# Current status of fast reactor cycle technology development (FaCT) project in Japan

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*Ryodai Nakai*
**Advanced Nuclear System Research and Development Directorate**
**Japan Atomic Energy Agency (JAEA)**

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# *Fast Breeder Reactor Cycle Policy in Japan*

- *Framework for Nuclear Energy Policy by Atomic Energy Commission (AEC) of Japan (Oct. 2005)*
  - It is necessary to promote R&D toward commercialization of FBR cycle technology from its potential of long-term energy security and reduction in radio-toxicity of radioactive waste.
  - A Feasibility Study on Commercialized FR Cycle Systems aims to establish the FBR cycle technological scheme by around 2015.
  - Development of FBR cycle aims at its commercial introduction at around 2050.
- *Science and Technology Basic Plan by Council for Science and Technology Policy (Mar. 2006)*
  - FBR cycle technology was selected as one of the key technologies of national importance.
- *Report on Nuclear Energy Policy of MEXT (Jul. 2006) and METI (Aug. 2006)*
  - A council was set up to investigate demonstration processes of fast breeder reactor cycle technology by MEXT, METI, JAEA, the electric utilities and plant vendors.
  - Development of a demonstration FBR aims at its introduction by around 2025.
- *"Basic Policy on Research and Development of Fast Breeder Reactor Cycle Technologies over the Next Decade" was decided by AEC (Dec. 2006)*

# FBR Cycle Development Program in JAPAN

2005 | 2010 | 2015 (JFY)

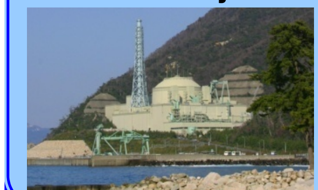
**Feasibility Study**
(JFY 1999-2005)
Identify The Most Promising Candidate Concept

C&R

**Review & Basic Policy by MEXT &AEC**

**Experimental FR "Joyo"**

**R&D at Prototype FBR "Monju "**



## Fast Reactor Cycle Technology Development Project (FaCT)

Decision of Innovative Tech. (2010)

Approved Confirmation (2015)

**R&D of Innovative Technologies**

**Conceptual Design of Commercial & Demonstration FBR Cycle Facilities**

**Commercialized FBR Cycle**

**R&D at "Monju "**
- Demonstrating its Reliability as an Operation Power Plant
- Establish Sodium Handling Tech.

**2015**
Production of the Conceptual Designs of Commercial and Demonstration FBR Cycle Facilities with R&D Programs

Basic Design & Construction

**2025**
Operation Start of Demonstration FBR & its Fuel Cycle Facility

Validation of Economy & Reliability

**2050**
Commercially Introducing of FBR Cycle Facilities

◆Cooperation with related Organization ◆International Cooperation（GNEP, GEN-IV, INPRO etc.）

# Overview of the FaCT Project

- **Overall schedule of FaCT**
  - Based on the previous Feasibility Study conducted from 1999 to 2005, and the government (MEXT) check and review.
  - Phase 1 (2006-2010): Design study and key technology R&D.
  - Phase 2 (2011-2015): Establishment of FBR cycle technology with conceptual design on demonstration and commercial FBR and fuel-cycle facility.

- **A 5-Party council was formed to discuss processes of demonstration and commercialization of FBR cycle systems in Japan.**

  5 Parties: MEXT, METI, electricity utilities, manufacturers, and JAEA

- **Leading Engineering Company was selected in April, 2007**

  Mitsubishi Heavy Industries (MHI) was selected as a “core” enterprise for FBR development. MHI then established the new company ”Mitsubishi FBR Systems Inc. (MFBR)” for designing and engineering for FBR.

