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Korean Status in Lifecycle-Based Cybersecurity Regulation for Nuclear Facilities

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1. Introduction

Cyber threats targeting nuclear facilities continue to evolve with the diffusion of digital technology, and the regulatory body is pursuing the Advancement of Nuclear Control Regulatory Technology project to establish a framework capable of continuously identifying emerging issues and responding to them promptly. Such a response requires a systematic analysis of the current regulatory framework, which is the starting point of regulatory rationalization — that is, of identifying and revising requirements that fail to reflect changes in the environment and in technology, or that operate differently from their intended purpose in practice.

Nuclear facilities are not limited to nuclear power reactors and relevant facilities; they also include research and educational nuclear reactors, nuclear fuel cycle facilities, facilities using nuclear materials, radioisotope facilities, radiation generating devices, interim spent fuel storage facilities, radioactive waste facilities, and foreign nuclear ships. Because the licensing system differs among facility types, the institutional lifecycle and the technical lifecycle do not always coincide. Kori Unit 1 and Wolsong Unit 1 underwent permanent suspension in June 2017 and December 2019, respectively, and power operation has ended, yet their operating licenses remain in force. The Act on Physical Protection and Radiological Emergency (hereinafter the "PPRE Act") [1], however, does not provide an explicit criterion for the endpoint at which regulation ceases to apply.

Accordingly, this study aims to survey the current status of domestic cybersecurity regulation, which is a prerequisite for rationalizing cybersecurity regulation over the entire lifecycle of nuclear facilities, and to identify regulatory improvements needed for each facility type and each lifecycle stage.

2. Regulatory Framework for Nuclear Cybersecurity

2.1. Legal Framework for Cybersecurity Regulation

The current domestic nuclear cybersecurity regulatory framework consists of a four-tier delegation structure extending from the governing statute down to the review and inspection criteria.

At the highest tier is the PPRE Act. The purpose of this Act is to protect the life and property of citizens by establishing a physical protection system and a system for preventing radiation disasters for the safe management and operation of nuclear materials and nuclear facilities, and the cybersecurity requirements are contained in Chapter II, Physical Protection of Nuclear Materials and Nuclear Facilities. At the second tier are the Enforcement Decree and the Enforcement Rule of the PPRE Act, which translate the statutory obligations into regulatory procedures.

The third tier comprises the Public Notices of the Nuclear Safety and Security Commission (NSSC). Three Public Notices govern the physical protection field: the Detailed Criteria by Item for the Contents of Physical Protection Regulations, etc. and International Transport Protection Plans [2]; the Regulation on Physical Protection Inspections of Nuclear Facilities, etc.; and the Regulation on Physical Protection Education and Drills. Among these, the first sets out in Appendix 4 the detailed criteria for preparing information system security regulations, thereby securing clarity in the cybersecurity review. At the final tier are the review and inspection criteria of the Korea Institute of Nuclear Nonproliferation and Control (KINAC), the technical support organization for regulation; five of these address cybersecurity, namely KINAC/RS-011, RS-015, RS-018, RS-019, and RS-020. These criteria are, however, working-level documents used by the technical support organization and differ in character from statutes and Public Notices; accordingly, the determination of regulatory coverage in this study was carried out within the scope of the Act and the Public Notices delegated thereunder.

2.2. Nuclear Facilities

The nuclear facilities subject to cybersecurity regulation are specified in Article 2(1)2 of the PPRE Act and Article 4 of its Enforcement Decree. Article 2(1)10 of the same Act, in turn, defines the scope of a nuclear licensee principally by reference to persons who have obtained permits and other authorizations under the Nuclear Safety Act [3], so that the facilities subject to cybersecurity regulation are directly linked to the facility classification of the Nuclear Safety Act. A comparison of the nuclear facilities defined in the two Acts identified differences in four facility types.

