

Scenario Analysis for a Transuranic Transmutation by Using Fast Reactors



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Contents

I. Introduction

- Gen-IV Fuel Cycle
- Status of Nuclear Fuel Cycle of Korea

II. Estimation of Spent Fuel and TRU Inventories

- Once-Through Cycle
- SFR Cycle
- ADS Cycle

III. Summary and Conclusion

I. Introduction

Gen-IV Nuclear Fuel Cycle

- ❑ Fuel Cycle for
 - Reducing Spent Fuel
 - Extending the Nuclear Fuel Supply by Recycling Used Fuel
- ❑ Reactor for Advanced Fuel Cycles
 - Sodium-Cooled Fast Reactor (SFR) for Full TRU Recycling
 - Accelerator Driven System (ADS) for Further TRU transmutation and Long-Life Fission Products Transmutation.

I. Introduction

Status of Nuclear Fuel Cycle of Korea

- ❑ Capacity of Nuclear Reactor at 2005 : 17.7 GWe
 - 16 PWR.
 - 4 PHWR.
- ❑ Capacity of Nuclear Reactor at 2015 : ~25 GWe
 - No More Construction of PHWR after 2000.
- ❑ Not determined the construction plan after 2015
 - Nuclear Power Demand Growth is Assumed by the Logistics Model.
- ❑ Advanced Fuel Cycle Scenarios
 - From 2040, SFR plant to be deployed commercially.
 - Study for the ADS will continue, and the deployment scenario will be determined later.

I. Introduction

Objectives of Study

- ❑ Analyze the Symbiotic Fuel Cycle between Existing and Fast Reactor Scenarios
- ❑ Estimate the SF and TRU Material flows

II. Estimation of Spent Fuel and TRU Inventories

Once-Through Cycle

□ **Initial Condition**

- Nuclear power

@2000 = 13.7 Gwe

@2015 = 25.2 Gwe

- Nuclear power growth rate

From 2016 to 2100 : depends on the Logistics model

- Operating reactors at 2000

PWR : 12

CANDU : 4 (No more construction after 2000)

□ **DYMOND Code**

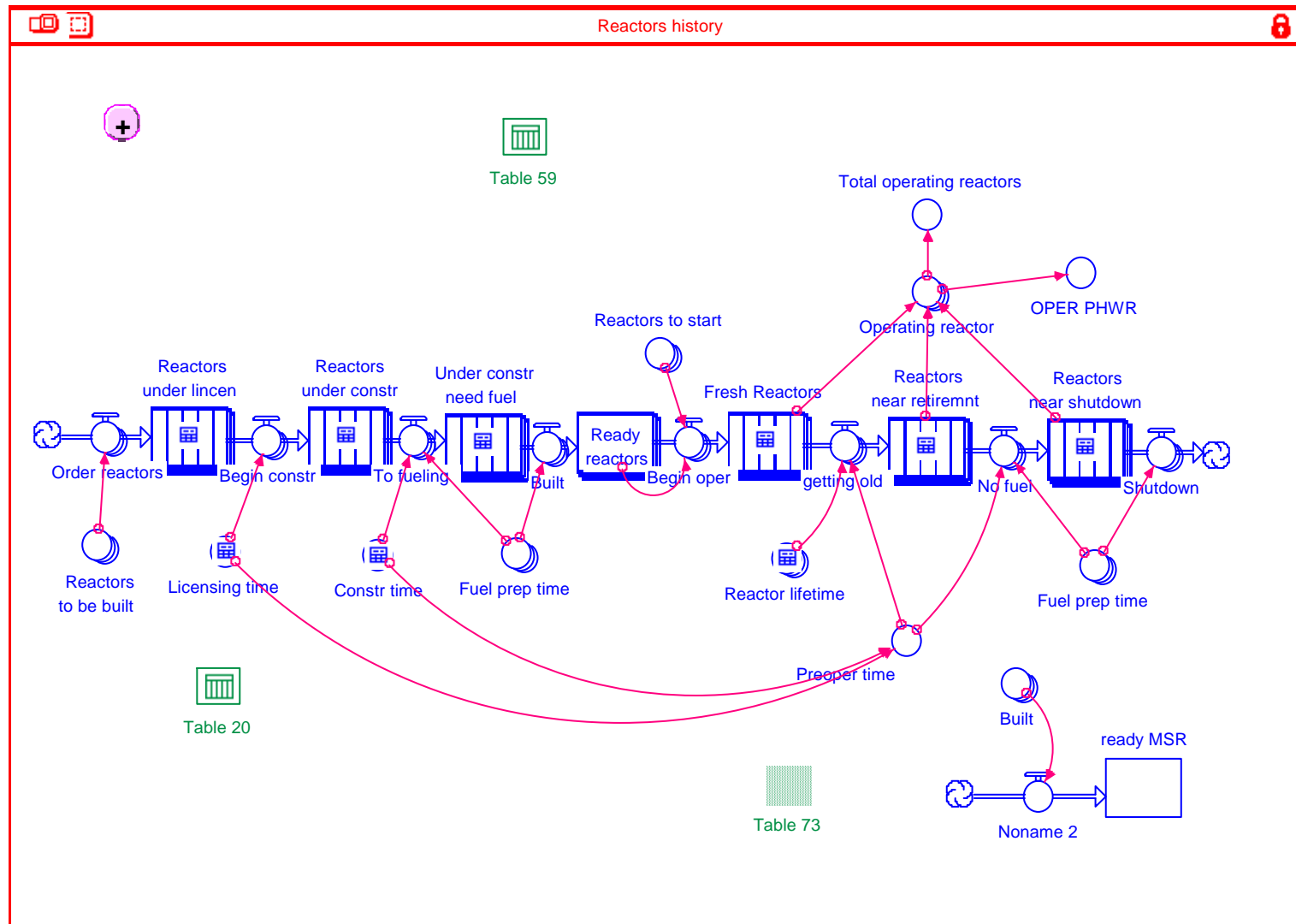
- Developed by ANL

- Dynamic Analysis Method (i-think software)

