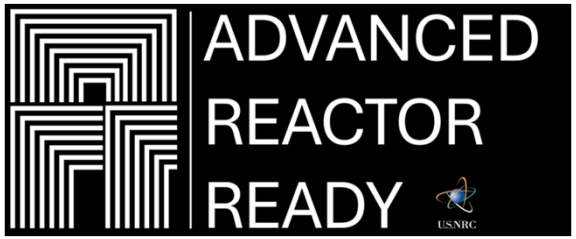
Nth-of-a-Kind Micro-Reactor Licensing and Deployment Considerations

NRC Public Information Meeting

November 6, 2024



https://www.nrc.gov/reactors/new-reactors/advanced.html

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Motivation for this Paper

- Stakeholders have expressed interest in rapid, widespread deployment of micro-reactors of a standard design on timeframes that are significantly shorter than current licensing timeframes.
- The NRC staff is currently in pre-application engagements with micro-reactor developers that are considering a wide range of deployment models with novel aspects such as standardization of operational programs and alternative site characterization.
- The NRC staff is prioritizing development of strategies to provide for the predictable and efficient licensing and regulation of these designs and operational models, and the identification and resolution of associated policy issues.

Background

- For licensing purposes, micro-reactors are commercial power reactors licensed under Section 103 of the Atomic Energy Act of 1954, as amended (AEA).
- Micro-reactors typically use non-light-water reactor technologies, are anticipated to have power levels on the order of several tens of megawatts thermal, small site footprints, low potential consequences in terms of radiological releases, and may have increased reliance on passive systems and inherent characteristics to control power and heat removal.
- Factory-fabricated transportable micro-reactors are a subset of micro-reactors that would rely heavily on standardization and mass production to simplify licensing and deployment.*

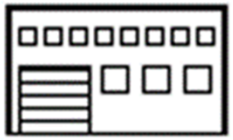
* See SECY-24-0008, "Micro-Reactor Licensing and Deployment Considerations: Fuel Loading and Operational Testing at a Factory," dated January 24, 2024 (ML23207A252).

Background

- For the purposes of this presentation, the term “NOAK micro-reactor” generally means a micro-reactor of a standard design that has been previously approved by the NRC through a design certification (DC), manufacturing license (ML), or final safety analysis report for a first-of-a-kind (FOAK) combined license (COL) or construction permit and operating license (CP/OL).
- NOAK micro-reactor licensing refers to licensing micro-reactors of a standard design for operation as power reactors at fixed sites.

Conceptual Deployment Model for Transportable Micro-Reactors

Factory or Manufacturing Facility



Fabricate the reactor, load fuel, and potentially operate the reactor for functional testing

Transportation to the Deployment Site

Reactors may contain fresh or irradiated fuel

Deployment Site – Power Operation

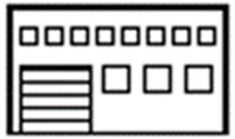
Stand-alone, self-contained micro-reactor design

Core module with onsite reactor building and power conversion equipment

Transportation from the Deployment Site

Reactors may contain spent or irradiated fuel

Decommissioning or Refurbishing Facility



Remove fuel and decommission the reactor, recycle components and systems, or refurbish and refuel the reactor for redeployment

Deployment Lifecycle

NRC Staff Draft White Paper

- Describes regulatory approaches the NRC staff is developing for consideration by the Commission related to two topics:
  1. Approval of standardized operational programs
  2. Alternative approaches for environmental reviews
- Includes Enclosure 3 with information on other topics related to licensing and deployment of NOAK micro-reactors
- The draft white paper and enclosures are available at:
  - Draft White Paper on Nth-of-a-Kind Micro-Reactor Licensing and Deployment Considerations (ML24268A310)
  - Enclosure 1 (ML24268A314), "Standardization of Operational Programs for Nth-of-a-Kind Micro-Reactors"
  - Enclosure 2 (ML24302A292), "Environmental Reviews for Nth-of-a-Kind Micro-Reactors"
  - Enclosure 3 (ML24268A317), "Technical, Licensing, and Policy Considerations for Nth-of-a-Kind Micro-Reactors"

Anticipated Licensing Strategy

- Phase 1: Robust upfront approval of a standard design
  - Approval of a maximally standardized design in a DC, ML, COL, or CP/OL
  - Approval of standardized operational programs, to the extent practicable
  - Completion of a generic environmental review, to the extent practicable
  - Completion of hearings covering the standard design
- Timeframes will vary based on the licensing pathway and reactor design and are bounded by the generic milestone schedules established by the NRC in response to the Nuclear Energy Innovation and Modernization Act of 2019 (NEIMA).

