CORE CONCEPT OF COMPOUND PROCESS FUEL CYCLE

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Objectives

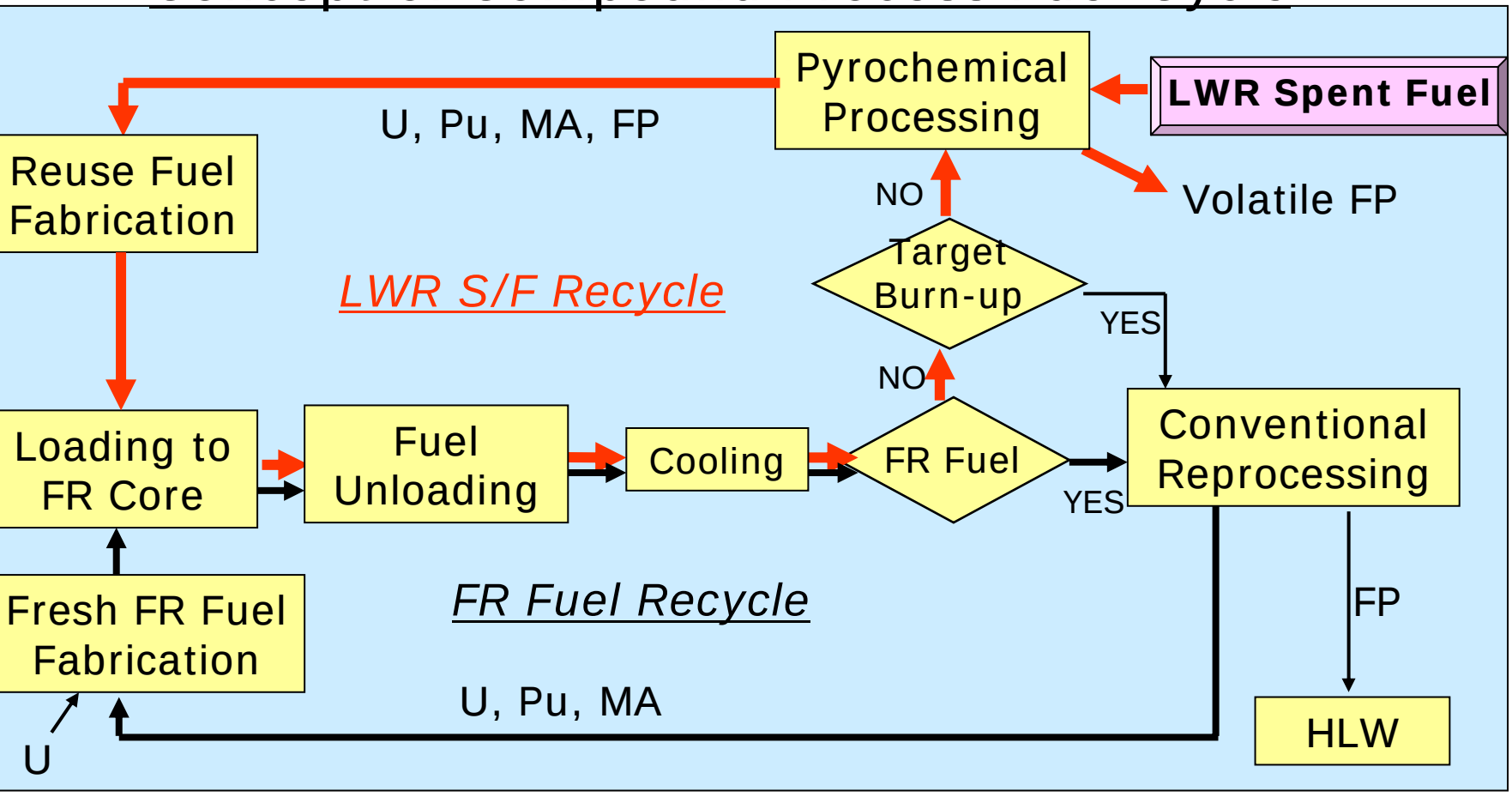
Proposal of innovative nuclear fuel cycle system
- economic competitiveness
- efficient utilization of nuclear fuel resources
- reduction of environmental burden
- enhancement of nuclear non-proliferation

Effective utilization of LWR spent fuel and suppression of LWR spent fuel pile-up

Smooth evolution from LWR system to fast reactor system

A new fuel cycle concept "Compound Process Fuel Cycle"

Concept of Compound Process Fuel Cycle



Pyrochemical Processing	-Pre-process procedure of conventional reprocessing (only de-cladding and pulverization) - Only volatile FP is removed	Voloxidation AIROX DUPIC

-LWR spent fuels are multi-recycled without conventional reprocessing but with only pyrochemical processing.
- U, Pu, MA, FP are recycled. → → utilization of FR core

Merits of the Compound Process Fuel Cycle Concept

(1) Significantly simplified process compared with conventional reprocessing → Economic competitiveness

