NRC Staff Draft White Paper on Licensing and Deployment Considerations for Factory-Fabricated Micro-Reactors

September 11, 2023

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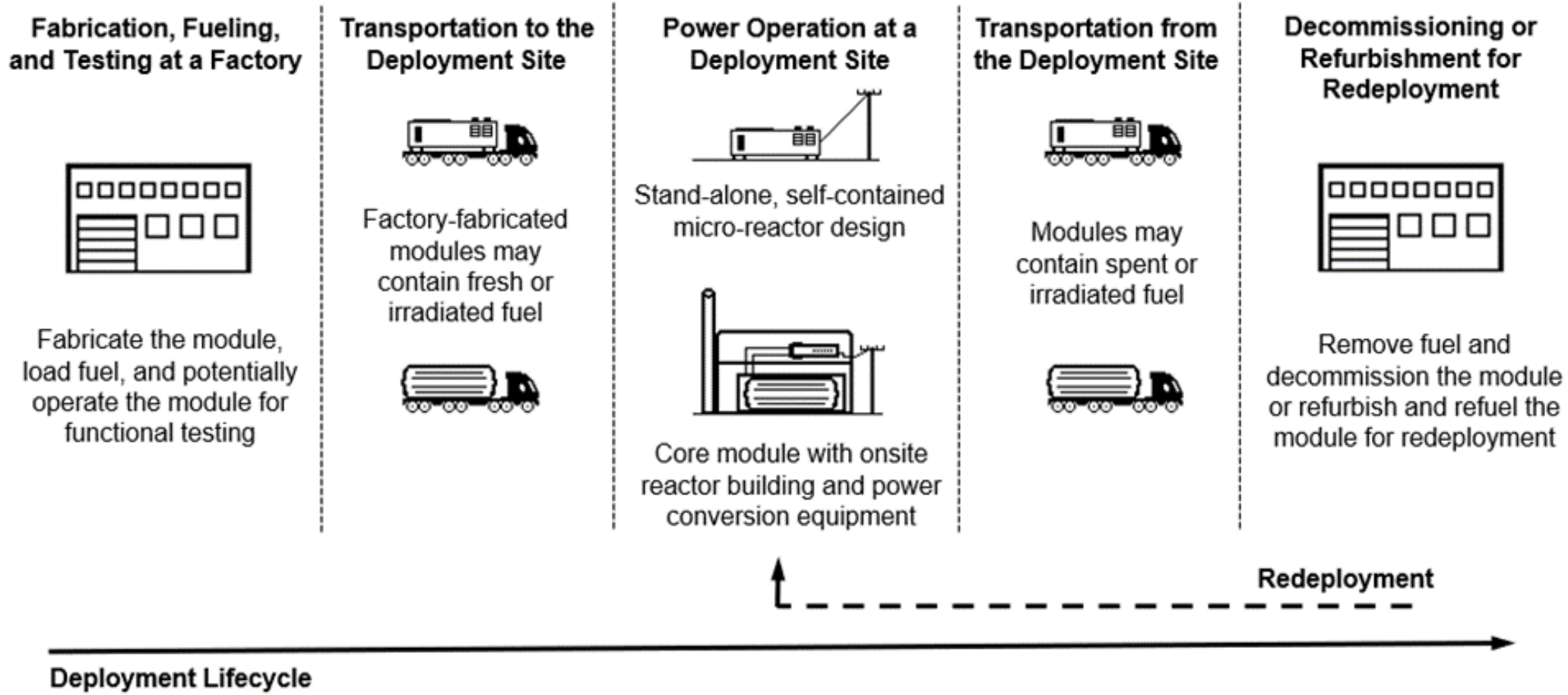
NRC Staff Draft White Paper

- Describes regulatory approaches the NRC staff is developing for consideration by the Commission related to three topics:
  1. Features to preclude criticality
  2. Fuel loading at a factory
  3. Operational testing at a factory
- Includes an enclosure with information on other licensing and deployment topics and potential near-term strategies and next steps the NRC staff is considering
- The draft white paper and enclosure are available at:

  Draft White Paper on Factory-Fabricated Micro-Reactor Licensing and Deployment Considerations (ML23236A598)

  Enclosure to the Draft White Paper on Factory-Fabricated Micro-Reactor Licensing and Deployment Considerations (ML23236A597)

Conceptual Deployment Model for Factory-Fabricated Micro-Reactors



Regulatory Approaches for Features to Preclude Criticality

- The NRC staff is developing approaches for features to preclude criticality for consideration by the Commission
  - Features to preclude criticality would make a factory-fabricated micro-reactor incapable of sustaining a nuclear chain reaction under any conditions
  - The Commission's historical position has been that operation of a reactor includes the loading of fuel and a reactor would be "in operation" when loaded with fuel regardless of whether features to preclude criticality are installed
  - The staff is considering an approach in which a factory-fabricated module that included features to preclude criticality would not be "in operation" when loaded with fuel and operation would begin with the removal of those features

