Journal of RADIATION INDUSTRY
Vol. 19, No. 3, pp. 285-296, 2025
https://doi.org/10.23042/radin.2025.19.3.285

Original article

Current Status of KEPIC Development for the Decommissioning of Nuclear Power Plants

Jiyeon Jun[1], Tae Young Kong[1,*], Hee Geun Kim[2], Hoyeon Lee[1], Changju Song[1], Seungho Jo[1], Jaeok Park[1], Kyungheum Kim[3], Wonhyeok Jeong[3], Byeonghoon Song[3], Taejun Chung[3], Gwansub Song[3], Seokhee Chung[3], and Seonkyung Lee[3]

[1]Department of Nuclear Engineering, Chosun University, 10, Chosundae 1-gil, Dong-gu, Gwangju 61452, Republic of Korea
[2]Division of Energy & Electrical Engineering, Uiduk University, 261 Donghae-daero, Gangdong-myeon, Gyeongju-si, Gyeongsangbuk-do 38004, Republic of Korea
[3]Department of Nuclear Codes & Standards, Korea Electric Association, 113 Jungdae-ro, Songpa-gu, Seoul 05718, Republic of Korea

ABSTRACT The Korea Electric Power Industry Code (KEPIC) has been used to ensure safety, reliability, and quality in the design, construction, and operation of nuclear power plants (NPPs). However, there has been no domestic experience in decommissioning commercial NPPs, which has resulted in the absence of specialized technical standards for this process. With the permanent shutdown and recent approval for decommissioning of Kori Unit 1, along with the increasing global demand for the decommissioning of aging NPPs, establishing technical standards in this area has become crucial. The current KEPIC framework primarily addresses design, construction, and operation, but it does not adequately cover the unique processes required for decommissioning, including radiation management, radioactive waste treatment, cutting and decontamination, and safety assessment. The lack of such standards can lead to safety degradation, insufficient regulatory linkage, and a decline in industrial competitiveness. In response to this need, the Korea Electric Association has initiated the development of 20 types of KEPICs specifically for nuclear decommissioning, scheduled to occur from 2023 to 2030 in three stages. The first stage is currently underway and includes the development of KEPICs for decommissioning cost assessment, source term evaluation, radiological characterization of systems, safety assessment, clearance of radioactive waste, metal cutting and dismantling, system decontamination, and the packaging, transport, and disposal of containers. The second stage will focus on developing KEPICs for site radiological characterization, cutting and dismantling of calandria and pressure tubes, dismantling biological shields and concrete, decontaminating metal and concrete, and managing liquid, gaseous, and solid radioactive waste. The final stage will establish standards for knowledge management, quality assurance, waste radioactivity measurement and verification, management of PHWR decommissioning wastes, mixed waste management, site reuse, and site restoration and decontamination. Out of the 20 KEPICs being developed, 10 will be promoted for international standardization to enhance domestic standards on a global scale and strengthen Korea's competitiveness in the nuclear decommissioning sector.

Key words: KEPIC, nuclear power plant, decommissioning, Korea Electric Association

1. Introduction

The Korea Electric Power Industry Code (KEPIC) was developed to ensure the safety, reliability, and quality of facilities and equipment in the power industry [1]. It serves as a key technical standard for Korea's electric power sector, outlining the technical and institutional requirements involved in the design, manufacture, construction, and operation of NPPs. KEPIC is based on the ASME Code (American Society of Mechanical Engineers Code) and has been adapted to meet local conditions, contributing significantly to the technological independence of the Korean nuclear power industry. Recently, following the permanent shutdown and decommissioning license approval of Kori Unit 1 in Korea, there has been a rapid increase in global demand for decommissioning due to the aging of operating nuclear power plants (NPPs) worldwide. Table 1 illustrates the operational and permanently shut-down status of NPPs around the world [2]. Analyzing the operational and decommissioned sta-

ISSN 1976-2402 **http://www.ksri.kr/**
Copyright© 2025 by Korean Society of Radiation Industry
***Corresponding author:** Tae Young Kong
Tel: +82-62-230-7158, E-mail: tykong@chosun.ac.kr
Received 4 September 2025 **Revised** 4 September 2025 **Accepted** 5 September 2025

Table 1. Overview of the global status of nuclear power plant operations, including permanent shutdowns and completed decommissioning, as of 2025

Country	Operating Reactors (units)	Permanently Shutdown (units)	Completed Decommissioning (units)
United States	94	41	17
France	57	14	0
Japan	14	27	1
China	57	0	0
Russia	36	11	0
Republic of Korea	26	2	0
India	21	0	0
Canada	17	6	0
United Kingdom	9	36	0
Ukraine	15	4	0
Sweden	6	7	0
Germany	0	36	4
Spain	7	3	1
Belgium	4	4	0
Czech Republic	6	0	0
Taiwan	0	4	0
Switzerland	4	2	0
Finland	5	0	0
Hungary	4	0	0
Slovakia	5	3	0
Pakistan	6	1	0
Argentina	3	1	0
Brazil	2	0	0
Bulgaria	2	4	0
Mexico	2	0	0
Romania	2	0	0
South Africa	2	0	0
Armenia	1	1	0
Iran	1	0	0
Netherlands	1	1	0
Slovenia	1	0	0
United Arab Emirates	4	0	0
Italy	0	4	0
Lithuania	0	2	0
Kazakhstan	0	1	0
Belarus	2	0	0
Total	416	215	23

tus of these plants reveals that decommissioning has become a critical issue in the global nuclear industry. In response to these developments, it is crucial to establish technical standards and institutional frameworks tailored specifically to nuclear decommissioning. However, the existing KEPIC framework primarily focuses on the design, construction, and operation of NPPs,

