

An Incomplete Demonstration Pathway: Structural Limits of Korea's SMR Special Act and Directions for Reform

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1. Introduction

Korea's *Special Act on the Promotion and Support of the Development of Small Modular Reactors (SMRs)* [1] represents an important institutional step toward the development of SMR technologies. The Act recognizes SMRs, non-light-water SMRs, and "SMR systems" as policy objects, while its statutory purpose explicitly includes research, development, and demonstration. This technology-inclusive scope can provide a broad policy basis not only for light-water SMRs, but also for advanced reactor applications involving high-temperature gas-cooled reactors (HTGRs), sodium-cooled fast reactors (SFRs), molten salt reactors (MSRs), industrial heat, hydrogen production, marine applications, and integrated energy systems.

A structural limitation, however, remains between this broad statutory recognition and the Act's explicit demonstration-support mechanism. Article 11 authorizes administrative, technical, and financial support for rapid demonstration, but limits such support to the demonstration of research reactors under Article 30-2(1) of the Nuclear Safety Act [1]. Consequently, the Act does not provide the same explicit demonstration-support basis for power reactors, process-heat reactors, marine applications, or first-of-a-kind (FOAK) reference plants.

This distinction is important. The absence of explicit support under Article 11 does not mean that such projects are legally prohibited or cannot be pursued under other laws. Rather, the issue addressed in this study is that the SMR Special Act itself does not yet establish an explicit support pathway connecting advanced reactor development to project-level demonstration and deployment.

This paper therefore argues that the Act is a meaningful first step but remains predominantly R&D-oriented in its operative mechanisms. The next policy task is to strengthen the statutory connection among technology development, demonstration, regulatory readiness, FOAK construction, commercial participation, and reference-project creation.

2. Analytical Framework and Structural Limits

For the purposes of this study, a deployment-oriented policy framework is assessed according to six functions: (F1) explicit demonstration scope, (F2) participation of project-level actors, (F3) enabling infrastructure, (F4)

Table I. Scope of Explicit Demonstration Support under Article 11

Demonstration Category	Explicit Support under Article 11	Policy Implication
Research reactor	Yes	Site, infrastructure, construction/operation, and cost support can be provided
Power/process-heat reactor	Not explicit	No equivalent explicit demonstration-support pathway under Article 11
Marine/FOAK reference project	Not explicit	Additional statutory or institutional support mechanism may be required

regulatory readiness, (F5) commercial risk-sharing mechanisms, and (F6) creation of operating reference projects. These functions distinguish technology development from the institutional conditions necessary to convert a mature design into a constructed and operating project. They are used as analytical lenses throughout this study.

The central structural gap is found in Article 11. While the provision authorizes support for sites, safety infrastructure, construction and operation, costs, research facilities, equipment, and experts, these measures are expressly tied to research-reactor demonstrations [1]. A research reactor can provide important technical and safety data, but it cannot by itself validate all project-level attributes of a power or process-heat demonstration project, including grid integration, industrial heat delivery, constructability, maintainability, operating economics, licensing repeatability, and supply-chain performance. Table I summarizes the difference in the explicit demonstration-support scope of Article 11.

The gap is particularly relevant for non-light-water SMRs because technology-specific characteristics generate technology-specific demonstration needs. SFR deployment may require system-scale validation of sodium handling and chemical-reaction control; HTGR deployment requires high-temperature heat-transfer, helium-system, graphite, and fuel-qualification evidence; and MSR deployment may require demonstration of salt chemistry, corrosion control, off-gas management, and associated material performance. Thus, statutory recognition of non-light-water technologies should be

accompanied by mechanisms that enable the validation infrastructure required for their licensing and deployment.

Article 5 provides a broader policy-planning foundation than Article 11 in several respects. The five-year basic plan already includes demonstration fuel-supply arrangements, public acceptance, human resources, international cooperation, and institutional improvement [1]. However, it does not expressly require a project-level commercialization strategy covering FOAK construction, site development, module manufacturing, equipment qualification, licensing interfaces, offtake, financing, export references, and decommissioning. These elements are important because SMR economics depend not only on reactor technology but also on modularization, standardization, factory-based construction, and economies of series [2].

3. From Technology Recognition to Demonstration and Deployment

Three principles can guide the transition from technology recognition to a more deployment-oriented framework.

