

EPRI ATF Research and Development

Presentation to the IAEA Nuclear Back-End
Webinar Series: Accident Tolerant Fuel

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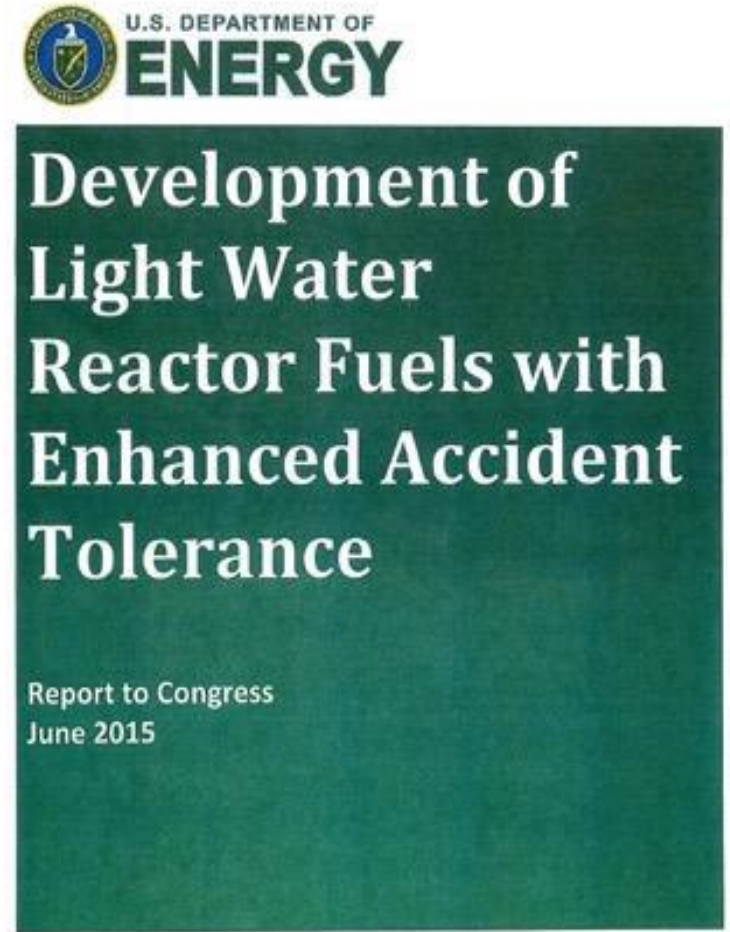
Vienna, Austria
December 2, 2020



Background: U.S. ATF History

- In 2012, U.S. Congress mandated DOE:
 - Develop LWR fuel with Enhanced Accident Tolerance
 - Facilitate loading of LTR/LTA into U.S. LWR by 2022
- DOE Three Phase Strategy:
 - Feasibility and down-selection to 3 ATF concepts
 - Develop and qualify ATF concepts
 - Commercialization for ATF concepts
- Utilities committed to accelerated deployment of ATF for improved safety and economic benefits

