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Leveraging Non-Power Reactors to Support Advanced Reactor Licensing

Steven Lynch
Non-Power Production and Utilization Facility Licensing Branch
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
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Classes of Non-Power Reactors

- Pursuant to the Atomic Energy Act (AEA), the U.S. Nuclear Regulatory Commission (NRC) licenses production and utilization facilities
- All currently operating reactors, both power and non-power, licensed as utilization facilities
- Two classes of non-power reactor licenses under the AEA:
  - Commercial Licenses (Section 103)
  - Medical Therapy and Research and Development Licenses (Section 104)

Commercial Licenses

- A commercial license is issued to utilization facilities that meet the following criteria of the AEA and the NRC's regulations, respectively:
  - The licensee recovers more than 75 percent of the annual costs of owning and operating the facility through sales of nonenergy services, energy, or both, other than research and development or education and training, and recovers more than 50 percent of annual costs through sales of energy to others, and
  - The licensee devotes more than 50 percent of the annual cost of owning and operating to sale of materials, products, energy, or services
- Examples of commercial non-power facilities, include:
  - Medical radioisotope facilities proposing to produce molybdenum-99 using production and utilization facilities
  - Prototype plants

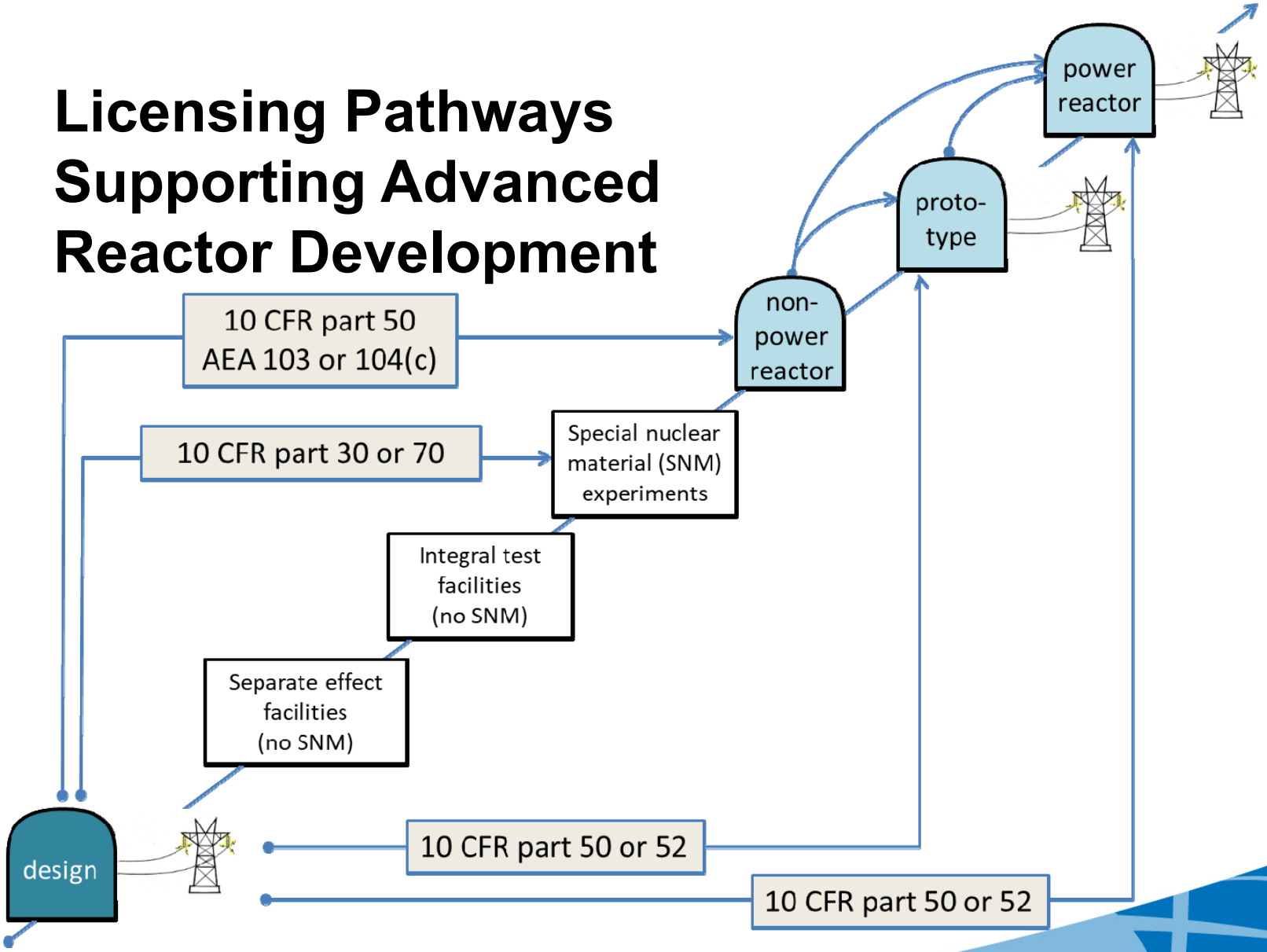
Research and Development Licenses

- All NRC-licensed non-power reactors (also known as research and test reactors) are licensed under Subsection 104(c) of the AEA for research and development activities
  - Research and test reactors must be useful in the conduct of research and development activities specified in Section 31 of the AEA
- AEA directs Commission to impose minimum amount of regulation of 104(c) licensees necessary to fulfill Commission's obligations
- NRC licenses research and test reactors under regulations in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities"