First, the Act should apply a technology-inclusive regulatory-readiness principle. Recognition of non-light-water SMRs should be linked to advance preparation for technology-specific fuels, coolants, materials, safety-analysis methods, test facilities, and qualification requirements. This is particularly important where advanced fuels are involved. The U.S. Department of Energy, for example, notes that many advanced reactor concepts require HALEU and that limitations in fuel availability may constrain deployment [3]. Regulatory readiness should therefore develop in parallel with reactor technology rather than after a FOAK project has already been proposed.

Pre-application regulatory engagement provides one relevant institutional example. The U.S. Nuclear Regulatory Commission maintains structured pre-application interactions with advanced-reactor developers, including non-light-water reactor vendors, to identify technical and policy issues before formal licensing applications [4]. Such an approach does not weaken regulatory standards; rather, it can improve regulatory predictability while preserving independent safety decision-making.

Korea has also begun to institutionalize a comparable pre-review pathway. The Nuclear Safety and Security Commission (NSSC) has operated pre-design review activities for future reactors, including the innovative SMR (*i*-SMR), in advance of formal licensing [5]. In May 2026, the Nuclear Safety Act was amended to introduce Article 100-2, under which applicants for a construction permit or standard design approval may request pre-review of reactor and associated-facility designs before filing the formal licensing application. The NSSC must consider the pre-review results in the subsequent licensing review, and Article 100-2 is scheduled to take effect on November 20, 2026 [6]. This

development indicates that regulatory readiness (F4) is increasingly being institutionalized through nuclear-safety legislation. The remaining policy challenge is therefore not to duplicate nuclear-safety regulation in the SMR Special Act, but to connect this emerging regulatory pathway with demonstration, FOAK construction, industrial participation, and reference-project creation.

Second, the Act should normalize demonstration as a distinct stage between design approval and commercial replication. Standard design approval demonstrates design-level regulatory maturity, but it is not equivalent to a constructed and operating reference plant. SMART100 obtained Standard Design Approval in 2024 and is described as a 365 MWth, 110 MWe passive SMR applicable to electricity generation, desalination, district heating, and process heat [7]. This case illustrates the distinction:

Design Approval ≠ Demonstration Project ≠ Operating Reference

A design approval does not itself establish a site, financing structure, offtake arrangement, construction organization, supply chain, or operating record. A deployment-oriented framework should therefore provide a policy bridge through which technically and regulatorily mature designs can progress toward reference projects.

Third, the Act should enable a public-private project-development framework. SMR commercialization requires participation beyond public research institutions, while private firms may face substantial FOAK licensing, construction, schedule, and market risks. Deployment therefore requires coordinated participation by utilities, vendors, EPC firms, industrial offtakers, shipbuilders, component suppliers, financiers, and relevant government institutions.

Table II summarizes selected domestic and international examples of policy functions that support the transition from R&D to demonstration and deployment. These examples should not be interpreted as legal models to be transplanted directly into Korean legislation. In particular, Korea's recent pre-review framework demonstrates that some deployment functions, such as regulatory readiness, can appropriately be established through the Nuclear Safety Act rather than duplicated in the SMR Special Act. Rather, the cases illustrate how different legal and policy instruments can collectively support FOAK risk sharing, regulatory readiness, project-level coordination, supply-chain development, and reference-project creation.

4. Reform Directions

Based on the above analysis, seven reform directions are proposed.

(1) Article 11 – Broaden the explicit demonstration-support scope.

Table II. Examples of Demonstration- and Deployment-Oriented Policy Functions

Case	Main Mechanism	Relevance to Korea
U.S. DOE Advanced Reactor Demonstration Program	Cost-shared industry demonstration and reduction of licensing, construction, and operational risks	Public-private FOAK risk sharing and operating demonstration [8]
U.S. NRC Advanced-Reactors Pre-application Activities	Early regulatory engagement and technology-inclusive review preparation	Regulatory readiness before formal licensing [4]
Korea NSSC / i-SMR Pre-design Review and Statutory Pre-review	Pre-design review for i-SMR and statutory pre-review under Article 100-2 of the Nuclear Safety Act	Domestic institutionalization of regulatory readiness before formal licensing [5,6]
UK GBE-N / Rolls-Royce SMR Programme	Publicly backed project development, site-specific design, regulatory engagement, supply-chain preparation, and progression toward FID	Government-supported transition from technology selection to an investable project [9]

The research-reactor-only limitation should be revised so that the provision can support demonstration reactors, demonstration facilities, and SMR-system demonstrations, including power, process-heat, and other applications where appropriate. Such support should remain subject to the licensing and safety requirements of the Nuclear Safety Act and other applicable legislation.

(2) Article 5 – Strengthen the commercialization-oriented basic plan.