(2) Small TRU loss rate compared with conventional reprocessing

No MA increase after multi-recycling → Reduction of environmental burden

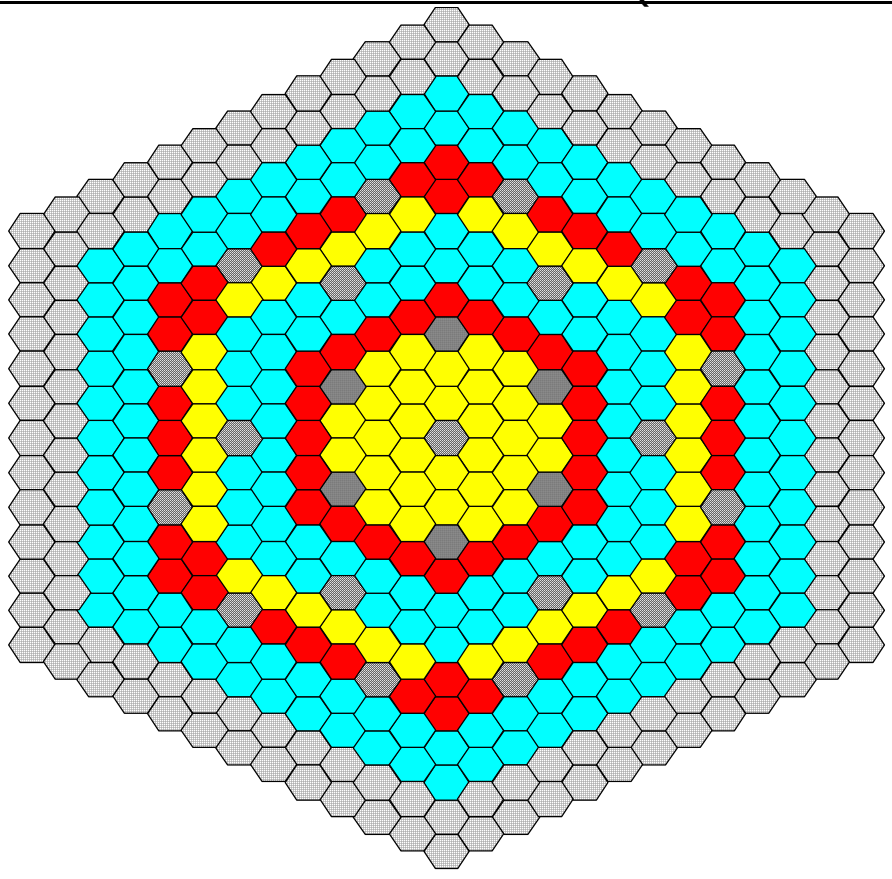
(3) More than 5 times increase in burn-up of LWR MOX spent fuel → Efficient utilization of resources

(4) Lumped processing of all actinides including FP → Nuclear non-proliferation

(5) Suppression of LWR spent fuel pile-up

Core Specification

In the case of LWR MOX S/F (60 GWd/t)



◎Conditions

- Max. linear heat rate
  < 400 w/cm
- Max. fast neutron fluence
  < 5×10^{27} /m^2
- Burn-up reactivity loss
  < 4% Δk/kk'

◎Major specifications

- Na cooled / MOX fuel
- Radial heterogeneous core
- Cycle length : 730 days
- Reactor thermal power
  : 2600 MWt
- Core height (FR fuel/LWR fuel)
  :100/160 cm

Fast Reactor Fuel
(2n-1) time Recycled LWR Fuel
2n time Recycled LWR Fuel
Control Rod (Main)
Control Rod (Buck up)
Radial Shield

Treatment of Residual FP in Recycled Fuel

Both of neutron absorption effect and volume effect* are taken into account.

