NUCLEAR ENERGY RESEARCH INITIATIVE

Economic, Repository, and Proliferation Impacts of Advanced Nuclear Fuel Cycles

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Project Description

Advanced nuclear fuel cycles that use plutonium or other minor actinides recovered from spent light water reactor (LWR) fuel can reduce the amount of material that would require geologic storage. This project will compare the use of fast reactor (FR) advanced nuclear fuel cycles with that of inert matrix fuel (IMF) in light-water reactors as a means of reducing actinide inventory, focusing on their economics and proliferation resistance.

In addition to making use of the current LWR fleet, IMF can offer a four-fold increase in repository capacity when compared to direct disposal of an energy-equivalent quantity of spent LWR fuel, with over 98 percent destruction of plutonium-239. Research also suggests that leaving IMF pins in the reactor after their reactivity has been depleted (effectively making them actinide targets) could offer a significant increase in actinide destruction. FRs can potentially increase repository capacity by more than an order of magnitude per kilowatt of electricity generated. However, FR spent fuel must be recycled many times in order to achieve this result, whereas the increase in repository capacity offered by IMF does not require reprocessing. Unlike previous studies which assumed that spent FR fuel be recycled continuously, this project will analyze the impact of IMF and FR transmutation strategies over a 100 year period, from 2030 to 2130.

Workscope

This project will accomplish the following tasks:

1. Determine the material balances (including proliferation sensitive materials) for IMF and FR fuel cycles that operate over a finite time period
    - Use university's burnup/criticality code, MCNPX/MONTEBURNS and REBUS-3, to determine the isotopic balances for representative transuranic vectors, typical LWR parameters, and FRs with different conversion ratios
2. Determine the radiological and heat load to a repository for each fuel cycle
    - Use ORIGIN 2.2 and the spent fuel composition for the respective IMF and FR cycles
3. Determine fuel cycle cost in $/kWhr for each of the respective fuel cycles
    - Apply probabilistic discount model unit cost data published by the OECD/NEA Investigate the effect of uncertainties in cost, discount rates, and time