Incremental Benefits = Easier
Transformative Benefits = Harder



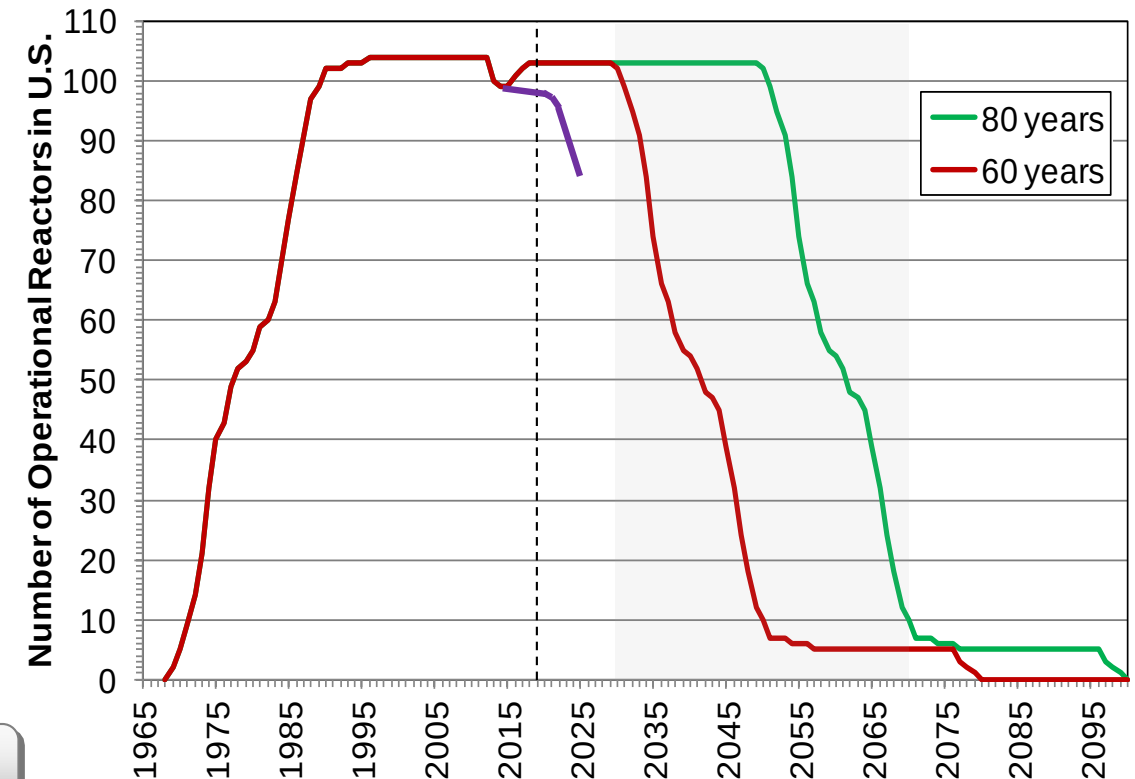
<https://nuclearfuel.inl.gov>

U.S. Industry Need for Accelerated ATF Implementation

- Challenge: traditionally long fuel design to deployment timeframes
- Limited window of opportunity:
 - Existing fuel testing facilities
 - Abundant R&D programs
 - Limited economic viability for ATF benefits to the existing fleet
- Milestone: mid-2020s for batch reloads of ATF (doped pellets and coated cladding), with increased enrichment to realize higher burnup