* : Reduction of heavy metal volume fraction due to residual FP in recycled fuel

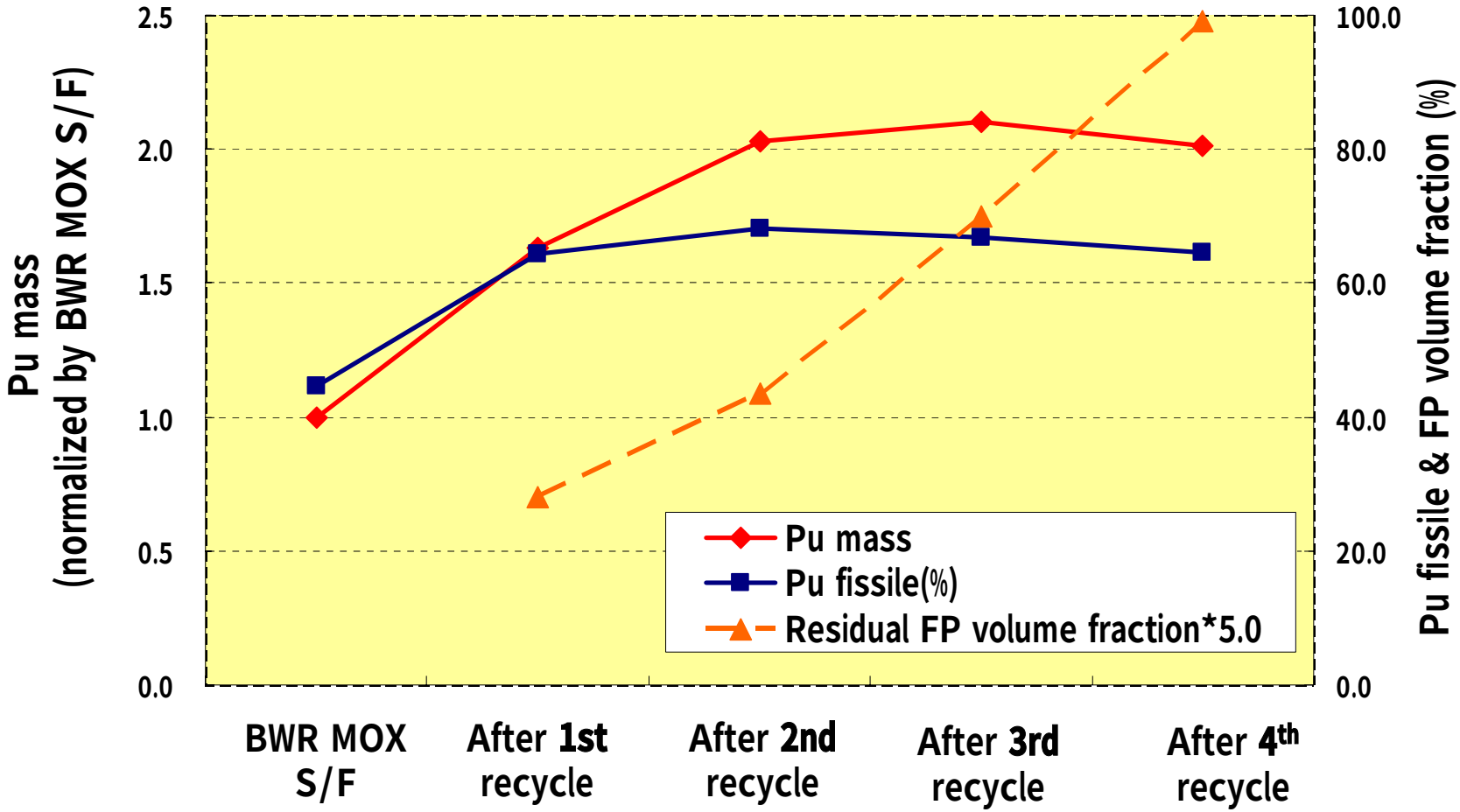
FP Removal Rates

Br	Kr	Xe	Cs	I	Te	Sb
1.00	1.00	1.00	0.98	0.98	1.00	1.00

Mo	Pd	Ru	Rb	Cd	In	
0.44	0.01	1.00	0.98	1.00	0.88	

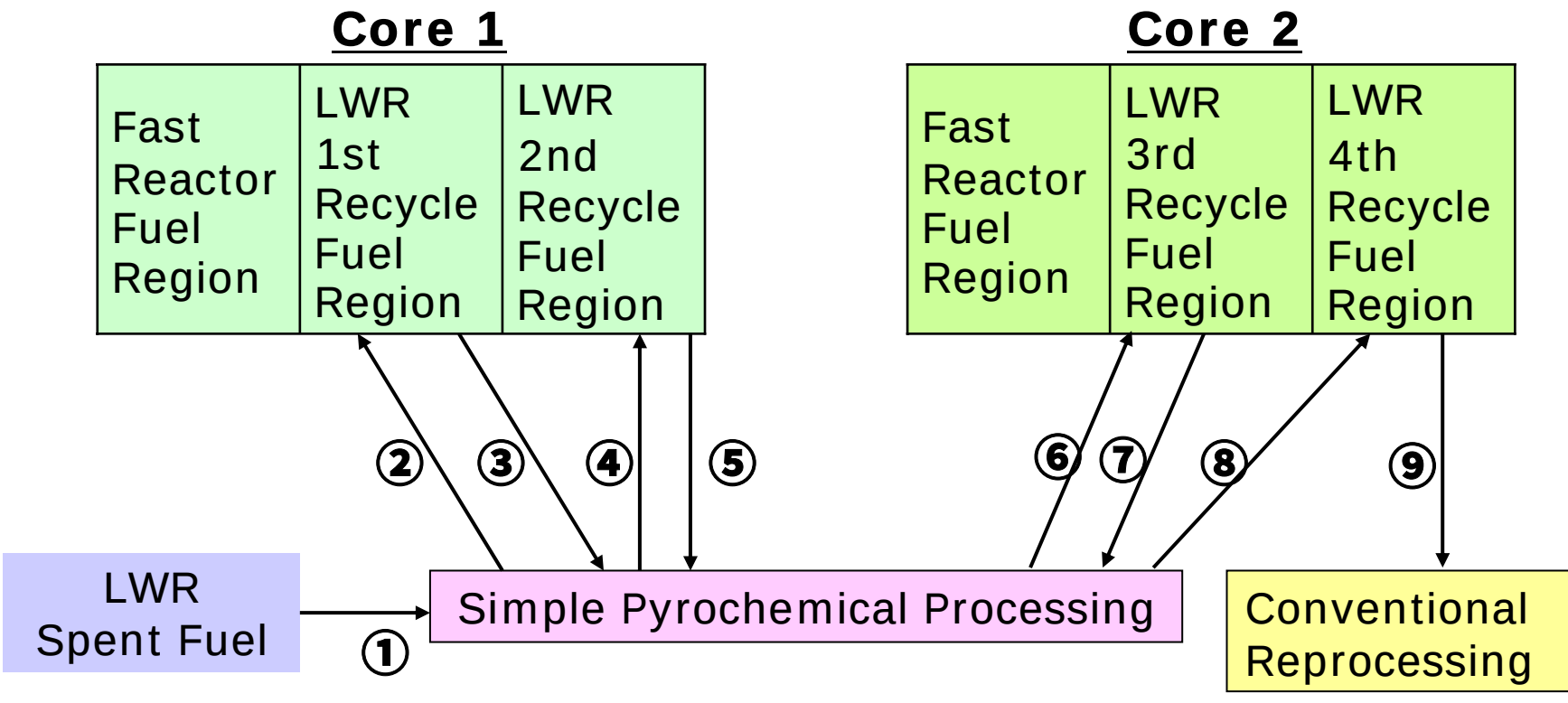
Changes during Recycling

(Pu Mass , Pu Fissile Content , FP Volume Fraction)



Pu mass & Pu fissile reach to equilibrium state after 1st or 2nd recycle while residual FP increases monotonically.
→ → Multi recycle is limited up to 4 times.