First, for educational nuclear reactors, the PPRE Act, unlike the Nuclear Safety Act, attaches the condition of "a thermal power of 100 W or more." The AGN-201K at Kyung Hee University, currently the only educational nuclear reactor in Korea, has a thermal power of 10 W

and is therefore excluded from the scope of cybersecurity regulation. Furthermore, a different quantitative threshold is applied to the same reactor category elsewhere in the legislation: with respect to radiation environmental surveys and radiation environmental impact assessments, the Nuclear Safety Act specifies only educational nuclear reactors with "a thermal power of 100 kW or more." The same reactor category is thus delimited by different quantitative thresholds depending on the regulatory purpose.

Second, for radioisotope facilities, differences were found from two perspectives. In terms of the scope of regulation, the Nuclear Safety Act makes the production, sale, use and other handling of radioisotopes subject to permission, whereas the PPRE Act includes as nuclear licensees only those persons permitted to produce, sell or use 18.5 PBq or more. Here, 18.5 PBq corresponds to 0.5 MCi. Under the IAEA categorization of radioactive sources, sources used in irradiation facilities are classified as Category 1, the highest risk category [4], and a typical large-scale irradiation facility holds sources on the order of 0.5 to 1 MCi; the threshold may therefore be understood as a conservative adoption of the lower bound of that range rather than as the numerical threshold of Category 1 itself.

Third, radiation generating devices and their auxiliary facilities are expressly designated as facilities subject to regulation under the Nuclear Safety Act but are not mentioned in the PPRE Act. Fourth, interim spent fuel storage facilities are likewise specified in the Nuclear Safety Act but have no express provision in the PPRE Act. However, since terms not separately defined in the PPRE Act follow the definitions of the Nuclear Safety Act, and since radioactive waste includes "spent nuclear fuel determined to be disposed of," there is room to interpret an interim spent fuel storage facility that stores such fuel as a storage facility for radioactive waste.

Because a nuclear licensee, as the object of cybersecurity regulation under the PPRE Act, means a person at a specific licensing stage with respect to the above facilities, the coverage of cybersecurity regulation differs from that of the Nuclear Safety Act with respect to these four facility types. These four differences are not all of the same character. For educational nuclear reactors and radioisotope facilities a quantitative level is set, below which a facility is not brought within the scope of regulation, which may be seen as one form of a graded application, although the basis on which those levels were set is not identified in the Act or its subordinate statutes; radiation generating devices and interim spent fuel storage facilities, on the other hand, are subject to no such level and are not referred to at all. It is therefore not readily apparent from the provisions alone whether these differences rest on a differentiation by risk.

2.3. Lifecycle Stages and Regulatory Items

Once the facilities subject to regulation have been identified, the next step is to ascertain up to which lifecycle stage the regulation extends. Table I presents the nuclear facilities subject to cybersecurity regulation, identified on the basis of the definition of a nuclear licensee under the PPRE Act, together with the licensing system applicable to each of those facilities under the Nuclear Safety Act.

Table I: Licensing systems under the Nuclear Safety Act for nuclear facilities

Nuclear facility	**Licensing system**
Nuclear power reactors, etc.	Standard design approval* – Construction permit – Operating license
Research reactors, etc.	Construction permit – Operating license
Educational reactors, etc. (≥100 W)	Construction permit – Operating license
Nuclear fuel cycle facilities	Construction permit – Operating license
Facilities using nuclear materials	Permission for use or possession
Radioisotope facilities, etc. (≥18.5 PBq)	Permission for production, sale or use
Radioactive waste facilities, etc.	Construction permit – Operating license
Foreign nuclear ships	Report of entry into or departure from port
‘etc.’ denotes the relevant facilities of each facility type. *: Added by the Partial Amendment Bill to the Act on Physical Protection and Radiological Emergency, proposed on 11 August 2025 (representative proposer: Rep. Choi Min-hee). The Bill was enacted as Act No. 21520 on 31 March 2026, which takes effect on 1 April 2027.	

