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New Nuclear Plant Designs

Background

The NRC encourages standardized nuclear power plant designs to help enhance safety and improve the licensing process. The Commission expects new reactors' safety systems to be simpler and use natural effects (such as gravity) or other innovative approaches. The NRC also regularly discusses new design issues with vendors proposing small modular and advanced (non-light water cooled) reactors. The agency's new reactor regulations (Part 52 in Title 10 of the Code of Federal Regulations) provide a predictable review to approve, or certify, new nuclear plant designs. The NRC based the certification process on decades of experience and research into reactor design and operation.

Pre-Application Review

The NRC's July 1986 "Statement of Policy for Regulation of Advanced Nuclear Power Plants" encourages reactor designers to discuss licensing issues with the agency before submitting a full license application. In 1988, the NRC provided additional "pre-application" guidance for advanced reactor design reviews in NUREG-1226, "Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants." Pre-application interactions with reactor designers are expected to identify and address topics such as:

- unique design features or systems, structures or components;
- new methods demonstrating the acceptability of safety features;
- potential Commission-level policy decisions; and
- potential research to resolve identified issues.

Design Certification Review

Applicants must provide enough information to show their design meets the NRC's safety standards. Applicants must also show their design resolves any existing generic safety issues, as well as issues that arose after the Three Mile Island accident. Applications must closely analyze the design's appropriate response to accidents or natural events. Applications must also lay out the inspections, tests, analyses and acceptance criteria that will verify the construction of key design features. In addition, the NRC also requires design certification applicants to assess how the designs protect the reactor and spent fuel pool from the effects of a large commercial aircraft impact. Certification reviews identify key information to consider in site-specific reviews for combined licenses. The NRC certifies acceptable

reactor designs by adding them to agency regulations through a rulemaking. This rulemaking certifies a design for 15 years, and a reactor vendor can seek renewal of a certified design.

Regulatory Structure for Advanced Reactor Licensing

In 2007, the NRC prepared for vendors submitting designs with advanced technologies by developing technology-neutral guidelines for plant licensing. These guidelines encourage future designs to incorporate additional safety and security where possible. The NRC issued a "Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing" (NUREG-1860) in December 2007.

The NRC developed the "Report to Congress: Advanced Reactor Licensing," in August 2012 (ML12153A014) to address a provision in the Consolidated Appropriations Act, 2012. This report discusses enhanced regulatory predictability and stability for advanced reactors.

In 2013, the DOE Office of Nuclear Energy and the NRC began working on how to apply "General Design Criteria for Nuclear Power Plants," Appendix A to 10 CFR Part 50, to advanced non-light water reactor designs. The NRC and DOE have held Advanced Non-Light Water Reactors Workshops on issues related to developing and deploying advanced designs. In 2016, the NRC issued a "Vision and Strategy" on preparing for non-light water reactor designs. In July 2019, the NRC provided to Congress two reports regarding expediting and establishing stages in the licensing process for commercial advanced nuclear reactors; and appropriately increasing the use of risk-informed and performance-based evaluations and regulatory guidance in licensing commercial advanced nuclear reactors.

Certified Designs

The NRC has certified six designs; two of those approvals have expired. Utilities can reference the other four designs when applying for a combined license to build and operate a nuclear power plant. The certified designs are:

WESTINGHOUSE AP1000

- **Advanced Boiling Water Reactor** design by GE Nuclear Energy (May 1997, amended to assess aircraft impacts in 2011, renewal under review);
- **System 80+** design by Westinghouse (formerly ABB-Combustion Engineering) (May 1997, expired June 2012);
- **AP600** design by Westinghouse (December 1999, expired January 2015);
- **AP1000 (Amended)** by Westinghouse (January 2007 and amended January 2012); and
- **Economic Simplified Boiling Water Reactor** design by GE-Hitachi (October 2014)
- **APR 1400** – design by Korea Electric Power Corporation and Hydro & Nuclear Power (September 2019).

Active Reviews

ABWR Renewal – GE-Hitachi applied for renewal of its ABWR version in December 2010. The staff expects the renewal review to be completed in 2020.

US-APWR - Mitsubishi Heavy Industries, a Japanese firm, applied to certify the U.S.-specific version of its Advanced Pressurized Water Reactor on Dec. 31, 2007. NRC review activities have been reduced at the applicant's request.

NuScale - NuScale submitted its small modular design for certification in January 2017. The staff expects the certification review to continue in 2020.

Pre-Application Reviews

Aurora – Oklo Inc. plans to submit a custom combined license application to the NRC in 2020 for its Aurora reactor design. A custom COL includes all the design information provided in a design certification application plus all the site-specific safety and environmental information in a COL application. Oklo's Aurora design is a compact fast reactor, cooled by liquid metal heat transport.

EM² – General Atomics expects to begin pre-application discussions with the NRC in 2020 regarding their Energy Multiplier Module design, a helium-cooled fast reactor.

IMSR – Terrestrial Energy is currently in pre-application discussions with the NRC regarding their Integral Molten Salt Reactor. The IMSR is a liquid-fuel, molten salt-cooled design.

Kairos – Kairos Power is conducting pre-application activities by submitting topical reports to the NRC for review and comment. The Kairos design is a pebble-bed, fluoride salt-cooled high temperature reactor.

MCFR – TerraPower is currently in pre-application discussions with the NRC. One reactor design from TerraPower is a molten chloride fast reactor. Another reactor design being developed by TerraPower is the Traveling Wave Reactor, a sodium-cooled fast reactor.

SMR-160 – Holtec notified the NRC in a January 2014 letter that the company has yet to determine a date for submitting its small modular SMR-160 design for certification. The NRC continues to examine policy issues regarding all small modular reactor designs.

Xe-100 – X-Energy is conducting pre-application activities by submitting topical reports to the NRC for review and comment. X-Energy's Xe-100 design is a pebble-bed, high-temperature gas-cooled small modular reactor.

Inactive Reviews

EPR - Areva applied to certify the EPR on Dec. 11, 2007. Areva asked the NRC suspend the review in February 2015.

Next-Generation Nuclear Plant (NGNP) - DOE and the NRC complied with the Energy Policy Act of 2005 in examining the NGNP advanced reactor project. DOE discussed reactor design options with potential industry partners. On July 17, 2014, the NRC provided feedback to DOE on key licensing issues for the project (ML14174A626).

mPower - Babcock & Wilcox restructured its small modular reactor program in 2014 to focus on mPower technology development. The company has yet to determine a date for submitting an application.

PBMR - A South African firm, Pebble Bed Modular Reactor Pty. Limited, notified the NRC in a letter dated Feb. 18, 2004, that it intended to apply for design certification. NRC staff held several public meetings with PBMR to discuss its activities and plans to submit pre-application information. The PBMR, a high-temperature reactor cooled by helium, has been mentioned as a possible NGNP design choice.

SMR-160 - Holtec notified the NRC in a January 2014 letter that the company has yet to determine a date for submitting its small modular SMR-160 design for certification.

Toshiba 4S - On Feb. 2, 2005, the NRC staff met with the city manager and vice mayor of Galena, Ala., to discuss the city's plans to build a Toshiba 4S reactor to provide its electricity. Toshiba held pre-application discussions with NRC staff through 2008 regarding the molten-sodium-cooled design.

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