# Radioactive Waste Generation in Pyro-SFR Nuclear Fuel Cycle

Fanxing Gao[1,2], Byung Heung Park[1], Won Il Ko[1]
[1]Korea Atomic Energy Research Institute
[2]University of Science & Technology
1045 Daedeokdaero, Yuseung-gu, Daejon 305-353, Republic of Korea
Corresponding author : gao@kaeri.re.kr

## 1. Introduction

Which nuclear fuel cycle option to deploy is of great importance in the sustainability of nuclear power. SFR fuel cycle employing pyroprocessing (named as Pyro-SFR Cycle) is one promising fuel cycle option in the near future. Radioactive waste generation is a key criterion in nuclear fuel cycle system analysis, which considerably affects the future development of nuclear power. High population with small territory is one special characteristic of ROK, which makes the waste management pretty important. In this study, particularly the amount of waste generation with regard to the promising advanced fuel cycle option was evaluated, because the difficulty of deploying an underground repository for HLW disposal requires a longer time especially in ROK.

## 2. Method and NFC option

### 2.1 Method

**Table 1.** Characteristics of the reference reactors.

| Reactor Parameters | PWR | SFR |
|---|---|---|
| Electric power (MWe) | 1,000 | 600 |
| Thermal efficiency (%) | 34.23 | 39.4 |
| Thermal power (MWt) | 2,921.4 | 1,522.8 |
| Load factor | 0.85 | 0.85 |
| Cycle length (full power day) | 290 | 332 |
| Total HM per core (tHM) | 69 | 20.3 |
| No. of batches | 3 | 6 |
| Conversion ratio | – | 0.6067 |

One is equilibrium model and the other is dynamic model. Equilibrium model focus on the batch study with the assumptions that the whole system is in a steady state and mass flow as well as the electricity production all through the fuel cycle is in equilibrium state, which calculates the electricity production within a certain period and associated material flow to obtain several criteria for assessment of the sustainability of nuclear power, e.g., resource utilization, waste generation, environment affects. Dynamic model takes the time factor into consideration to simulate the actual cases. Compared with the dynamic analysis model, the outcome of equilibrium model is more theoretical which may offer relatively clear and direct comparisons, especially with regard to the large uncertainty of the development of the pyro-technology evaluated. In this study equilibrium model was built to calculate the material flow on a batch basis. Characteristics of the reference reactors are listed in Table 1.

### 2.2 Main components of nuclear fuel cycle

The breakdown structure of the nuclear fuel cycle scheme is specified by the series of components (or steps) included in the four fuel cycle options of this study, shown in Fig.1. Material flow data is also specified in Fig.1.

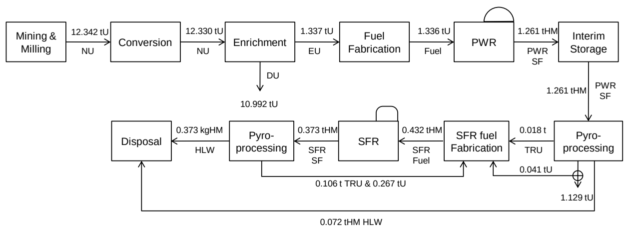


Fig.1. Main components in the nuclear fuel cycle

## 3. Results and Discussion

### 3.1 Waste categorization

LILW-SL mainly comes from the reactor operation. The second contributor of LILW-SL is the back-end reprocessing. The Pyro-SFR introduces smaller amount of LILW-SL with regard to the ceramic form of waste used for fission products, such as Cs and Sr, decay storage, so the capacity of the near-surface disposal facility needed is the smallest among these four options. The capacity of geological disposal facility built for LILW-LL is determined by the volume of LILW-LL produced by each option. As listed in Table 2, setting the OT Cycle as the basis, the capacity of geological disposal facility for the Pyro-SFR Recycling was around 70%.

**Table 2.** Radioactive waste generations .

| | | OT | Pyro-SFR |
|---|---|---|---|
| LILW-SL | Volume ($m^3$/TWh) | 13.409 | 10.784 |
| LILW-LL | Volume ($m^3$/TWh) | 1.629 | 1.192 |
| HLW | Volume ($m^3$/TWh) | 3.130 | 0.055 |

Almost all the HLW comes from the back-end of the fuel cycle. The analysis showed that the Pyro-SFR Recycling option produces the smallest amount of HLW since high heat generating elements such as Cs and Sr are selectively separated as LILW-SL for decay storage and TRUs are recovered to be used as fuel in the SFR by the pyroprocess. The waste containing Cs and Sr will be transferred into ceramic form for decay storage for around 300 years by surface disposal as LILW-SL. The removal of Cs, Sr, and TRUs from the HLW stream enables the volume of the HLW to be the smallest among the considered fuel cycle options.

### 3.2 Radioactivity of HLW

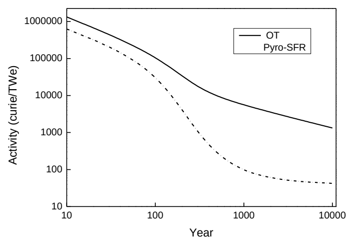


Fig. 2 Activity of HLW in various nuclear fuel cycles

The activities of wastes mainly come from fission products and actinides, which determine the shielding requirement during several operations, e.g., transportation, interim storage, final disposal facilities, and treatment system. Figure 2 shows the changing radioactivity of HLW from the different nuclear fuel cycle options as a function of cooling time. Total HLW from Pyro-SFR Recycling generates less decay heat than other options. The activity is governed by fission products during the first ~100 years and by actinides after that period. At the beginning of cooling, activity decreases moderately with all the four options and then, after approximately 100 years of cooling, the radioactivity decreases dramatically especially with Pyro-SFR Recycling because of its TRU utilization strategy.

### 3.2 Decay Heat of HLW

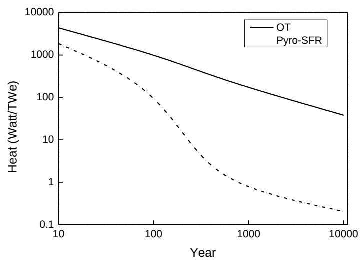


Fig. 3 Decay heat generated from HLW in various nuclear fuel cycles

Decay heat generated from wastes from a given nuclear fuel cycle could be a measuring criterion to quantify the ease or difficulty of waste management. The decay heats from HLW generated in the fuel cycle options decrease with time and their behaviors are compared in Fig. 3. It is clearly shown by Fig. 3 that the decay heat generated from HLW in Pyro-SFR Recycling is the smallest and decreases rapidly among the considered options due to TRU recycling.

### 4. Conclusion

In this study, the Pyro-SFR Recycling was quantitatively investigated for nuclear energy policy development in ROK by employing the idealized equilibrium material flows focusing on the radioactive waste generation.

On the whole, the volumes of LILW generated in OT Recycling and Pyro-SFR Recycling differ slightly. However, Pyro-SFR Recycling shows clear advantages in controlling HLW generation with regard to the waste amount, the decay heat, and the activity.

### References

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