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General Comment

See attached file(s)

Attachments

Comment on Docket NRC-2017-0029-BTI

October 14, 2021

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Comment on NuScale SMR Design Certification Rulemaking

(Docket-NRC-2017-0029)

This letter and its enclosure provide the perspective of the Breakthrough Institute on the NuScale SMR Design Certification Rulemaking.

The Breakthrough Institute is an independent 501(c)(3) global research center that identifies and promotes technological solutions to environmental and human development challenges. We advocate appropriate regulation and licensing of advanced nuclear reactors to enable the commercialization of innovative and economically viable emerging nuclear technologies, which we believe to represent critical pathways to climate mitigation and deep decarbonization. The Breakthrough Institute does not receive funding from industry.

Sincerely,

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The Breakthrough Institute

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Enclosure: Attachment A - Comment on NuScale SMR Design Certification Rulemaking

Attachment A:

Comment on NuScale SMR Design Certification Rulemaking

Preface

This report provides a summary of the review of the NuScale Small Modular Reactor (SMR) and Design Certification Application (DCA) and associated Nuclear Regulatory Commission (NRC) review process. It also provides a review of the proposed rulemaking, which will allow licensees seeking to build the NuScale SMR to do so, by referencing the rule. The report provides the required information to enable an adequate understanding of NuScale as a company and the SMR design, in particular. It also provides an overview of the regulatory review process and associated documents. It further provides a set of recommendations for reactor vendors, regulators and policymakers.

1. Background and Ownership of NuScale

NuScale Power is a privately owned nuclear reactor design vendor, which was formed in 2007. Fluor Corporation is the majority and strategic investor in NuScale, while minority investors include Sargent and Lundy, ARES corporation, Oregon State University, ENERCON, DOOSAN Heavy Industries and ARES Corporation and ULTRA Electronics are minority investors. NuScale has locations in the United States and United Kingdom, with over 400 employees.

1.1 NuScale Technology Development

As of the date of this report, NuScale has currently designed a Small Modular Reactor (SMR) plant and is working on the design of a microreactor. [1] The NuScale SMR plant is constituted of several power modules, with each module producing up to 77Mwe. It should be note that at the time of submission of the DCA, the NuScale power module output was specified as 50Mwe, but has since been uprated by NuScale to 77Mwe. Hence, the total SMR plant size depends on the number of modules in the plant. The plant power can be scaled up to match demand by including more modules. The proposed plant sizes range from 4 modules producing 308Mwe, up to 12 modules producing 924Mwe. The NuScale SMR received Design Approval in August, 2020, making it the first SMR to receive NRC design approval.

1.2 NuScale Small Modular Reactor History

NuScale Power was initially formed in 2007 for the purpose of commercializing the basic SMR technology, which had been developed at Oregon State University through the US Department of Energy funded Multi-Application Small Light Water Reactor (MASLWR) program. Fluor Corporation acquired a lead investment position in 2011 and NuScale won a competitively awarded US DOE grant of approximately $300 million. The total public and private investment in NuScale technology as of the time of this report is over $1billion. The design development efforts have resulted in several peer reviewed academic studies and over 530 worldwide patents.

1.3 Overview of the NuScale SMR Design

The NuScale SMR is constituted of multiple NuScale Power Modules (NPM). The NPM is an integral package that includes the reactor vessel, steam generators, pressurizer, and containment vessel. The reactor within the NPM is 65 feet in height and 9 feet in diameter, and sits in a containment vessel measuring 76 feet in

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[1] It should be noted that the NuScale design had been completed to an extent that it could be reviewed for regulatory approval, which is a level of design completion that is focused on safety functionality and not on performance or design optimization. As an example, the Westinghouse AP1000 design was submitted for NRC review in 2002, and the initial design certification was received in 2004, however the AP1000 design effort continued until 2014. Hence, it should be noted that the NuScale SMR design may still be undergoing design modifications to incorporate additional safety features beyond standards required by the regulator, and other changes for improved performance.

height x 15 feet in diameter. The reactor and containment vessel operate inside a water-filled pool that is built below grade. The reactor operates using the principles of buoyancy driven natural circulation; hence, no reactor coolant pumps are needed to circulate water through the reactor, as in LLWRs. Water passes over the core, gets heated and rises through a riser located at the center of the vessel. The heated water exits the at the top of the riser and is drawn back downward by water that is cooled passing through the steam generators. The water is then pulled by gravity back down to the bottom of the reactor where it again flows over the core. Water in the reactor system is kept separate from the water in the steam generator system to prevent contamination. As the hot water passes over the hundreds of tubes in the steam generator, heat is transferred through the tube walls and the water inside the tubes turns to superheated steam. The steam is channeled to a small turbine that is attached by a single shaft to an electrical generator. After passing through the turbine, the steam loses its energy and is cooled back into liquid form in the condenser and pumped by the feed water pump back to the steam generator where it begins the cycle again.

