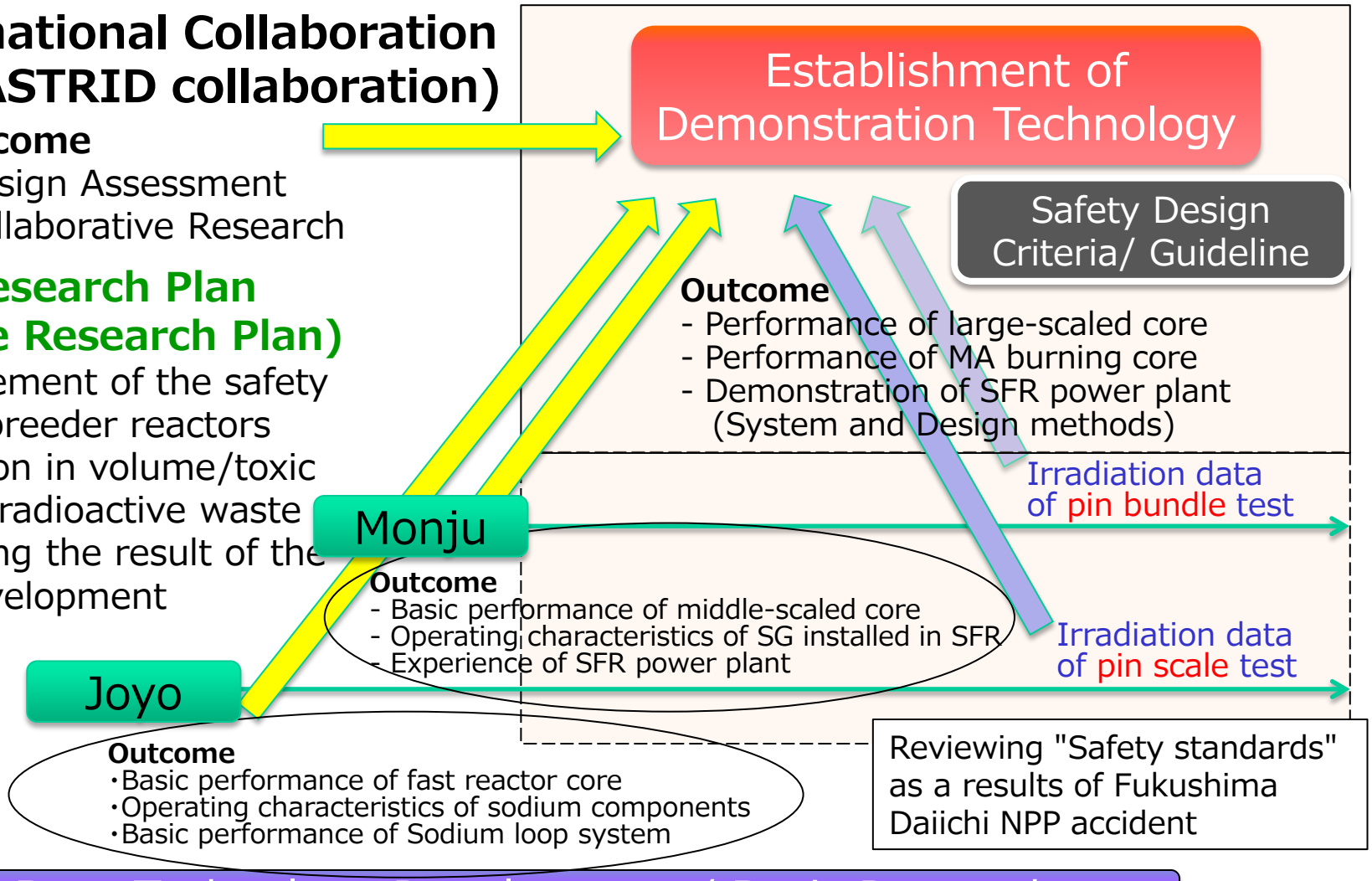
R&D roadmap of FR systems

- **International Collaboration (ex. ASTRID collaboration)**

Outcome
- Design Assessment
- Collaborative Research
etc

Monju Research Plan (FR Cycle Research Plan)

