Considerations of regulators and developers for SMR development: The case of U.S. NRC

Young A Suh
Korea Institute of Nuclear Safety (KINS)
sya@kins.re.kr

1. Introduction

Nuclear power, especially small module reactors (SMRs), is in the spotlight worldwide as a means of carbon neutrality, primarily because of its safety and economic feasibility. The US NRC reviewed NuScale's Design Certification (DC), and it is in the rule-making process. Also, South Korea is in the process of developing the innovative-SMR (iSMR), with a licensing goal of 2028. This paper suggests the preparations of regulators and developers necessary to address changes in the SMR regulatory environment. The work draws on cases involving the U.S, NRC and U.S. developers.

2. The NRC's and developers' response to NuScale

Even before NuScale Power applied for SMR design certification (2016), the NRC sought to identify potential licensing issues through its Pre-Application Review (PAR) procedures (2008-2016). The NRC published the Design-Specific Review Standards (DSRS) in 2016.

The PAR is a process implemented by an agreement between potential applicants (e.g., utility and reactor designers) and regulators before a licensing application is submitted. The PAR makes it possible to check key licensing issues before the official licensing application so that applicants can reduce the risk of licensing. Also, the PAR can help regulators become more familiar with the design of the target nuclear power plant and prepare for licensing review issues.

The DSRS for the NuScale SMR design was developed to guide the review of the design features not covered by the existing NRC Standard Review Plan (SRP, NUREG-0800). Public discussion of the draft NuScale DSRS began in July 2015, and the final DSRS was published in August 2016.

The Nuclear Energy Institute (NEI) pointed out that NuScale's pre-interaction with the NRC was not as effective as desired, resulting in more than eight years of review and a $12 million regulatory fee. Accordingly, NEI developed guidelines of a Regulatory Engagement Plan (REP) in 2018 [1]. The REP establishes Rules of Engagement between the applicant and the NRC. The primary goal of the REP is to reduce regulatory uncertainty by establishing applicant-regulator agreements as early as possible.

NuScale submitted a Standard Design Approval (SDA) REP (Rev. 1, 2020) [2] for NuScale NPM-20 (77 MWe per module), which improved output compared with the existing NuScale SMR (50 MWe per module). The SDA REP includes Final Safety Analysis Report (FSAR) content optimization, design changes, policy issues, interaction types and frequencies, project management discussions, schedules, and budgets.

3. The NRC's and developers' response to Advanced Reactor (AR)

3.1. NRC's efforts

The NRC has long considered policy directions for the AR and has published the second revision of the policy statement on AR regulation in 2008 [3]. The policy statement includes the following. ① To ensure more timely and effective regulation, the Commission identifies regulatory requirements for ARs early through the fastest possible interaction between applicants, suppliers, other government agencies, and the NRC. ② It is necessary to provide an independent evaluation of the safety and security characteristics of AR design to all stakeholders, including the public. ③ The NRC should develop appropriate evaluation and response capabilities for innovative reactor designs through regulatory verification and review.

In December 2016, the NRC Vision and Strategy draft document [4] was established and promulgated to assure NRC readiness to effectively and efficiently review and regulate non-LWRs. The visions are to strengthen technology readiness, to optimize regulatory readiness, and to optimize communication.

The new NRC vision and strategy is a 10-year program (2016-2025), primarily aimed at (1) timely and effective SMR conceptual design assessment and (2) development of guidelines and preparation for the required staged regulatory review process. Ultimately, it is to support the licensing activities of developers by creating comprehensive licensing procedures and regulatory guidelines for new reactors. The items below show six key strategic areas that regulators, developers, and stakeholders should prepare for together [5].

·Strategy 1. Staff development and knowledge management
·Strategy 2. Analytical tools
·Strategy 3. Regulatory framework
·Strategy 4. Consensus codes and standards
·Strategy 5. Resolution of policy issues

·Strategy 6. Communications

In July 2017, the NRC developed Implementation Action Plans (IAPs) which identified specific activities to achieve non-LWR vision and strategy. The NRC staff expects to conduct near-term (0–5 years), mid-term (5–10 years), and long-term (beyond 10 years) regulatory reviews to achieve non-LWR readiness.

The NRC has published a report titled "Advanced Reactor Program Status" (2021), which includes ongoing activities in the six strategic areas of the IAP (listed above) and major achievements up to 2020. It also reflects the opinions of stakeholders and pending issues. Ultimately, the U.S. has a policy commitment to retain and maintain technology for the world's best new reactor by achieving its licensing strategy goal.

The core activity among the six strategies is strategy 3. change of regulatory framework. To achieve its strategic goals, the NRC is (1) establishing a Flexible Licensing Processes for Advanced Reactors; (2) developing a guideline on Technology-Inclusive, Risk-Informed, and Performance-Based (TIRIPB) regulatory infrastructure; and (3) developing the General Design Criteria (GDC) applicable to AR technology.

In December 2017, the NRC developed the "Regulatory Review Roadmap for Non-LWR" to lay the foundation for the exchange of mutually relevant information between designers and regulators. This is a roadmap that enables formal and informal contact with regulators at the licensing stage corresponding to the level of design development. Topics that can be discussed through pre-application interactions include technology readiness level (TRL) evaluation of development technology, PIRT (Phenomena Identification and Ranking Table) evaluation, and regulatory issues. As a result of these discussions, developers can adjust R&D schedules or development plans.