- **International cooperation including GIF, GNEP, INPRO, etc.**

# Development Targets for FaCT Project

## Safety and Reliability

| | |
|---|---|
| SR-1 | Ensuring safety equal to future LWR and related fuel cycle facilities |
| SR-2 | Ensuring reliability equal to future LWR and related fuel cycle facilities |

## Sustainability

### Environment Protection

| | |
|---|---|
| EP-1 | Radioactive influence through normal operation no more than future LWR cycle |
| EP-2 | Emission control of environment transfer substances which can restrict in safety limits |

### Waste Management

| | |
|---|---|
| WM-1 | Reduction of an amount of radioactive waste compared with future LWR cycle |
| WM-2 | Improvement of waste managementability equal to or more than future LWR cycle |
| WM-3 | Reduction of radio-toxicity compared with future LWR cycle |

### Efficient Utilization of Nuclear Fuel Resources

| | |
|---|---|
| UR-1 | Breeding ratio to enable transition to fast reactor, and its flexibility |

## Economical Competitiveness

| | |
|---|---|
| EC-1 | Electric generation cost which can match other power plants |
| EC-2 | Investment risks no more than future LWR cycle |
| EC-3 | External costs no more than future LWR cycle |

## Proliferation Resistance & Physical Protection

| | |
|---|---|
| NP-1 | Adoption of institutional measures and application of technical features which can enhance proliferation resistance |
| NP-2 | System design of physical protection and its development |

# Main Features of JSFR

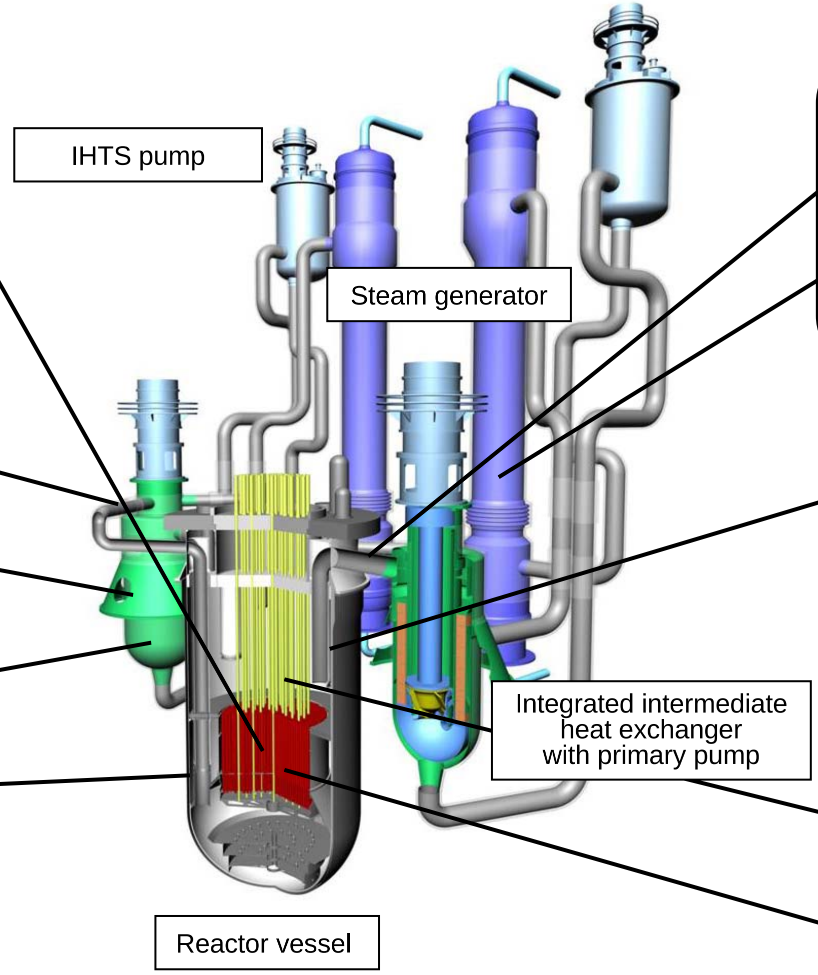
*- 1,500 MWe large-scale SFR with MOX fuel,*
*- Innovative technologies for enhancement of reactor core safety, high economic competitiveness and countermeasures against specific issues of sodium*

## Advanced Loop-type Sodium-cooled Fast Reactor

・ODS steel cladding tube for high burnup

**Reduction in material amount and building volume through the adoption of innovative technologies**

- 2-loop arrangement for a simplified plant system
- High-chromium steel structural material for a shortened piping length
- Integrated intermediate heat exchanger with primary pump for a simplified primary cooling system
- Compact reactor vessel
- Fuel handling system for system simplification
- Steel plate reinforced concrete structure building for reduction of material amount




