Japan's Nuclear Scenario for Long-Term Sustainability

2006 ANS Annual Meeting
Reno, Nevada, June 4-8, 2006

Satoru KONDO
Advanced Nuclear System R&D Directorate
Japan Atomic Energy Agency

Policy on Nuclear Fuel Cycle in Japan

- **AEC of Japan: "Framework for Nuclear Energy Policy" in October 2005**
  - **Nuclear energy to sustain stable energy supply of 30-40% even after 2030.**
  - **A closed fuel cycle with reprocessing and commercial FR deployment, after 2050.**
  - **A Feasibility Study on FR cycle systems to be continued toward 2015, for government review.**

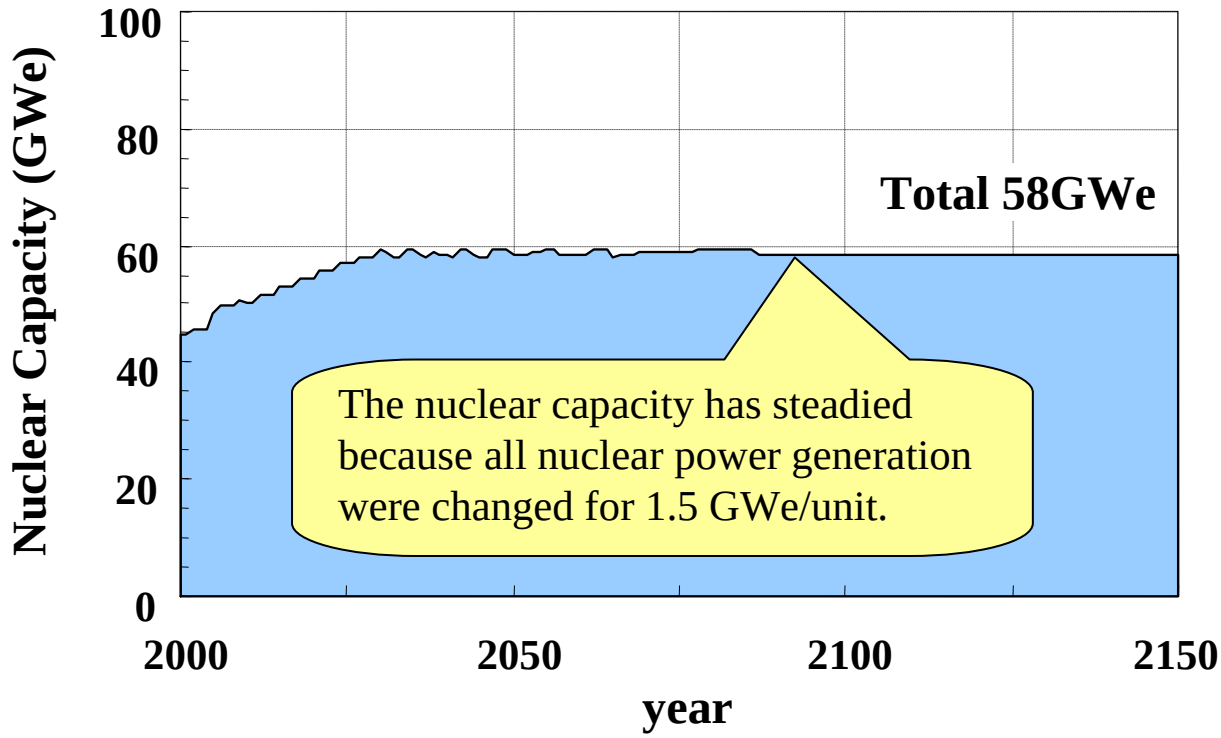
Purpose of the Scenario Study

- **Evaluate fuel cycle requirements (uranium demands, spent fuel storage, etc.).**
- **Assess the needs for FR cycle deployment in Japan, for long-term sustainability (up to 2150)**
  - **Saving uranium resources**
  - **Reducing high-level radioactive wastes for the environment.**