Anticipated Licensing Strategy

- Phase 2: NOAK licensing leveraging the upfront approvals
  - Streamlined administrative processes
  - NRC staff safety and security reviews focusing on confirmation of site suitability
  - NRC staff site-specific environmental review that applies the upfront generic environmental review, as appropriate*
  - Confirmatory inspections at the place of fabrication and deployment site, as appropriate
  - Verification of completion of inspections, tests, analyses and acceptance criteria (ITAAC) for a COL or confirmation of compliance with license conditions for a CP/OL and conduct of readiness for operation inspections
  - Completion of site-specific hearings

Regulatory Approaches for Review of Standardized Operational Programs

- Current Commission policy does not support review and approval of the operational requirements (i.e., parts or aspects of operational programs) in the context of DC or ML application review beyond those that are material to the finding on the safety of the design.
  - Advanced Boiling Water Reactor (Volume 62 of the FR, page 25806 (62 FR 25806)) discusses that the operational requirements were not accorded finality because the operational matters were not comprehensively reviewed and finalized for the DC.
- The NRC staff anticipates that most operational programs for a specific micro-reactor design could be standardized by an applicant for a DC or ML to support NRC review and approval.
- This would support a streamlined review of a COL or CP/OL application that referenced the approved operational programs.

Regulatory Approaches for Review of Standardized Operational Programs

- The NRC staff is exploring approaches to review operational matters at the design approval stage (ML or DC) for a standard micro-reactor design
  - Option 1 (O1): Status quo
    - Currently staff can review and approve operational programs through topical reports or the design-centered review approach
  - Option 2 (O2): Review and approval of operational programs proposed in a DC or ML application
    - An applicant would have the option to provide proposed measures to satisfy operational programs as part of a DC or ML application
    - Assuming the proposed measures are fully described and constitute an essentially complete program such that staff could make a safety finding, and that the staff comprehensively reviewed the proposed measures, this would provide additional regulatory stability for those programs when referenced by COL or CP/OL applicants