- Modified to apply to Korean Nuclear Fuel Cycle

II. Estimation of Spent Fuel and TRU Inventories

□ DYMOND Code-Reactor History Model



II. Estimation of Spent Fuel and TRU Inventories

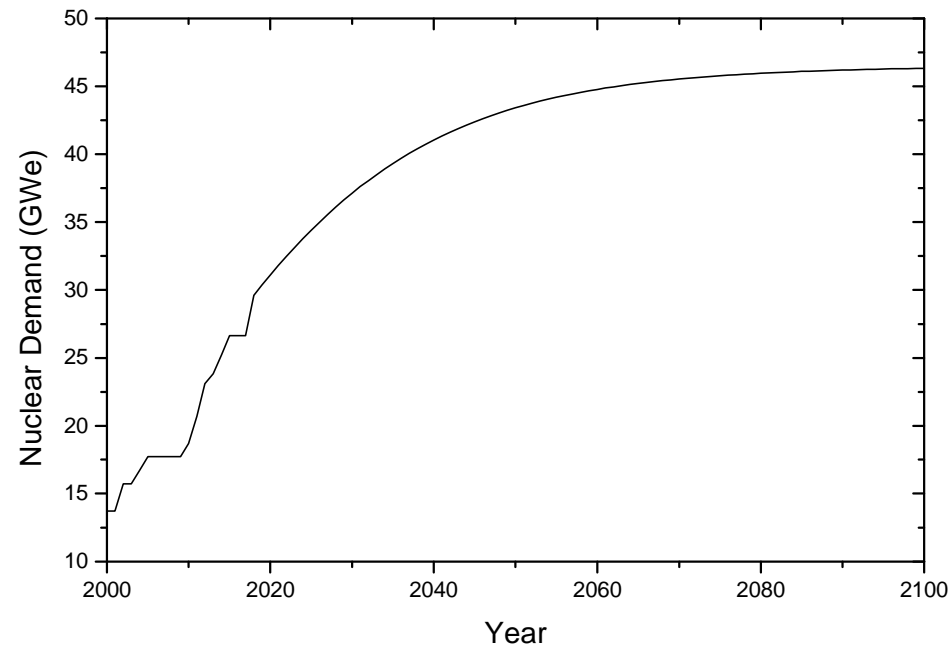
□ Reactor Specifications

	PWR	CANDU	SFR	ADS
Reactor power, GWe	1.0	0.713	0.6	0.35
Burnup, GWd/t	40	7	113	190
Fissile content, wt%	4	0.71	11.7	11.7
Life time, yrs	40	30	60	60
Thermal efficiency, %	35	35	39	35
Load factor, %	85	85	85	85
Cycle length, yrs	1.5	1	1.5	0.5
Number of batch	3	1	4	7.5
Mass fraction in charge				
U	1.0	1.0	0.6674	0.1653
TRU	-	-	0.2826	0.8310
Fission products (FP)	-	-	0.0481	0.0037
Mass fraction in discharge				
U	0.9471	0.9890	0.6501	0.1525
TRU	0.0113	0.0037	0.2718	0.6579
FP	0.0416	0.0072	0.0781	0.1896

II. Estimation of Spent Fuel and TRU Inventories

Once-Through Cycle

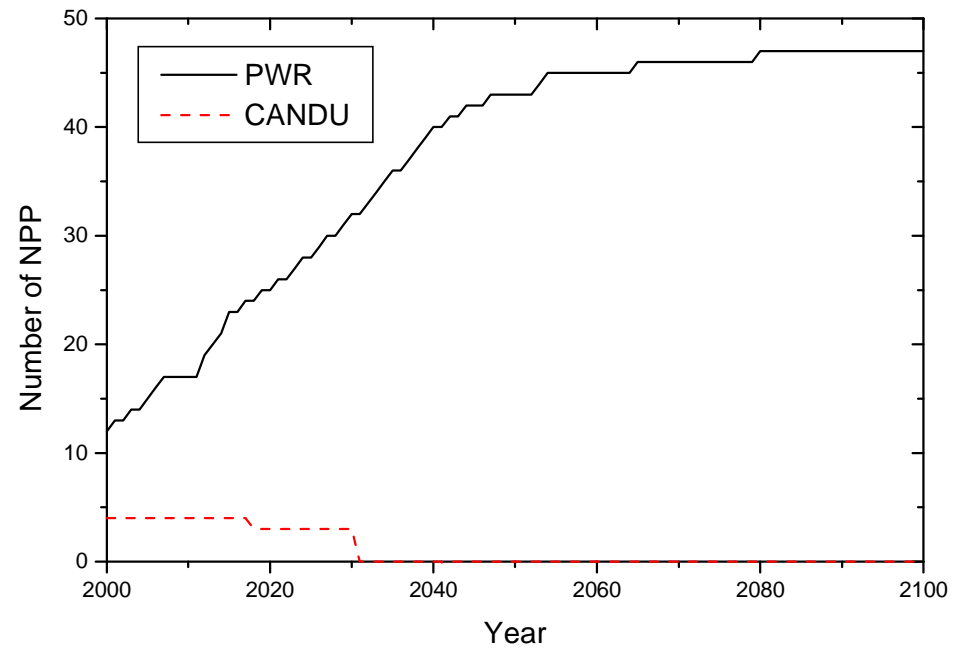
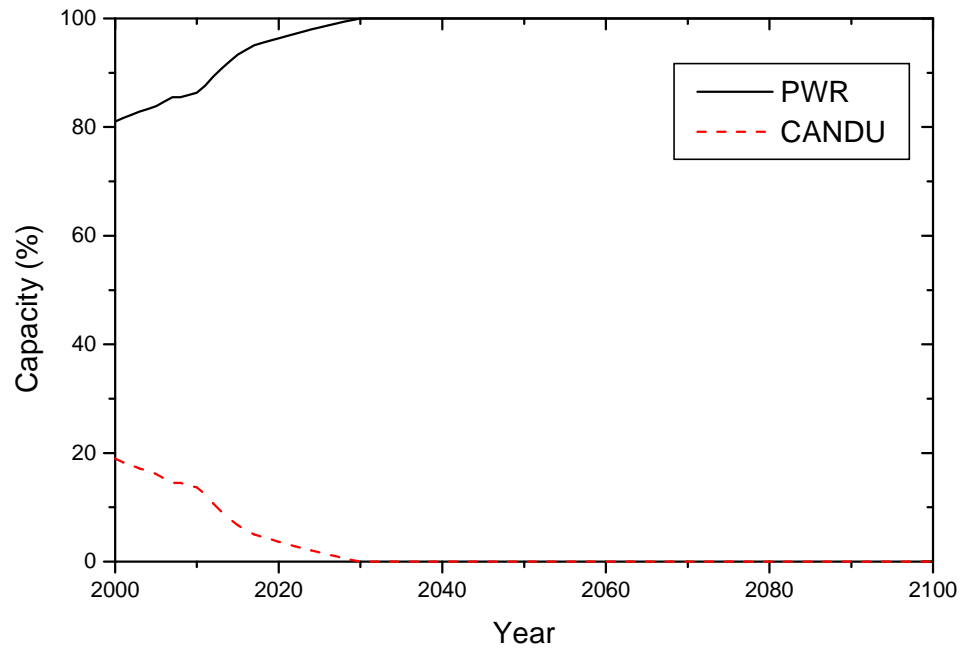
- Nuclear Energy Demand