In addition to the elements already required by the Act, the basic plan should explicitly address FOAK construction, site and infrastructure strategy, module manufacturing, equipment qualification, fuel supply, licensing interfaces, supply-chain development, offtake, financing, export references, and decommissioning.

(3) Article 8 – Establish cross-ministerial coordination for deployment.

Governance should connect science and technology policy with energy, industry, finance, maritime applications, exports, and nuclear-safety policy. Participation of nuclear-safety authorities should support early coordination and regulatory readiness without compromising the independence of licensing and safety decisions.

(4) Article 9 – Support regulatory readiness for non-light-water SMRs.

Institutional improvement should complement the emerging pre-review framework under the Nuclear Safety Act by supporting technology-inclusive safety-analysis methods, test and validation infrastructure, fuel and coolant qualification, codes and standards, and international regulatory cooperation. The SMR Special Act should facilitate regulatory preparedness and supporting infrastructure without duplicating the licensing authority or review procedures established under nuclear-safety legislation.

(5) Article 10 – Extend support toward FOAK engineering and industrial readiness.

Support should include, where appropriate, module fabrication, component qualification and certification, quality assurance, manufacturing readiness, demonstration infrastructure, and generation of operating data.

(6) Article 12 – Provide an enabling basis for commercial risk sharing.

Rather than placing all financial instruments directly in the SMR Special Act, Article 12 could provide an enabling and coordinating basis for policy finance, public procurement, long-term offtake arrangements, and other FOAK risk-sharing measures implemented through relevant fiscal, energy-market, procurement, and financial legislation.

(7) Article 13 – Expand the role of special zones.

SMR R&D zones should be capable of supporting demonstration and industrialization functions, including test and validation infrastructure, manufacturing and supply-chain activities, and demonstration-support facilities, while remaining subject to applicable nuclear-safety, environmental, and land-use requirements.

Table III summarizes the structural gaps identified in the relevant provisions of the Act, maps them to the six analytical functions defined in Section 2, and presents the corresponding reform directions proposed in this study.

5. Conclusions

Korea's SMR Special Act is an important legislative milestone. It establishes a broad statutory vocabulary for SMRs, non-light-water SMRs, and SMR systems and expressly recognizes demonstration as part of national SMR development policy. Nevertheless, its operative mechanisms do not yet provide a complete pathway from technology development to project-level demonstration and deployment.

The central issue is Article 11. The provision offers substantial forms of demonstration support but expressly limits rapid-demonstration support to research reactors. This limitation does not prohibit power, heat, marine, or FOAK demonstration projects under other applicable laws. It does, however, mean that the SMR Special Act itself does not provide these projects with an equivalent explicit demonstration-support mechanism.

The next legislative task should therefore be to connect R&D policy with demonstration and

Table III. Structural Gaps, Analytical Functions, and Reform Directions

Article	Existing Role	Structural Gap	Primary Analytical Function(s)	Proposed Direction
5	Five-year basic plan	Project-level FOAK, manufacturing, licensing, financing, and offtake strategy not explicit	F3; F5; F6	Add deployment and commercialization strategy
8, 9	Governance and institutional improvement	Limited connection between technology development and project/regulatory readiness	F2; F4	Cross-ministerial coordination and non-LWR regulatory-readiness roadmap
10	Development, tests, analysis, cooperation, standardization	Limited explicit support for industrial and FOAK readiness	F3	Manufacturing, qualification, infrastructure, and operating-data support
11	Rapid demonstration support	Explicit support limited to research-reactor demonstrations	F1; F6	Include broader demonstration reactors, facilities, and SMR-system demonstrations
12	Joint companies and research associations	FOAK commercial risk-sharing mechanisms not explicit	F2; F5	Create enabling basis for finance, procurement, offtake, and risk sharing
13	R&D special zones	Demonstration and industrialization functions not explicit	F3; F6	Enable demonstration-support and industrialization functions

F1: Explicit demonstration scope; F2: Project-level actors; F3: Enabling infrastructure; F4: Regulatory readiness; F5: Commercial risk sharing; F6: Operating reference projects.

deployment by broadening the explicit support scope, complementing the emerging pre-review framework under the Nuclear Safety Act with technology-specific validation infrastructure, preparing FOAK construction and manufacturing capabilities, establishing public-private risk-sharing mechanisms, and creating pathways to operating reference projects.

The objective is not to transform an R&D statute into a substitute for nuclear-safety, energy-market, fiscal, or procurement legislation. Rather, the SMR Special Act should function as an enabling and coordinating statute that bridges technology development and commercial deployment while preserving the independence of nuclear safety regulation.

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