

Analyses of Nuclear Emergency Preparedness and Response Regulations Between U.S. and South Korea

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ABSTRACT

Nuclear emergency preparedness and response (EPR) regulatory systems have evolved through different trajectories in each country. IAEA GSR Part 7, published in 2015, offered international recommendations for these countries to be able to adopt. EPR framework of South Korea evolved independently and inconsistently, while it was affected directly and indirectly by both U.S. and IAEA regulatory systems, and the resulting hybrid contains potential issues for the global deployment of small modular reactors (SMRs) and other advanced nuclear facilities. As a preliminary step for characterizing these inconsistencies, this paper examines the U.S. and South Korean EPR regulatory frameworks against 10 items derived mainly from recent NRC documents (RG 1.242 and SECY-22-0001) for the SMR regulations. The comparative analyses for the 10 items reveal that 3 issues are observed as the most consequential for SMR deployment. These concern the linkage between EP obligations and licensing milestones, the facility classification system and its technical basis, and the EPZ sizing methodology. The results lead to discussion of structural origins and policy implications that will be developed in a subsequent study.

Keywords: *emergency preparedness and response, comparative analysis, U.S., South Korea*

1 INTRODUCTION

Small modular reactor (SMR) and advanced reactor programs are currently expanding in multiple countries. In the U.S., several non-light-water SMR designs are progressing through licensing under department of energy (DOE) demonstration programs. In South Korea, the SMR Special Act entered into force in February 2026, establishing binding obligations for harmonization with international standards in advance of the SMR and other advanced reactor deployments. The IAEA Nuclear Harmonization and Standardization Initiative (NHSI) was launched in 2022 as a multilateral mechanism for regulatory convergence on SMR designs [1].

Emergency preparedness and response (EPR) regulations were initially developed around large nuclear power plants (NPPs), and especially, light-water reactors (LWRs). Their application to other types of nuclear facilities is quite different between countries in terms of scope, criteria, and flexibility. Both the U.S. and South Korea recognize and refer to IAEA GSR Part 7 [2] as the international standards, but their EPR frameworks differ between the two countries. This paper compares the two frameworks using 10 items derived from recent NRC documents. The 10-item comparison reveals 3 issues, which are observed as the most consequential for SMR deployment.

2 METHODOLOGY

The comparison framework is derived from recent NRC documents addressing EP for SMRs and non-light-water reactors. RG 1.242 [3] and SECY-22-0001 [4] are the primary sources. Other documents, including RG 1.101 [5], RG 2.6 [6], RG 3.67 [7], NUREG-0654 [8], and NUREG-0849 [9], are also used as supplementary sources for commercial LWRs, research reactors, and non-reactor facilities. DOE Order 151.1E [10] and subordinate guides provide a reference for public nuclear facilities outside NRC responsibility. In total, 10 items covering scope, criteria, and flexibility of EPR design are extracted from these documents:

- (1) Facility scope: Nuclear facility classes under the regulation.
- (2) Licensing scope: Licensing steps to which EP arrangements are tied.
- (3) Regulated target: Allocation of EP responsibilities among designers, licensees, regulators.
- (4) Dose criteria: Reference dose values for implementing protective actions.
- (5) Terminology: Definitions of emergency planning zone (EPZ), SMR, and related concepts.
- (6) Regulatory flexibility: Exemptions from existing prescriptive rules and backfitting.
- (7) Graded requirements: Differentiation of EP requirements by relevant hazard level.
- (8) Background: Stated basis for regulatory change.
- (9) Response capability: National capability for food restriction and radiological assessment.
- (10) International alignment: Reference to international standards (IAEA GSR Part 7 [2]).

For each item, the positions of the U.S. and South Korea are investigated and compared. Section 3 presents the side-by-side comparison. Section 4 groups the observed divergences into 3 issues observed as the most consequential for SMR deployment.

3 COMPARATIVE ANALYSIS

3.1 United States

The U.S. EPR regulatory system for nuclear facility types is distributed across different regulatory layers. The Atomic Energy Act defines the authority of the NRC and the DOE. 10 CFR 50 governs basically LWR EP through §50.47 and Appendix E. 10 CFR 50.160, effective December 2023, provides a performance-based EP option for SMRs, non-light-water reactors, and non-power production and utilization facilities. 10 CFR Part 53, effective April 29, 2026, consolidates risk-informed and technology-inclusive regulation for SMRs and other advanced reactors, with EP arrangements linked through §50.160. There are other regulations for non-reactor facilities. 10 CFR 72, for example, covers spent fuel storage facilities.