The NPM is a simplified version of existing Large Light Water Reactors (LLWR), in that it eliminates reactor coolant pumps, large pipes and other major components found in LLWRs. These components have been eliminated by demonstrating that safety objectives are achieved without their inclusion. Specifically, certain active safety systems such as reactor coolant pumps and containment sprays have been replaced by passive safety systems such as natural convective cooling and natural aerosol deposition phenomena respectively. These passive systems are enabled by thermal hydraulic conditions enhanced by geometric configurations and placement of the NPM in a pool of water to serve as an ultimate heat sink. The geometric configuration is such that the NPM reactor core is 1/20th the size of LLWR cores. The integrated design allows the elimination of certain postulated accidents such as large pipe breaks, as the need for piping between major components is eliminated.

The NuScale power module design has multiple features that differ from current large light-water reactors. Due to these differences the NuScale power module design was granted 17 exemptions to certain requirements under 10 CFR 50. Some of the most significant features that diverge from typical light-water reactors are:

1.3.1 No AC or DC Power for Safe Shutdown and Cooling: Current LLWRs require AC or DC power for safe shutdown. The NPM however does not require

AC or DC power, and no operator or computer aided action, it only requires the existing inventory of water within the pool it is submerged in.

1.3.2 Helical Coil Steam Generators (HCSG): The NPM is able to achieve compactness by innovative geometric configurations such as the helical steam generator tubes, which allow for a large heat transfer surface area in a small volume. Given the circulation force is natural convective flow, the HCSG provides a relatively low pressure drop, which does not impede the flow. The once-through counter-flow design enables the generation of superheated steam and good thermal efficiency using natural circulation flow.

1.3.3 High Strength Steel Containment Immersed in a Cooling Pool: The containment vessel serves as a heat exchanger and transfers reactor heat to the pool water, which limits the containment pressure, which eliminates the need for containment spray systems for cooling.

1.3.4 Maintaining containment in a vacuum limits heat exchange during normal operation: This minimizes reactor vessel heat loss, limits oxygen content, and prevents component corrosion, eliminating the requirement for physical reactor vessel insulation and hydrogen recombiners.

1.3.5 Small and Efficient Core Design Limits Source Term: The NPM has 1/20 of the nuclear fuel of a large-scale reactor. Its small decay heat, inherent stability, and reactor physics eliminates fuel damage in all postulated design basis events, including those with failure of all control rods to insert. For postulated beyond design basis events, radionuclide particle transport is limited due to the lower starting inventory and geometric and thermal hydraulic conditions that assist with deposition of the radionuclide particles. Hence, radiation from fuel damage is well below regulatory limits at the plant site boundary.

1.3.6 Digital Instrumentation & Control (I&C): A field programmable gate array digital I&C system provides comprehensive monitoring and control of all plant systems in a single control room.

2. NuScale SMR Design Certification Application Summary

This section summarizes the major elements of the NuScale SMR DCA, which include the schedule, contents, and major NRC communication documents.

2.1 Schedule

The following major activities and dates were associated with the Nuclear Regulatory Commission (NRC) review of the NuScale DCA:

a. Acceptance Review

i. Issue acknowledgement letter to applicant - 01/18/17
ii. Publish Federal Register Notice of receipt of application - 02/15/17
iii. Issue acceptance letter to applicant - 03/23/17
iv. Publish Federal Register Notice of docketing of application - 03/20/17

b. Safety Review

i. Phase 1 – Preliminary Safety Evaluation Report (SER) and Requests for Additional Information - 04/16/18
ii. Phase 2 – SER with Open Items - 07/12/19
iii. Phase 3 - ACRS Review of SER with Open Items - 07/12/19
iv. Phase 4 – Advanced SER with No Open Items - 12/12/19
v. Phase 5 – ACRS Review of Advanced SER with No Open Items - 07/31/20
vi. Phase 6 – Final SER with No Open Items - 08/28/20

2.2 Major Documents and Contents of the NuScale DCA

The NuScale DCA contained over 12,000 pages and was submitted in the following 10 parts listed in *Table I*. The DCA also included 14 associated topical reports. This list is provided for the reader's reference, to allow further review of specific topics as desired. The documents are publicly available and may be accessed from the NRC's website.