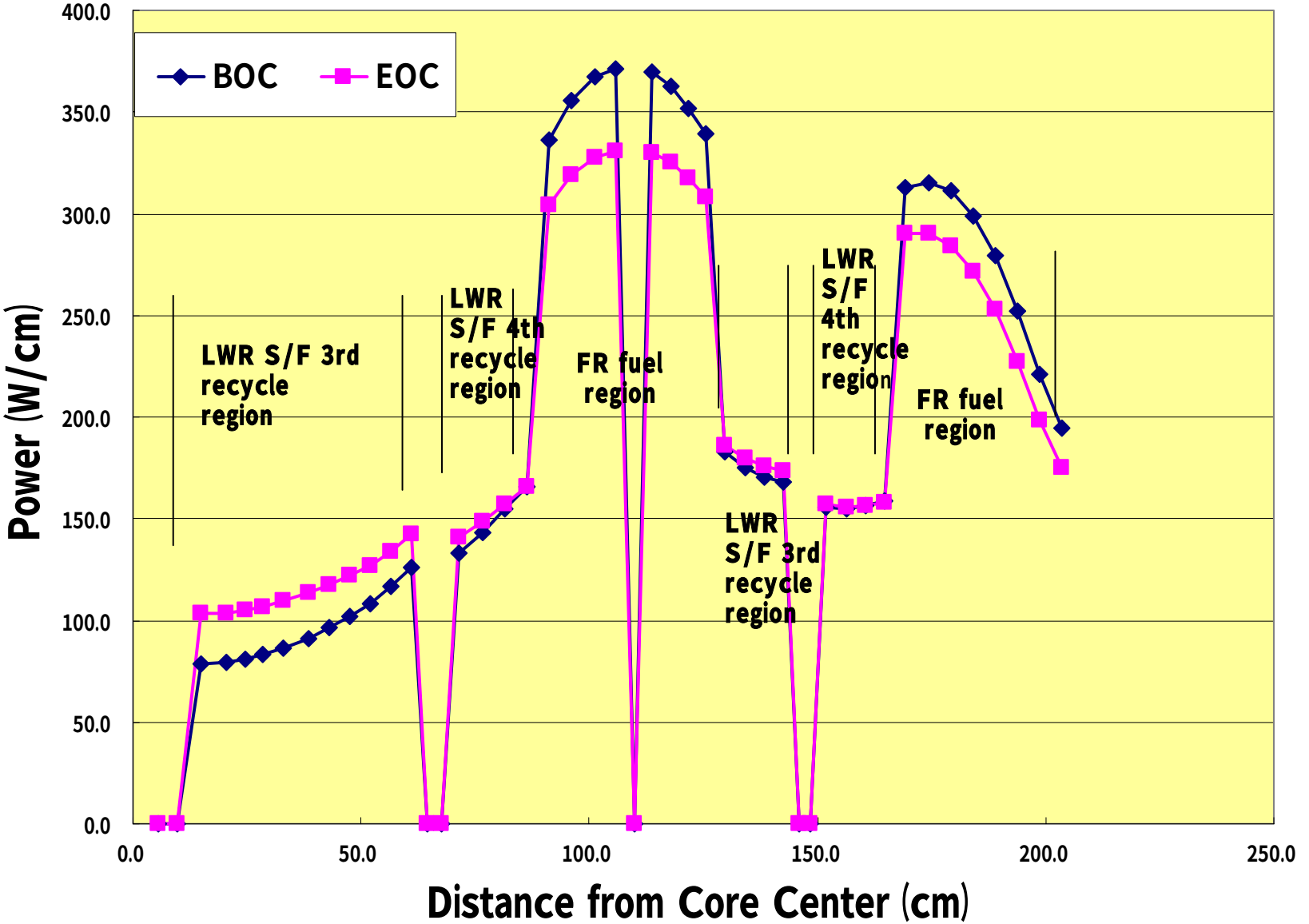
Fuel Flow of LWR Spent Fuel



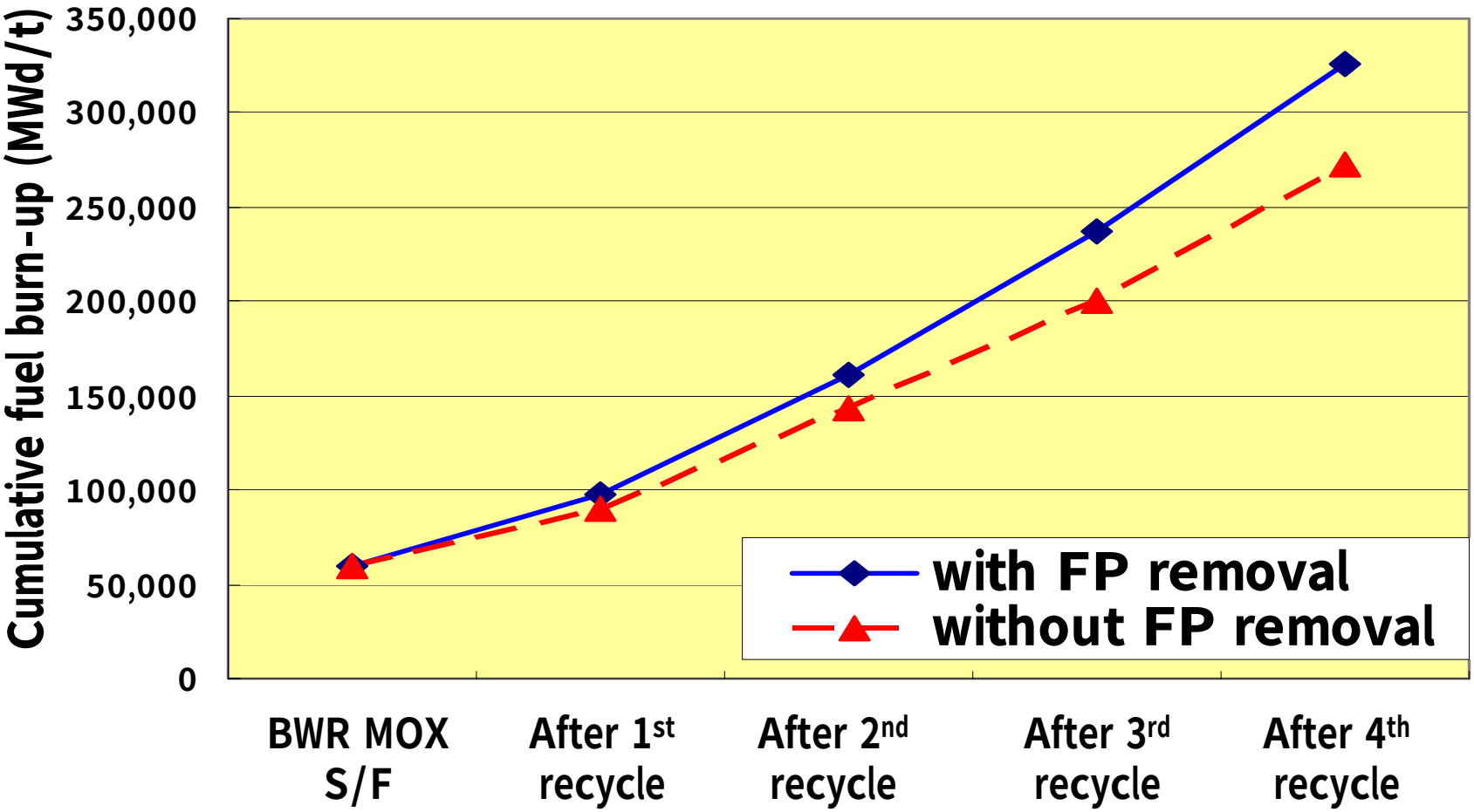
Major Core Nuclear Characteristics

Item	Core 1 (1st & 2nd time recycle)	Core 2 (3rd & 4th time recycle)
Pu enrichment of fast reactor fuel (wt%)	26.2	23.9
Burn-up reactivity loss (%Δk/kk')	3.78	3.95
Maximum fast neutron fluence (n/m^2)	3.9×10^{27}	3.9×10^{27}
Maximum linear heat rate (W/cm)	383	371
Breeding ratio (EOC)	1.08	0.99

Power Distribution in Radial Direction (Core 2 --- 3rd and 4th Recycle)



Fuel Burn-up Evolution



The burn-up of BWR MOX fuel reaches 330 GWd/t which corresponds to more than five times of that of BWR MOX S/F.

Changes during Recycling
(MA Mass and MA Composition)

