

I. Introduction

- A. Purpose of the work: investigate the effect of deploying HALEU-fueled advanced reactors on the nuclear fuel cycle in the US
- B. Scope:
 - 1. US facilities
 - 2. select advanced reactors: USNC MMR, X-energy Xe-100, NuScale VOYGR
 - 3. Front-end and back-end of the fuel cycle
- C. Motivations
 - 1. U.S. wants to develop a supply chain of HALEU
 - 2. HALEU has broad uses outside of reactors [1]
 - 3. Benefits of using HALEU in reactors
 - a. higher burnups
 - b. reduced LCOE
 - 4. Changing the fuel form affects fuel cycle dynamics
- D. Goals
 - 1. understand how deploying HALEU reactors affects resource demand
 - 2. understand which components of the fuel cycle are most sensitive to HALEU deployments
 - 3. understand how implementing recycling with HALEU reactors affects the fuel cycle
 - 4. understand how possible avenues to obtain fuel for HALEU reactors can affect neutronics
 - a. neutron flux
 - b. k-eff
 - c. β -eff
 - d. feedback coefficients,
 - e. lifetimes
 - f. uranium utilization in general
 - g. breeding ratio

II. Lit Review

- A. The nuclear fuel cycle
 - 1. Once-through vs recycle [2]
 - 2. Enrichment facility/SWU calculations [2]
 - 3. Recycling processes [2]
 - a. overview of aqueous reprocessing
 - b. Known changes to LWR fuel cycle by recycling
- B. Fuel Cycle simulators
 - 1. Why we use them, their benefits
 - 2. why multiples have been created
 - 3. ideal functionalities and capabilities [3, 4]
 - 4. uses of fuel cycle simulators
 - a. Department of Energy (DOE) Evaluation & screening [5]
 - (1) Differences in EG 01 and EG 02
 - b. EG29 analysis [6]
 - c. verification [7]
 - 5. CYCLUS [8]

- a. basic fundamentals
 - b. CYCAMORE [9]
 - c. addresses many of the things brought up by [3]
 - d. comparison to other codes [10]
 - e. verification [11]
 - 6. sensitivity analysis
 - C. Reactors with HALEU
 - 1. fuel forms (ceramic vs metallic vs TRISO)
 - 2. Effects of changing from 5% to 7% for PWR [12]
 - a. no effects on reactivity coefficients
 - b. more mining and enrichment per energy unit generated
 - c. reduced energy normalized quantity of waste
 - d. slight decrease in radioactivity of waste
 - 3. Effects on NuScale SMR [13]
 - a. increases fast to thermal flux ratio
 - b. more burnable poisons
 - c. larger concentration of fission product poisons
 - 4. Effects of impurities [14]
- ### III. Methodology
- A. Reactors, including serpent models
 - 1. USNC MMR [15]
 - 2. X-energy Xe-100 [16]
 - 3. NuScale VOYGR [17]
 - B. material flow in fuel cycles
 - 1. Once-through – once-through-flow figure
 - 2. recycle – recycle-flow figure
 - C. sensitivity analysis and optimization
 - D. downblending/re-enriching effects
- ### IV. Material requirements – Once through fuel cycles
- A. Scenario Definitions
 - B. Results
 - 1. Reactor deployment
 - a. No growth scenarios
 - b. 1% growth scenarios
 - 2. Uranium resources
 - a. No growth scenarios
 - b. 1% growth scenarios
 - 3. SWU capacity
 - a. No growth scenarios
 - b. 1% growth scenarios
 - 4. Waste
 - a. No growth scenarios
 - b. 1% growth scenarios
- ### V. Model fuel cycle with recycle

A. Scenario Definitions

B. Results

1. Reactor deployment

- a. No growth scenarios
- b. 1% growth scenarios

2. Uranium resources

- a. No growth scenarios
- b. 1% growth scenarios

3. SWU capacity

- a. No growth scenarios
- b. 1% growth scenarios

4. Waste

- a. No growth scenarios
- b. 1% growth scenarios

VI. Sensitivity analysis and optimization

A. Results

VII. Effects on neutronics

A. Models

B. Results

VIII. Conclusions

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