U.S. Department of Energy

Project Title

Transient Safety Analysis of Fast Spectrum TRU Burning LWRs with Internal Blankets

PI: Tom Downar – University of Michigan **Collaborators**: Mujid Kazimi – MIT

Program: MS-RC

ABSTRACT

The Light Water Reactor (LWR) is a very mature technology with a vast industrial and licensing infrastructure and in the US it has become the most reliable source of energy. However, because the uranium utilization of light water reactors (LWR) is very low, the US DOE is actively considering fast spectrum reactors to increase the energy extracted from the nuclear fuel and to reduce the amount and radio-toxicity of the nuclear waste by burning the Transuranic (TRU) isotopes from the current fleet of LWRs. TRU burning is most efficient in a fast spectrum reactor and the leading technology in the US has been to use sodium as coolant. Unfortunately, the US does not have a well developed infrastructure for sodium-cooled fast reactors (SFR) and the specific capital cost of the sodium-cooled fast reactor designs is considerably higher than that of LWR. This has encouraged the consideration of alternate technologies and over the years and several hard spectrum water reactor design concepts proposed for TRU burning. There has been considerable interest in hard spectrum Light Water reactors over the years. Most designs claim a negative MTC using axially heterogeneous fuel (alternating fissile/fertile zones). However, the inherent decoupling of the core in this type of design posed potential safety issues which were beyond the analysis capabilities of existing codes and most of the designs were abandoned. The considerable advances in computational capabilities and space-time dependent multiphysics codes has made it possible to revisit the issues of safety of high conversion lattice reactors. The objective of the work proposed here is to examine the safety issues common to high conversion LWRs with axial blankets. However, in order to perform this analysis to a level of sophistication which would provide credible conclusions, the work here will focus on a specific reactor design. One of the most mature and complete designs is the innovative Resource-Renewable BWR (RBWR) that has been proposed and developed by Hitachi, who has developed several variants of core designs for the RBWR to include the RBWR-AC core that is designed to have a conversion ratio of 1.0 (or 1-2% above 1.0) and the RBWR-TB2 core that is designed to have a low conversion ratio of ~0.5. Both RBWR core designs can fit within the pressure vessel of the well proven ABWR and deliver the same total power as the ABWR. Hence, the specific capital cost of the RBWR should be smaller than of the presently available SFR designs and the infrastructure required for RBWR deployment is expected to be less. In 2007 Hitachi contracted EPRI to conduct an independent technological evaluation of the RBWR. Due to the very strong coupling between the neutronics and thermal-hydraulics in the RBWR cores and to their high level of heterogeneity, the evaluation required the development of sophisticated core simulation models including coupled code models based on the U.S. NRC code system. Our preliminary evaluation confirmed that both the RBWR-AC and RBWR-TB2 core designs can achieve and maintain their conversion ratio design goals at an equilibrium cycle. However, our preliminary analysis did not perform confirmatory safety calculations and we identified several issues with the safety performance that suggested detailed coupled code transient analysis would be necessary. This is the objective of the work proposed here.