II. Estimation of Spent Fuel and TRU Inventories

Once-Through Cycle

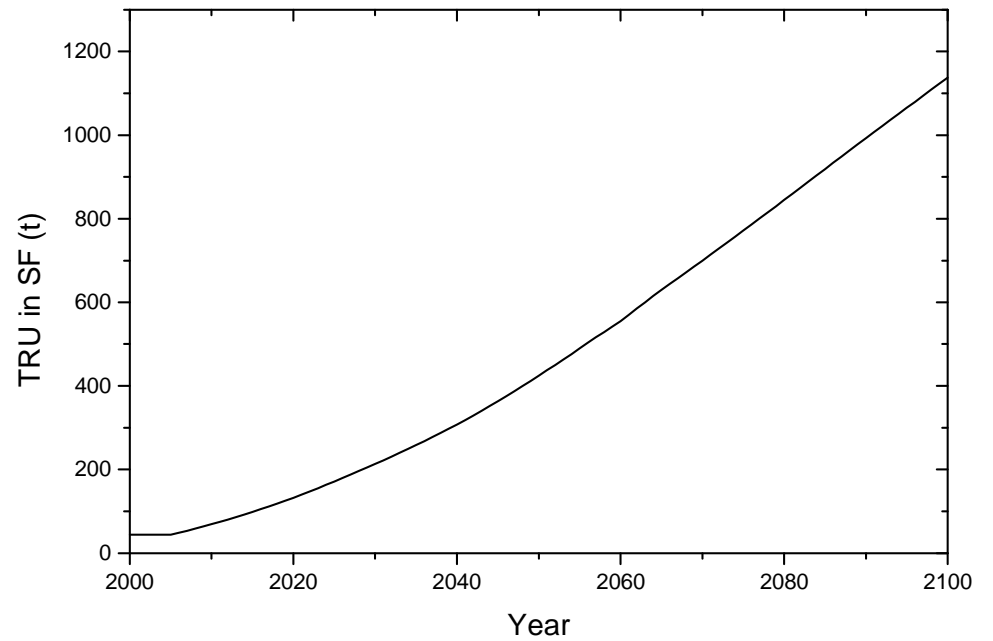
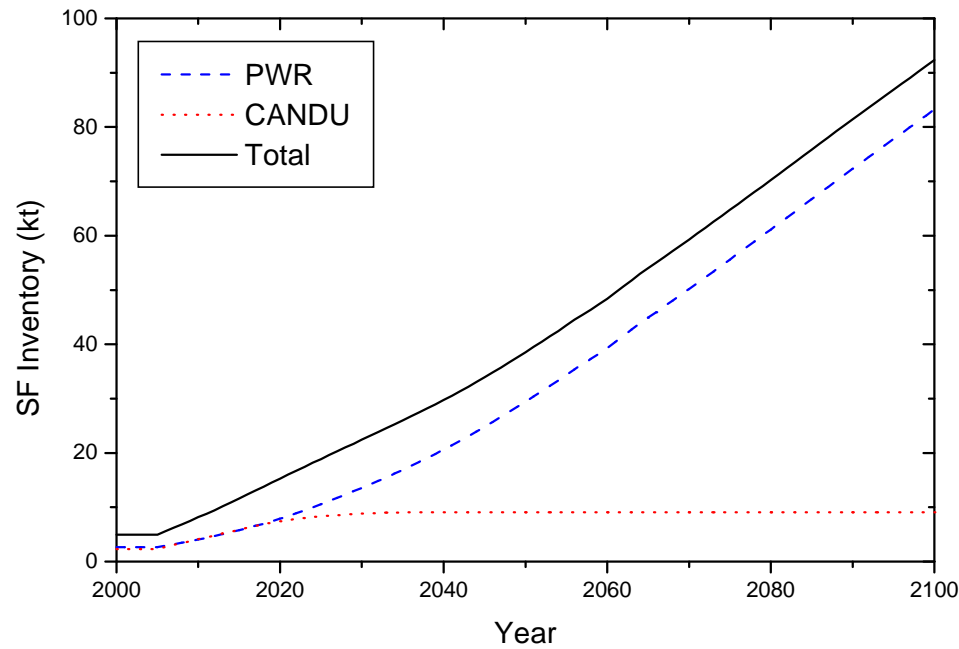
- ❑ Reactor Capacity and Number of Operating Reactors



