Overview of DOE Regulatory Development

Advanced Non-Water Technologies, Regulatory Framework Modernization

Molten Salt R&D Program Review

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Overview of DOE Regulatory Development - Advanced Non-Water Technologies

- All advanced reactor deployments will need to develop a design and associated safety case that satisfy regulatory requirements regarding protection of the public.
- Multiple and integrated technical inputs are needed (advanced materials, cybersecurity, radionuclide transport analysis, etc.), and rely heavily on DOE programs.
- Multiple DOE program efforts, including NRIC, the Advanced Reactor Regulatory Development Programs, and the Advanced Manufacturing Materials Technologies program help close technical and regulatory gaps that are inherent in the licensing tree for new advanced technologies.





Overview of Regulatory Development Structure

Advanced Reactor Regulatory Development is one part of the DOE's Advanced Reactor Demonstration Program

- Advanced Reactor Demonstration Projects (funded via DOE's OCED)
- Risk Reduction for Future Demonstrations
- National Reactor Innovation Center
- Advanced Reactor Regulatory Development
- Advanced Reactor Safeguards

Advanced Reactor Regulatory Development then has four major components:

- Regulatory Framework Modernization
- Fast Reactor Regulatory Development R&D
- Molten Salt Reactor Regulatory Development R&D
- Gas Reactor Regulatory Development R&D





Connections to DOE-NE Mission

DOE-NE Mission Advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs.

Mission Goal #2 Enable deployment of advanced nuclear reactors.

ObjectivesReduce risk and time needed to deploy advance nuclear technology.Develop reactors that expand market opportunities for nuclear energy.Support a diversity of designs that improve resource utilization.

Note: Every commercial deployment of an advance reactor will require regulatory engagement by the developer and the facility's owner/operator(s).



Focus, Research, Regulatory Reform, Support Energy Dominance



Unleashing Nuclear Energy

"As global energy demand continues to grow, America must lead the commercialization of affordable and abundant nuclear energy."

Chris Wright | Secretary of Energy



Overview Regulatory Framework Modernization Program

Regulatory Framework Modernization within the Regulatory Development subprogram coordinates with the industry and the NRC to address and resolve key regulatory framework issues that directly impact the "critical path" to advanced reactor demonstration and deployment.

This area focuses on risk-informing and adapting ("modernizing") the regulatory framework for commercial reactor facilities, including:

- Resolving Commission policy issue.
- Developing adaptations of light water reactor (LWR) based regulations for advanced non-LWRs.
- Establishing risk-informed, performance-based NRC license application content and review criteria guidance.
- Establishing risk-informed regulatory approaches for key parts of the plant operations phase.

These program efforts are focused on achieving formal NRC endorsement or approval, where applicable, to ensure these areas of regulatory uncertainty are clearly resolved.

Note: The identification and prioritization of topics address specific regulatory challenges faced by Advanced Reactor Demonstration Program awardees and benefit the broader advanced reactor stakeholder community.



Regulatory Framework Modernization Program efforts eliminated regulatory uncertainties in key areas supporting advanced reactor deployments. Key achievements include:

Licensing Modernization Project (LMP) – NRC endorsed in Regulatory Guide (RG) 1.233

• Established a risk-informed and performance-based approach to advanced reactor design and licensing.

Technology Inclusive Content of Application Project (TICAP) – NRC endorsed in Regulatory Guide 1.253

- Provides guidance to both industry and NRC staff on LMP-based license application content expectations.
- Being utilized by the two DOE-ARDP awardees (TerraPower & X-energy) for commercial licensing.

Further Development of Risk-Informed and Performance-Based (RIPB) Approach

- Technology Inclusive Risk Informed Change Evaluation (TIRICE): Guidance developed for non-LWRs to evaluate facility changes in accordance with 10 CFR 50.59 for licensees using the Licensing Modernization Project approach.
- Technology Inclusive Management of Safety Case (TIMaSC): Project focuses on integrating various activities associated with risk-informed change management for plants with an LMP-based safety case.