Japanese Nuclear Energy Scenarios (AEC-2005)

CASE	Note
I. Direct disposal scenario (CASE 1)	LWR once-through (direct disposal of all spent fuels)
II. Partial reprocessing scenario (CASE 2)	Reprocessing of a part of spent fuels and directly disposing of the remainders (Rokkasyo LWR reprocessing will terminate in 2047)
III. Reprocessing of all spent fuels	Continuation of nuclear fuel cycle policy
Pu recycling in LWR scenario (CASE 3-A)	Continuation of LWR cycle by plutonium thermal utilization in LWR
FR cycle deployment scenario (CASE 3-B)	FR cycle to be deployed after 2050 with minor-actinide (Np, Am, Cm) recycling.
IV. Interim storage scenario (CASE 4)	FR cycle will be deployed in 2050 after interim storage.

Main Assumptions (1/2)

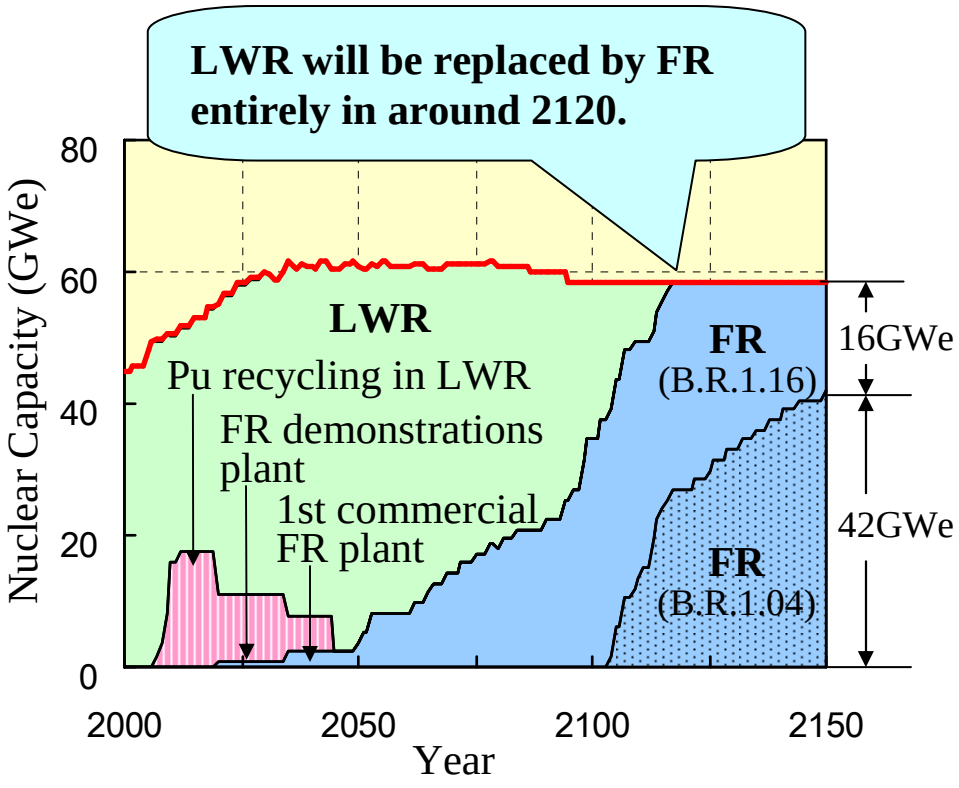


Nuclear Power Generation Capacity in Japan (58GWe)

