

# U.S. NRC's High Burnup and Increased Enrichment Project Plan

High Burnup and Increased  
Enrichment Technical Group  
U.S. NRC Public Meeting  
9/12/19

# Speakers

- Jason Drake, Project Manager, Division of Licensing Projects, Office of Nuclear Reactor Regulation (NRR)
- Kevin Heller, Reactor Systems Engineer, Division of Safety Systems (DSS), NRR
  - In-reactor performance
- Marilyn Diaz; Chemical Engineer; Division of Fuel Cycle Safety, Safeguards, and Environmental Review; Office of Nuclear Material Safety and Safeguards (NMSS)
  - Fuel fabrication and transportation
- Michelle Gonzalez, Reliability and Risk Engineer, Division of Risk Assessment, Office of Nuclear Regulatory Research (RES)
  - Probabilistic risk assessment
- James Corson, Reactor Engineer, Division of Systems Analysis, RES
  - Analysis capability and development

# Overview

- Background
- Purpose and description
- Parallels with ATF Project Plan
- Open items
- Activities covered by project plan
  - In-reactor performance
  - Enrichment, Fabrication and transportation
  - Probabilistic risk assessment
  - Analysis capability development
- Next steps

# Background

- Industry is pursuing deployment of near-term ATF (chromium-coated cladding) by 2023
  - Supported by DOE
  - Appear on track with R&D and licensing strategies
  - Lead test assemblies under irradiation
- Industry has indicated that extended burnup and enrichment limits will be sought to support ATF deployment
  - Project plan considers up to 75 GWd/MTU rod average burnup and up to ~8% enrichment

# Background

- NRC's ATF Project Plan does not account for the preparatory actions of this additional activity
  - Initial plan did not address implementation of potential 'benefits' of ATF
- Higher burnup and increased enrichment plan fills this gap
  - Appendix A to ATF Project Plan
  - Actions parallel ATF activities in both scope and time
- As with ATF, early engagement is critical to timely licensing

# Purpose

The high burnup and increased enrichment (HBU+IE) project plan outlines activities associated with *preparing the agency* to conduct effective and efficient reviews of proposals for higher burnup and increased enrichment fuels (e.g., ATF)

# HBU+IE Project Plan Description

- Appendix of the ATF Project Plan
  - Many activities will be performed in parallel with ATF activities
- Includes preliminary estimates of lead time necessary to complete activities in each area
- Focused on activities expected from *2019-2023*
- Is intended to be a living document

# HBU+IE and ATF Parallels

- NRC will not perform independent confirmatory testing
  - Data will be available from DOE, industry, and others
  - All integral fuel behavior data to be provided to NRC to perform code assessments
- Interaction with DOE, EPRI, vendors, licensees, and other organizations will take place:
  - in real time
  - in advance of licensing submittals

# HBU+IE and ATF Parallels

- Interactions with external stakeholders will keep staff and stakeholders informed about developments that can affect activities in the plan
- The NRC will be appropriately resourced to execute the activities in the plan
  - Expect significant increase in workload based on current industry plans to pursue HBU+IE in conjunction with ATF

# HBU+IE Open Items

- Identify any necessary changes to existing regulatory framework
  - Example: 50.68 spent fuel pool enrichment limit
- Identify whether (and what) regulatory guidance needs to be generated to accommodate licensing of HBU+IE fuel designs under current framework

# In-Reactor Performance

- Identify and address any changes to the in-reactor regulatory framework that may be required to support implementation of HBU+IE in light of the technical issues they present
  - Fuel integrity (cladding and/or pellet)
  - Nuclear criticality safety
- NRC staff plans to map the technical issues to regulatory requirements and guidance to determine the scope of changes that are needed to facilitate the use of HBU+IE fuels (e.g., NUREG-0800, NUREG/CR-7219, and 50.68 to allow >5% enrichment)
- NRC staff will engage stakeholders to address any gaps prior to licensing for general use

# In-Reactor Performance

- Licensing strategy
  - Expect industry will take an incremental approach
  - NRC envisions two strategies:
    - Near-term: exemption requests
    - Longer-term: rulemaking
- Benchmarking and data collection needs
  - Lead test assembly programs provide characterization of irradiated material properties and performance
  - Beneficial for qualifying analytical codes and methods and developing safety design bases