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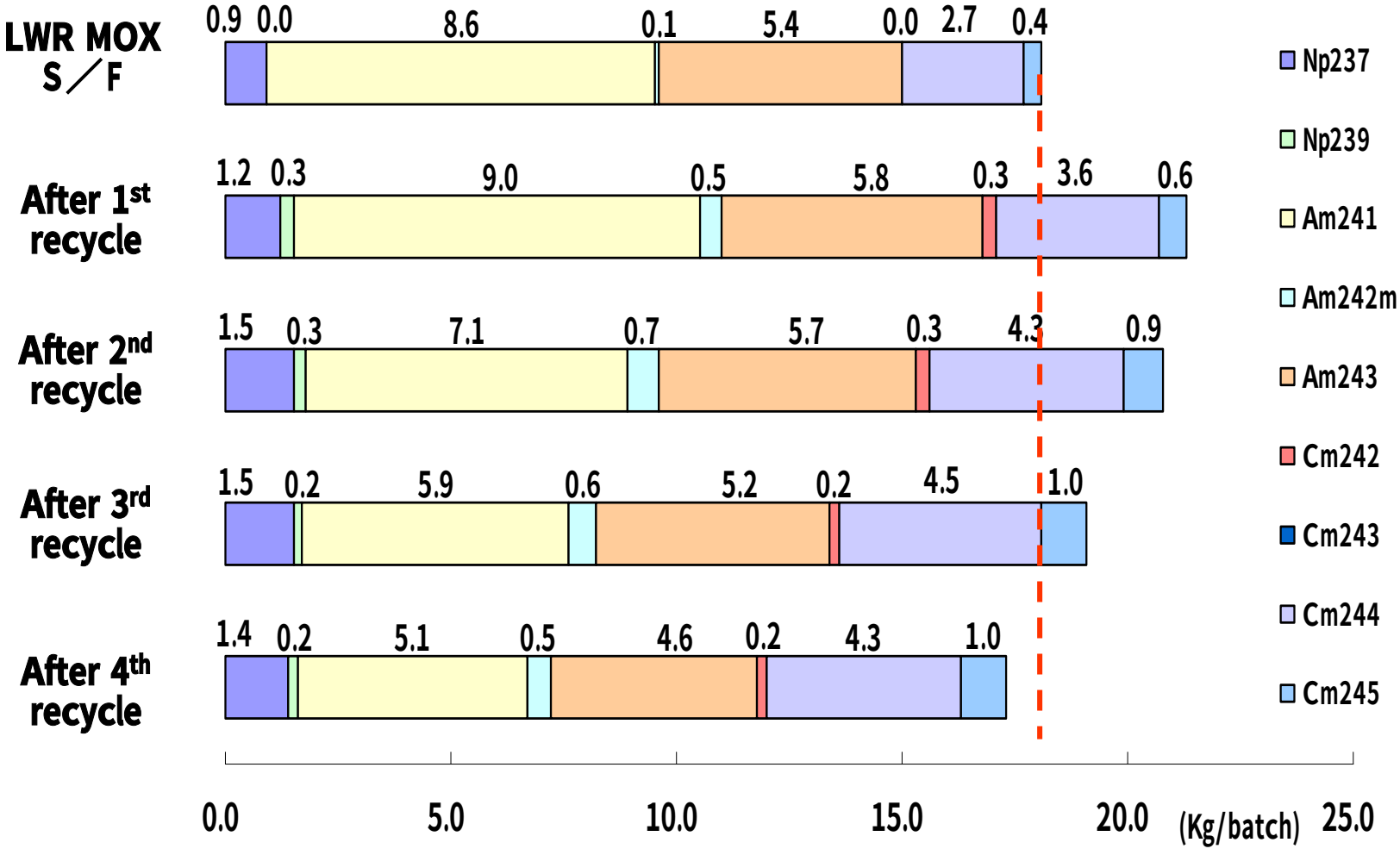
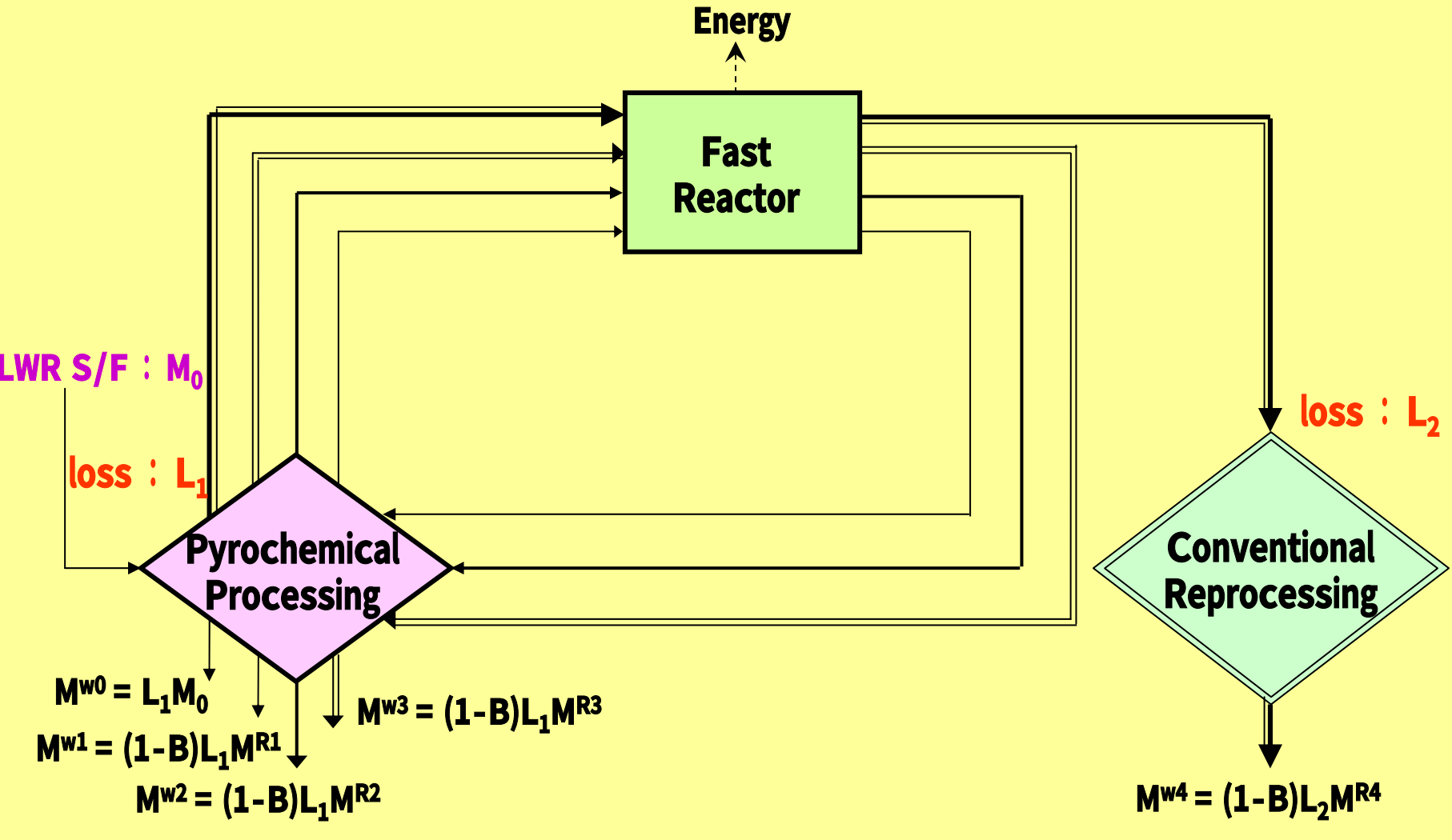