**Prevention of sodium chemical reaction**

- Complete adoption of a double-walled piping system
- Steam generator with straight double-walled heat transfer tube

・Inspection and repair technology under sodium

**Enhancement of reactor core safety**

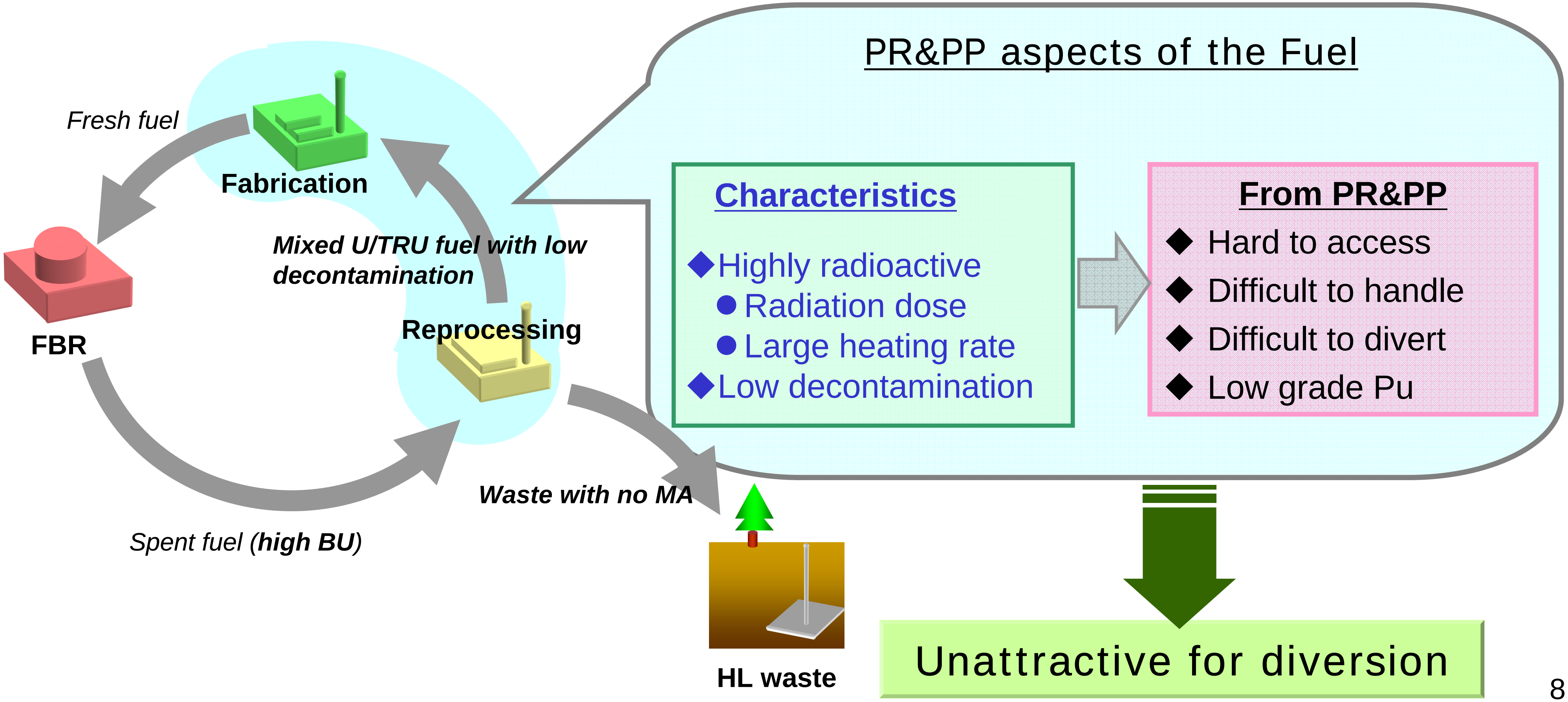
- Passive reactor shutdown system and decay heat removal by natural circulation
- Re-criticality free core concept during severe core damage
- Seismic structural design

