—ABSTRACT—

Can Thermal Reactor Recycle Eliminate the Need for Multiple Repositories?

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Because of the limited physical area of the geological strata, the planned Yucca Mountain repository in the United States has limited capacity for disposal of spent nuclear fuel (SNF) and high-level waste (HLW). The amount of SNF or HLW that can be disposed of per unit area is constrained by the decay heat generated by the radioactive wastes. Excessive decay heat raises the temperature and may degrade the performance of the repository. The decay heat is primarily from ^{241}Am, plutonium, ^{137}Cs, ^{90}Sr, and the associated decay products. If these radionuclides are removed, more waste can be put in the repository without exceeding temperature limits. Removal of the americium and plutonium can increase the repository capacity by a factor of 5, while the simultaneous removal of these actinides and ^{137}Cs and ^{90}Sr increases the capacity by a factor of 42.

Because of the ~30-year half-lives of cesium and strontium, these radionuclides can be separated from SNF and stored until they decay away, thus removing the repository heat load from these radionuclides. The long half-lives of americium and plutonium do not allow for this option. If they can be destroyed, the repository capacity can be dramatically increased. In the United States, the only existing machines that can destroy actinides are light-water reactors (LWRs). This raises the question of whether the actinides can be destroyed by recycle in these reactors. Far greater resources will be required if a new type of reactor is needed for actinide burning.

To address this question, a two step approach is adopted. The first step is to show a proof-of-principle demonstration of the ability to destroy all actinides in LWRs. The second step is to begin a much longer, more complex task of characterizing and identifying practical systems that meet the multiple requirements for actinide burning. Nearly complete destruction of actinides can be accomplished in LWRs by using high-enriched uranium as the driver fuel to minimize the generation of higher actinides. For decades, the High-Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory has been used to produce californium, starting with various actinides. As a high-enriched reactor, the HFIR demonstrates the possibility of burning essentially all the actinides. Because some of the early LWRs used high-enriched uranium, an experience base already exists. This paper describes the uranium penalty for the high-enriched uranium option and some preliminary considerations regarding the use of LWRs *to destroy all actinides*—at the same time incorporating more realistic ground rules for LWR operations such as not using weapons-grade uranium and minimizing uranium consumption.