Accelerating ATF is a Heavy Lift

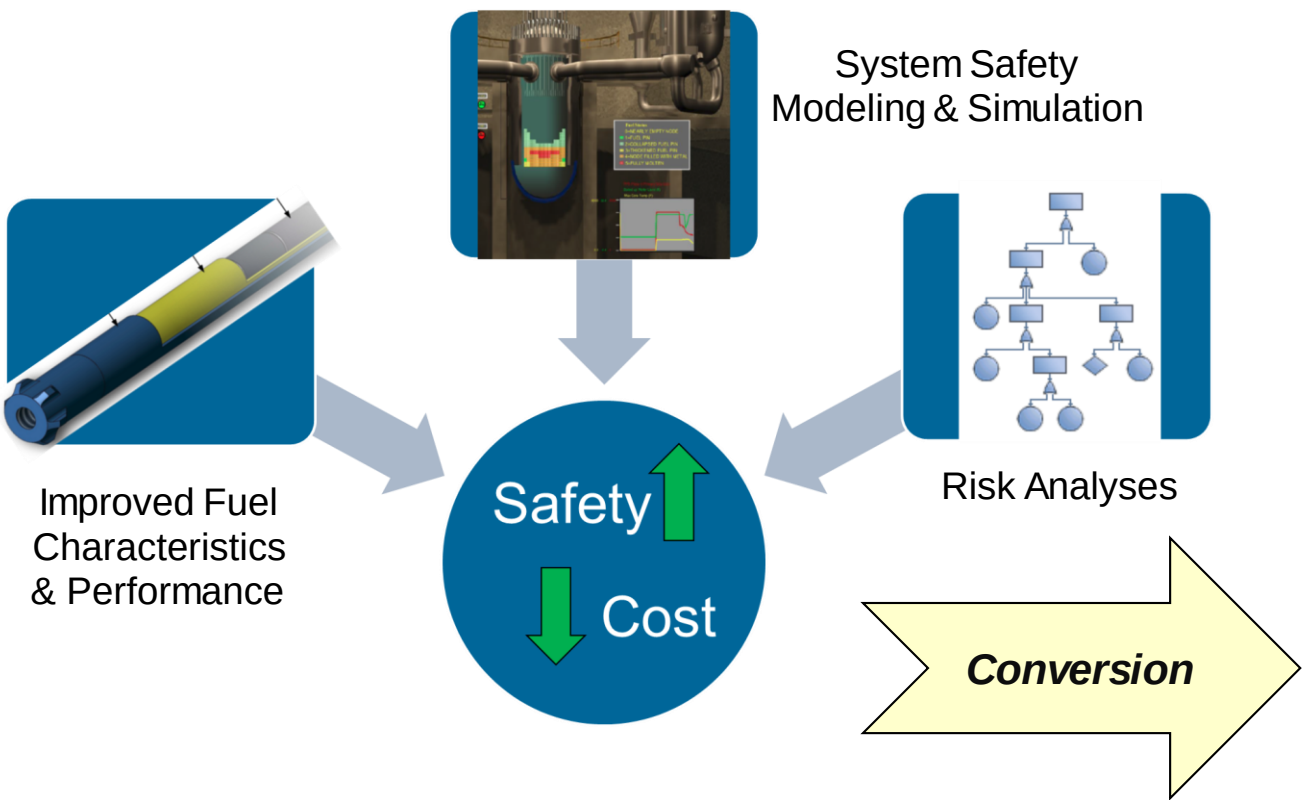
Projected operating life for Domestic LWR fleet



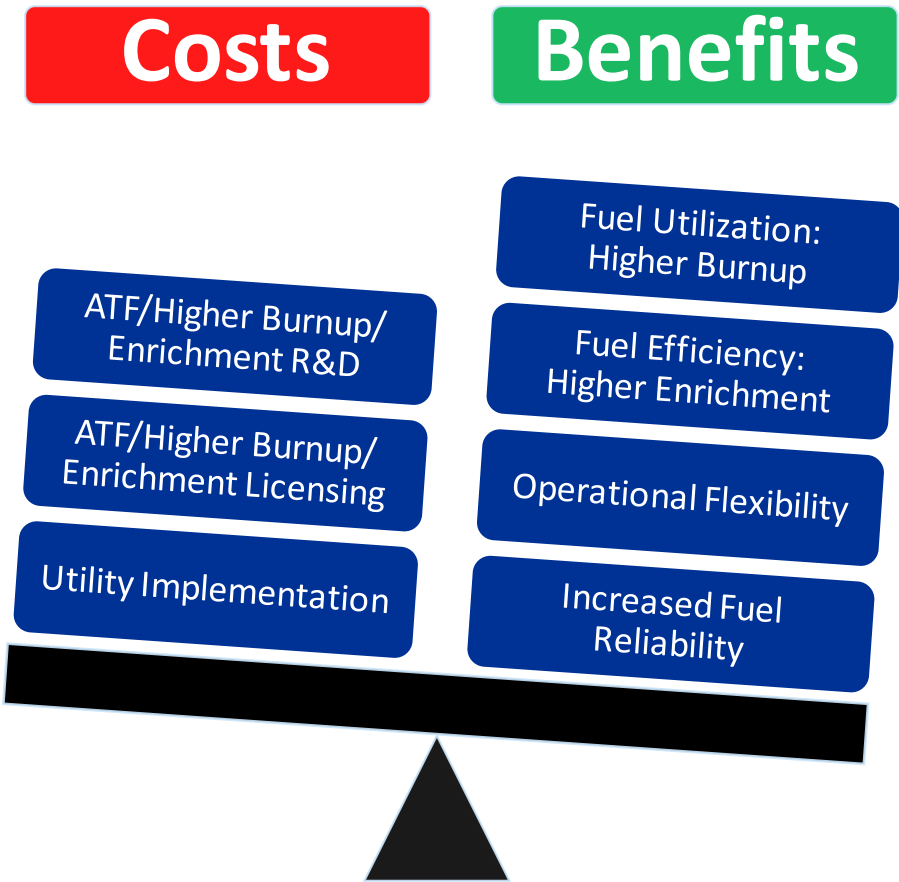
EPRI ATF Research and Development Efforts