While participating in the licensing modernization project (LMP), the NRC developed and published draft regulatory guidelines on the TIRIPB methodology, which is the 2019 licensing standard for new reactors [6]. The TIRIPB regulation aims to expand and apply the existing relevant parts of the RIPB regulatory framework to ARs. This guideline focuses on (1) selection of Licensing Basis Events (LBEs); (2) safety classification of structures, systems, and components (SSCs) and associated risk-informed special treatments; and (3) determination of defense-in-depth (DID) adequacy for non-LWRs. These three items are currently being analyzed and developed according to four representative new reactor designs, including two microreactors (Westinghouse, Oklo), a sodium fast reactor, and a high-temperature gas-cooled pebble bed reactor. Through the Nuclear Energy Innovation and Modernization Act (NEIMA), the NRC has prepared a rule-making plan (SECY-20-0032, 2020) for a "Technology Neutral Regulatory Framework" and is scheduled to complete the rule by 2027.

The NRC and DOE are jointly developing and implementing plans to develop GDC, the most essential element for licensing an AR design. Currently, the 10CFR50 Appendix A general design standard is based on the existing LWR design. To apply it to the non-LWR designs, improvements and revisions must be made that specifically address AR design technology. In April 2018, the NRC developed and presented RG 1.232, "Guidance for Developing Principal Design Criteria (PDC) for Non-LWRs," as a designer's regulatory guideline for non-LWR designs. Based on this, advanced reactor design criteria (ARDC) are being developed for application to fourth-generation non-LWR designs and specifically for two reactors (DC of SFR and MHTGR).

*3.2. **U.S. Congress's AR efforts***

The U.S. Congress established three pillars of legislation (NEICA, NEIMA, Energy Act 2020) for new reactors. The three legislative pillars are R&D promotion base, regulatory system improvement, and budget support. These are key to the development, deployment, and commercialization of new reactors. The legislation helps promote the development of new reactors that require a large, long-term budget by removing uncertainty in project promotion and enhancing its reliability.

In September 2018, the U.S. Congress enacted the Nuclear Energy Innovation Capabilities Act (NEICA) to support the development of new reactors. This law clarifies the role of DOE in the development of new reactors and promotes private-public cooperation. Through this law, DOE is promoting the construction of a Versatile Test Reactor (VTR) (February 2019) and the establishment of the Nuclear Reactor Innovation Center (NRIC) (August 2019), as well as the Advanced Reactor Demonstration Program (ARDP).

Members of the U.S. Senate proposed NEIMA in March 2017. In December 2018, the U.S. Congress passed NEIMA to secure the regulatory expertise necessary for the development and commercialization of new reactors and to improve and modernize the regulatory framework. The purpose of this legislation is to accelerate the development and deployment of new reactors by ensuring the efficiency of licensing by instructing the NRC to improve and modernize the existing commercial LWR-based licensing framework for application to new reactors. The main contents of the licensing clause in NEIMA Section 103(a) are (1) establishing stages within the licensing process; (2) increasing the use of risk-informed, performance-based licensing evaluation techniques and guidance; (3) research and test reactor licensing; (4) establishing, by the end of 2027, a technology-inclusive regulatory framework that encourages greater technological innovation; and (5) supporting training and expertise.

The U.S. Congress passed the Energy Act of 2020 in December of that year, specifying support for a wide range of energy sectors, including the development of new reactors. This law provides the legal basis for supporting nuclear R&D projects such as high-assay low-enriched uranium (HALEU), nuclear fuel development, ARDP, VTR, and nuclear hybrid projects. This law provides long-term R&D budget support. In particular, it recommends budget expenditures for AR R&D over the next five years (2021-2025).

4. Conclusions

It is necessary for Korea to reorganize its regulatory requirements and improve the existing licensing framework as the development of domestic SMRs, including iSMR, increases rapidly. To this end, the roles and preparations of regulators and developers were examined based on the experience of NuScale and AR in the United States.

The NRC has prepared PAR procedures, DSRS, policy statements for AR regulation, and the NRC's vision and strategies for AR. Developers have also prepared to develop a guideline of REP and submit a REP for the SMR. The U.S. Congress established the three legislative pillars (NEIMA, NEICA, Energy Act 2020) to lay the foundation for the regulatory advancement of new reactors.

Based on the U.S. case, Korean developers and regulators can consider their respective roles in the future as follows.

The regulatory bodies (KINS and NSSC) need to present policy directions, principles, and strategies for SMRs through a declaration of SMR policy to improve SMR licensing efficiency.

Regulatory agencies also need to establish regulatory strategies that reflect regulatory verification technology, regulatory framework/procedures, and stakeholder communication. They also need to establish mid-and long-term implementation plans to achieve these strategies.

The current status of SMR design development in Korea can be seen to correspond to the REP and PAR licensing stage. Therefore, developers need to establish design concepts and REPs and establish interaction strategies with regulatory agencies.

For the above reasons, the KINS will be promoting regulatory improvement R&D (2022-2028) aimed at developing a safety regulatory framework specifically for SMRs and a pre-licensing safety review program.

This paper has limitations because it contains only the US cases that follow the Anglo-American law system. Accordingly, future work will be needed the investigation and analysis of the cases of countries (e.g., Japan) that follow the civil law system like the ROK. In addition, since the policy issue of domestic SMR may be quite different from the United States, research that outlines this and suggests solutions will be conducted as future research.

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REFERENCES

[1] “Guidelines for Development of a Regulatory Engagement Plan” (NEI 18-06), 2018

[2] “NuScale SMR Standard Design Approval Regulatory Engagement Plan”, 2020

[3] NRC-2008-0237, Policy Statement on the Regulation of Advanced Reactors

[4] NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness (2016) ML16139A812, draft revision 1

[5]NRC Non-Light Water Reactor Near-Term Implementation Action Plans (ML17165A069) 2017 July

[6] SECY-19-0117, RG 1.233 "Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," on December 2, 2019.