

Three Structural Barriers to Risk-Informed Regulation in Korea: A Comparative Legal–Technical Review

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1. Introduction

Korea's nuclear energy program was built through active importation of U.S. reactor designs and regulatory frameworks. Regulatory guidelines issued by the Korea Institute of Nuclear Safety (KINS) and the Nuclear Safety and Security Commission (NSSC) mirror many U.S. Regulatory Guides, and this direct transfer succeeded in producing rapid safety standardization within a deterministic regulatory culture built around single-failure criteria, engineering margins, and design-basis accidents.

However, as the US NRC began transitioning toward Risk-Informed Regulation (RIR)[1] in the 1990s—leveraging probabilistic risk assessment (PRA) to prioritize regulatory attention on areas of highest safety significance—the gap between US and Korean regulatory paradigms began to widen. While Korea has made numerous attempts to adopt RIR over the past 30 years, it has encountered fundamental barriers. This study examines these barriers by separating them into three distinct dimensions: legislative hierarchy, judicial doctrines of acceptable risk, and administrative risk/uncertainty management. Understanding these conceptual challenges is crucial as the global nuclear sector pivots toward Small Modular Reactors (SMRs), which are heavily reliant on RIR for licensing and design.

2. The First Challenge: Rulemaking Authority and Legislative Hierarchy

The first challenge is structural and relates to how legislative authority is delegated to administrative agencies. In the United States, the Code of Federal Regulations (10 CFR) possesses the full status of 'Legislative Rules.' Enacted by the NRC under the strict procedural requirements of the Administrative Procedure Act (APA), these rules undergo rigorous notice-and-comment rulemaking. Once finalized, 10 CFR regulations carry the same binding legal authority as statutory laws enacted by Congress. This legal status allows the NRC to set legally enforceable, quantitative risk-informed criteria that bind both the operators and the courts.

Korea's administrative system operates under a rigid, continental civil law hierarchy. According to Articles 75 and 95 of the Korean Constitution, the delegation of legislative power is strictly confined to Presidential

Decrees (대통령령) and Prime Ministerial or Ministerial Ordinances (부령). Administrative bodies, including the Nuclear Safety and Security Commission (NSSC), do not possess the constitutional authority to independently issue regulations with external binding force (대외적 구속력) unless specifically and concretely delegated by a superior statute. Consequently, detailed technical and quantitative risk guidelines—such as the KOSHA Guides for chemical carcinogens or NSSC technical standards—are classified as 'administrative rules' (행정규칙) or 'soft law.' Because these rules lack formal legislative authority, the Korean judiciary does not recognize them as binding trial norms, preventing the establishment of a stable, legally binding quantitative risk regulatory framework.

3. The Second Challenge: The Lack of a Judicially Established Acceptable Risk Standard

The second barrier lies in the judicial treatment of acceptable risk. In the US, the boundary of 'acceptable' industrial and environmental risk was quantitatively defined through landmark judicial precedents. Most notably, in the Benzene Decision of 1980 (Industrial Union Department v. American Petroleum Institute)[4], the US Supreme Court ruled that the government must prove a risk is 'significant' before issuing new regulations, explicitly suggesting that a lifetime risk of 1 in 1,000 (0.1%) represents a legally defensible threshold of significance. This numerical benchmark was subsequently adopted by the US NRC in its 1986 Safety Goals Policy Statement[6], which set quantitative health objectives (QHOs) restricting nuclear-induced fatality risks to 0.1% of existing background risks.

In contrast, the Korean judiciary has refused to endorse any quantitative acceptable risk standards. The fundamental legal precedent addressing this is the 1975 medical malpractice case (Supreme Court Decision 74 다 1006)[5]. In this ruling, the Supreme Court recognized the doctrine of 'permitted risk', acknowledging that certain highly beneficial social activities (like medical surgery or industrial engineering) possess inherent, unavoidable risks that must be tolerated if standard preventative protocols are met. However, the Court defined this doctrine purely in qualitative, behavioral terms—focusing on whether the practitioner fulfilled a qualitative duty of care, rather than satisfying a quantitative probability of failure. Because the courts

do not accept numerical risk limits as a defense, meeting administrative safety goals (such as the NSSC's 2001 Quantitative Safety Goal of 0.1%) does not provide utility with legal immunity or a defense against post-hoc negligence claims in civil or criminal trials.

4. The Third Challenge: Inherent Uncertainty and Official Risk Baselines

The third challenge is technical and administrative, focusing on the treatment of uncertainty. Risk is inherently probabilistic and carries deep epistemic and aleatory uncertainties. For a regulator to implement RIR, the government must officially recognize and publish baseline risks and their uncertainties. In the US, this was accomplished through the landmark NUREG-1150 study (1990)[2]. The US NRC spent massive resources to quantify severe accident risks and their uncertainties for five representative US plants. This study did not merely provide point-estimate numbers; it utilized advanced probability distributions to represent uncertainty, thereby establishing a legally and scientifically standardized risk baseline. This official baseline allowed the industry and the regulator to have a shared, public starting point for PRA-based regulatory trade-offs.

In Korea, while the NSSC formally adopted a '0.1% Quantitative Safety Goal' in its 2001 Severe Accident Policy[8], the government has never officially published Korean-specific baseline risk profiles or their associated uncertainties. The Korean regulatory authority has historically relied on utility-developed PRA model and the risk profiles, without engaging in public discussions regarding Korea's unique operating experiences, safety culture, or local environmental parameters, related to uncertainties in the risk profiles. This administrative omission creates a technical vacuum. Without an officially developed (not endorsed) baseline and a formalized methodology to process epistemic uncertainty, Korean PRA models are often perceived by the public and the judiciary as arbitrary mathematical exercises rather than objective, scientific regulatory tools.

5. Comparative Analysis and SMR Licensing Implications

To highlight the systemic friction, Table 1 contrasts the regulatory, judicial, and technical structures of the United States and Korea regarding risk-informed decision-making.

Dimension	United States	Korea
Legislative Status	10 CFR has legislative rule status under APA; directly binding on courts and operators.	NSSC standards and guidelines classified as internal administrative rules; lack external binding force.

Acceptable Risk	Quantitatively defined (1/1,000 threshold of significance) via 1980 Benzene Decision.	Qualitatively defined via 1975 medical permitted risk doctrine; refuses to accept quantitative thresholds.
Uncertainty Baseline	Officially published and modeled via NUREG-1150; standardized risk profiles.	No officially published baseline risks or uncertainty profiles

These structural discrepancies are particularly critical for the deployment of Small Modular Reactors (SMRs). Modern SMR designs—which integrate passive safety systems to drastically reduce the probability of core damage—cannot be licensed economically under traditional deterministic rules. SMR licensing relies on the NRC's RIPBR approach, where reduced physical containment requirements are legally traded off against highly confident, PRA-proven risk profiles.[7] If Korea attempts to partially import these US technical standards without first establishing an equivalent legislative, judicial, and administrative infrastructure, it will encounter severe regulatory gridlock.

6. Conclusion

Because of these three major legislative, judicial, and technical challenges, most continental civil law countries, including Japan and France, have only been able to adopt the US RIR framework in a highly restricted, supplementary manner. As the nuclear industry prepares for the deployment of SMRs, Korea cannot rely on a simple 'translation' of US technical guidelines.

To successfully utilize risk-informed regulations, Korea must meticulously align its legal and technical frameworks—codifying quantitative risk goals into formal Presidential Decrees to satisfy the constitutional principle of statutory reservation, developing a judicial doctrine of quantitative 'permitted risk', and establishing a standardized national database to officially model baseline risk uncertainties.

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