# Comparison of FBR Design Specifications

| | Joyo (MK-III) (experimental) | Monju (prototype) | J-SFR (commercial) |
|---|---|---|---|
| Year of criticality | 1977 | 1994 | 2050 (2025 Demo) |
| Power level | N/A (140 MWth) | 280 MWe (714 MWth) | 1500 MWe (3570 MWth) |
| Core height/diameter (cm) | 50 / 80 | 93 / 180 | 100 / 540 |
| Reactor vessel height/diameter (m) | 10 /3.6 | 17.8 / 7.1 | 21.2 / 10.7 |
| Average burnup (GWd/t) | 70 | 80 | 150 |
| Core fuel | MOX | MOX | Low-decontamination, TRU MOX |
| Fuel cladding material | 316ss or improved | 316ss | ODS |
| Operation cycle (months) | 2 | 5 | 26 |
| Reactor coolant temp (C) | In 350 / out 500 | 397 / 529 | 395 / 550 |
| Number of loops | 2 (double walls) | 3 | 2 (double walls) |
| 1ry coolant flow rate (t/h) | 1,350 X 2 | 5,100 X 3 | 32,700 X 2 |
| Natural convection DHR | no | no | yes |
| Steam generators | N/A | Evaporator/superheater, helical coil tubes | Straight double-wall tubes |

# Proliferation Resistance Strategy of FBR Cycle

- ◆ No pure Pu in the cycle, but mixed U/TRU fuel with low decontamination (containing FPs)
- ◆ The fuel is unattractive for diversion and is believed to be inherently proliferation resistant



# Main Features of Fuel Cycle System

- Low decontaminated TRU fuel → Simplify process without U/Pu partitioning and purification
- Adjusting Pu content in solution → Reduction of powder treatment processes

## Advanced Aqueous Reprocessing

**U crystallization process that can dramatically reduce the extraction process flow**

### No Pu Separation

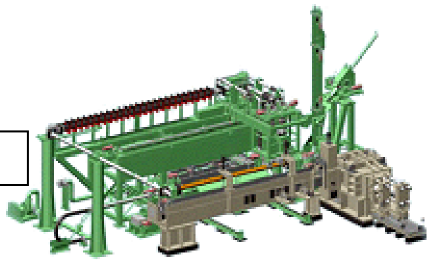
**Single cycle co-extraction of U, Pu and Np with low decontamination**

### No Purification

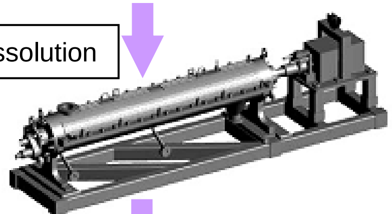
**No Purification processes of U and Pu because the recovery in low-decontamination process is permitted.**

**MA recovery by using extraction chromatography that allows the use of compact components and a lower amount of secondary waste**

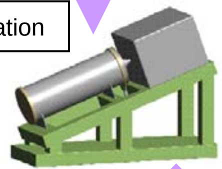
Disassembling and Shearing



Dissolution



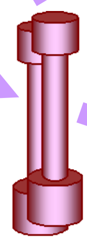
Crystallization



Co-extraction

U/TRU Mixture

Adjustment of Pu content



High-level liquid waste

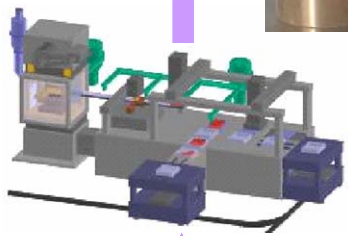
MA recovery by extraction chromatography

## Simplified Pelletizing Fuel Fabrication

### Remote Fabrication

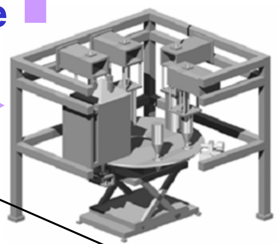
**In-cell fuel fabrication enabling low decontamination and MA recycle**

