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Implications of Recent Calculations on Actinide Partitioning in Light-Water Reactors (LWRs)

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INTRODUCTION

Advanced Fuel Cycle Initiative (AFCI) studies were made to assess effects of existing light water reactor (LWR) spent fuel accumulation in the United States, coupled with the absence of fast spectrum reactors and accelerator-driven systems, on the capability to partition/transmute actinides during the next ~300 years. Existing and advanced LWRs would be used.

SCENARIO EVALUATED

The processing scenario evaluated assumed that (1) 2000 MT/year of spent fuel, irradiated to 45 GWd/MT and decayed for 30 years, is processed; (2) recovered plutonium and 90% of the neptunium are transmuted in LWR MOX fuel; and (3) minor actinides, consisting of americium, curium, and 10% of the neptunium, are transmuted in "burnable poison" type targets.

BENEFITS OF SCENARIO EVALUATED

The scenario evaluated offers significant benefits which include (1) extended lifetime for the repository; (2) lower costs for partitioning and transmutation of plutonium and the minor actinides, and for storage of spent fuel; (3) maintenance of proliferation resistance for the fissile plutonium in spent fuels; and, (4) efficient use of fuel/target fabrication facilities. The lifetime of the repository would be extended significantly because all of the plutonium and minor actinides would be "in process," or "in storage" and only fission products would be put into the repository.

The lower costs would be achieved primarily because no capital investment for a special transmuter reactor (fast reactor, accelerator-driven system, etc.) would be required. Instead, only existing and new LWRs would be utilized.

Moreover, no new storage capacity would be needed for spent fuels and irradiated targets because the number of spent fuel assemblies would remain the same after the scenario is begun. Even though the total inventory of plutonium would rise during the early cycles, ~98% of the plutonium would be contained in stored spent fuel and would be protected by high radiation (the "Spent Fuel Standard"). This is because the spent fuel would be reprocessed and re-irradiated at intervals within which the fission products, ^{137}Cs and ^{90}Sr, both with half-lives of ~30 years, exist in significantly high concentrations.

Further, the scenario evaluated would allow efficient use of the fabrication facilities because the larger fraction (uranium-plutonium-neptunium) can be fabricated into MOX fuel in conventional glove-box-contained equipment, whereas the smaller fraction (americium-curium-diluent) will require more expensive shielded containment. Also, the scenario would allow different irradiation and/or decay times for the MOX fuel and minor actinide targets if necessary to optimize the transmutation process.

SUMMARY

Current studies have shown that significant benefits can be obtained by multi-cycle transmutation of plutonium and the minor actinides in LWRs, and that key advantages are obtained by processing ~30-year-decayed spent fuel rather than the more traditional 5- or 10-year-decayed fuel. A key feature in the scenarios evaluated is the dilution effect of bringing spent MOX fuel and irradiated MA targets together with fresh LWR-UO_2 spent fuel at the beginning of the separations processing. Because of the relatively small amounts of plutonium and MAs produced, the LWR-UO_2 spent fuel will always provide $\geq$ 80% of the feed material for the next irradiation cycle. The second feature of the scenario evaluated is that key reactions (decay of ^{241}Pu and ^{244}Cm) occur during the 30-year decay period and cause an alteration in the transmutation path, which results in greater production of the lighter plutonium nuclides via transmutation of ^{241}Am and a minimization of the production of ^{244}Cm.