Regulatory Framework Modernization: Recent Major Accomplishments

- NEI submitted NEI 24-05 to NRC on July 2, 2024, proposing a new risk-informed risk-informed emergency planning (EP) approach aligned with updated NRC regulations. Initial feedback received during a late 2024 public stakeholder meeting; awaiting written feedback.
- Argonne and X-energy are implementing the risk-informed EP approach for X-energy's design as a test case; NDAs completed.
- Argonne revised draft guidance for low-frequency seismic events based on feedback from NEI's Advanced Reactor Regulatory Task Force; collaborating with EPRI and NEI for next steps and alignment with new 10 CFR Part 53 language.
- Issued "Gaps and Challenges Report" for Molten Salt Reactor liquid fuel qualification in September 2024 to support future license applicants' fuel qualification reports.
- ANL received concurrence from American Nuclear Society (ANS) board for a two-stage approach to update and reissue ANS 54.8, "Liquid Metal Fire Protection in LMR Plants."
- Regulatory Development Integration and Coordination Working Group compiled 10 CFR Part 53 comments to enhance rule flexibility and address security and transportation aspects.





Relationship Between Risk-Informed Design/Licensing Approaches

Licensing Modernization Project: Methodology for establishing a risk-informed, performance-based MP safety case for a non-light water reactor. (NRC Endorsement via RG1.233) NEI 18-04 / RG 1.233 Technology Inclusive Content of Application Project: Documentation of portions of ΓΙCAP the Safety Analysis Report (SAR) content for applicants using LMP. (NRC Approval via RG 1.253) NEI 21-07 / RG 1.253 **Technology Inclusive Risk Informed Change Evaluation:** TIRICE Criteria for determining if prior NRC approval is required for changes for a licensee using LMP and TICAP. (Submitted to NRC under NEI 22-05) **NEI 22-05 Technology Inclusive Management of Safety Case:** Clarity on how to manage portions of the Safety Case (e.g. PRA TIMaSC change control, changes to understanding of plant states. (Ongoing FY25 Activity)



Performance-Based Physical Security Framework - Application Guidance

Guidance for Performance-Based Physical Security Analysis (co-funded with the Advanced Reactor Safeguards and Security (ARSS) Program

- Background: NRC has initiated 2 performance-based physical security rulemakings for Advanced Reactors.
 - Alternative Physical Security Requirements for Advanced Reactors (NRC-2017-0227).
 - 10 CFR Part 53: Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors (NRC-2019-0062).
- Rulemakings provide opportunities for advanced reactor applicants and licensees to use performance-based modeling to justify a physical security system design vs. the traditional prescriptive program minimum requirements.
- Guidance is needed to support applicant submission format and content for regulatory decision-making consistency.

Rulemaking: Alternative Physical Security Requirements for Advanced Reactors



Protecting People and the Environment



Performance-Based Physical Security Framework

Objective: Develop a performance-based framework for the licensing of a physical protection system (PPS) that meets the proposed 73.100 requirements (as part of the Part 53 Rulemaking package).

This framework will allow reactor applicants and licensees to use performance-based approaches rather than traditional prescriptive methods to ensure physical security at commercial nuclear plants.

Key Components of the Framework:

- **Offsite Response**: Credit private or local law enforcement response.
- Security Bounding Time: Adversary interference preclusion time / Reasonable assurance of protection time.
- **Operator Actions**: Allowed operator recovery and mitigating actions.
- Advanced Security Technologies: Incorporate cutting-edge security technologies.
- Security by Design: Integrate security by design methods and alternative protective strategies consistent with advanced and small modular reactors.
- Method for using performance-based elements within a 73.55 licensed physical protection system.



Recent Regulatory News and Actions

NRC Progress with Advanced Reactors



ermit safety			
eview 50%	* <u>Terra Innovatum (SOLO)</u>		
aster than			
he generic chedule goal	* <u>University of Illinois at</u>		
	<u> Urbana-Champaign -</u>		
Ū	NANO Nuclear Energy Inc.		
	X-Energy LLC		
	<u>XE100)</u>		
ADVANCED REACTOR READY *	<u>(XL-100)</u>		
	X-Energy, LLC (XENITH)		
	Inactive Projects - There are		