EPRI ATF Safety and Economic Benefits Studies

EPRI ATF Safety Benefits Scoping Study



Industry ATF Business Case

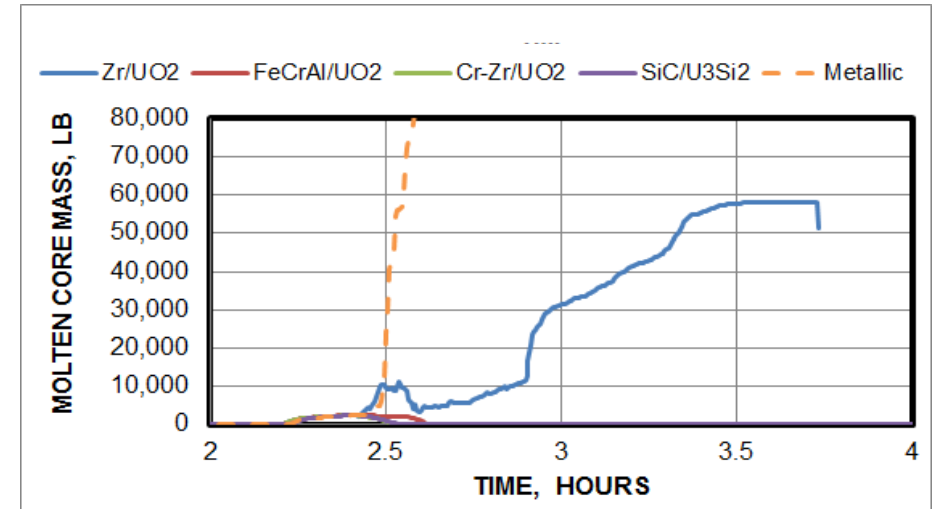


Conversion of ATF Safety Benefits to Economic Benefits

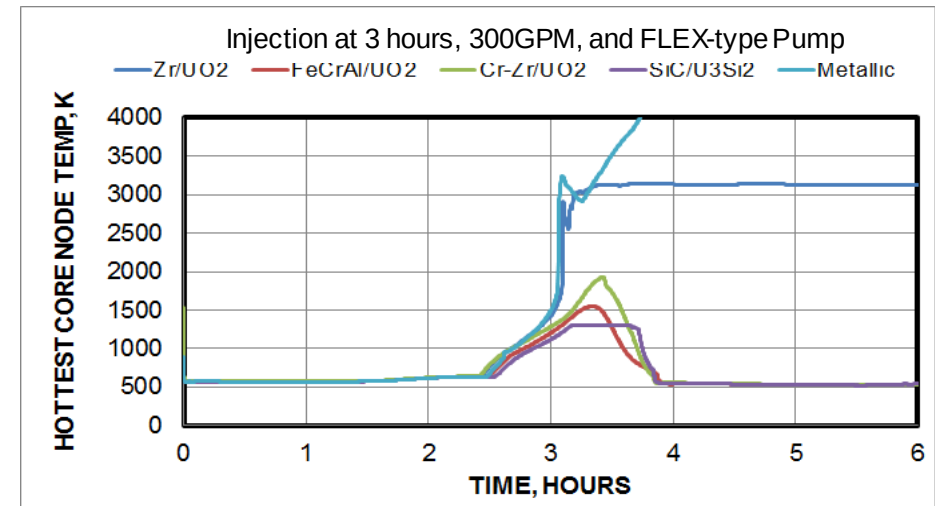
EPRI ATF Safety and Economic Benefits Studies