Pin fabrication and assembly of bundle



**Die lubricating-type pelletizing without lubricant-mixing**

Pelletizing and Sintering



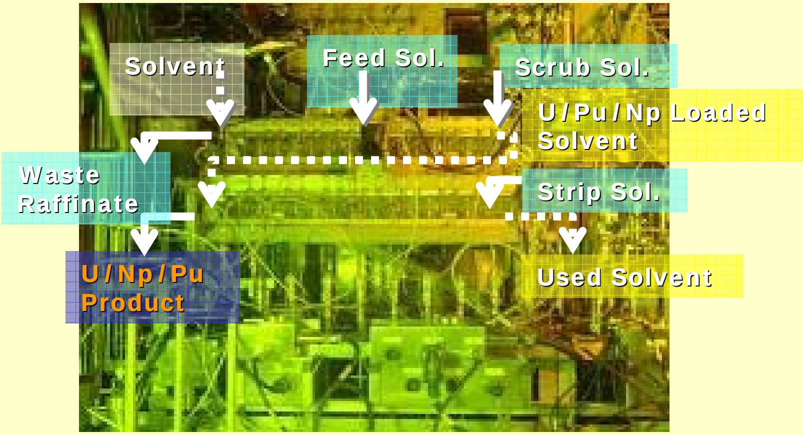
**Powder mixing process is removed by adjusting Pu content at solution state**

Denitration, Calcination & Reduction, Granulation

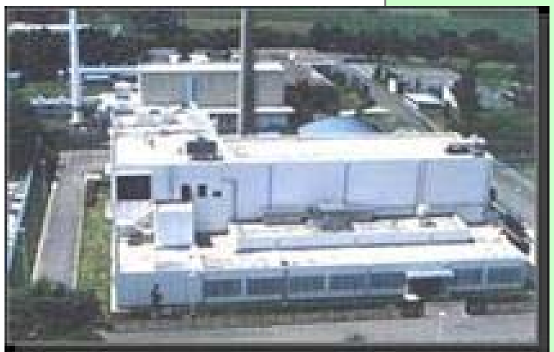
**Adjustment of Pu content at solution state is enabled by integrating reprocessing and fuel fabrication plant**

# R&Ds on Fuel Cycle System

## Advanced Aqueous Reprocessing
(U / Pu / Np Co-Recovery)

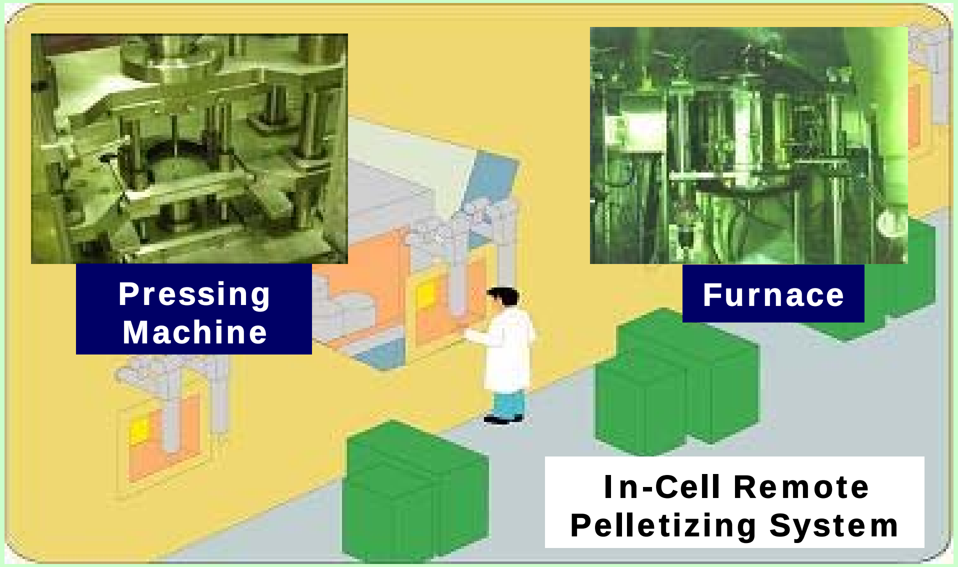


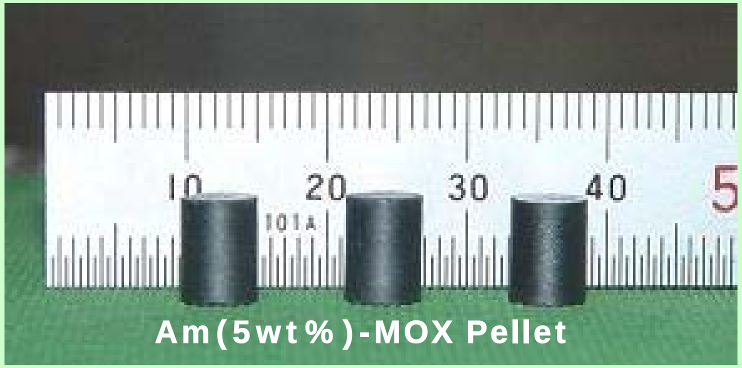

Chemical Processing Facility
(CPF)