MA mass shows no increase after multi-recycling.

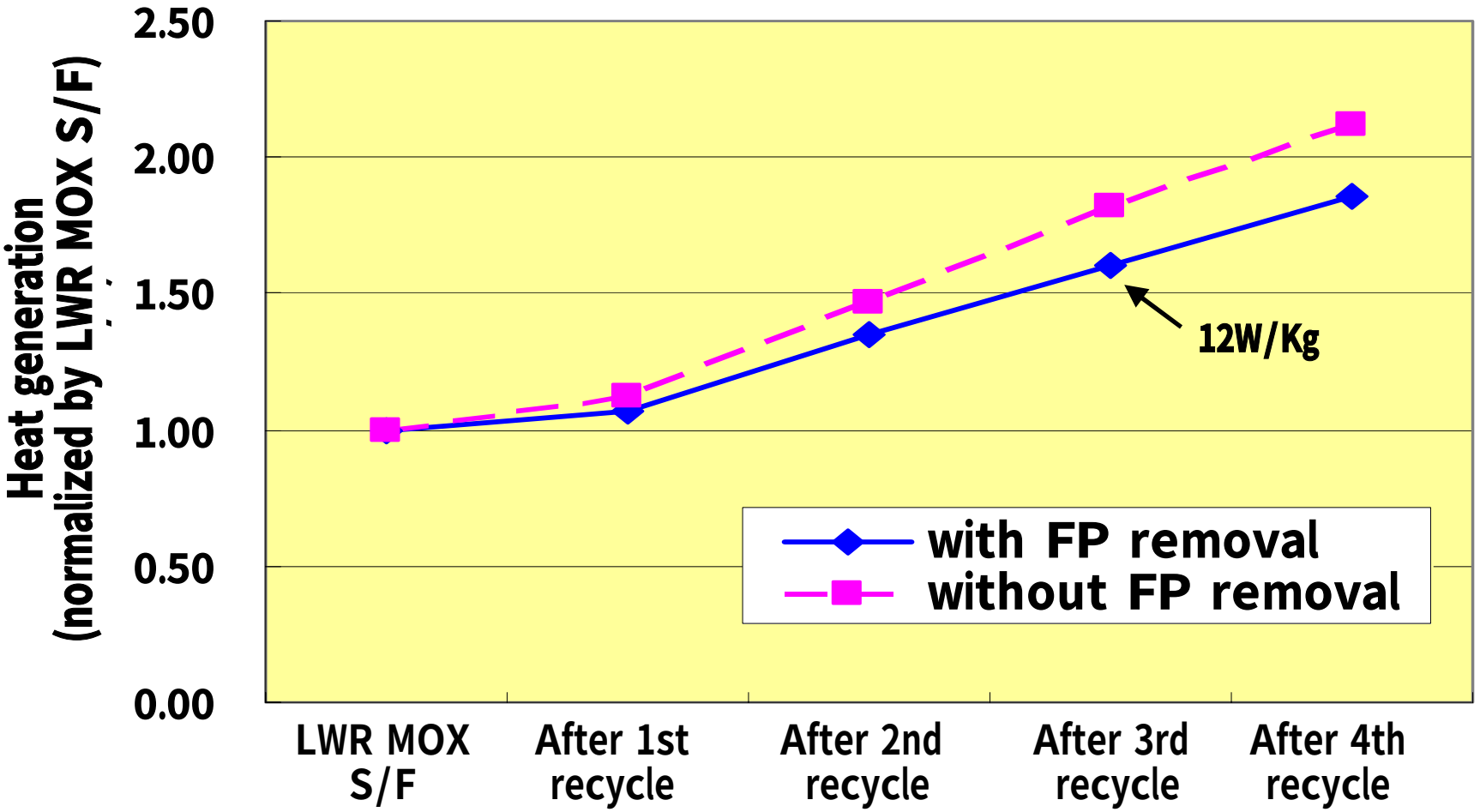
Actinide Mass which Leaks out of the System



$$\frac{\text{Compound process cycle}}{\text{Conventional reprocessing}} \approx (0.78+3.76L1/L2)/5 \quad \begin{matrix} = 0.91 & (L1 = L2) \\ = 0.23 & (L1/L2 = 0.1) \end{matrix}$$