II. Estimation of Spent Fuel and TRU Inventories

Once-Through Cycle

- Total Spent Fuel and TRU in SF



II. Estimation of Spent Fuel and TRU Inventories

SFR Cycle

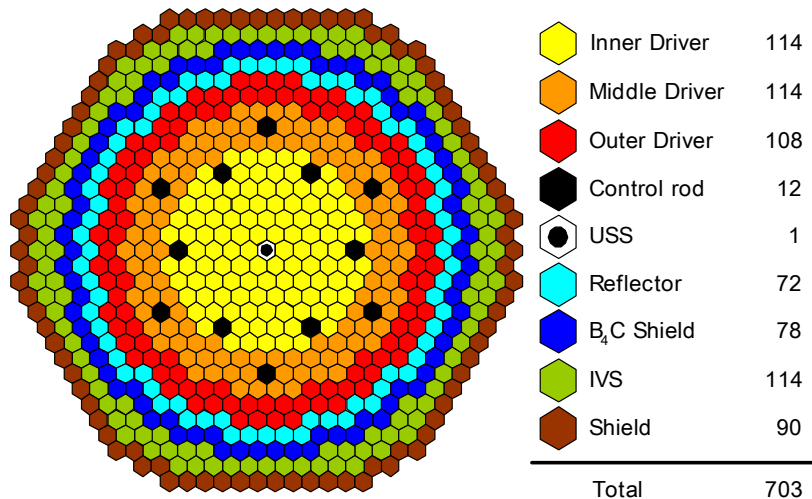
- ❑ KALIMER : Korea Advanced Liquid Metal Reactor
 - Pool type, Sodium-Cooled Fast Reactor
 - Reactor Power : 600 MWth
 - Closed Fuel Cycle by Recycle the TRU

- ❑ Calculation Condition
 - KALIMER Deployment Scenario
 - 2040 – 2100 : 50 % in Capacity

II. Estimation of Spent Fuel and TRU Inventories

SFR Cycle

- ❑ Reactor Data- Burner
(CR ~0.77)



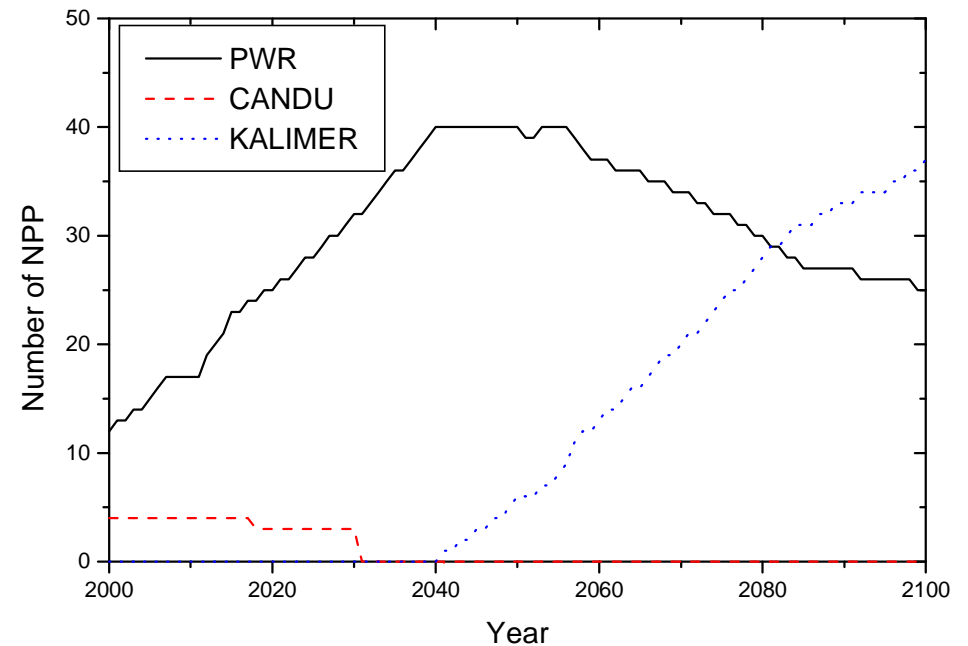
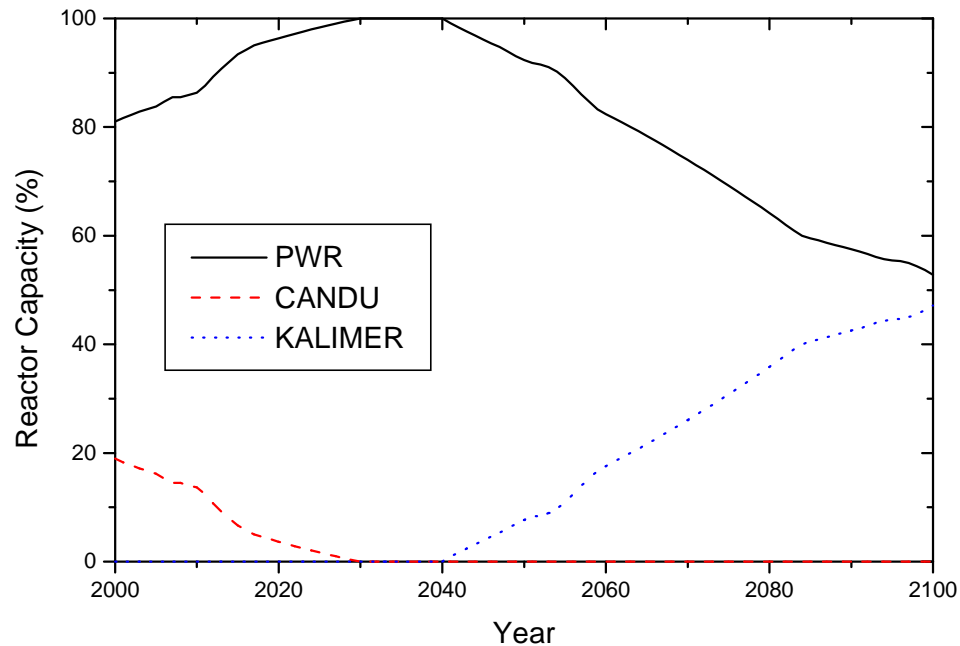
Material Flow (%)