- Safety benefits vary among:
 - ATF cladding/fuel concepts
 - BDBA/DBA/AOO Accident scenarios
 - Reactor type and specifics
- For severe accident cases:
 - Enhanced coping times of ~1-3 hours
 - ATF delays core damage, however, restoration of core cooling needed to prevent core damage
 - Specific ATF concepts may have limited Three Mile Island-2 core damage
- For DBA/AOO cases:
 - Potential greater benefits through safety margin improvements to support operational enhancements
- General agreement of modeling results:
 - Vendors, MIT, UW, INL, and ORNL

TMI-2 Molten Core Mass



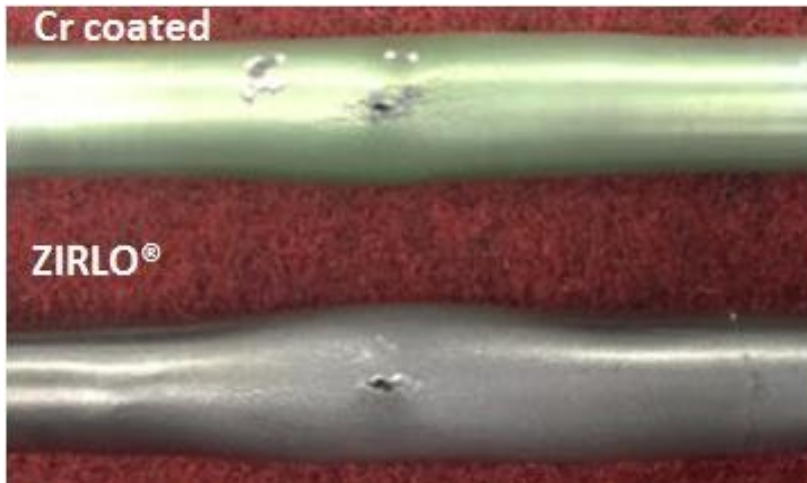
PWR LOFW + Feed & Bleed at 3hrs



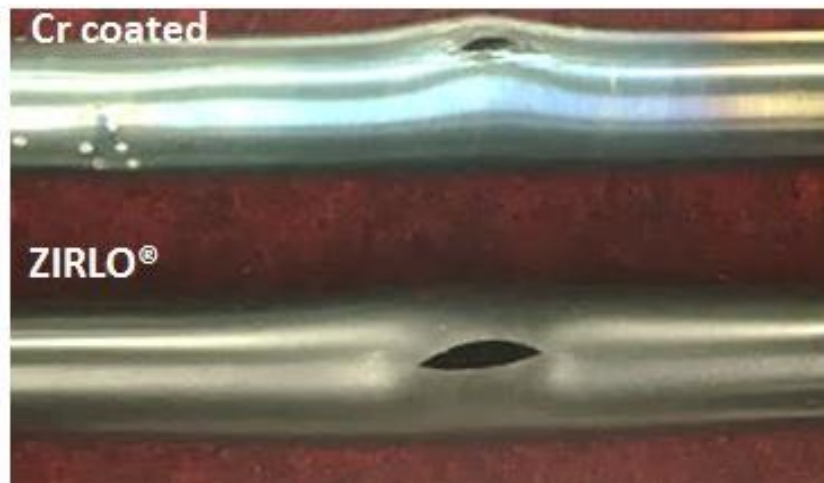
Potential Benefits of Coated Cladding

- Current regulatory framework sufficient for licensing:
 - NRC ATF Interim Staff Guidance (NRC-ISG-1) (01/20)
 - NRC presentation at EPRI Extended Storage Collaboration Program Meeting
- Enhanced coping times for various accident scenarios
- Reduces potential for fuel relocation during LOCA
- Enables better efficiencies with increased enrichment to realize higher burnup