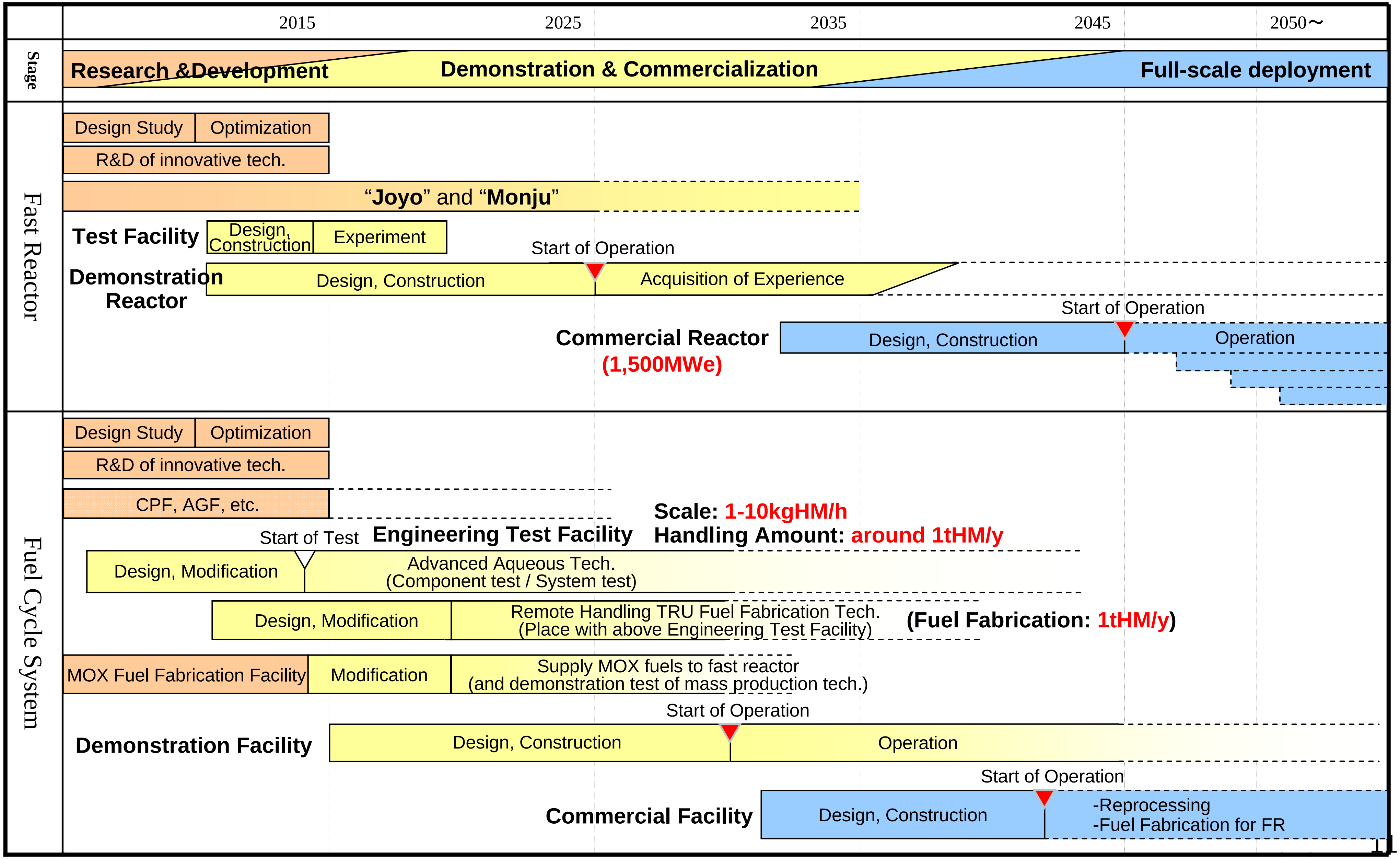
Alpha Gamma Facility
(AGF)

## Fuel Fabrication
(In-Cell Remote Pelletizing)



# R&D Roadmap toward commercialization (Draft)



# International Cooperation

- The FBR cycle system development actually needs a wide spectrum of knowledge and much technical evidence.