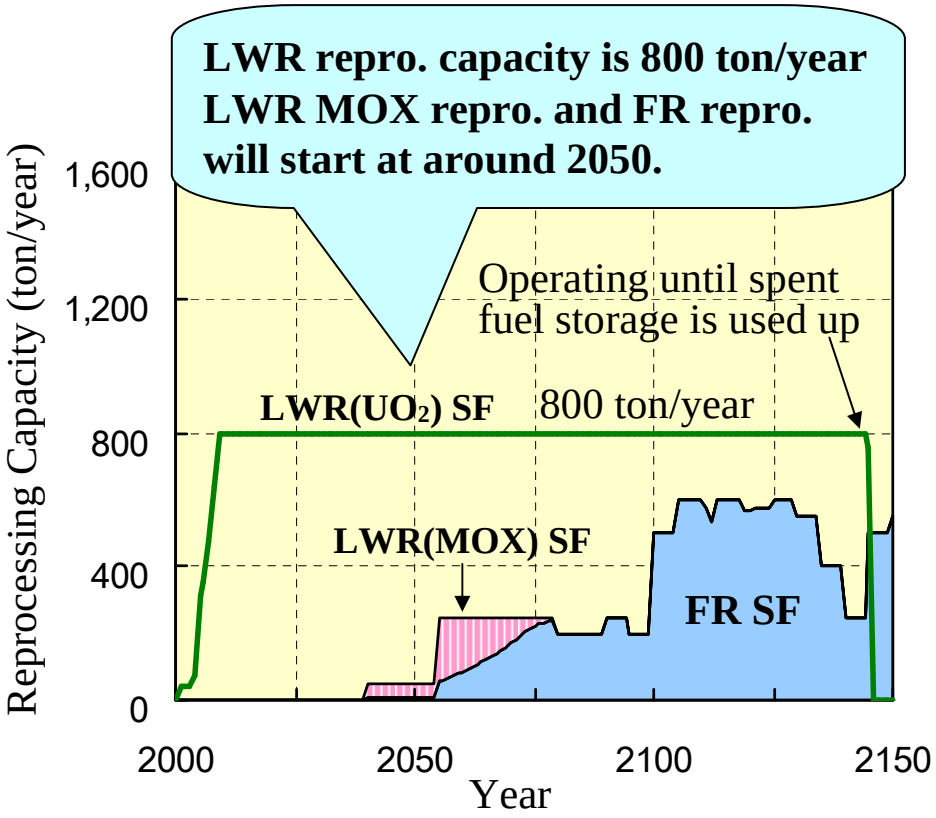
Main Assumptions (2/2)

Data item	Assumption
LWR reprocessing	Rokkasho reprocessing plant 2009-2046: 800 tons/year 2nd plant (or replaced RRP) 2047- : 800-1200 tons/year (MA recovery after 2047)
FR reprocessing	introduced in accord with SF arisings (with assuming 99.9% MA recovery)
Pu recycling in LWR	Introduced in accord with Pu recovered from LWR reprocessing after 2000 (phase out after FR introduction)
FR introduction	Introduced at 2050 in accord with Pu recovered from LWR and FR reprocessing with MA multi-recycle
LWR reactor characteristic data	Burnup : 45-60 GWd/t BWR : PWR = 6 : 4, MOX : UO_2 = 1: 2
FR reactor characteristic data	Burn up: 150 GWd/t (core) B.R. : about 1.0-1.2, MA recycle (The upper limit of MA content in the new FR fuels is 5%.)

Capacities for Reactors and Reprocessing Plants
(Case 3-B:FR cycle deployment)