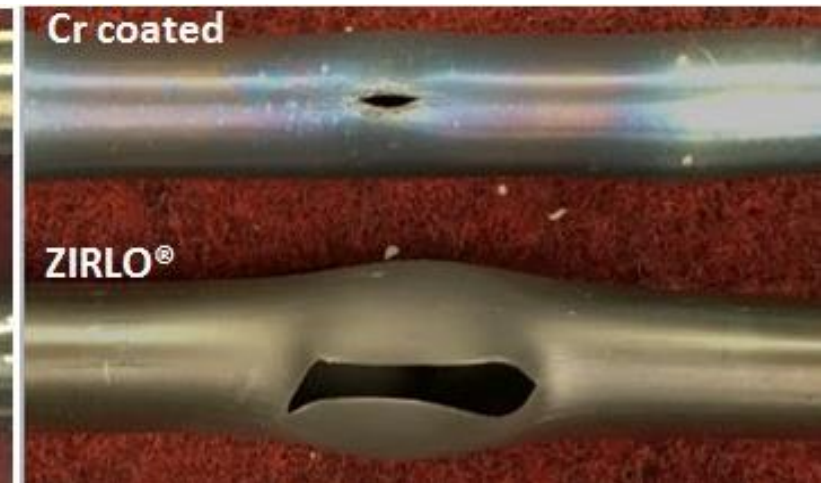
200 psi (1.4MPa)



800 psi (5.5 MPa)



1800 psi (12.4 Mpa)