# In-Reactor Performance

- License amendment requests typically provide an “Environmental Consideration” section that discusses possible environmental impacts
  - Amendments for HBU+IE might not meet the criterion for categorical exclusion
    - Amendments will need to provide information on potential environmental impacts to facilitate staff’s environmental review
    - Potential source of review complexity
  - To minimize review complexity, staff may consider addressing environmental impacts generically
  - Necessity of effort will become clearer as NRC engages with external stakeholders

# Enrichment, Fabrication and Transportation

- Identify and address any changes to the regulatory framework for fuel enrichment, fabrication and transportation, and spent fuel storage required to support implementation of HBU+IE in light of the technical issues they present
  - NRC staff anticipates current guidance, review plans, and regulatory criteria are adequate to address technical issues for fabrication and transportation
- Licensing can likely take place using existing regulatory processes

# Enrichment, Fabrication and Transportation

- Fuel Cycle
  - Front end: enrichment, fabrication and transportation of feed material and fuel assemblies
  - Back end: transportation and storage of spent fuel
- Feed Material
  - Assurance of criticality safety
    - Licensees of enrichment facilities will need to submit amendments
    - Transportation of UF<sub>6</sub> enriched to >5% requires design and certification of new packages, modification of existing packages, or exemptions
  - Facility operation expected to be similar to current operation

# Enrichment, Fabrication and Transportation

- Fuel fabrication and transportation
  - Fabrication facility licensing of evolutionary fuel design can likely take place using existing regulatory processes
  - Existing regulations and guidance are considered adequate for processing transportation requests
- Spent fuel transportation and storage
  - Benchmarking and data collection needs
    - Assurance of fuel integrity given age-related phenomena
    - Assurance of criticality safety
  - Existing regulations and guidance considered adequate to address

# Probabilistic Risk Assessment

- Develop capabilities to support risk-informed activities following implementation of HBU+IE fuels
- Plant-specific licensee PRA models and NRC PRA models used for operational activities and oversight activities, respectively
  - Key tenet of risk-informed decision making is these models reflect the as-designed, as-operated plant
  - HBU+IE may affect these models
    - Near-term increases in burnup and enrichment expected to be marginal, and have limited or no effect on models
    - Long-term increases may have a larger effect on models

# Probabilistic Risk Assessment

- More information needed from industry to create a meaningful plan
  - When does industry expect to engage with the NRC in this area?
- NRC interactions with industry and vendors (e.g., technology update meetings) will be used to encourage an approach consistent with existing regulatory requirements and guidance
- Will leverage other ATF-related activities as feasible, and assure PRA models continue to accurately model the plants' risk profiles

# Analysis Capability Development

- Develop independent confirmatory calculation capabilities to:
  - Provide staff insight on phenomenology of HBU+IE on transient and accident scenarios
  - Identify risk-significant contributors to safety analyses
  - Assist in focusing NRC staff reviews
- Much of the analytical investigation needed to assess the impacts of HBU+IE for in-reactor performance, criticality safety, and PRA models and to support changes in regulatory requirements and guidance will be via confirmatory calculational capabilities

# Analysis Capability Development

- Disciplines identified for development to support reviews include fuel performance, thermal hydraulics, neutronics, and source term analysis
- For each code, estimates consider the need for:
  - A scoping study to identify code development needs
  - Model development
  - Model validation
  - Integral assessment

# Analysis Capability Development

- Code development activities for HBU+IE will be integrated and sequenced, as appropriate, with activities for ATF (e.g., participate in PIRT exercises for increased enrichment)
- Lead times to develop full analytical capabilities can vary by discipline and code
- Experimental data is a prerequisite for most work to prepare confirmatory codes

# Phenomena Identification and Ranking Table Exercises

- PIRTs are being developed as part of NRC's preparatory actions

PIRT	Date	
	NRR	NMSS
High Burnup	N/A	9/2021
Increased Enrichment	9/2021	9/2021

- Will follow chromium-coated cladding example
  - Initial report
  - Panel convened
  - Final report

# Meetings and Stakeholder Interactions

NRC staff is committed to participating in:

- Industry project update meetings to maintain programmatic awareness of industry efforts
- Key technical domestic and international update meetings, experimental program review meetings, and conferences

# Next Steps

- Assess stakeholder feedback and enhance HBU+IE plan
- Early and frequent engagement with vendors and licensees to understand
  - licensing strategies
  - timelines for submittals
- Complete NRC led PIRT exercises where knowledge gaps exist

# Questions?

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