- Improvement of the safety of fast breeder reactors
- Reduction in volume/toxic level of radioactive waste
- Compiling the result of the FBR development



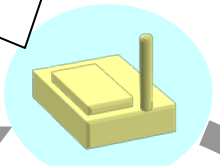
Reactor Physics, Thermal-hydraulics, Safety, Component & Material, Instruments, Fuel material, In-service inspection, Maintenance (Facilities: AtheNa, MELT, SWAT, PLANDTL, HTL, FMF, MMF, AGF, Sodium-Engineering Research

Research projects of FR cycle technologies

◉ Improvement of the flexibility in Pu use, verification of MA partitioning and transmutation technologies, etc. are necessary for obtaining technological perspective on the reduction of the volume and radio-toxicity of radioactive wastes

Reprocessing:
- Development of MA partitioning process and performance evaluation
- Establishment of feasible process concepts

Comprehensive system evaluation:
- Integration of information in each area & narrowing prospective system concepts
- Verification of effects on reduction of the volume and radiotoxicity of radioactive wastes

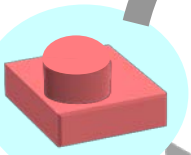


Reprocessing

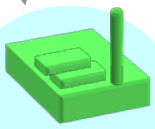
Spent MOX fuel

U, Pu, MA

Evaluation of volume reduction, etc. by utilization of FR cycle



FR



Fuel Fabrication

Reactor Characteristics & Reactor system:
- Feasibility confirmation of FR plant technologies
- Acquisition of characteristics of MA-containing core

Fuel Fabrication:
- Remote MA-bearing MOX fuel fabrication technology
- Determination of fuel composition range applicable

MA-bearing new MOX fuel

Fuel Development & Irradiation Test:
- Systematic irradiation tests of MA-bearing MOX fuel, High Pu-contents MOX fuel

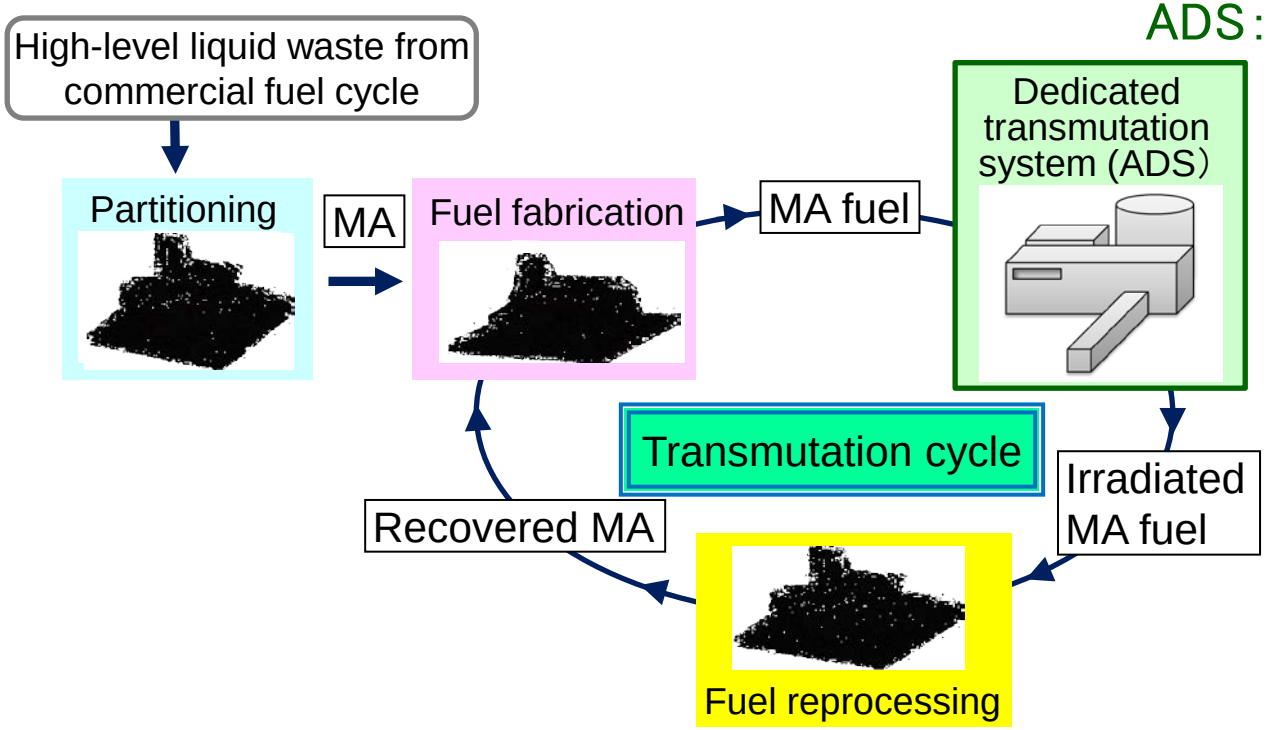
Double-strata Fuel Cycle Concept with ADS for MA Transmutation