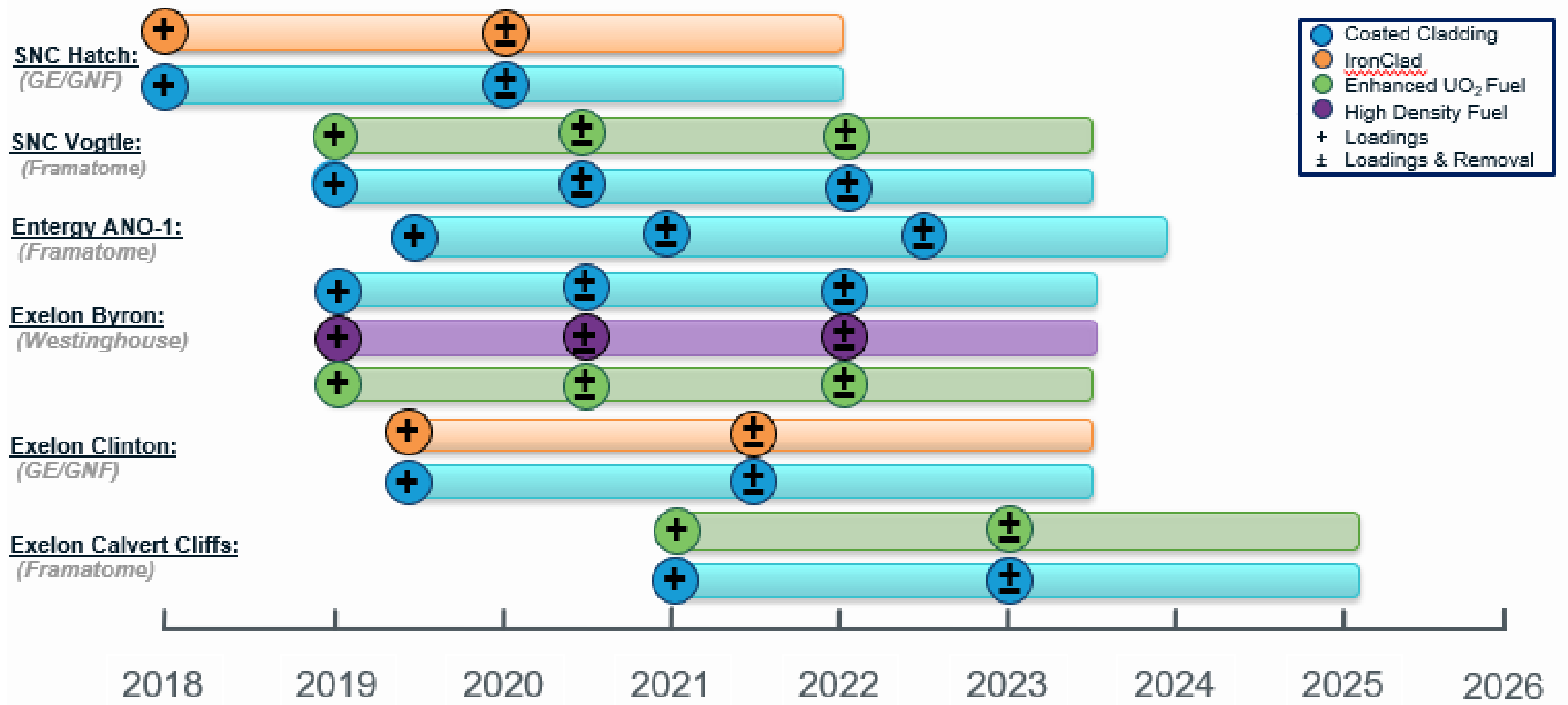


Photos provided with permission of Westinghouse Electric Corporation

Accelerating ATF Deployment with Increased Enrichment and Burnup



Key U.S. ATF Fuel Milestones



EPRI ESCP Workshop on Evaluating Advanced Fuels Impacts on Back-End Operations

EPRI Extended Storage Collaboration Program

2010-2019

Regular May and December meetings, in US
14 International SC meetings
6 subcommittees

2020

~675 members from **22** countries
Over 185 participants, representing 10 countries, attended Winter 2019 meeting
4 subcommittees

2009

1st ESCP meeting
1 country,
39 participants
2 subcommittees

Workshop on Advanced Fuels Impacts on Back-end (11/19)

1. ATF Description and Benefits

- ATF/HE/HB Industry Perspective and Plans, John Williams (Southern)
- ATF Industry Directions, Ben Holtzman (NEI)
- DOE Advanced Fuels Campaign - ATF Program, Bill McCaughy (DOE)
- ATF/HE/HB Program Benefits for Nuclear Industry, Al Csontos (EPRI)

2. Used Fuel Program Overviews

- DOE UFD Program Overview & Perspective, Ned Larson (DOE)/ Sylvia Saltzstein (SNL)
- NRC Activities and Perspectives on ATF and HBU/HE Fuel, Meraj Rahimi (NRC)
- IAEA Perspectives, Christoph Gastl (IAEA)
- A preliminary assessment of the disposability of spent accident tolerant fuels, David Hambley (NNL)

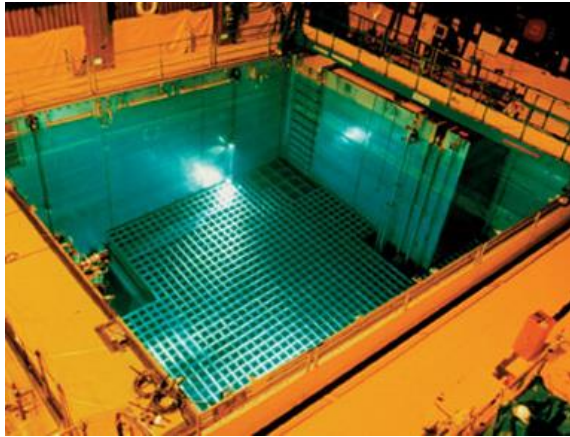
3. Descriptions for Advanced Fuels

- Westinghouse Advanced Fuel Designs, Zeses Karoutus and Kallie Metzger (Westinghouse)
- Framatome Advanced Fuel Designs, Chris Lewis (Framatome)
- GE/GNF Advanced Fuel Designs, Paul Cantonwine (GNF)

