# A Rough Estimation of the Repository Footprint of HLW for the Used Fuel Management Option

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## 1. Introduction

The potential benefits of processing (reprocessing or recycling) the used nuclear fuel regarding the repository footprint, toxicity and nonproliferation have been discussed and estimated. The pyroprocessing technology linked to sodium fast reactor should be one of the perspective solutions of the used nuclear fuel management in Korea. The repository footprint of high level wastes for the used fuel management option are roughly estimated by only decay heat load and compared with the direct disposal option.

## 2. Estimation of the Repository Footprint for High Level Wastes

### *2.1 ANL in 2005 [1]*

ANL quantified the potential for partitioning and transmutation to increase utilization of geologic repository space, described the heat transfer characteristics that control the loading of the repository, and identified the chemical elements that need to be removed from the spent fuel and recycled. As shown in Fig. 1, factors in increasing the loading of a repository depending on the separations efficiency were estimated with the following conditions;

- Built in volcanic rocks (tuffs) 344 m above the water table.
- Thermal criteria: 96℃ at midway between the drifts and 200℃ on the drift wall surface
- Heat removal: ventilation
- Elements separated: Pu, Am, Cm, Cs, Sr
- Reference fuel: 50 GWD/MTU
- Cooling time: 25 years
- Forced ventilation: for 75 years

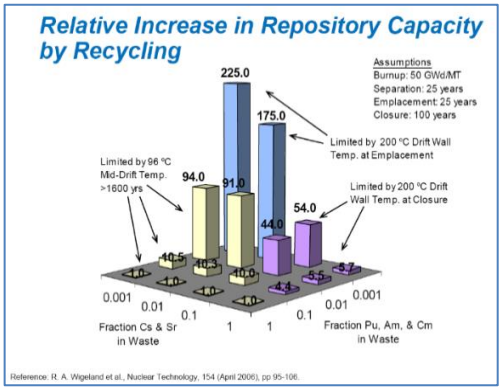


Fig. 1. Potential Repository Drift Loading Increase as a Function of Separation Efficiency for Pu, Am, Cm, Cs, Sr.

It was shown that removal of Pu, Am, Cm, Cs and Sr from used PWR fuel has the potential for reducing the size of a repository by up to a factor of 225 compared with direct disposal.

### *2.2 KAERI in 2017 (Preliminary Feasibility Study on Pyroprocessing) [2]*

KAERI has performed the preliminary feasibility study on pyroprocessing in terms of economics, effectiveness, safety and safeguards. Based on the dynamic model of the Pyro-SFR option, the repository footprint of HLW were estimated with the following conditions;

- Built in granite 500 m below the water table.
- Thermal criteria: 100℃ in the bentonite
- Heat removal: conduction through bentonite buffer
- Elements separated: TRU, Cs, Sr
- Reference fuel: 55 GWD/MTU.
- Cooling time: 40 years

It was shown that removal of TRU, Cs and Sr by 99.9% from used PWR fuel has the potential for reducing the size of a repository by up to a factor of 270 compared

with direct disposal (13.54 $km^2$ for the 60,000 ton of PWR used fuel).

*2.3 This Study*

A repository footprint of HLW depends on various design features of a repository and HLW characteristics. Its detailed estimation requires much time and efforts due to many variables. In this study, repository footprints depending on separation efficiency of TRU, Cs and Sr were roughly estimated with assuming that it is directly proportional to only decay heat load of HLW and compared with those by ANL as shown in Fig. 2. Correlative relationship between two estimations is observed and the rough estimation could be used for relative comparison of a repository footprint.

Repository footprints as a function of separation efficiency of TRU, Cs and Sr from the used PWR fuel are roughly estimated as listed in Table 1. It is appeared that a repository footprint could be reduced by a factor of 10, 66 and 160 with a separation efficiency of 0.9, 0.99 and 0.999, respectively.

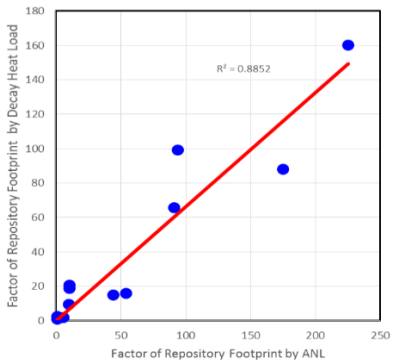


Fig. 2. Correlative Relationship between Repository Footprint Estimated by ANL and This Study.

Table 1. Repository Footprints Depending on Only Decay Heat Load of HLW with Used PWR Fuel Processing

| Element | Separation Efficiency of TRU, Cs and Sr | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.000 | 0.900 | 0.950 | 0.990 | 0.995 | 0.999 | 1.000 |
| TRU (watt/ton) | 472.01 | 47.20 | 23.60 | 4.72 | 2.36 | 0.47 | 0.00 |
| Cs/Sr (watt/ton) | 632.09 | 63.21 | 31.60 | 6.32 | 3.16 | 0.63 | 0.00 |
| U (watt/ton) | 0.075 | 7.5E-05 | 7.5E-05 | 7.5E-05 | 7.5E-05 | 7.5E-05 | 0.00 |
| Misc. (watt/ton) | 5.83 | 5.83 | 5.83 | 5.83 | 5.83 | 5.83 | 5.83 |
| Sum (watt/ton) | 1110.00 | 116.24 | 61.03 | 16.87 | 11.35 | 6.93 | 5.83 |
| **Factor** | **1** | **10** | **18** | **66** | **98** | **160** | **190** |

## 3. Conclusion

A rough estimation of a repository footprint depending on decay heat load of HLW was proposed for the used fuel management option.

## REFERENCES

[1] R.A. Wigeland, et. al., “Separations and Transmutation Criteria to Improve Utilization of a Geological Repository”, Nuclear Technology, 154, 95-106 (2006)

[2] Won-Il Ko, et al., “Preliminary Feasibility Study on Pyroprocessing”, KAERI/TR-6872/2017