Fuel and Waste Considerations for Small Modular Reactors and Advanced Reactors

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Overview

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- NRC advanced reactor program
- Examples of SMR designs – LWR and non-LWR
- Overall regulatory framework
- Considerations regarding fuel and waste for LWR and non-LWR designs
- Conclusions

Advanced Reactor Program

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- There is domestic and international interest in the possible licensing, construction, and operation of small modular reactors (SMRs)
- There are designs for both light-water and non-light water advanced reactors
- All of the designs will likely propose unique features or approaches
- The Commission has directed the staff to think expansively and engage stakeholders early with respect to SMRs

Generation mPower

http://www.babcock.com/products/Pages/mPower-Reactor.aspx

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- 180 MWe modules
- Integral nuclear system design
- Passive safety systems
- Underground containment
- Four-year operating cycle between refueling
- Less than five percent enriched uranium
- North American shop-manufactured

NuScale Power Inc.

http://www.nuscalepower.com/

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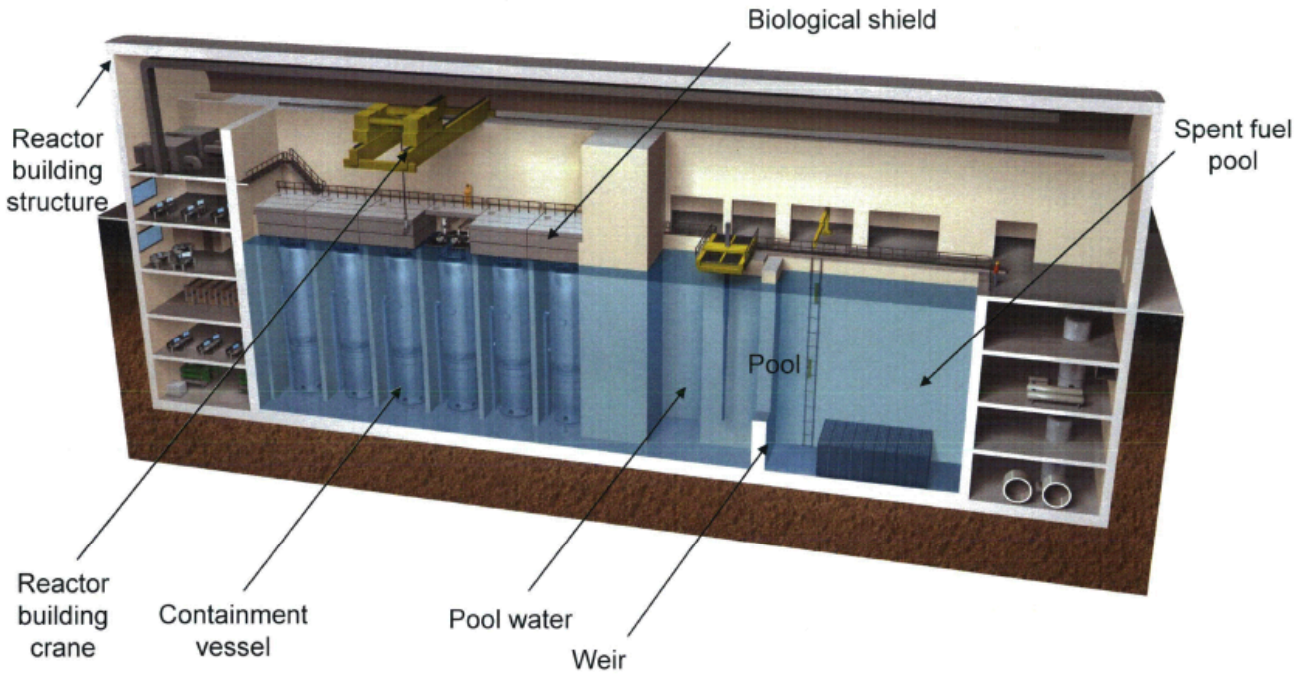
Reactor Building

Reactor building houses reactor modules, spent fuel pool, and reactor pool



- Each module installed in own isolated bay – up to 12 modules
- Natural circulation – normal and post accident (no reactor coolant pumps; no emergency core cooling pumps)
- 37 standard 17x17 PWR fuel assemblies (half height)
- Internal helical steam generator and pressurizer
- 45MWe net power/module