The lifecycle stages reached by the regulation have been extended by a recent amendment to the Act. Under the PPRE Act [1], amended on 31 March 2026 and scheduled to take effect on 1 April 2027, the obligation to prepare and obtain approval for physical protection regulations and related documents has been extended to applicants for standard design approval of nuclear power reactors and relevant facilities, for a construction permit for nuclear power reactors, research and educational nuclear reactors and nuclear fuel cycle facilities, and for a construction and operating license for radioactive waste facilities. As shown in Table I, however, the licensing system differs among facility types; it is therefore necessary to define a lifecycle that can be applied to nuclear facilities in general and to match it with the lifecycle based on the existing licensing system.

As one example of such a general lifecycle, the National Intelligence Service has promulgated the Guidelines on Lifecycle Security by Design for National Nuclear Facilities [5] as a policy guideline for

security by design at domestic nuclear facilities; these Guidelines present the lifecycle of a nuclear facility in eight stages, namely planning, development planning, design, implementation, testing, installation, operation and decommissioning. In this study, from a comprehensive perspective applicable irrespective of facility type, the lifecycle was defined as design, development, operation, suspension and decommissioning, and was matched with the lifecycle based on the licensing system presented in Table I. Design corresponds to standard design approval; development to a construction permit and the prior review conducted before the commencement date of construction; operation to an operating license before permanent suspension and to the various permissions and reports for use, possession, production and sale; suspension to permanent suspension; and decommissioning to decommissioning.

The PPRE Act presents review, inspection and drill evaluation as the regulatory items for cybersecurity. Review is the procedure for confirming whether the information system security regulations submitted by a nuclear licensee satisfy the statutory requirements and have been appropriately established so as to protect the computers and information systems within the facility against electronic infringement; it is conducted at every licensing application stage that exists for the facility concerned, including standard design approval. Inspection is the procedure for confirming compliance with the information system security regulations and the need for supplementation, with cybersecurity matters included within the scope of the physical protection inspection; the initial inspection is in principle conducted before nuclear materials, radioactive materials or radioactive waste are carried into the nuclear facility, and periodic inspections are conducted every two years for each business office or site. Drill evaluation is the regulatory activity whereby the NSSC evaluates the results of drills conducted for persons performing physical protection duties and may order necessary measures; it is carried out at the same lifecycle stages as inspection.

The PPRE Act and its subordinate statutes prescribe the objects of application and the timing of performance for review, inspection and drill evaluation individually, but do not directly divide them by the lifecycle stage of a nuclear facility. Mapping them onto the five lifecycle stages defined above, review applies from design through decommissioning, whereas inspection and drill evaluation apply only from operation onward. The reason differs between the two earlier stages: at the design stage an applicant for standard design approval is not a nuclear licensee, and the amendment extends review alone to such an applicant, whereas at the development stage a person who has obtained a construction permit is already a nuclear licensee under Article 2(1)10 of the PPRE Act, but the facilities and equipment to be inspected have not yet been completed and the time for the initial inspection, which falls at the beginning of the operation stage, has not yet arrived. In Table II, lifecycle stages that fall within a single licensing stage are merged into one cell: the operating license covers operation, suspension and decommissioning, and, where no standard design approval procedure exists, the construction permit covers both design and development.

3. Status of Cybersecurity Regulatory Coverage

Table II: Status of cybersecurity regulatory coverage by nuclear facility and lifecycle stage under the PPRE Act

○: Covered under the PPRE Act; ◐: Excluded under the PPRE Act;
–: Not applicable, as the regulatory item cannot be performed at that stage or the stage does not arise for the facility
D: Design; DV: Development; OP: Operation; SU: Suspension; DC: Decommissioning.