Table I: Major Documents and Contents of the NuScale DCA:

Part	Title
1	General and Financial Information
2	Final Safety Analysis Report
	Certified Design Descriptions and Inspections, Tests, Analyses, & Acceptance Criteria (ITAAC)
	Introduction and General Description of the Plant
	Site Characteristics and Site Parameters
	Design of Structures, Systems, Components and Equipment
	Reactor
	Reactor Coolant System and Connecting Systems
	Engineered Safety Features
	Instrumentation and Controls
	Electric Power
	Auxiliary Systems
	Steam and Power Conversion System
	Radioactive Waste Management
	Radiation Protection
	Conduct of Operations
	Initial Test Program and Inspections, Tests, Analyses, and Acceptance Criteria
	Transient and Accident Analyses
	Technical Specifications
	Quality Assurance and Reliability Assurance
	Human Factors Engineering
	Probabilistic Risk Assessment and Severe Accident Evaluation
	Mitigation of Beyond-Design-Basis Events
	Multi-Module Design Considerations
3	Applicants Environmental Report - Standard Design Certification
4	Generic Technical Specifications
5	Emergency Plans
6	Security Plans

Part	Title
7	Exemptions
8	License Conditions; Inspections, Tests, Analyses & Acceptance Criteria (ITAAC)
9	Withheld Information
10	Quality Assurance Program Description

2.3 Major NRC Review and Response Documents Related to the NuScale DCA

The NRC periodically provided several documents in support of the NuScale DCA review, which are provided in. This list is provided for the reader's reference, to allow further review of specific topics as desired. The documents are publicly available and may be accessed from the NRC's website.

Table II: NRC Review Documents

Date	Description
05/22/17	Review Schedule for the NuScale Power, LLC, Standard Design Certification of a Small Modular Reactor
03/23/17	NuScale Power, LLC - Acceptance of an Application for Standard Design Certification of a Small Modular Reactor
03/20/17	Federal Register Notice on Acceptance of NuScale Power, LLC Application for Standard Design Certification of a Small Modular Reactor (82 FR 15717 (FR DOC # 2017-06309); March 30, 2017)
02/15/17	Federal Register Notice on Availability of the NuScale Design Certification Application (82 FR 11372 (FR DOC # 2017-03438); February 22, 2017)
01/18/17	Acknowledgment of Receipt of the NuScale Design Certification Application

3. Comments and Recommendations Based on a Review of the NuScale DCA Proposed Rulemaking

Comment 1: Acknowledgement of Rigorous and Complete Review by the NRC

The NRC and NuScale should be commended for performing an extensive and rigorous review of the NuScale DCA. The review process was clear and well communicated in a manner that provides a high level of public confidence.

Recommendation 1: Document Lessons Learned from the NuScale DCA for Posterity and Knowledge Sharing

Considering the first-of-a-kind nature of the NuScale design, and certain aspects of the DCA submission, several lessons were learned. These lessons should be documented and disseminated for general knowledge and improvement of future DCA submissions. It will also assist COL applicants to proceed more effectively with their applications.

Comment 2: Prescriptive Nature of Current Regulations Required NuScale to Seek Exemptions and Retains Regulatory Uncertainty for COL Applicants.

Current regulations are written in a specific, prescriptive manner, which is based on large light water reactor operational experience and incidents. As an example, 10CFR part 50 "Domestic Licensing of Production and Utilization Facilities", provides control room staffing requirements based on a set of assumptions applicable to LLWRs. This will require a COL applicant that seeks to deploy the NuScale reactor to seek exemptions if they wish to use the number of operators recommended by NuScale.

The prescriptive nature of the regulations also required NuScale to seek exemptions from a standard, rather than simply describing how safety objectives are met by the NuScale design. NuScale was required to apply for a total of 17 exemptions, which were granted by the NRC based on technical justifications provided by NuScale.

Recommendation 2: Allow the Implementation of the Proposed Risk-Informed Technology Inclusive Regulatory Framework Approach for COL Applicants Referencing the NuScale DCA.

The current proposed rulemaking for a Risk-Informed Technology Inclusive regulatory framework includes elements that would improve regulatory certainty for COL applicants. Specifically, the framework includes provisions for performance-based demonstrations that would enhance the ability of COL applicants to demonstrate that safety objectives have been met, without seeking exemptions.

Comment 3: Unresolved Technical Issues Present a Regulatory Risk to COL Applicants

The NRC identified three issues that were unresolved open items in the DCA. These items are the Shielding Wall Design, Containment Leakage from the combustible gas monitoring system and steam generator stability during density wave oscillations. These unresolved issues create regulatory uncertainty for COL applicants.

Recommendation 3: Genericize the Outstanding Issues to Allow Effective Resolution

Considering the DCA has been approved with these items being outstanding, and with the NRC identifying the COL applicants as potentially being responsible for dispositioning the items, the nuclear industry should consider genericizing the issues. This would allow the issues to be addressed through various mechanisms and allow the research community to assist in retiring these technical issues. There is also a provision for COL applicants to include in the plant-specific DCA, multi-module considerations that were not included in the NuScale DCA. The NRC should clarify what the potential outstanding multi-module considerations are and provide guidance on how they may be resolved. The industry can then genericize the issues and allow them to be dispositioned by the research community.

4. Conclusion

The Breakthrough Institute concludes that approval of the NuScale DCA by the NRC is appropriate. This is based on our independent review of the contents of the DCA and the rigorous review processes undertaken by the NRC and supported by NuScale.