<System outline>

- Transmutation cycle is attached to commercial cycle : **Double-strata**
- **Accelerator Driven System (ADS)** is used as dedicated transmutation system

<Characteristic>

- MA can be confined into a small cycle and transmuted efficiently.
- Both commercial fuel cycle and transmutation cycle can be optimized according to their purposes, respectively.



ADS : Accelerator Driven System

- Proton beam from super-conducting LINAC is introduced to spallation target.
- Generated fast neutrons keep the chain reactions of MA fuel in sub-critical system.
- Fission energy is used for power generation.

Transmutation with ADS and MA fuel cycle

<ADS>

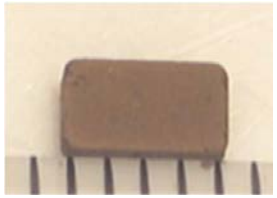
- Super-conducting proton LINAC – Liquid Pb-Bi target – U-free MA fuel, Pb-Bi coolant
- R&D items : Accelerator, Beam window, Pb-Bi handling, Measurement and control of sub-critical system, etc.

<MA fuel cycle>

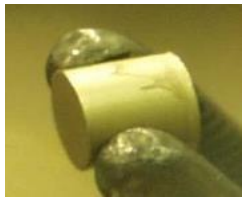
- Partitioning : MA recovery by solvent extraction method from HLLW generated in commercial fuel cycle
- MA fuel : Nitride is the first candidate
- MA fuel reprocessing : Pyrochemical process with molten salt and liquid metal

Over flow of Pb-Bi in loop experiment

Small scale fabrication test of nitride fuel



(Am,Zr)N



$(Pu_{0.21}Am_{0.21}Zr_{0.58})N$

Hot cell experiments with real HLLW

It is necessary to establish technological basis which can give required data for the judgement of the realizability and practicability.

International cooperation for FR and ADS

International Cooperation is significant to R&D for verification of technical feasibility of SFR and ADS. Key issues of these cooperation:

- SFR: verification of effectiveness in reducing environmental burdens and establishment of safety technology of FR system
- ADS: R&D for engineering feasibility of subcritical system with high power accelerator

France

- Reactor & advanced nuclear energy system
- Advanced fuel cycles
- Prototype/demonstration reactor (incl. ASTRID)
- Operation/Maintenance

Russia

- Vibro-compacted fuel
- ODS cladding irradiation

Kazakhstan

- Re-criticality elimination mechanism (EAGLE project)

U.S.A.

CNWG activities

- Fast reactor technology
- Fuel cycle technology
- Waste management

EU

- ◆ Partitioning and transmutation technology
- ◆ Experimental ADS and irradiation tests (MYRRAH project)

Trilateral Collaboration

- Design goal and high level requirement for prototypes goals
- Safety principles and infrastructure needs
- Irradiation test of MA bearing fuels (GIF GACID project)

IAEA

- INPRO (Scenario study)
- TWG-Fast reactors
- TWG-Nuclear fuel cycle options
- ●◆ Coordinated research activities (CRPs)

GEN IV International Forum

- SFR (Advanced fuel, Component Design &BOP, Safety and Operation, Safety Design Standard)

OECD/NEA

- ◆ NI 2050
- ◆ Innovative fuels

● SFR
◆ ADS

Thank you for your attention!