4. Panel Discussion - Impact on Dry Storage Discussion Panel

- Meraj Rahimi (NRC)
- George Carver (NAC)
- Debu Mitra-Majumdar (Holtec)
- Prakash Narayanan (Orano)
- Al Csontos (EPRI)

Potential Impact of ATF & Higher Burnup/Enrichment



Spent Fuel Pool

- Criticality
- SFP heat load management
- Accident Analysis



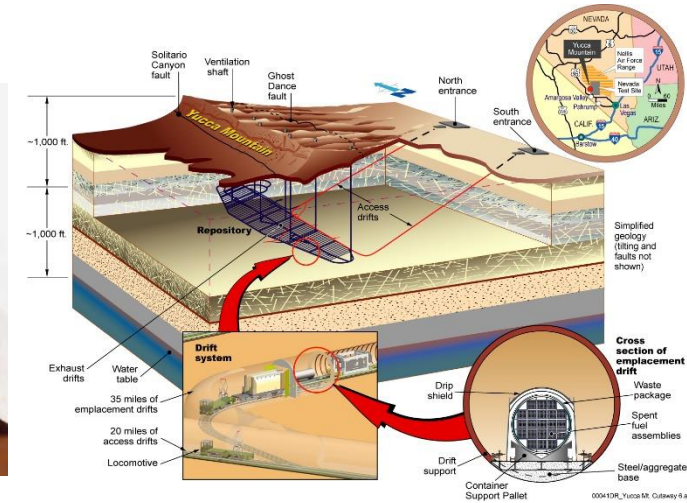
Dry Storage & Centralized

- Criticality
- Heat Load Limits
- Cladding/Fuel Properties
- Accident Analysis



Transportation

- Criticality
- Fuel/clad properties during transportation
- Accident Analysis



Disposal

- Criticality (long term impact)
- Heat load management
- Fuel and cladding properties

Coated Claddings Limited Impact to Back-End Operations
Higher Burnup/Enrichment Potentially Greater Impact

Current ATF R&D Relevant to Back-end Operations

- High temp oxidation and coating stability
 - OECD/NEA KIT Quench Test Program
 - IAEA Coordinated Research Projects ACTOF & ATF-TS
- Hydrogen pickup and permeability
- Coated Cladding Performance Modeling:
 - Balloon/burst and relocation
- DOE data needs for ATF and higher burnup and enrichment for back-end operations
 - Report expected 2021
- EPRI Spent Fuel Pool Criticality Modeling
- EPRI Decay Heat Testing and Modeling
- EPRI Workshop: Sensors for SNF Operations
 - December 14-15, 2020 (Virtual)



Summary

- EPRI providing independent assessments to the nuclear utilities on potential ATF safety and economic benefits and regulatory hurdles:
 - 3002012250: ATF Technical Update: Valuation 1.0, Gap Analysis, Valuation 2.0
 - 3002015091: ATF Safety & Economic Benefits
 - 3002014603: Coated Cladding Gap Analysis
- Focused R&D to accelerate ATF deployment:
 - Domestic and international collaborations with numerous stakeholders
- Holistic considerations for the impact of ATF to entire fuel cycle:
 - EPRI Workshop on Advanced Fuels Impacts on Back-end Operations
 - EPRI Extended Storage Collaboration Program 2020 Conference
 - EPRI Sensors Workshop for Spent Fuel Operations (Dec 14-15, 2020)

Together...Shaping the Future of Electricity