Fuel Material	BEOC	EEOC
Total U	66.7	65.0
Total Pu	28.3	27.2
Total FP	4.8	7.8

II. Estimation of Spent Fuel and TRU Inventories

SFR Cycle

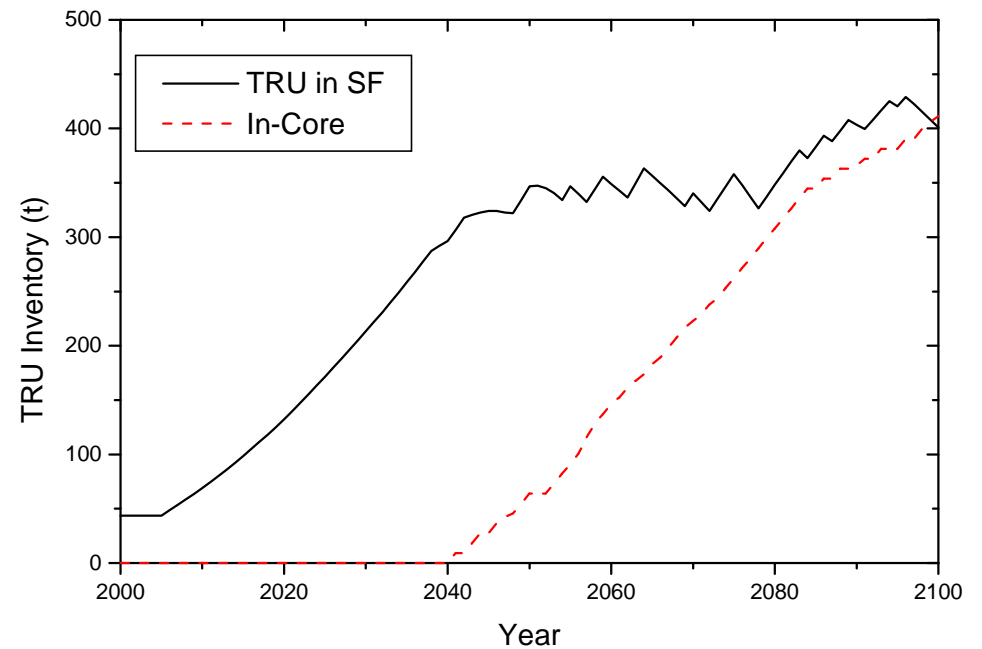
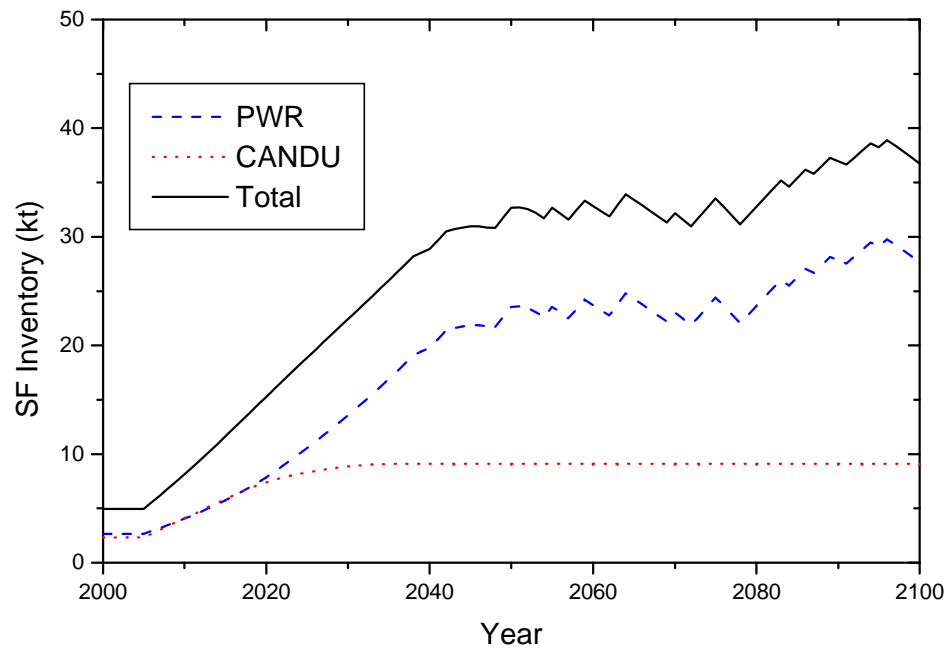
- ❑ Reactor Capacity and the Number of Operating Reactors



