Influence of Alternative Fuel Cycles on Uncertainty Associated with Geologic Disposal

Mark Nutt
Argonne National Laboratory, USA[1]

Rob P. Rechard
Sandia National Laboratories, USA

Mark Sutton, James A. Blink, H.R. Greenberg, M. Sharma
Lawrence Livermore National Laboratory, USA

Bruce A. Robinson
Los Alamos National Laboratory, USA

Abstract

Advanced nuclear fuel cycles, including those that partition and transmute key radionuclides, could potentially prove beneficial to managing high-level radioactive waste that must be stored, transported, and ultimately disposed. The potential benefits of advanced nuclear fuel cycles have been evaluated previously, focusing on potential to reduce the long-term risk or dose of geologic disposal and efficiencies that could be gained with respect to thermal management within a mined geologic repository. These efforts have sometimes claimed that the removal of key radionuclides from the waste could have an added benefit of reducing the effort required to treat uncertainty within a safety assessment. This paper explores this claim by providing a qualitative evaluation of the impact advanced nuclear fuel cycles on the treatment of uncertainty associated with geologic disposal.

The characterization of uncertainty and its treatment within a safety analysis is a fundamental aspect of evaluating the performance of geologic disposal. In this context, uncertainty includes parameter uncertainty, model form uncertainty, and the technical basis for inclusion or exclusion of specific features, events, and processes (FEPs) as part of scenario uncertainty.

A considerable amount of work has been completed worldwide regarding the treatment of uncertainty within a safety analysis for geologic disposal, but has considered only the waste streams and waste forms generated by nuclear fuel cycles currently in use. Regulators have also established requirements and guidance for treating uncertainty within the safety analysis. This evaluation leverages on this knowledge and broadens it to consider the impacts of advanced nuclear fuel cycles.

The qualitative evaluation of the impact on uncertainty from alternative fuel cycles was conducted by considering a generic list of FEPs, as derived from the NEA FEP database, applicable to the geologic disposal of high-level waste in a variety of generic geologic media (mined geologic disposal in salt, clay/shale, crystalline rock and deep borehole disposal in crystalline rock). Two aspects of impact are pertinent to the evaluation of such FEPs: (a) the effort to characterize the uncertainty, and (b) the impact on components of the safety analysis model. Both direct and indirect influences of the radionuclide inventory within the waste on each FEP were determined. An example of a direct influence would be release of key radionuclides from a degrading waste form. An example of an indirect influence would be coupled thermal-hydrologic-chemical processes where the heat generated by the waste depends on the radionuclide inventory in the waste. If no such influence is identified, it can be concluded that the uncertainty associated with that FEP is independent of the radionuclide inventory and, therefore, independent of the fuel cycle. An example of such a FEP is ground water flow far from the repository.