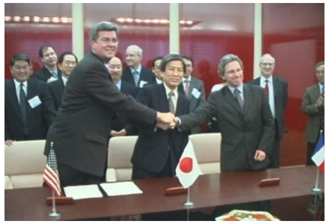
## GEN IV International Forum

Generation-IV International Forum (GIF)

Members: 12 countries and 1 organ

Feb.2005 – Framework Agreement

Feb.2006 – SFR System Arrangement



SFR Projects:

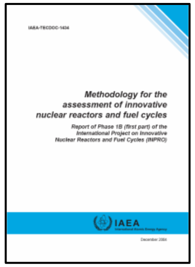
- Design, Integration & Assessment
- Safety & Operation
- Advanced Fuel
- Comp. Design & BOP
- GACID

## INPRO

International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)

Members: 26 countries and 1 organization

Dec.2004 – Published the method-ology for the assessment of INS


Methodology for the assessment of innovative nuclear reactors and fuel cycles
Report of Phase 1B (first part) of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)
IAEA

Japan joined INPRO in April 2006.

JAEA is cooperating the Joint Study on Assessment of an INS based on CNFC-FR.

## GNEP

Feb.2006 – U.S.DOE Announced the Global Nuclear Energy Partnership (GNEP)

Aug.2006 – U.S.DOE Requested for Expressions of Interest (EOI) and proposed two-track approach

Sep.2006 – JAEA submitted EOI with domestic organizations.

April. 2007 – US and Japan signed Joint Nuclear Energy Action Plan to promote nuclear energy cooperation