II. Estimation of Spent Fuel and TRU Inventories

SFR Cycle

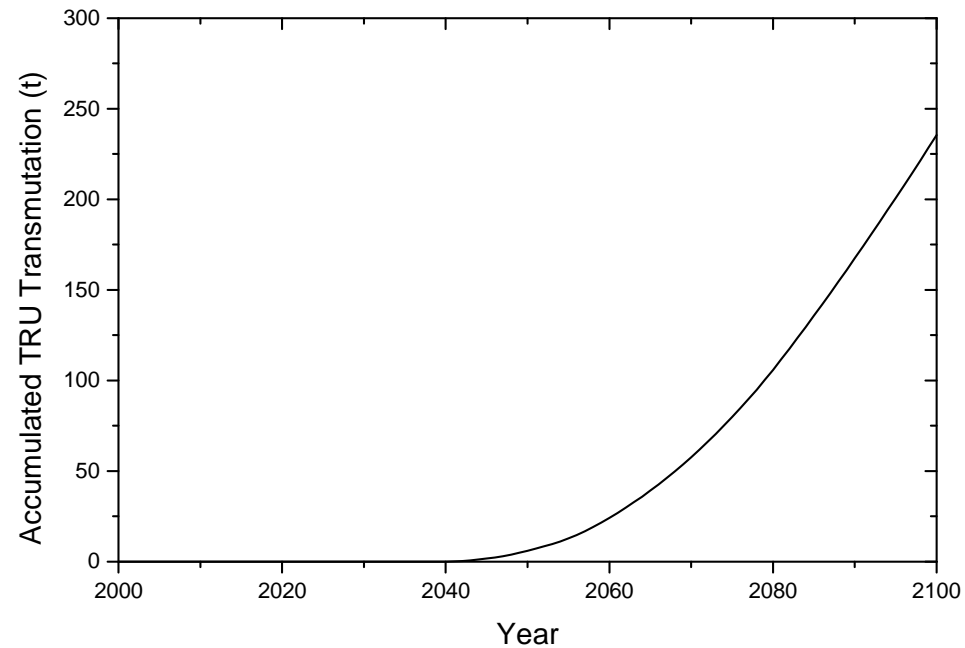
- SF and TRU Inventories



II. Estimation of Spent Fuel and TRU Inventories

SFR Cycle

- TRU Transmutation



II. Estimation of Spent Fuel and TRU Inventories

ADS Cycle

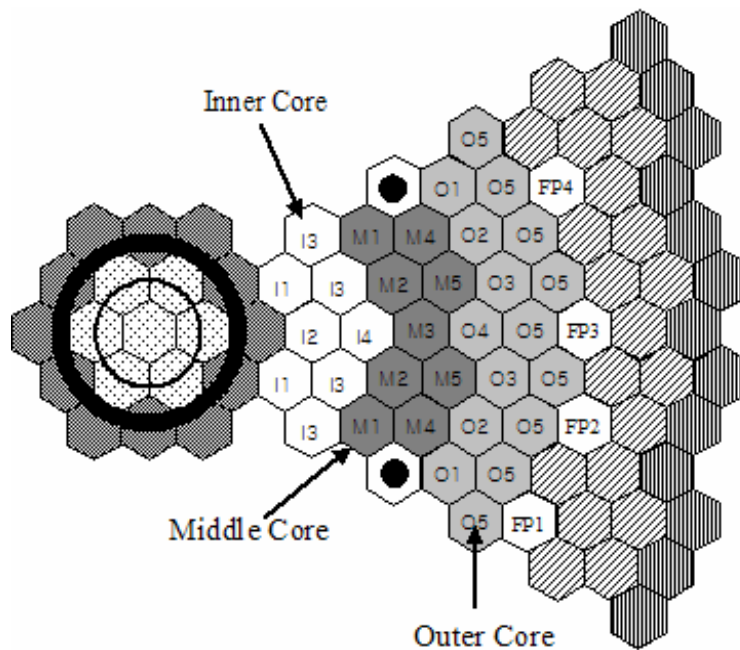
- ❑ HYPER : Hybrid Power Extraction Reactor
 - Accelerator Driven System (Sub-critical Fast Reactor, k-eff:0.98)
 - Reactor Power : 350 MWth
 - Transmute TRU or Long-lived Fission Products (Tc-99, I-129)

- ❑ Calculation Condition
 - HYPER Deployment Scenario
 - 2040 – 2100 : 40 % in Capacity

II. Estimation of Spent Fuel and TRU Inventories

ADS Cycle

- ❑ Reactor Configuration



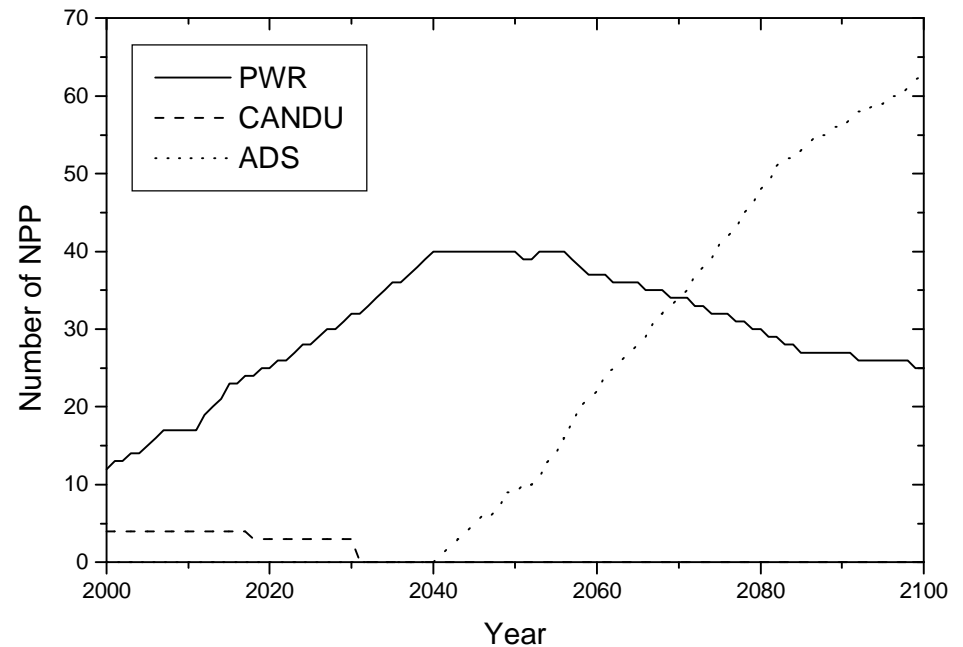
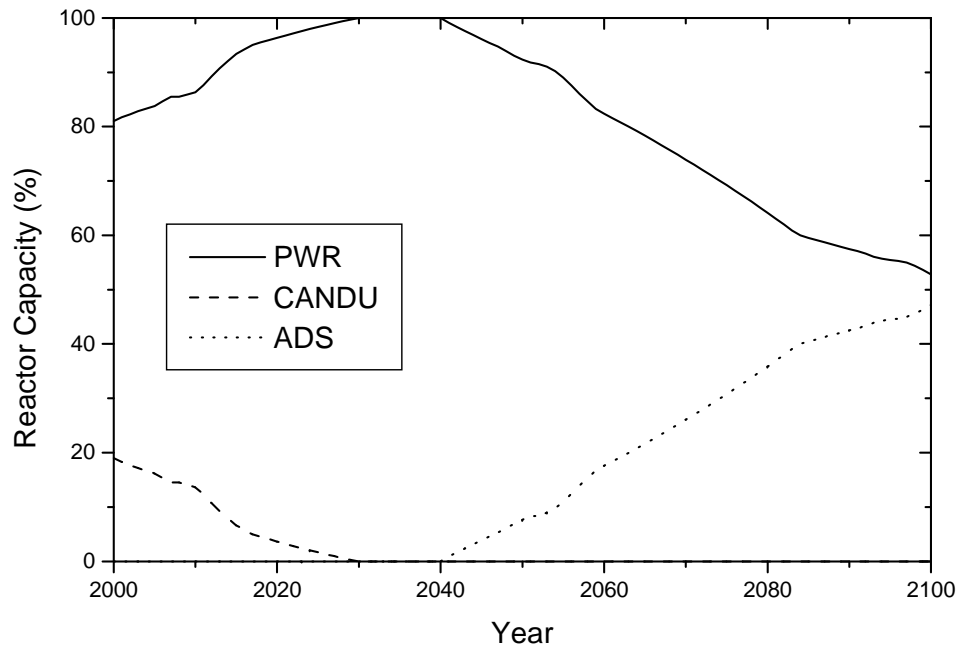
Material Flow (%)