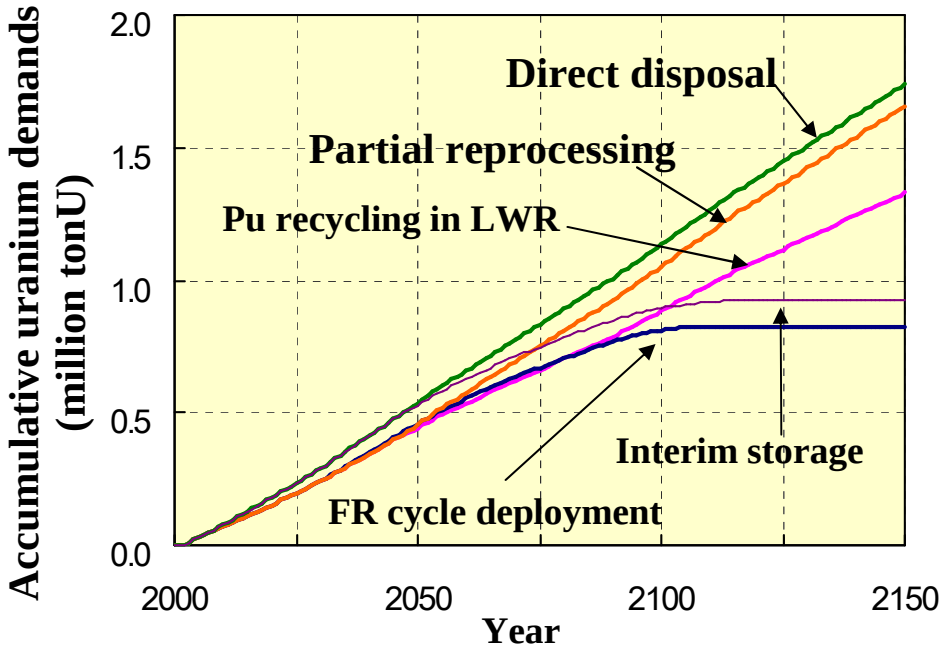


Capacity for each type reactor
(Case 3-B:FR cycle deployment scenario)

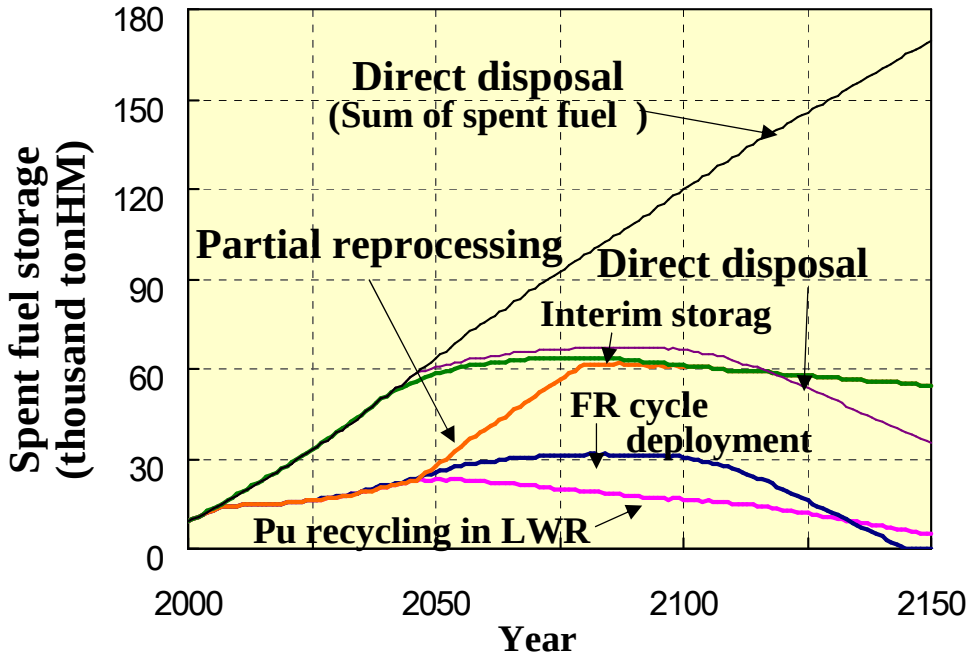


Reprocessing capacity
(Case 3-B:FR cycle deployment scenario)