Regulatory guides translate these rules into design choices. RG 1.101 [5] supports NUREG-0654 [8] for NPPs. RG 2.6 [6] governs research and test reactors. RG 3.67 [7] covers fuel cycle and materials facilities. RG 1.242 [3] provides the performance-based alternative with §50.160. The emergency classification scheme for reactors uses 4 classes: Notification of Unusual Event, Alert, Site Area Emergency, and General Emergency. Fuel-cycle and spent-fuel facilities use a reduced scheme with 2 classes (Alert, Site Area Emergency) under 10 CFR Part 72. Facilities operated under DOE authority follow DOE Order 151.1E [10], which establishes Alert, Site Area Emergency, and General Emergency classifications. There is a backfit rule in 10 CFR 50.109, which protects existing licensees from retroactive application of new requirements.

The U.S. framework features a graded EP regulation, multiple licensing pathways, separation of EP responsibilities among designers, licensees, and regulators, consistent use of dose criteria (EPA Protective Action Guides), and a performance-based alternative pathway that coexists with prescriptive rules. Alignment with IAEA GSR Part 7 is declared in RG 1.242.

3.2 South Korea

South Korea's EPR regulation is anchored in a single integrated statute, the Act on Physical Protection and Radiological Emergency, which covers both physical protection and EP. The current binary zone structure, which contains precautionary action zone (PAZ) and urgent protective action planning zone (UPZ), was introduced through the 2014 amendment of the act following the Fukushima Daiichi accident. The lowest regulation is NSSC Notice 2025-8 [11], which specifies basis for EPZ radii of various nuclear facilities and other related parameters. The SMR Special Act of February 2026 adds a mandate for international standard compliance.

The regulator is the Nuclear Safety and Security Commission, supported by 2 technical support organizations (KINS for safety and EP review, KINAC for physical protection, and KIRAMS for medical response). Nuclear licensees are categorized in binary classes as large-scale or small-scale, with exemption thresholds for research reactors with small power (< 100 W) and radioisotope facilities with small licensed amounts (< 18.5 PBq). In South Korea, licensee(facility-type)-specific fixed ranges of EPZ basis are applied. Commercial NPPs use PAZ 3–5 km and UPZ 20–30 km. Research reactors apply only UPZ graded by thermal power, with approximately 0.5 km for 2–10 MW_t, 1.5 km for 10–50 MW_t, and 5 km for 50–100 MW_t. Spent fuel treatment facilities have UPZ about 5 km. Fuel processing, nuclear material possession, and radioisotope facilities as well as other small-scale licensees use a site-boundary UPZ. There are 3 emergency classes: white (facility emergency), blue (site area emergency), and red (general emergency), applicable across all facility categories.

Overall, the Korean framework adopts two licensee classifications, does not formally assign designer-side EP responsibilities, and applies prescriptive fixed EPZ distances. Alignment with IAEA GSR Part 7 is partially achieved.

4 DISCUSSION

The 10-item comparison reveals 3 issues observed as the most important for SMR deployment: EP-licensing linkage, facility classification and its technical basis, and EPZ sizing methodology. Each is described as below, where their structural origins and policy responses should be further analyzed.

(i) EP-licensing linkage. The U.S. framework anchors EP obligations to licensing milestones, including the construction permit, the early site permit, and the standard design certification. The South Korean framework does not tie emergency plan submission to a licensing milestone. Such inconsistency will be prominent at timing of future SMR deployment.

(ii) Facility classification and its technical basis. The U.S. framework distinguishes facility classes (explicitly for DOE, and implicitly for nuclear regulatory commission) and scales EP requirements. The Korean framework applies a binary licensee distinction with exemption thresholds that are not accompanied by a technical documented basis such as dose criteria. Whether the current binary structure accommodates SMRs is questionable.

(iii) EPZ sizing methodology. The U.S. framework permits performance-based EPZ sizing under 10 CFR 50.160 and RG 1.242 [3]. The Korean framework applies prescriptive and fixed EPZ ranges under NSSC Notice 2025-8 [11], which fall within the generic zone ranges suggested by IAEA GS-G-2.1 [12]. The facility-specific analytical basis for such EPZ values is not publicly documented. Introducing performance-based option along with the existing prescriptive structure is another major issue.

The 3 issues are interrelated and require amendment of regulations at statutory level. A systematic analyses of these structural features will be developed in a subsequent study.

5 CONCLUSION

This paper compared the U.S. and South Korean EPR regulatory frameworks using 10 items derived from recent NRC documents. The comparative analyses revealed 3 issues observed as the most important in future, especially for SMR deployment: EP-licensing linkage, facility classification and its technical basis, and EPZ sizing methodology. Their structural origins and corresponding policy implications should be developed in a subsequent study. The subsequent study will integrate a historical-institutional analysis, an alignment assessment against IAEA GSR Part 7 in detail.

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