Regulatory Approaches Considered for Environmental Reviews

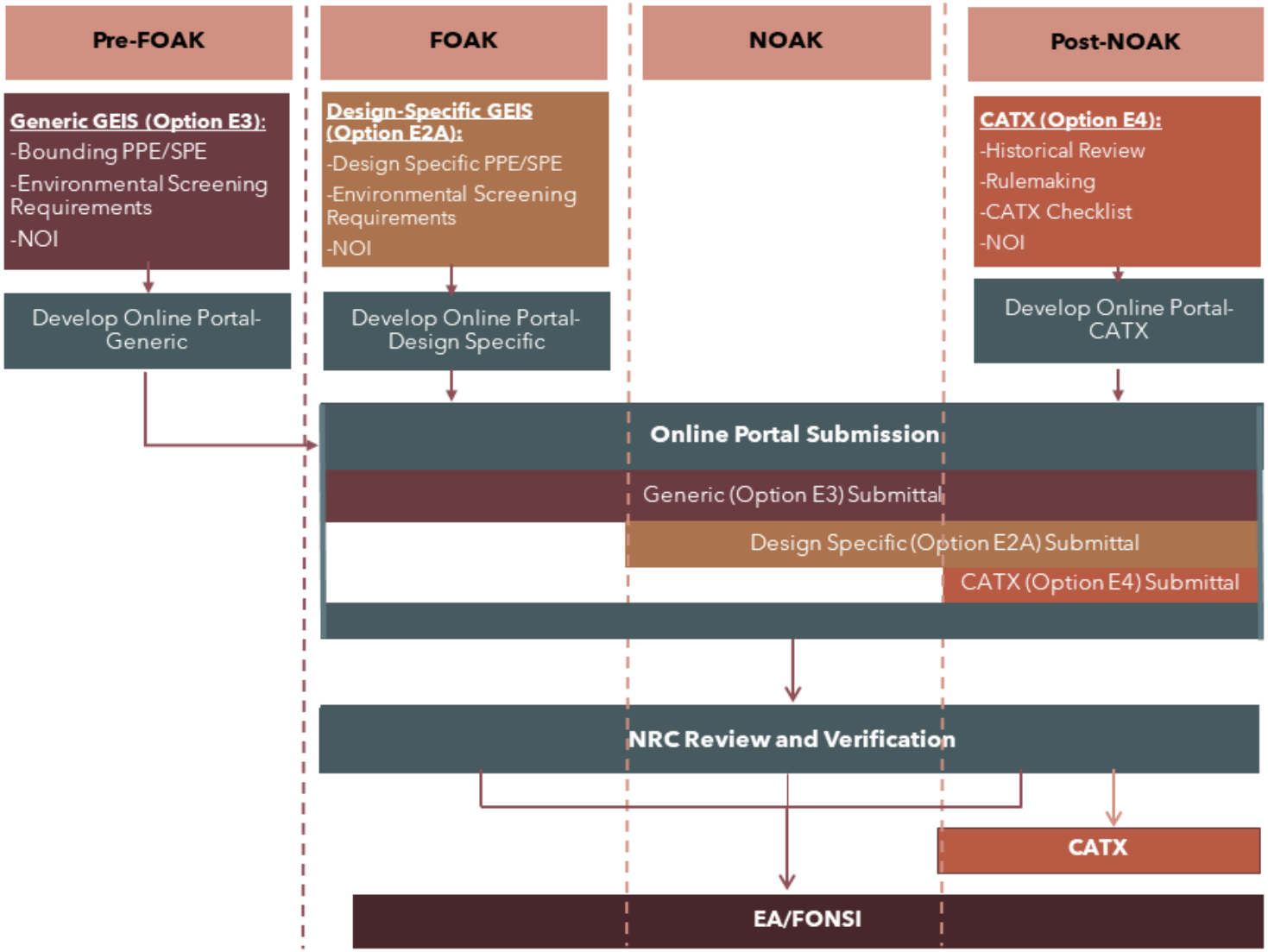
- The current regulatory process is to perform an environmental impact statement (EIS) for nuclear power reactors (Option E1).*
- The NRC staff is considering options for environmental reviews for micro-reactors.
- Any EIS, generic environmental impact statement (GEIS), or environmental assessment (EA) under any option could be tiered from the New Reactor GEIS (NUREG-2249) once final.

* See SECY-24-0046, "Implementation of the Fiscal Responsibility Act of 2023 National Environmental Policy Act Amendments" (https://www.nrc.gov/docs/ML2407/ML24078A013.html), for discussion of the current process for environmental reviews and potential changes related to the Fiscal Responsibility Act of 2023.

Regulatory Approaches Considered for Environmental Reviews

Option	Environmental Review for First-of-a-Kind	Environmental Review for Nth-of-a-Kind
E2A - Design-Specific GEIS	• GEIS or • Generic EA w/ Exemptions	• Supplemental EA tiered from FOAK GEIS or EA
E2B - Expanded Environmental Reviews for MLs and DCs	• EIS or • EA with Exemptions	• Supplemental EA tiered from FOAK EIS or EA
E3 - Micro-reactor Online Environmental Review Portal	• EIS or • EA with Exemptions • Develop Online Portal	• Applicant supplies site-specific data into Online Portal • NRC develops EA tiered from First-of-a-kind EIS/EA or from New Reactor GEIS based on applicant submission on Portal
E4 - Design-Specific Categorical Exclusions (CATX)	• EIS or • EA with Exemptions • Develop CATX and Checklist	• Applicant supplies site-specific data using Checklist • NRC determines if CATX applies

Regulatory Approaches for Environmental Reviews



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Maximal Design Standardization

- The regulations in 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants,” provide several regulatory pathways for design standardization, including manufacturing licenses, design certifications, and standard design approvals, under which most safety issues would be resolved.
- Maximal standardization would involve approval of a standardized micro-reactor design and subsequent deployment under a COL or CP/OL without any significant departures from the standardized design.
- Maximal design standardization could allow micro-reactors of a standard design to be deployed to most sites in the U.S. with minimal need for site-specific features or the associated additional NRC reviews and approvals.