Cumulative Uranium Demands

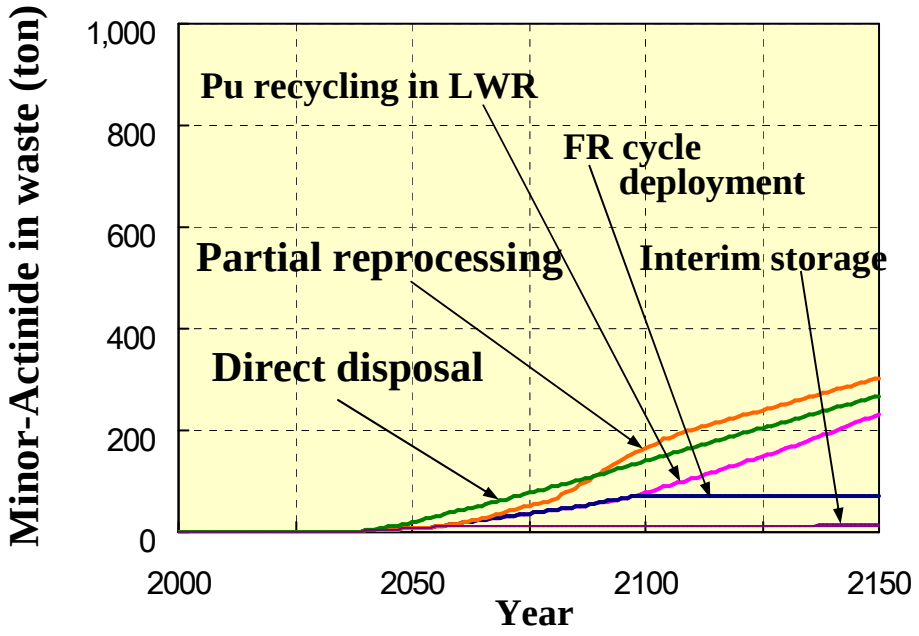


UO_2 Spent Fuel Storage



UO_2 Spent fuel storage

MA in Spent Fuel/Vitrified Waste



