Nuclear Proliferation Resistance in Feasibility Study on Commercialized Fast Reactor Cycle Systems

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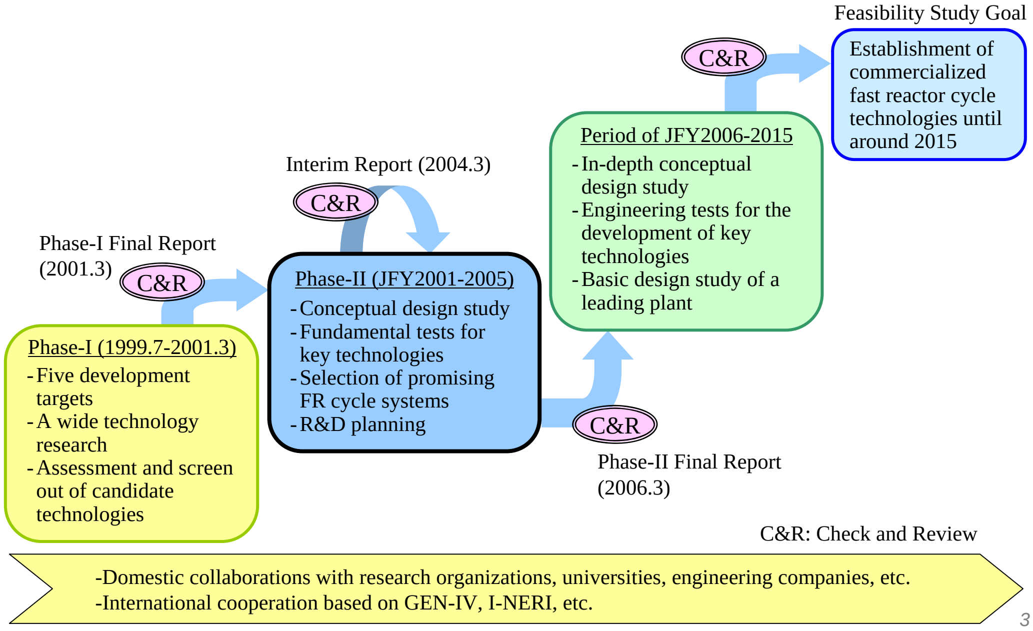
Steps of the Feasibility Study



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Five Goals of the Feasibility Study

- ***Safety***
  - Risks caused by introduction of FR cycle should be small compared with risks that already exist in society.
- ***Economic Competitiveness***
  - Achieve power generation cost comparable to that of future LWRs and other energy resources.
  - Ensure cost competitiveness in the global market.
- ***Reduction of Environmental Burden***
  - Reduce the amount of radioactive waste generated in the course of plant operation and maintenance as well as decommissioning.
  - Reduce the radiotoxicity of radioactive waste by means of burning or transmuting long lived nuclides.
- ***Efficient Utilization of Nuclear Fuel Resources***
  - Produce sustainable nuclear fuel.
  - Respond to diverse needs for energy resources.
- ***Enhancement of Nuclear Non-Proliferation***
  - Reduce burden of nuclear Physical Protection and safeguards (no pure plutonium in any FR cycle process and increase radioactivity of fuel materials).
  - Effectively operate non-proliferation system (remote process and monitoring system.)

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Nuclear Proliferation Resistance of Fuel Recycling
– Design requirement and criteria for evaluation –

Design requirement		Criteria for evaluation
Design which is considered on physical protection (PP) and safeguards (SG)	➡	Efficient application of system for PP and SV by utilizing remote surveillance and automation
No isolated Plutonium	➡	No plutonium isolated through whole processes
Limited access by high exposure from lower decontaminated and/or TRU fuel	➡	Realize limited access to obtain and utilize lower decontaminated and/or TRU fuel

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Nuclear Proliferation Resistance of Fuel Recycling
– Design with consideration on PP and SV –

<u>Technical requirement on PP</u>
Installing barrier and detection system for invasion