Changes during Recycling

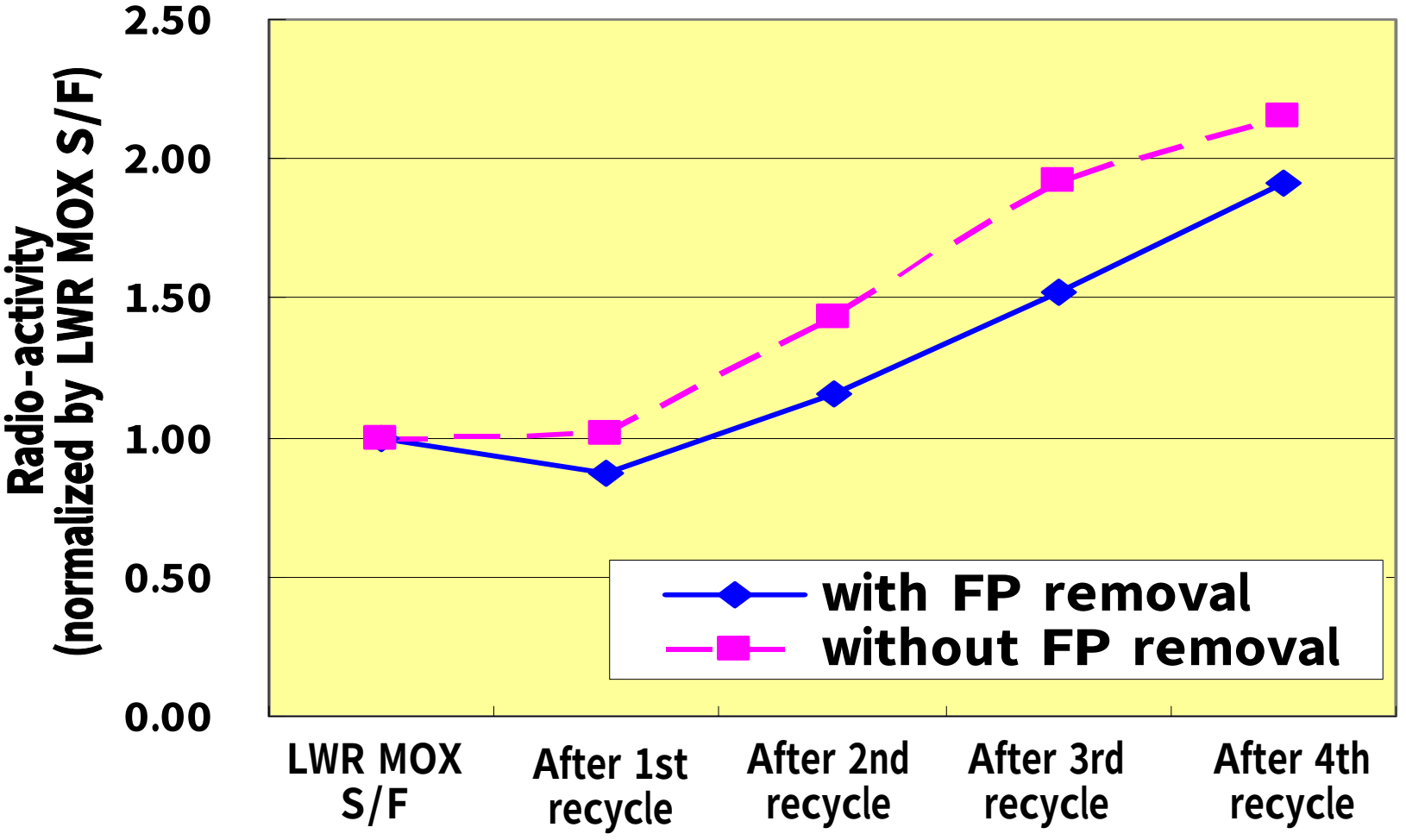
(Fuel Heat Generation -- after 4 year cooling)



Increase of fuel heat generation due to multi-recycling is less than twice of LWR S/F.

Changes during Recycling

(Fuel Radioactivity-- after 4 year cooling)



Conclusions

○A new fuel cycle concept “Compound Process Fuel Cycle” is proposed.

○The feasibility of the cycle has been studied, mainly in core characteristics, taking an example for BWR MOX spent fuel.

Major Results

○The BWR MOX spent fuel can be recycled 4 times achieving more than 330 GWd/t of burn-up.

○Efficient utilization of resources and reduction of environmental burden can be expected.

- Reduction of actinide mass leaking out of the system
- No MA mass increase after recycling
- More than 5 times increase in fuel burn-up

○Economic competitiveness, enhancement of nuclear non-proliferation, and suppression of LWR spent fuel can be expected.