MA in SF and vitrified waste after disposal

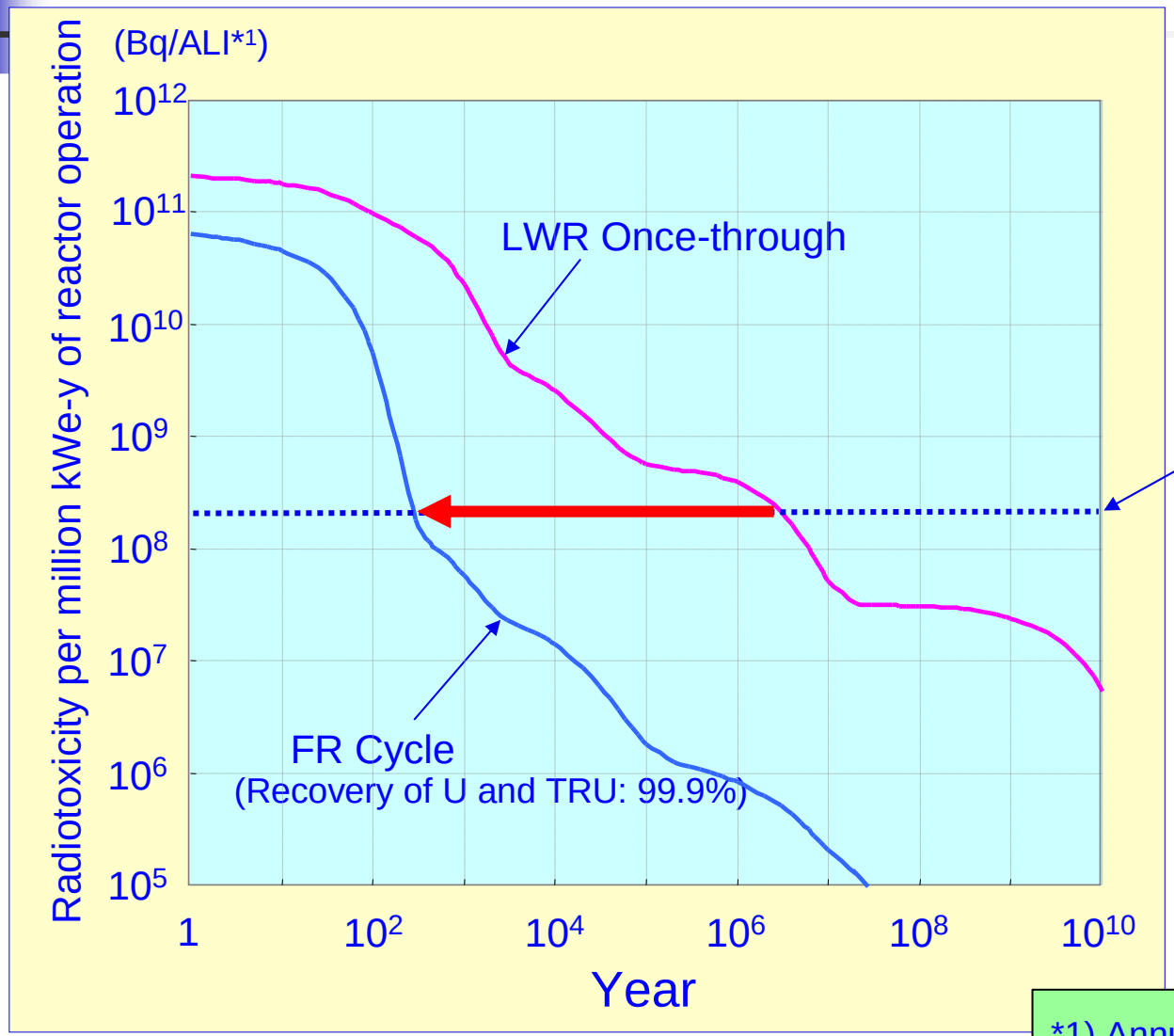
Targets of FR Cycle System Development (Feasibility Study)