Fuel Material	BEOC	EEOC
Total U	16.53	15.25
Total TRU	83.10	65.79
Total FP	0.37	18.96

II. Estimation of Spent Fuel and TRU Inventories

ADS Cycle

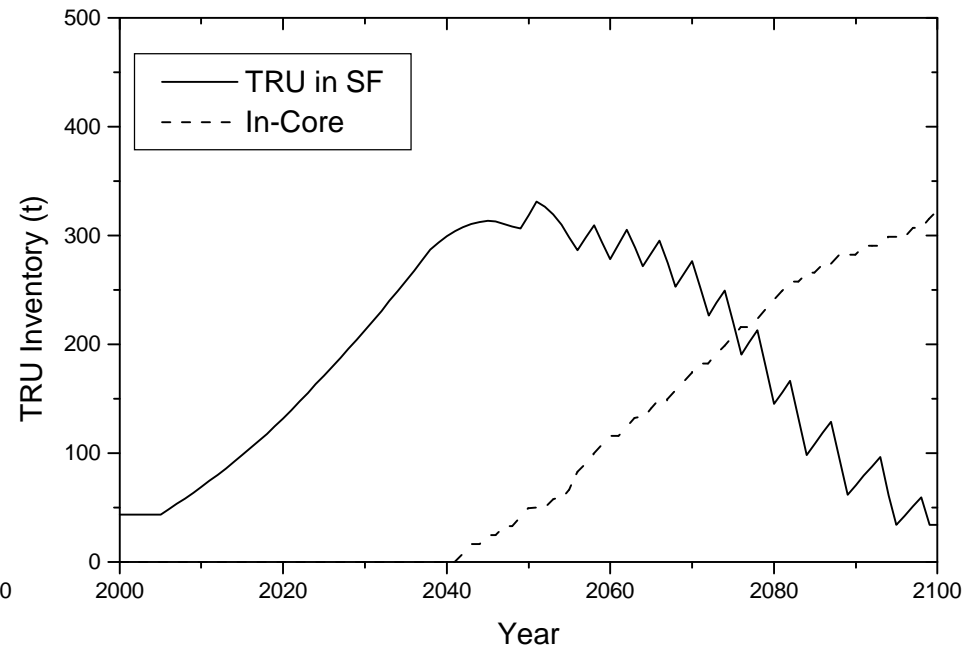
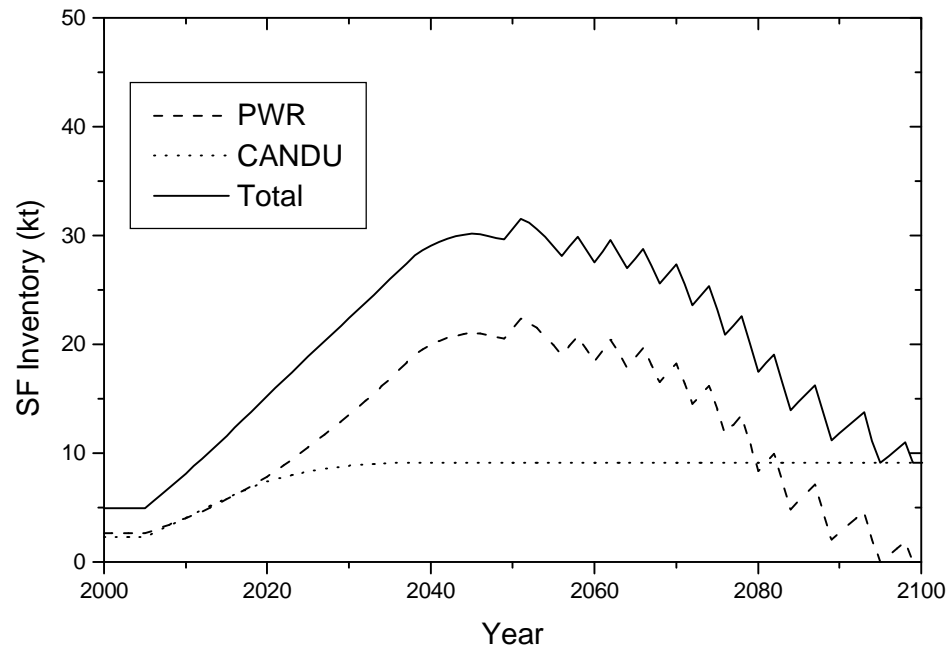
- Reactor Capacity and the Number of Operating Reactors



