NRC Licensing of Small Modular Reactors (SMRs)
Purpose

• The purpose of this section is to provide an understanding of the differences that the NRC is encountering with licensing SMRs (small light-water reactor technology)
  ➢ Modular designs
  ➢ Nuclear safety review areas
  ➢ Environmental review areas
  ➢ SMR review challenges
  ➢ SMR lessons-learned
Differences in Licensing SMRs

• In general, the same regulatory framework applies to SMRs as to large LWRs; however, gaps may exist
• Gaps in regulatory and guidance documents are a continually evolving challenge
• Gaps change according to changes in technologies and approaches
• Addressing gaps in a completely technology-neutral, meaningful way is difficult
Differences in Licensing SMRs

• Not all gaps warrant the same amount of NRC focus or resources
  - Safety or security significance
  - Likelihood of guidance in that area actually being needed
  - Timing of the need

• The NRC is always scanning the horizon for future gaps and prioritizing them
Part 50 vs. Part 52 Licensing

**“2-step” licensing - Part 50**

- Preliminary Safety Analysis Report
- Construction Permit
- Construction and further design
- Final Safety Analysis Report
- Construction complete
- Operating License
- Operation*

**Alternative licensing - Part 52**

- Early Site Permit
- Design Certification
- Site/design information
- Final Safety Analysis Report
- Combined License
- Construction
- Verification (ITAAC)
- Operation*

*Includes Pre-operational testing
Nuclear Safety Review Areas

- Site Characteristics and Site Parameters
- Systems, Structures, Components, and Equipment Design
- Reactor Internals
- Reactor Coolant and Connected Systems
- Engineered Safety Features
- Digital Instrumentation and Controls/Electrical Power
- Auxiliary Systems
- Steam and Power Conversion Systems
- Radioactive Waste Management and Radiation Protection
- Conduct of Operations
- Initial Test Program and ITAAC
- Transient and Accident Analysis
- Technical Specifications
- Quality Assurance Program
- Human Factors Engineering
- Severe Accidents
Environmental Review Areas

- Seismology
- Geology
- Hydrology
- Meteorology
- Geography
- Demography (population distribution)
- Site Hazards Evaluation
- Radiological Effluent Releases
- Radiological Dose Consequences
- Emergency Preparedness (with FEMA)
- Security Plan Feasibility
SMR Review Challenges

• New first-of-a-kind designs
  ➢ Modular construction
  ➢ Completeness of the design
  ➢ Applicability of existing regulations
  ➢ Verification and validation of computer codes
  ➢ Applicability of prior operating experience

• Smaller applicant organizations in some cases
  ➢ Important that they have experience with nuclear licensing requirements
  ➢ Important that they are adequately staffed to address regulator questions in a timely manner during reviews
Modular Designs - AP1000 Modules

CA01 Steam Generator / Refueling Channel
CA02 In-Containment Refueling Water Storage Tank (IRWST) Interior Wall
CA03 IRWST Perimeter Wall
CA04 Reactor Vessel Cavity
CA05 Access Tunnel / Passive Core Cooling and Volume Control System Equipment Room Wall
CA20 Aux Building
SMR Lessons-Learned

- A rigorous safety basis and understanding is still essential for new designs
- If an organization is mostly familiar only with large light water reactors (LWRs), a mindset change may need to occur
- Sustained focus on the most safety-significant aspects of the design is important
- Complete understanding of the design as a whole assists the applicant and the regulator
- Successful completion of first-of-a-kind reviews will result in streamlined Nth-of-a-kind reviews
- Early and frequent communication with applicants is crucial, both prior to and during the regulator’s review
NRC Licensing of Advanced Reactors
Purpose

• The purpose of this section is to provide an understanding of the differences that the NRC is encountering with licensing Advanced Reactors (small non-light water reactor technology)

  ➢ Advanced Reactor design landscape
  ➢ Ensuring readiness for licensing Advanced Reactor designs
New Non-Light Water Licensing

Companies in active pre-application engagement:

- X-Energy
- TerraPower & GE-Hitachi
- Kairos Power
- Terrestrial Energy USA
- General Atomics Energy
- Westinghouse Electric Company

Oklo Aurora – first advanced reactor licensing application submitted March 2020. Microreactor – 1.5 MWe
Advanced Reactor Landscape

**Liquid Metal Cooled Fast Reactors (LMFR)**
- TerraPower/GEH (Natrium)*
- GEH PRISM (VTR)
- Advanced Reactor Concepts
- Sodium-Cooled
- Westinghouse
- Columbia Basin
- Hydromine
- Lead-Cooled

**High-Temperature Gas-Cooled Reactors (HTGR)**
- X-energy *
- Framatome
- StarCore
- MIT
- TRISO Fuel
- General Atomics (EM2)*
- General Atomics

**Molten Salt Reactors (MSR)**
- Kairos *
- Kairos (Hermes | RTR)
- Liquid Salt Cooled
- TerraPower
- Southern (TP MCFR) | RTR
- ACU | RTR *
- Elysium
- ThorCon
- Muons
- Flibe
- Alpha Tech
- Liquid Salt Fueled

**Micro Reactors**
- Westinghouse (eVinci)*
- BWX Technologies
- X-energy
- Radiant | RTR
- Transportable
- Ultra Safe
- University of Illinois RTR
- Oklo
- Stationary

**ARDP Awardees**
- Demo Reactors
- Risk Reduction
- ARC-20

**In Licensing Review**
- Preapplication
- Research/Test Reactor

**Legend**
- *: Preapplication
- RTR: Research/Test Reactor
Ensuring Readiness for Licensing and Safe Deployment of Advanced Reactors in the United States

- NEIMA implementation
- First advanced reactor COL application
- DOE advanced reactor demonstration program
- Part 53 rulemaking CFR
- Environmental initiatives
Ensuring Readiness for Licensing

• Risk-Informed Performance-Based Licensing Approaches
  ➢ Draft Regulatory Guide (DG) 1353

• Technology Inclusive Policy Issues
  ➢ Functional Containment
  ➢ Security
  ➢ Emergency Preparedness

• Nuclear Energy Innovation and Modernization Act (NEIMA)
Questions?