Examples of Non-Light Water Reactor Designs

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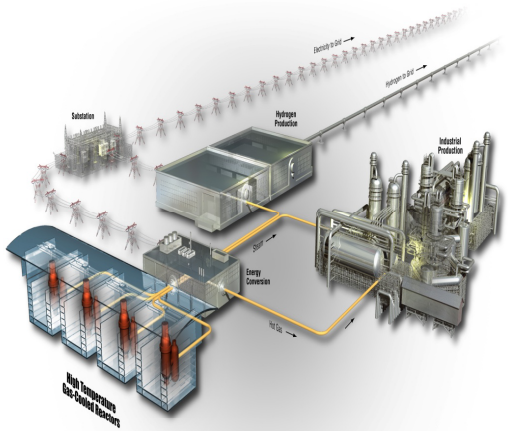
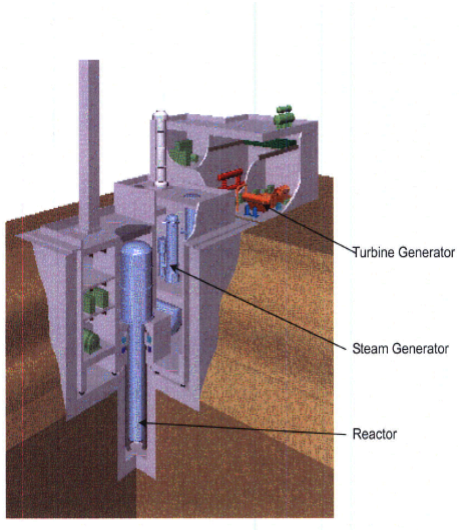
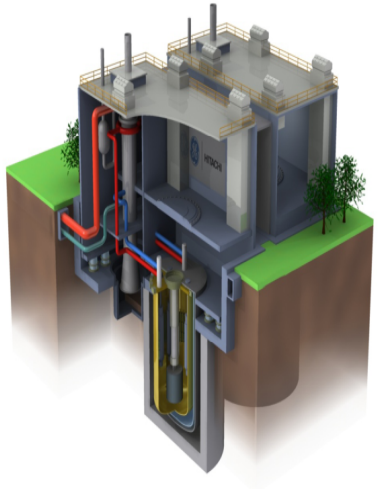
High Temperature Gas-Cooled Reactors (HTGRs)



Liquid Metal Reactors



4S (Super-Safe, Small and Simple)



PRISM (Power Reactor Innovative Small Module)

Licensing Process

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Licensing process, criteria and basic requirements for SMRs:

- Same licensing process as currently used
  - One-step (Part 52) or two-step (Part 50)
- Criteria and basic regulatory requirements will not change
  - Applicants may request exemptions if justified
- Developing specific review guidance for the designs

Examples of Sections in Review Guidance for SMRs

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- Chapter 11: Radioactive Waste Management
- Section 9.1.2: New and Spent Fuel Storage
- Appendix to Section 11.4: Design Guidance for Temporary Storage of Low-Level Radioactive Waste

Fuel for LWR SMRs

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- UO_2 fuel with shorter assemblies for most light-water SMR designs
- Approach will likely be the use of spent fuel pools followed by dry storage
- May require transportation and cask vendors to revise their designs due to differences in size
- Existing NRC guidance can likely be used because no substantively unique features.

Radwaste for LWR SMRs

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- Expected that composition of low-level wastes will be similar to large LWRs
- Have not seen specific waste evaluations or estimates yet
- 10 CFR 61 regulations and guidance would apply

Fuel for non-LWRs

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- New fuel types for non-LWR technologies may include:
  - Higher enrichment (e.g., 19%)
  - Different fuel forms (e.g., pebbles)
- Will likely require design, licensing, and construction of new types of fuel fabrication facilities
- Will likely require transportation and cask vendors to revise their designs, or develop completely new designs
- New research and new computer models may be needed to support assumptions made about fuel and spent fuel characteristics and behavior
- Modifications may be needed to NRC regulations

Radwaste for non-LWRs

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- May generate unique waste streams that are very different from LWRs
- Have not seen information regarding waste composition or forms
- Have not seen waste management or disposal approaches (e.g., would pebble fuel be placed in a pool?)
- In general, 10 CFR 61 applies to all low-level radioactive waste disposal licensees and therefore would likely apply to non-LWR waste
- NRC staff would assess its regulations and guidance to ensure they are adequate to protect public health and safety for non-LWR fuel and waste

Conclusions

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- In general, NRC expects that current regulations are broad enough that they can be applied to waste from light-water SMRs. Changes may be needed for non-LWR designs but it is too early to say for sure.

- We encourage developers to consider the waste streams that may be generated by their designs to provide early identification of any unique issues, and to consider both the front-end and back-end of the fuel cycle for their designs. There is likely a mixture of technical and policy issues that could become challenges for deployment of these technologies if the issues are not addressed early.

- The NRC will evaluate estimated waste streams to confirm that their management is conducted in such a way to protect public health and safety.

Back-Up Slide: NRC Thinking on SMRs

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- **SECY-10-0034**: Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs
- **SECY-11-0024**: Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews
- **SECY-11-0079**: License Structure for Multi-module Facilities Related to Small Modular Nuclear Power Reactors
- **SECY-11-0098**: Operator Staffing for Small or Multi-module Nuclear Power Plant Facilities
- **SECY-11-0112**: Staff Assessment of Selected Small Modular Reactor Issues Identified in SECY-10-0034
- **SECY-11-0152**: Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors
- **SECY-11-0178:** Insurance and Liability Regulatory Requirements for Small Modular Reactor Facilities
- **SECY-11-0181**: Decommissioning Funding Assurance for Small Modular Nuclear Reactors
- **SECY-11-0184**: Security Regulatory Framework for Certifying, Approving, and Licensing Small Modular Nuclear Reactors
- **Commission Memo**: Status of Staff Activities to Address Mechanistic Source Term Methodology (12/29/11)
- **Commission Memo**: Staff Assessment of the Manufacturing License Requirements Issue for Small Modular Reactors (3/27/13)
- **Commission Memo**: Current Status of the Source Term and Emergency Preparedness Policy Issues for Small Modular Reactors (5/30/13)
- **Commission Memo**: Update Regarding Recommendations for Use of Risk Insights for Small Modular Reactor Reviews (1/30/14)