GACID: Global Actinide Cycle International Demonstration

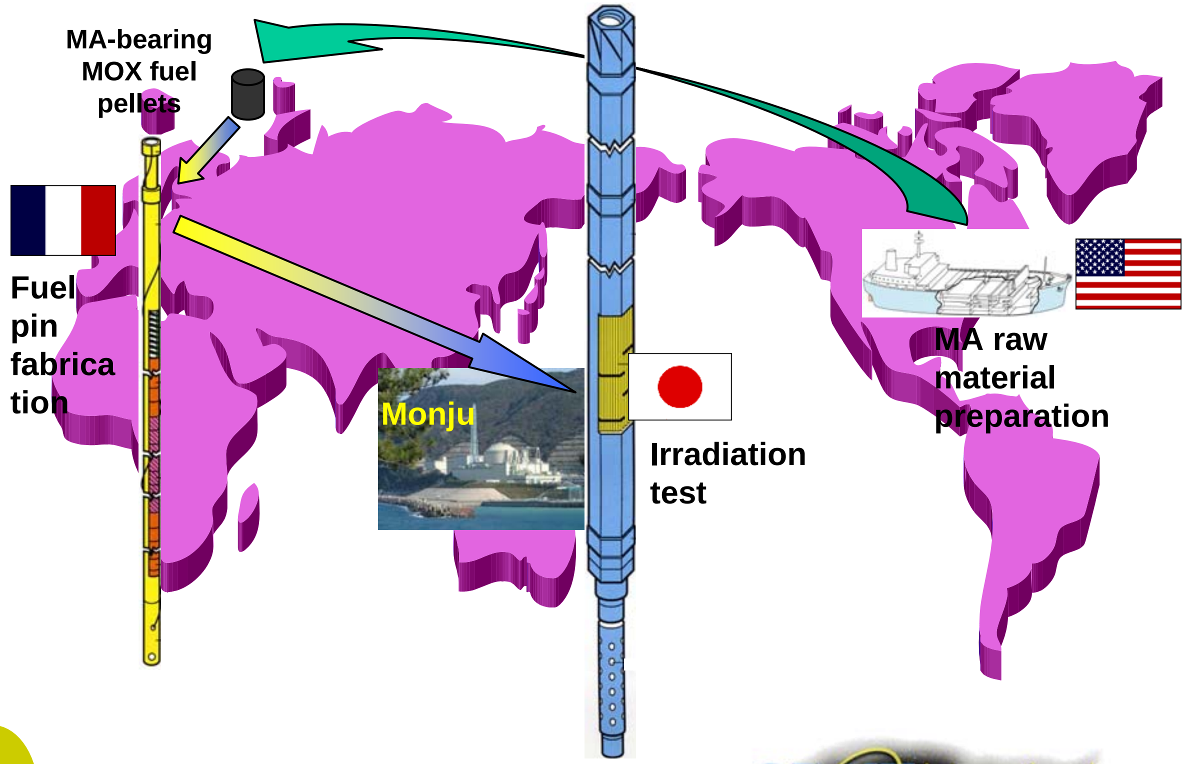
INS: Innovative Nuclear Energy System

CNFC-FR: Closed Nuclear Fuel Cycle with Fast Reactors

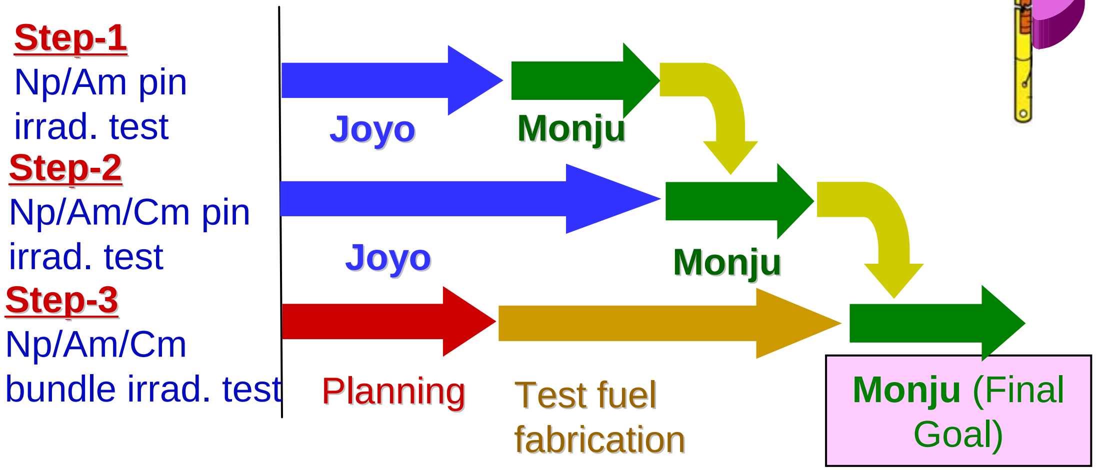
# Actinide Cycle International Demonstration (GIF/SFR GACID Project)

- *Objective: to demonstrate, using Joyo and Monju, that **FRs** can transmute MAs (Am/Np/Cm) and thereby reduce the concerns of high-level radioactive wastes.*
- *A phased approach in three steps.*
- *Material properties and irradiation behavior are also studied.*

***Tri-lateral collaboration in GACID pin-scale tests.***




***GACID overall schedule***




- *The Project is being initiated, by CEA, DOE and JAEA, as a GIF/SFR project.*



*GACID: Global Actinide Cycle International Demonstration*

# Concluding Remarks

- *JAEA is carrying out "FaCT Project" toward demonstration and commercialization of FBR cycle technology*
- *Innovative but challenging R&Ds for the following concepts:*

  *Reactor: Sodium-cooled FBR with U/TRU oxide fuel*

  *Fuel cycle: Advanced aqueous reprocessing*

  *(No Pu separation, No purification and MA recovery),*

  *Simplified pelletizing in-cell fuel fabrication*

- *Major milestones of development plan:*
  *2015 Establishment of FBR cycle technology for commercialization and development plan*
  *2025 Operation start of Demonstration FBR*
  *before 2050 Start of commercial introduction of FBR cycle*
- *International collaboration plays important roles in many aspects: global common goals, cost and knowledge sharing, etc.*