Nuclear Facility		Regulatory Item														
		Review					Inspection					Drill Evaluation				
		D	DV	OP	SU	DC	D	DV	OP	SU	DC	D	DV	OP	SU	DC
Nuclear power reactors, etc.		○(1)	○	○			–	–	○			–	–	○		
Research reactors, etc.		○		○			–		○			–		○		
Educational reactors, etc.	Thermal power < 100 W	◐														
	Thermal power ≥ 100 W	○		○			–		○			–		○		
Nuclear fuel cycle facilities		○		○			–		○			–		○		
Facilities using nuclear materials		○					–		○			–		○		
Radioisotope facilities, etc.	< 18.5 PBq	◐														
	≥ 18.5 PBq	○					–		○			–		○		
Radiation generating devices and auxiliary facilities		◐														
Interim spent fuel storage facilities		◐(2)														
Radioactive waste facilities, etc.		◐(3)	○	○			–		○			–		○		
Foreign nuclear ships		–	–	○	–	–	–	–	○	–	–	–	–	○	–	–

'etc.' denotes the relevant facilities of each facility type. Based on the PPRE Act as amended on 31 March 2026, effective 1 April 2027.
(1) Applicants for standard design approval are included among the persons subject to approval under the amended PPRE Act
(2) where interim spent fuel storage facilities are interpreted as not being included in 'radioactive waste facilities'
(3) where they are interpreted as being included.

Table II states the position under the amended PPRE Act, which takes effect on 1 April 2027; the extension of review to the design and development stages reflects that amendment, whereas inspection and drill evaluation are unaffected by it. From Table II, the point at which review begins to apply differs among facility types. Nuclear power reactors are the only facilities for which a standard design approval procedure exists, and review is accordingly marked ○ at the design stage as well as at the development stage. For research and educational nuclear reactors and nuclear fuel cycle facilities, no such procedure exists and the construction permit covers both design and development, so the two stages are merged into a single cell and marked ○, applicants for a construction permit being included among the persons subject to approval. For radioactive waste facilities the design stage is shown separately and marked ◐, depending on whether interim spent fuel storage facilities are interpreted as included (notes (2) and (3)). For facilities using nuclear materials and radioisotope facilities of 18.5 PBq or more, only a single licensing stage exists, so that permission is not divided by lifecycle stage; all five stages are accordingly merged into a single cell and review is marked ○ throughout. For foreign nuclear ships, only a report of entry into or departure from port exists, so review is marked ○ at the operation stage alone and the remaining stages are marked –, as they do not arise under Korean jurisdiction.

From the perspective of regulatory items, inspection and drill evaluation are marked – at the design and development stages, since at the design stage the applicant is not a nuclear licensee and at the development stage the time for performance has not yet arrived, as set out in Section 2.3. The same mark is used where a lifecycle stage does not arise for the facility at all, as with the suspension and decommissioning stages of foreign nuclear ships. By contrast, ◐ indicates a facility excluded from the coverage of the PPRE Act.

4. Conclusions

This study organized the coverage of cybersecurity regulation by nuclear facility, lifecycle stage and regulatory item, by tracing the delegation relationships from the Act down to the review and inspection criteria. Three implications were derived.

First, securing regulatory consistency should begin not merely with aligning the names of facilities but with clarifying their definitions and quantitative thresholds. The PPRE Act should expressly address radiation generating devices and interim spent fuel storage facilities, and the quantitative thresholds of a thermal power of 100 W and of 18.5 PBq should be supported by a basis for a graded approach, such as a safety goal or risk.

Second, the scope of review, now extended to the standard design approval, construction permit and construction and operating license stages, should be reflected consistently in the Enforcement Decree and Enforcement Rule, the Public Notices of the NSSC, and the review and inspection criteria. Where an amendment to the Act changes the persons subject to approval or the point at which regulation begins to apply, the subordinate provisions should be revised accordingly.

Third, operation, permanent suspension and decommissioning are administered under a single operating license, but should be distinguished according to changes in technical condition and risk. In doing so, it is necessary to establish criteria for strengthening, relaxing or terminating the application of cybersecurity requirements, taking into account the condition of the facility, the remaining nuclear materials and digital assets, the physical protection functions that continue to be maintained, threats, and radiological consequences.

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