NRC Current Pre-Application Activity

High Temperature Gas Reactors	Light Water Reactors	Molten Salt Reactors / Molten Chloride Fast Reactors	Sodium Cooled Fast Reactors	Other Designs/ Not Specified	
Energy Northwest	Deep Fission	Abilene Christian University	* ARC Clean Technology	Aalo Atomics	
General Atomics	GE-Hitachi BWRX-300	<u>Kairos Power, LLC</u>	Oklo Inc.	Appalachian Power Company	
<u>General Atomics</u> <u>Electromagnetic Systems</u>	* <u>Last Energy</u>	<u>Natura Resources</u>	<u>TerraPower & GE - Hitachi</u> <u>Natrium</u>	Blue Energy, Inc.	
* Radiant Industries, INC.	SMR, LLC (Holtec)	<u>TerraPower, LLC</u>		Duke Energy - Belews Creek, NC	
* <u>Terra Innovatum (SOLO)</u>	<u>TVA - Clinch River Nuclear</u> <u>Site</u>	<u>Terrestrial Energy USA,</u> I <u>NC.</u>		<u>Japan Atomic Energy</u> <u>Agency</u>	
* <u>University of Illinois at</u> <u>Urbana-Champaign -</u> NANO Nuclear Energy Inc.	Westinghouse AP300			*Shepherd Power, LLC	
<u>X-Energy, LLC</u> (<u>XE-100)</u>				<u>Texas A&M University -</u> <u>RELLIS Campus</u>	
X-Energy, LLC (XENITH)				* Westinghouse eVinci	
Inactive Projects - There are no Inactive Projects at this time					

* Indicates Microreactor Design



Current NRC Applicants, Type, and Status

Abilene Christian University – NRC Licensed Test Reactor (MSR)

• On September 16, 2024, the NRC issued a construction permit for the Molten Salt Research Reactor (MSRR) to ACU.

Kairos Power – NRC Licensed Test Reactors (MSRs)

• On November 21, 2024, the NRC staff issued construction permits to Kairos Power LLC (Kairos) authorizing construction of the two reactors for the Hermes 2 test reactor facility in Oak Ridge, Tennessee.

TerraPower Natrium – Power Reactor Facility (Salt Storage System)

 On May 21, 2024, the staff issued a letter notifying US SFR Owner, LLC (USO), a wholly owned subsidiary of TerraPower, LLC, that the Kemmerer Power Station Unit 1 construction permit application has been accepted and docketed for review.

Long Mott Generating Station – Power Reactor Facility

• On March 31, Long Mott Energy, LLC, a wholly owned subsidiary of The Dow Chemical Company, submitted a construction permit application for the Long Mott Generating Station (LMGS) which would be sited in Calhoun County, Texas. (Long Mott will utilize the X-energy Xe-100 High Temperature Gas-Cooled Reactor.)



ADVANCE ACT Regulatory Impacts

- Establishing a licensing structure to support efficient, timely, and predictable regulatory reviews, with specific efforts focused on licensing at brownfield and retired fossil-fuel electric generating sites and on siting at existing nuclear plant sites (secs. 505, 206 & 207).
- Developing a regulatory framework for microreactors (sec. 208).
- Identifying unique issues related to use of advanced reactors for non-electric applications (sec. 203).
- Evaluating advanced manufacturing techniques to build nuclear reactors better, faster, cheaper, and smarter (sec. 401).
- Qualifying and licensing of advanced nuclear fuel concepts (sec. 404).
- Assessing the licensing framework for mass-manufactured fusion devices (sec. 205).
- Streamlining the environmental review process (sec. 506).





Potential Areas of Interest for DOE RFM Projects in FY-26

Artificial Intelligence in the Regulatory Space

• Advanced Reactor License Applications – Generation and Review

SMR and Micro Reactor Regulatory Development

- Transportation / Factory Fueling / Factory Testing
- NEPA and EPZ Right Sizing
- Aircraft Impact Rule
- Technology-Neutral, Accident Containment-Based Path to Reduce Nuclear Power Costs
- Evaluating the Regulatory Viability of Accelerated Materials Deployment in the Advanced Reactor Design Process

License Transitions

- Part 50/52 transitions to Part 53 ESPs
- Design Certifications to Part 53
- DOE Authorization to NRC License
- NRC Test Reactor to Commercial



Questions

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