Regulatory Approaches for Fuel Loading at a Factory

- The NRC staff is developing approaches for licensing fuel loading at a factory under the existing regulations for consideration by the Commission:
  - Facility operating license issued pursuant to 10 CFR Part 50 or a combined license issued pursuant to 10 CFR Part 52 that limits operation to fuel loading
  - Manufacturing license for manufacture and possession of the utilization facilities and a license to possess special nuclear material issued pursuant to 10 CFR Part 70 with provisions for the utilization facilities to include features to preclude criticality

Regulatory Approaches for Operational Testing at a Factory

- The NRC staff is developing approaches for licensing operational testing at a factory under the existing regulations for consideration by the Commission:
  - Facility operating license issued pursuant to 10 CFR Part 50 or a combined license issued pursuant to 10 CFR Part 52 that limits operation to that needed for operational testing
  - Facility operating license issued pursuant to 10 CFR Part 50 *based on the regulations for non-power reactors*, that limits operation to that needed for operational testing

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Considerations related to initial fuel load and authorization to operate at the deployment site for reactors that arrive pre-loaded with fuel

- Deployment strategies that include loading fuel or operational testing at a manufacturing facility would result in fueled reactors arriving at the deployment site
- Several requirements in the Atomic Energy Act of 1954, as amended (AEA), and 10 CFR Parts 50 and 52 that are related to public notifications, the opportunity for hearing, authorization to operate the facility, and others are premised on fuel being initially loaded at the deployment site
- The NRC staff is considering whether there is a suitable alternative to “initial loading of fuel” at the deployment site that could be used as an alternate milestone and would accomplish the underlying purpose of the AEA and regulations

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Timeframe for authorization to operate at the deployment site

- Factory-fabricated micro-reactors may have significantly simpler and shorter construction activities at the deployment site compared to large light water reactors and could be ready to begin operation in days to weeks to a few months after obtaining a construction permit or combined license
- Several requirements in the AEA and 10 CFR Part 50 and Part 52 that are related to the environmental review, the schedule for intended operation, public notifications, the opportunities for hearing, authorization to operate the facility, and others include timeframes that could add up to many months in total
- For licensing under 10 CFR Part 52, the NRC staff plans to clarify the circumstances under which the schedule for intended operation and initial fuel load can be accelerated and is considering ways to streamline public notifications, hearings, and the authorization to operate, as appropriate
- For licensing under 10 CFR Part 50, the NRC staff is considering opportunities to expedite steps in the processing and review of applications for facility operating licenses, such as acceptance review and docketing, milestones for hearings, and the supplement to the environmental impact statement

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Licensing replacement reactors

- Factory-fabricated micro-reactors might be periodically replaced with reactors of the same design at the end of their lives or fuel cycles, and each reactor would be required to have its own combined license or facility operating license
- A licensee might have multiple fueled reactors on site in various states of operation and shutdown to allow for transition from the operating reactor to the replacement reactor with minimal downtime. This would need to be considered in the safety and environmental reviews
- The NRC staff previously addressed similar concepts and considered licensing options for multi-module facilities in SECY-11-0079, “License Structure for Multi-module Facilities Related to Small Modular Nuclear Power Reactors,” dated June 12, 2011 (ADAMS Accession No. ML110620459)
- The NRC staff is considering approaches under 10 CFR Part 50 and Part 52 where the construction permit application or combined license application would cover all reactors envisioned to be operated at the deployment site and each reactor would be authorized to begin operation under its own facility operating license or combined license once the Commission had made the required findings

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Autonomous and remote operations

- Proposed designs for factory-fabricated micro-reactors (and potential designs for other types of reactors) might include autonomous and remote operational characteristics to reduce the number of operators and other categories of personnel at the facility site
- As previously noted in SECY-20-0093, “Policy and Licensing Considerations Related to Micro-Reactors,” dated October 6, 2020 (ADAMS Accession No. ML20129J985), both autonomous and remote operations raise potential policy-related matters
- The NRC staff plans to further develop its understanding of the industry deployment models for factory-fabricated micro-reactors with respect to industry plans for remote and autonomous operations, identify any gaps in the existing human factors engineering review needed to address the deployment models, and develop the technical bases for any new guidance that may be needed

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Transportation of fueled reactors

- Factory-fabricated micro-reactor developers (and potentially developers of floating nuclear power plants that use reactors with higher power levels) envision transporting fueled reactors from a fabrication site or a refurbishment and refueling facility to the deployment site for operation and later removing fueled reactors from the deployment site at the end of their useful lives or fuel cycles
- Transportation packages for factory-fabricated micro-reactors may consist of the reactor itself or the reactor plus additional overpack, as needed. Packages for transporting a micro-reactor from the factory to the deployment site could be either a Type A fissile (Type AF) or Type B fissile (Type BF) package, as defined in 10 CFR Part 71
- The NRC staff intends to use the existing regulatory framework (primarily 10 CFR Part 71) to review transportation of fueled commercial micro-reactors in the near term, which may include the use of the alternate test criteria in 10 CFR 71.41(c), the special package authorization option in 10 CFR 71.41(d), or exemptions, as appropriate

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Storage of fuel after irradiation in a power reactor