1. **Safety**
2. **Economic competitiveness**
3. **Reduction of environmental burden**
4. **Efficient utilization of uranium resources**
5. **Proliferation resistance**

These targets are:

- **Required for long-term sustainability for nuclear energy, and**
- **consistent with Gen-IV International Forum objectives.**

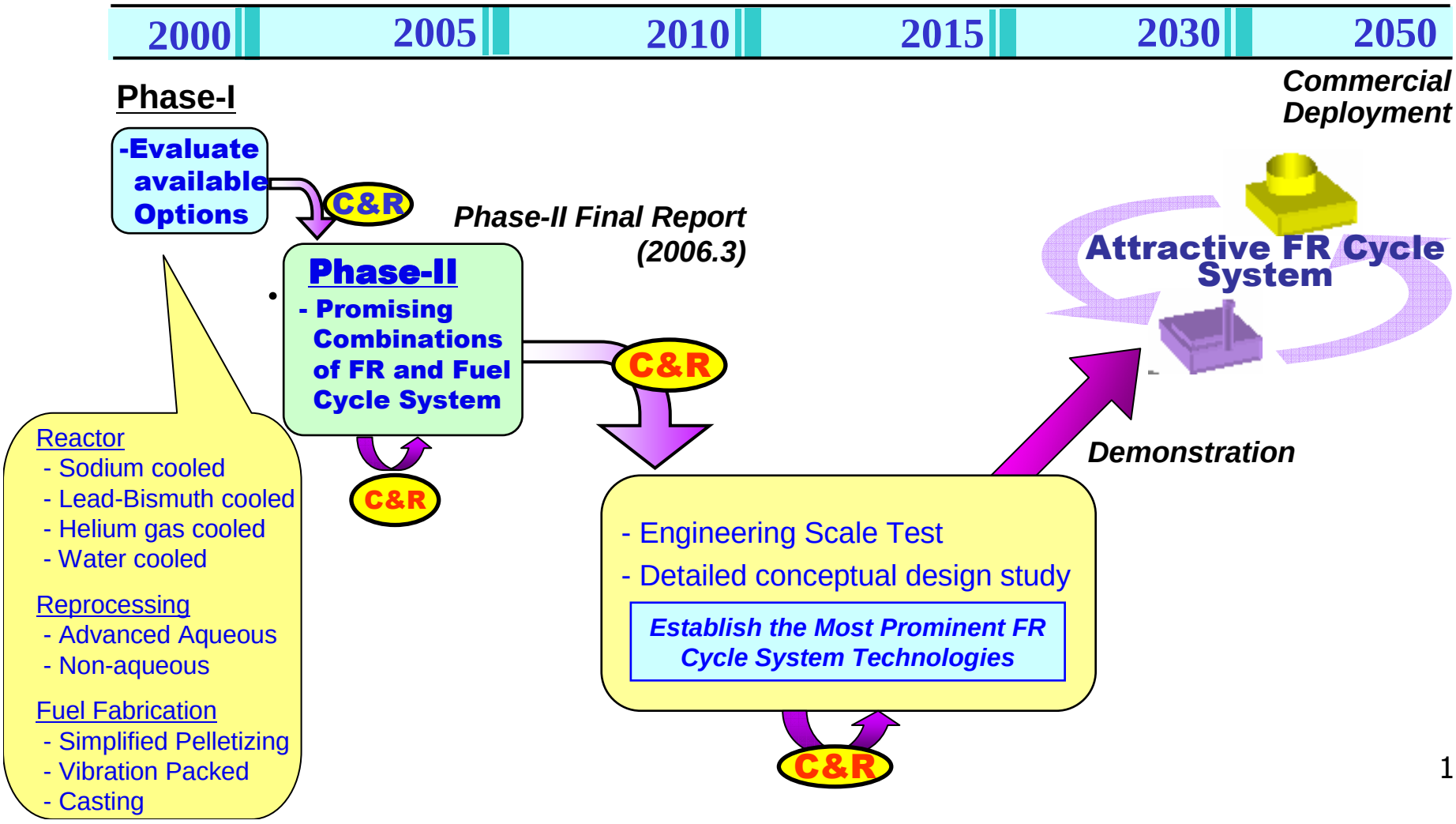
Reduction of Environmental Burden by FR Cycle



Radiotoxicity level of natural uranium

*1) Annual Limit of Intake

Feasibility Study on FR Cycle System (JAEA+utilities)



Results of Phase-2 Feasibility Study

- **For reactor systems:**
  - **Sodium-cooled FR (SFR) satisfies all the requirements, and is a primary option for commercialization.**
  - **Oxide fuel (MOX) with MAs is the first priority with metal fuel option being retained.**
- **For fuel-cycle systems:**
  - **A combination of advanced aqueous reprocessing + simplified pellet fuel fabrication satisfies all the requirements, and is a primary option.**

Conclusions

- **FR cycle option is superior for long-term sustainability with reduced environmental burden.**
- **The FR cycle technology receives a high national priority (AEC policy framework, CSTP's 3rd Science/Technology basic plan).**
- **R&Ds on FR cycle, esp. for advanced/innovative technologies proposed, shall continue toward 2015, for commercial deployment from 2050.**
- **This direction is consistent with GIF, INPRO and other international framework.**