⇨ Considered current system

<u>Technical requirement on SV</u>

- Confirmation of material balance and inventory change by determining area of material balance and points for analysis and measurement
- Corresponding to inspection
- Acting sealing, confinement by surveillance and surveillance

⇨

- Investigated on application of current SV system including NRTA (Near Real Time Accounting)
- Applicable to Advance Aqueous Reprocessing
- Investigated on potential for rationalization of SV

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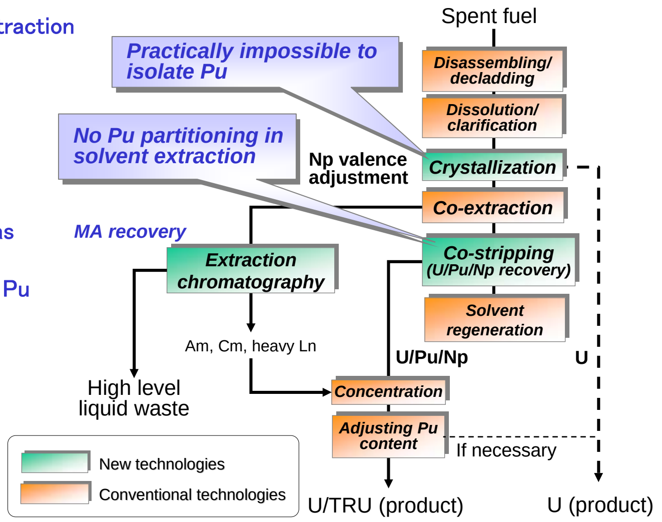
Advanced Aqueous Reprocessing What is the "NEXT" Process ?

Plutonium partitioning for Advanced Aqueous Reprocessing

- No Pu partitioning in solvent extraction
  - Increased technical difficulty to isolate Pu
- Adjustment of ratio of U : Pu by uranium crystallization
  - Major part of U is separated as solid uranyl nitrate
  - Inherently difficult to isolate Pu from U and fission products, practically impossible to separate Pu from dissolver solution of spent fuel



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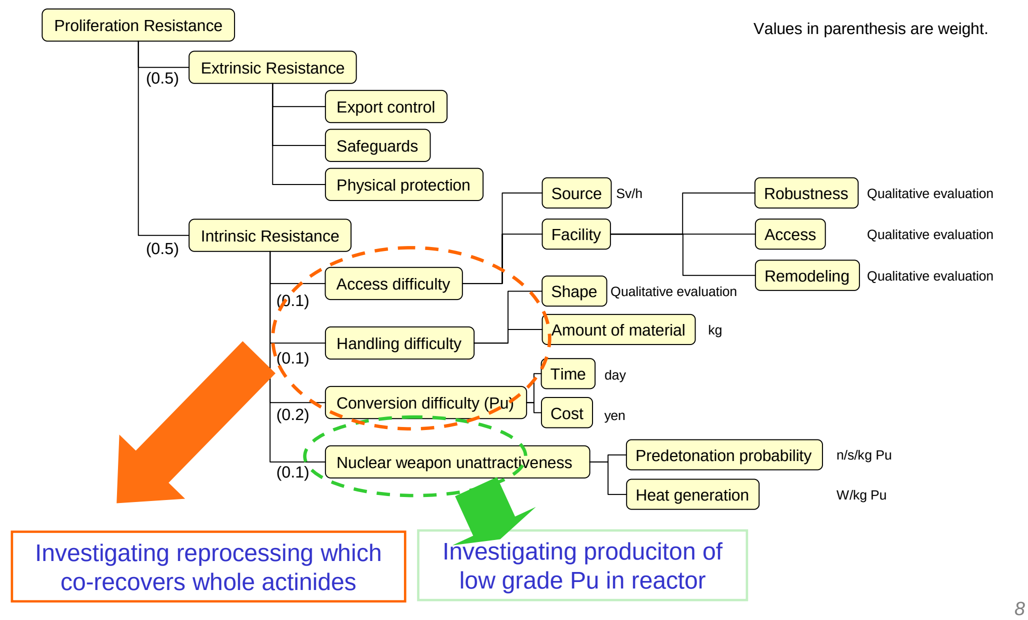
Criteria of Evaluation for Nuclear Proliferartion Resistance



