Accident Tolerant Fuels to Support Power Uprates in LWRs

PI: Juliana Pacheco Duarte (UW-Madison)

Co-PIs: Ben Lindley and WooHyun Jung (UW-Madison), Jason Hou (NCSU), Robert Armstrong and Svetlana Lawrence (INL), David Lyle Luxat (SNL), Kolton Urso and Dale Bradish (Constellation), Maupin Keith (Framatome), Russell Stachowski (GNF)

Topic Area 2: Existing Plant Optimization

Collaborators: Michael Corradini (UW-Madison), Al Csontos (NEI)

ABSTRACT:

Power uprates in Light Water Reactors (LWRs) have been used by U.S. utilities to increase their cost-effectiveness by producing more electricity with a nominal cost increase. With the approval of the Inflation Reduction Act in 2022, there is a real economic incentive to boost nuclear energy production through ample power uprates using low 5-10% enriched uranium plus (LEU+) fuel and higher burnups (up to 75 GWd/tU peak rod average burnup). The superior material behavior and corrosion-resistant properties of near-term (*e.g.*, Doped UO_2 and coated Zr-alloy) and long-term (*e.g.*, SiC and FeCrAl cladding) accident tolerant fuels (ATFs), make it possible to allow power uprates in LWRs beyond the current levels; it requires, however, in-depth operational and safety analyses to evaluate potential impacts.

We will examine a set of fuel technical improvements by exploring ATF performance benefits to enable higher thermal power uprates resulting in the identification of those with the highest chance of success. In consultation with our advisory board, considerations will be given to ensure that the outcomes of this project will not require major changes to the existing LWR fuel assembly design and reactor coolant systems that would be economically unattractive.

Steady-state neutronic and thermal-hydraulic core design and optimization using SCALE/PARCS, or suitable equivalent code system, will be performed for the proposed baseline and uprated core design with ATF materials. This will be followed by accident analysis and severe accident analysis using MELCOR and complemented with preliminary fuel performance and economic analysis. We will simulate one anticipated operational occurrence, one design basis accident (a large break loss of coolant accident), and one severe accident (a long-term station blackout) for both PWR and BWR. A set of performance metrics was identified, and it will be used in this project.

The proposed research will result in the expansion of the state of knowledge in the use of ATF materials to support power uprates in LWRs while coupled with fuel enriched up to 10% and qualified for use at higher burnup levels. This project concurs with the industry goals to deploy ATF materials with increased enrichment and higher burnup to i) enhance safety performance, ii) improve plant economics, iii) increase fuel efficiency, and iv) decrease waste production.