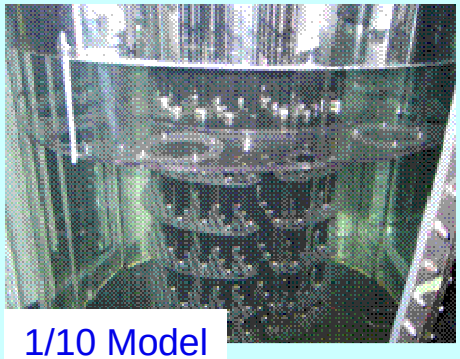
R&D for SFR Design Innovations

Compact reactor vessel

→ High sodium velocity

→ Hot vessel design

→ Single rotating plug



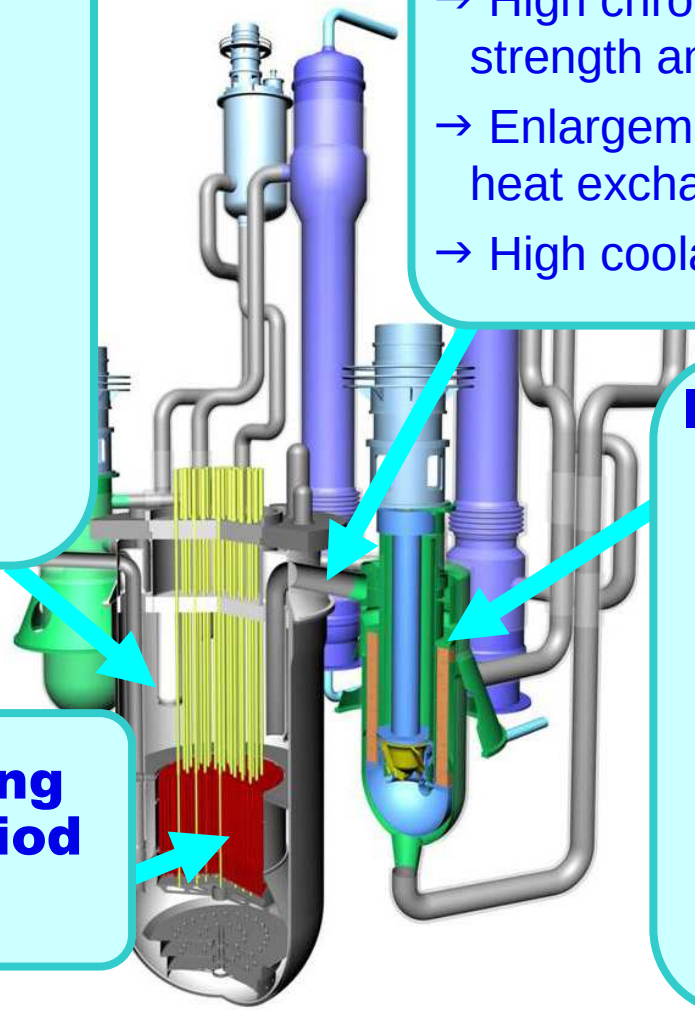
1/10 Model

Short piping in 2 loops

→ High chromium steel with higher strength and lower thermal expansion

→ Enlargement of the capacity of the heat exchangers

→ High coolant flow rate



IHX integrated with primary pump

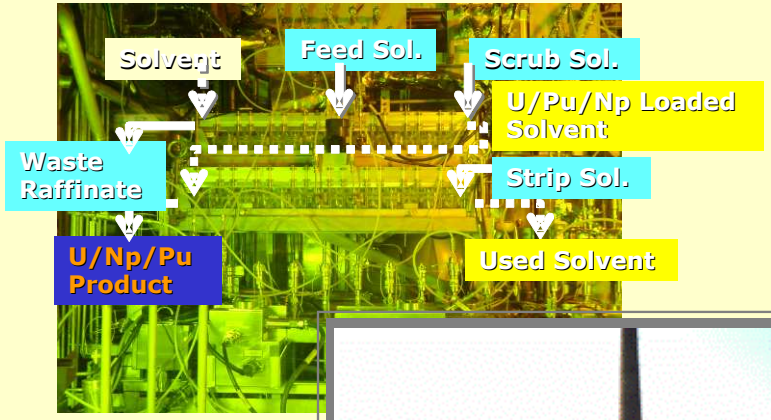
1/4 Model

High burn-up and long operation cycle period

→ ODS cladding material

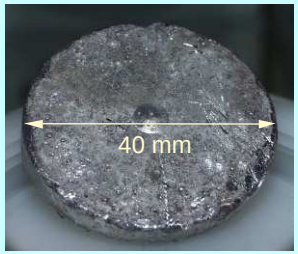
R&D for Fuel Cycle System

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



Non-aqueous Reprocessing (Electro-refining)

Metallic uranium deposit



Metallic Product

Fuel Fabrication (In-Cell Remote Pelletizing)