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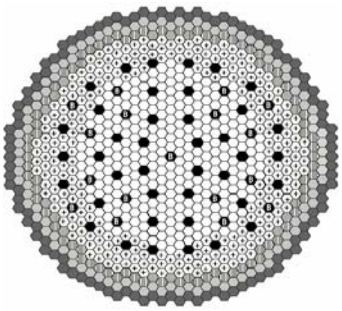
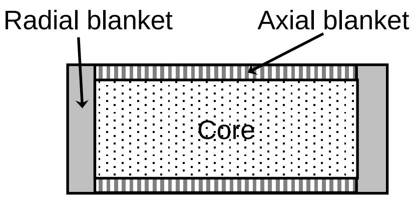
A study on enhancement of nuclear proliferation resistance in a reactor system

◆Target : No weapon-grade plutonium in a system



Spec. of a large MOX-fueled core

Thermal power	3570 MW
Electric power	MW
Operation cycle length	800 day
Fuel exchange batch	4
Average fuel burnup	147 GWd/t
Breeding ratio	1.1



Pu isotopic composition ($^{239}Pu/^{240}Pu$)

Fresh fuel (Core) : 57% / 34%

Discharged fuel

Core : 54% / 35%

Radial blanket : 95% / 5%

Axial blanket : 90% / 9%

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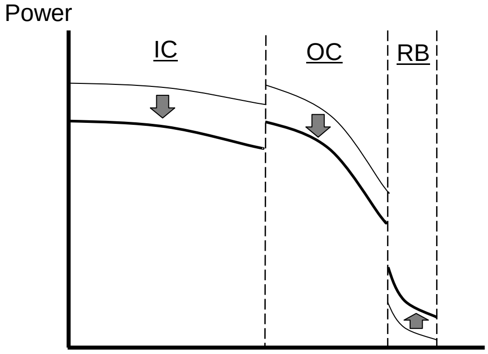
Addition of low grade Pu fuel to the blankets A case of 5% addition



	Influence
Plutonium inventory	+14%
Breeding ratio	-0.03
Average fuel burnup	- 5.5%

Change of Power Share

Core : Blanket

93% : 7%

⇩

88% :12%

Pu isotopic composition in discharged fuel ($^{239}Pu/^{240}Pu$)

Core : 55% / 35%

Radial blanket : 69% / 24%

Axial blanket : 71% / 23%

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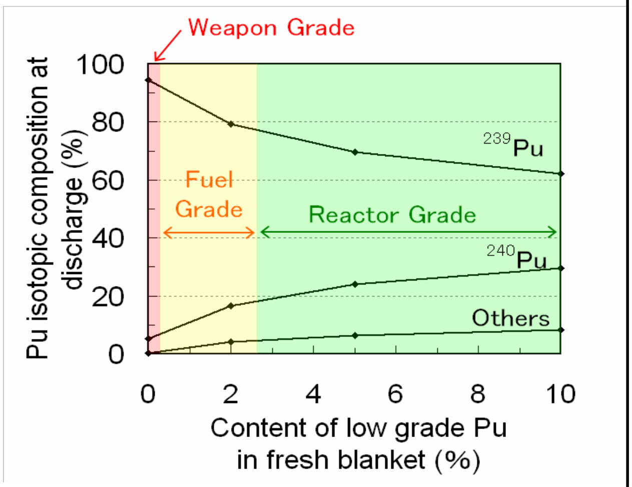
Pu composition in discharged blanket with low grade Pu addition

- Addition of low grade Pu into blankets is effective for the degradation of discharged Pu from blankets.
- Pu in blankets becomes reactor grade by more than 3% of the addition.
- The deterioration in breeding ratio could be endurable with design changes.
- Further evaluation is necessary on the impact to the fuel fabrication cost.