Supporting Advanced Reactor Development

- Designers may choose to construct and operate a small facility, such as a research or test reactor, prior to a full scale commercial facility based on factors such as data needs, cost, safety, and time
- Data obtained from a research or test reactor could be used to fulfill the testing requirements of 10 CFR 50.43(e) during subsequent application for a license, approval, or certification for a prototype or commercial reactor
- Any data obtained using a research and test reactor and subsequently used to support a commercial nuclear power plant design would need to meet quality assurance requirements set forth in 10 CFR Part 50 Appendix B

Licensing Pathways Supporting Advanced Reactor Development



Testing Supported by Non-Power Reactors

Capabilities of structures, systems, and components demonstrated through a combination of testing, operating experiences, and operational programs, including:

- Separate Effects Tests
  - Demonstrate adequacy of physical models to predict physical phenomena
- Integral Effects Tests
  - Demonstrate interactions between different phenomena and system components and subsystems identified and predicted correctly
- Fuel and Materials Qualification Tests
  - Demonstrate adequacy of performance of fuel and materials under operational conditions
- Pre-operational Tests
  - Demonstrate capability of structures, systems, and components to meet performance requirements and design criteria
- Initial Startup Tests
  - Demonstrate that the facility will operate in accordance with its design and is capable of responding as designed to anticipated transients and postulated accidents

Prototype Plants and Commercial Licensing

- A prototype plant is defined as nuclear reactor or power plant used to test design features or new safety features, such as the testing required under 10 CFR 50.43(e)
  - May be similar to, and can be, a first-of-a-kind or standard design in all features, and size, but may include additional safety features
  - May be used in place of or as an evolution of a research or test reactor to test new or innovative design features and to validate integral system models to support future commercial reactor designs
- To satisfy 10 CFR 50.43(e) testing requirements, prototype plants if either of the following conditions are met:
  - Applicant can demonstrate performance of each safety feature, considers interdependence of effects among safety features, and has sufficient data on safety features, or
  - Applicant uses prototype plant to fulfill testing requirements with certain operational restrictions

Non-Power Reactor Licensing Process

- Non-power reactors must receive both a construction permit and operating license
- Applications contain both general and technical information
- Construction permit application
  - Environmental report
  - Preliminary safety analysis report (PSAR)
- Operating license application
  - Update to environmental report, as necessary
  - Final safety analysis report (FSAR)
- Applications may be submitted separately or together
- Testing facilities and commercial facilities may request limited work authorization to allow certain construction activities prior to the issuance of a construction permit

NRC Safety Review Methodology

- Safety reviews for construction permit and operating license applications conducted in accordance with Commission's regulations
- The level of detail needed in a construction permit application and NRC staff's safety evaluation report different than for combined operating license or operating license
  - The PSAR includes preliminary design of the facility, while the FSAR includes final design of the facility, as well as plans and programs not provided in PSAR
- Staff's reviews tailored to design and safety significance of the technology using appropriate regulatory guidance
  - NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"
  - Interim Staff Guidance Augmenting NUREG-1537
  - Other guidance (e.g., regulatory guides and industry standards) and engineering judgment used, as appropriate

Preparing for Future Licensing Reviews

- With assistance from Oak Ridge National Laboratory, NRC staff is adapting NUREG-1537 to provide new guidelines for preparing and reviewing an application for a molten salt reactor
  - Updated guidance may also include considerations for power conversion systems
- Similar guidelines could be prepared in the future for other advanced reactor technologies licensed as research or test reactors
- In October 2019, NRC staff published a draft white paper providing an approach to reviewing the licensing basis information for advanced reactors, which may inform future advanced research reactor reviews

New Technology Licensing Accomplishments

- Issued two construction permits for non-power production and utilization facilities used for medical radioisotope production in recent years
  - SHINE Medical Technologies (February 2016)
  - Northwest Medical Isotopes (May 2018)
- Reviews completed in under two years from the time of application docketing
- Safety considerations comparable non-power reactors:
  - Fission heat removal
  - Decay heat generation
  - Fission gas release
  - Fission product buildup
  - Accident scenarios
- …and fuel cycle facilities:
  - Target manufacturing
  - Radiation protection
  - Material processing
  - Criticality control
  - Chemical hazards

Elements of Success

- For novel technologies, early interactions between NRC staff and applicants support efficient application processing and review
- Public pre-application meetings
  - Promote engagement between NRC and potential applicant
  - Inform the development of high-quality applications
  - Inform budgeting and resource allocation
  - Inform public of NRC process
- Best practices from construction permit application reviews:
  - Emphasis on most safety-significant technical aspects
  - Focused requests for additional information
  - Weekly status calls

Impact of Medical Radioisotope Facility Reviews

- Experience gained from reviews supporting a more responsive and efficient technology-inclusive regulatory framework at the NRC
- Leading initial licensing activities at NRC by considering technologies beyond light water and non-power reactors
- Review of construction permit and operating license applications setting example for future advanced reactor reviews
- Success made possible through technical and licensing expertise provided by inter-office working group