Grading the Level of Site Characterization

- A standardized design for a micro-reactor could establish bounding parameters for site characteristics that are important to the safety review so that micro-reactors of the standard design could be deployed at suitable sites throughout most of the U.S.
- The NRC staff is considering approaches for grading the level of site characterization for micro-reactors of a standard design (and potentially other reactors) based on the applicable hazards for the specific micro-reactor design, the amount of margin included in the design for each bounding site parameter, and the amount of margin to appropriate dose reference values.
- A graded approach could focus on how a construction permit or combined license applicant can provide the required site characterization information and demonstrate that the bounding parameters are met for the candidate site.

Deployment Site Emergency Preparedness

- The existing regulations for emergency preparedness in 10 CFR Part 50, “Domestic licensing of production and utilization facilities,” and 10 CFR Part 52 apply to licensing micro-reactors of a common design.
- 10 CFR 50.160 provides an alternative risk-informed and performance-based EP framework that can be used by micro-reactors.
- The NRC staff is exploring approaches for streamlining the review of emergency preparedness for licensing NOAK micro-reactors considering that potential accidents may result in low doses at the site boundary and, under certain circumstances, might not require extensive off-site response. Acceptable siting criteria could potentially be described and bounded for certain reactor designs allowing for more efficient licensing of NOAK micro-reactors.

Deployment Site Security

- The existing requirements for security apply to licensing micro-reactors of a common design, including various regulations in 10 CFR Part 73, “Physical Protection of Plants and Materials.”
- The NRC has ongoing activities that would apply to micro-reactors, such as those associated with SECY-22-0072, “Proposed Rule: Alternative Physical Security Requirements for Advanced Reactors” (https://www.nrc.gov/docs/ML2133/ML21334A003.html), and SECY-23-0021, “Proposed Rule: Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors” (https://www.nrc.gov/docs/ML2116/ML21162A093.html).
- The NRC staff is considering additional approaches for streamlining the review of security for licensing NOAK micro-reactors, including the possibility to standardize operational aspects of security, to the extent practical.

Streamlined Processing of License Applications and Licensing Documents

- Licensing applications referencing an approved micro-reactor design that leverages maximal design standardization will likely be nearly identical, with some possible minor variations related to licensee-specific or site-specific information.
- NRC-generated licensing documents, such as the NRC staff safety and environmental evaluations, license, and required Federal Register notices, will likely be very similar for licensing each individual micro-reactor of a standard design, with appropriate variations to reflect site-specific considerations.
- The NRC staff is considering approaches for using electronic licensing forms, licensing document templates, and automation to streamline processing and review of micro-reactor applications to reduce the timeframes for acceptance review, docketing, safety review, environmental review, concurrence, license issuance, and other steps.

Construction Inspection

- Micro-reactors of a common design might be “self-contained” in that they would be almost entirely fabricated at a factory and require minimal site preparation or construction activities at the deployment site, or they might consist of a “core module” that is fabricated in a factory and then incorporated into or connected to permanent structures and systems constructed at the deployment site, such as a reactor building and power conversion equipment.
- In either case, it will be necessary for the NRC staff to verify completion of ITAAC in support of a finding for authorization to operate under 10 CFR 52.103(g) or to verify substantial completion of construction for issuance of an operating license under 10 CFR 50.56 and 50.57(a)(1).
- As discussed in SECY-23-0048*, the NRC staff is considering approaches for risk-informed and performance-based inspections at both the fabrication facility and deployment site that can be completed within the expected timeframes for licensing and deployment of NOAK micro-reactors.

*SECY-23-0048, "Vision for the Nuclear Regulatory Commission's Advanced Reactor Construction Oversight Program" (ML23061A086)

Stakeholder Engagement

- Public advanced reactor stakeholder meetings in December 2023 and March and July 2024
  - Favorable feedback from stakeholders on the scope of the paper and the options developed by staff
  - Anticipated engagement on guidance for implementation of Commission direction
- Public meetings with various micro-reactor developers and stakeholders
- Nuclear Energy Institute (NEI) proposal paper, “Regulations of Rapid High-Volume Deployable Reactors in Remote Applications (RHDRA) and Other Advanced Reactors” (ML24213A337) dated July 31, 2024
- Public meeting November 6, 2024, on the NRC staff’s draft white paper

Next Steps

- Develop a Commission paper on NOAK micro-reactor licensing and deployment considerations:
  - Request Commission direction on regulatory approaches for standardizing operational programs
  - Request Commission direction on options for alternative environmental reviews
  - Provide information on other topics related to NOAK micro-reactor licensing

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