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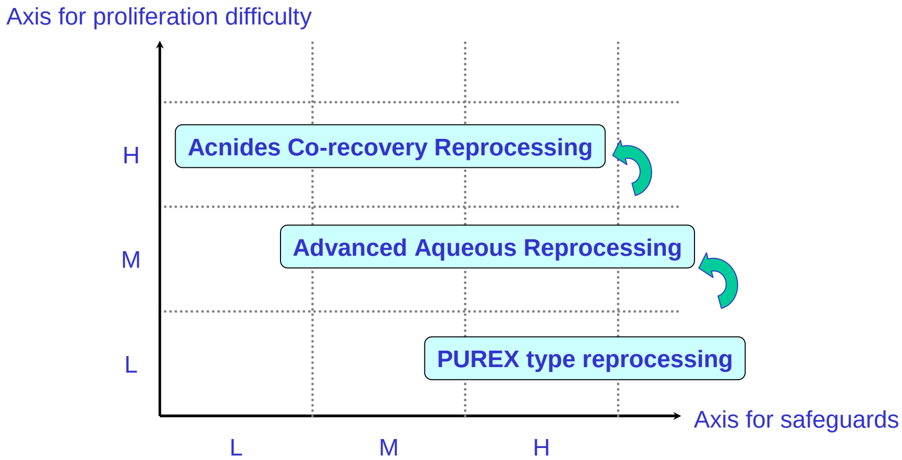
Proposal for Improving Proliferation Resistance



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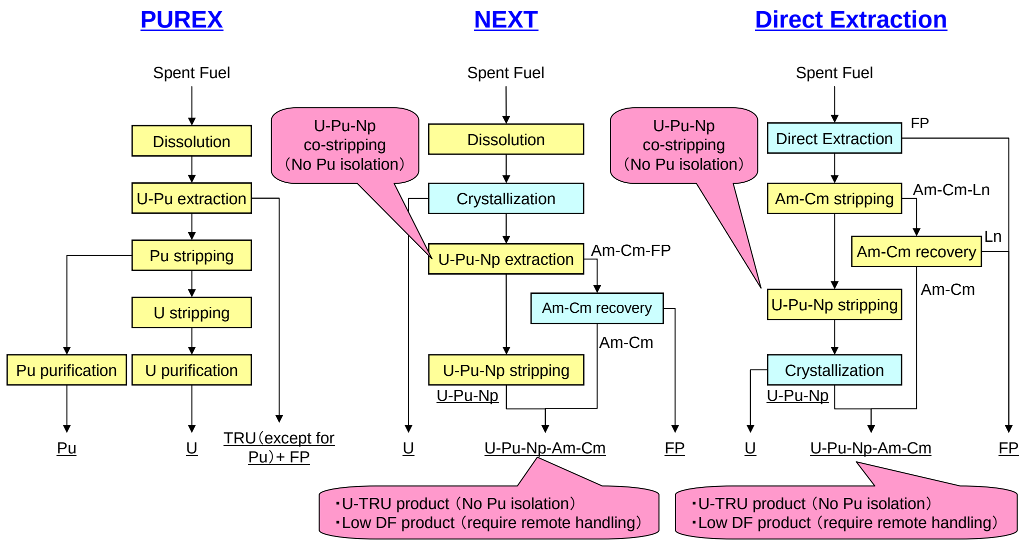
Study of Improved Reprocessing Considering Non-Proliferation by Means of Actinides Co-recovery



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Conclusion

- For FS (FR cycle development in Japan), proliferation resistance shall be an important goal of development and R&D will be conducted to enhance “intrinsic” resistance.
- “Extrinsic” proliferation resistance will be enhanced by investigating methods for safeguards and by its application to design study although its stage is at conceptual design.
- International cooperation with IAEA and countries concerned is essential for suitable adaptation to changing circumstance of nuclear proliferation.

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