II. Estimation of Spent Fuel and TRU Inventories

ADS Cycle

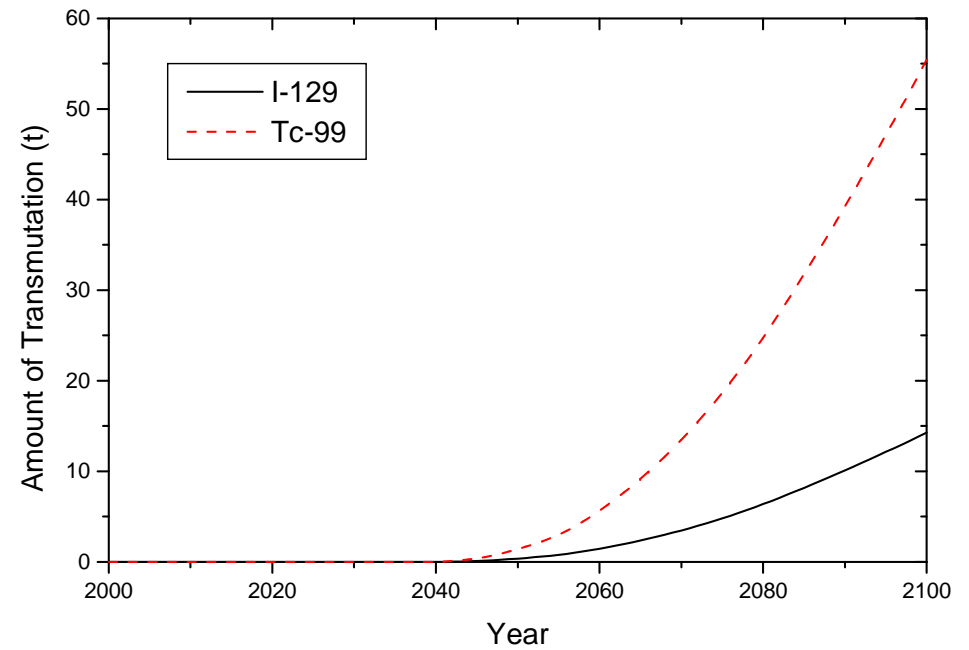
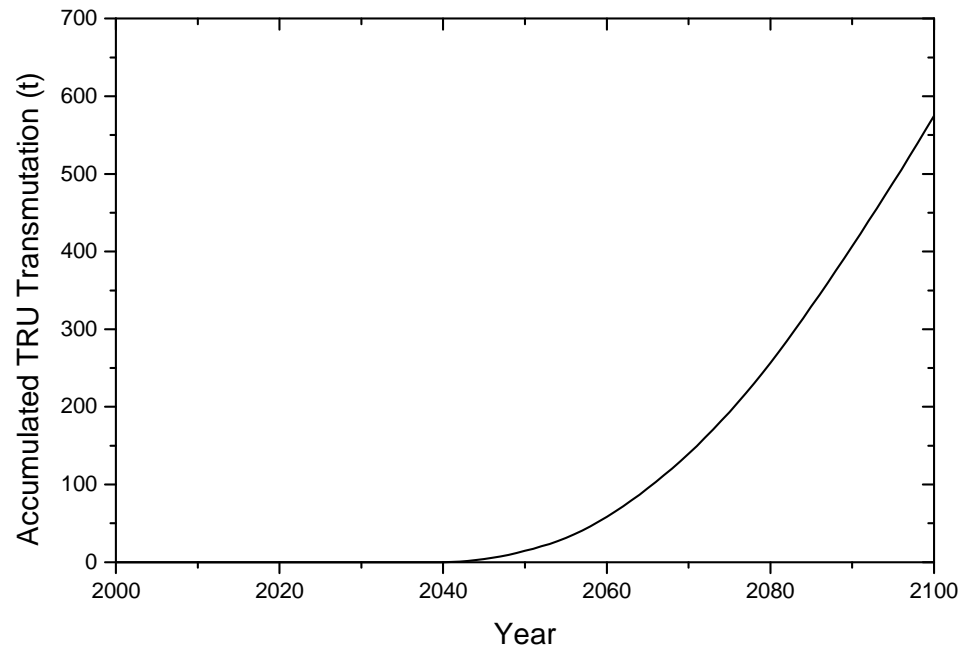
- SF and TRU Inventories



II. Estimation of Spent Fuel and TRU Inventories

ADS Cycle

- TRU and Fission Products Transmutation



III. Summary and Conclusion

□ From Once-Through Cycle

- The nuclear power demand in 2100 grows to 46.3 Gwe.
- The amount of total SF in 2100 will be 92000 ton.
- The amounts of TRUU is estimated to be 1140 ton.

□ From Fast Reactor Cycles

- The total SF of SFR cycle: 36700 ton.
ADS cycle: 9100 ton.
- The amount of TRU in the SF of SFR cycle: 400 ton.
ADS cycle: 34 ton.
- Transmuted amount of TRU by SFR: 235 ton.
ADS: 570 ton.
- Transmuted amount of I-129 and Tc-99 by ADS are 14 and 55 ton, respectively.

□ Consequently, the SFR and ADS Cycles Can Effectively Reduce the SF and TRU Inventories. In the future, an economic analysis is recommended for an implementation of an advanced fuel cycles.