- Depending on the duration between withdrawal of the fuel from the reactor (or the final reactor shutdown) and placement into a dry storage facility, different regulations may apply to the storage of the reactor fuel
- The definition of spent fuel in 10 CFR 72.3 includes criteria that the fuel has been withdrawn from a nuclear reactor following irradiation and has undergone at least one year's decay since being used as a source of energy in a power reactor
- In order to store irradiated power reactor fuel that had been withdrawn from a reactor for less than a year in an independent spent fuel storage installation, the licensee would be required to apply for a specific license under 10 CFR Part 72 and request and justify exemptions addressing the one-year decay time requirement in the regulations
- The NRC staff intends to engage with stakeholders as they further develop their strategies for handling and storage of irradiated and spent fuel generated in factory-fabricated micro-reactors

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Decommissioning process and decommissioning funding assurance

- Factory-fabricated micro-reactor deployment models might involve transporting a reactor away from the deployment site to a facility at a different location for decommissioning at the end of its life or for refurbishment and refueling before re-deployment
- Depending on the activities to be conducted at a decommissioning facility or a refurbishment and refueling facility, the facility may need to be licensed under a combination of the regulations in 10 CFR Part 30 for byproduct material, Part 50 or 52 for a facility operating license or combined license, Part 70 for special nuclear material, and Part 72 for spent fuel storage
- The deployment site licensee would need to establish decommissioning funding assurance that considers the cost of removing the reactor from the site and decommissioning it elsewhere in addition to the cost of decommissioning activities at the deployment site. The NRC staff may consider site-specific decommissioning cost estimates that appropriately account for all activities at both locations and all waste disposal costs

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Siting in densely populated areas

- Some micro-reactor license applicants might seek to site reactors at locations that are inconsistent with the current Commission policy and the regulations in 10 CFR 100.21(b), i.e., a location within a population center of 25,000 residents or more
- The NRC staff is currently revising the population-related siting guidance in Regulatory Guide (RG) 4.7, “General Site Suitability Criteria for Nuclear Power Stations,” Revision 3, issued March 2014 (ADAMS Accession No. ML12188A053) to provide technology-inclusive, risk-informed, and performance-based criteria to assess certain population-related issues in siting advanced reactors
- In the near term, the staff will continue its effort to revise RG 4.7 and will review license applications in accordance with current Commission policy that allows alternative population-related criteria but precludes siting a commercial power reactor, no matter the size or type of reactor, within a population center of 25,000 residents or more

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Commercial maritime applications

- The NRC staff is aware of growing interest in commercial maritime applications of factory-fabricated micro-reactors and other reactor technologies for stationary power production, marine vessel propulsion, production of decarbonized fuels, and other uses
- Depending on the particular application, deployment of commercial maritime reactors could introduce a host of policy issues and legal matters, especially for nuclear propulsion in the international shipping industry
- The NRC staff will continue to engage with stakeholders and monitor developments related to commercial maritime applications and assess the need for future Commission direction

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Commercial space applications

- The NRC staff is aware that developers are considering space applications of factory-fabricated micro-reactors. However, the NRC staff is not aware of any plans for fully commercial space applications
- In the case of a fully commercial space application of a factory-fabricated micro-reactor, the NRC's established regulatory jurisdiction and licensing authority would cover the related terrestrial activities prior to launch activities, which would be under the authority of the Federal Aviation Administration's Office of Commercial Space Transportation (a part of the Department of Transportation)
- If developers engage the NRC staff on terrestrial activities related to commercial space applications of factory-fabricated micro-reactors, the NRC staff intends to apply the established regulatory framework, as informed by the potential licensing approaches and strategies outlined in this presentation

Other Licensing and Deployment Topics and Potential Near-Term Strategies and Next Steps

Commercial mobile applications

- Factory-fabricated micro-reactor deployment models might include scenarios where the reactor would be operated on an as-needed, where-needed basis, such as for disaster relief or to meet temporary increases in demand
- The current regulatory framework for reactor licensing is not conducive to this deployment strategy because the regulations in 10 CFR Part 100 apply to every site at which a reactor may be operated, and NRC's implementation of the National Environmental Policy Act relies on performing an environmental review that contemplates a particular site
- The AEA and regulations in 10 CFR Parts 50 and 52 for licensing utilization facilities also require opportunities for public hearings before the Commission can issue a facility operating license or authorize operation under a combined license. These may take a minimum of several months to complete, limiting the ability to rapidly deploy a reactor to meet immediate, short-term needs
- The NRC staff will monitor developments in the commercial sector related to deployment models and the demand for commercial mobile micro-reactor licensing. The staff will assess the need for future Commission direction and rulemaking in this area

Next Steps

- Develop a Commission paper on licensing and deployment considerations for factory-fabricated micro-reactors:
  - Request Commission direction on “features to preclude criticality”
  - Request Commission direction on regulatory approaches for loading fuel and operational testing at the factory
  - Provide information on other topics, including the NRC staff’s related near-term strategies and next steps

Questions and Answers

Attendees may ask questions of the NRC staff or make comments about the issues discussed throughout this meeting; however, the NRC is not actively soliciting comments towards regulatory decisions at this time