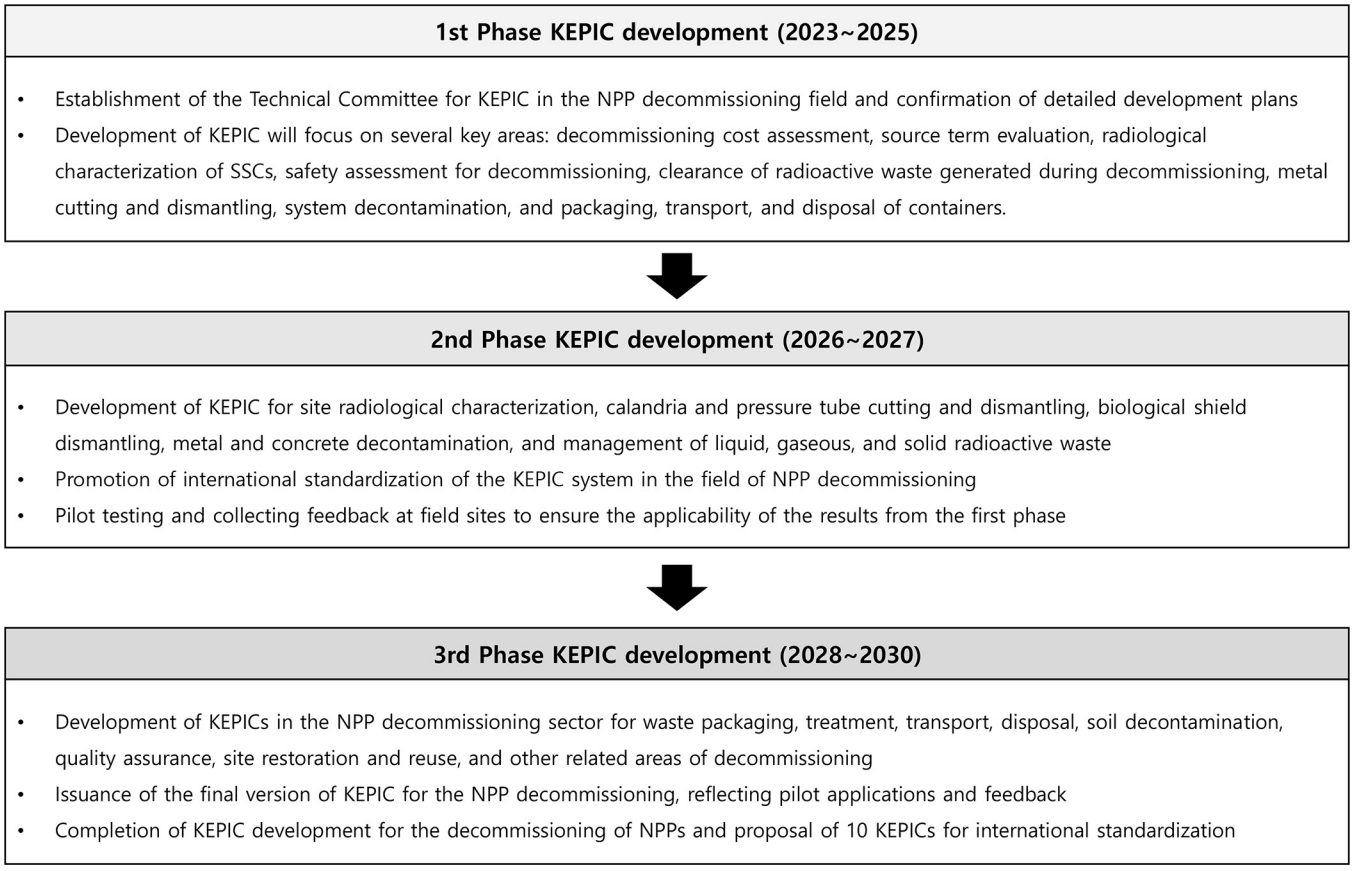

Fig. 1. Progress Status of KEPIC Development for the Decommissioning of Nuclear Power Plants by Phase

with very limited standards pertaining to decommissioning.

Decommissioning NPPs involves more than just managing them after they've stopped operating. It requires unique technical expertise and complex processes, including radiation management, the classification of radioactive waste, and the cutting and dismantling of structures. These processes differ from those involved in the construction and operation stages of the plants. However, the current KEPIC standards do not provide detailed procedures for essential aspects such as licensing and quality assurance in the decommissioning process. The lack of these technical standards can lead to several issues, including reduced safety at decommissioning sites, inadequate coordination with regulatory authorities, and a decline in the competitiveness of the decommissioning industry.

The development of KEPIC has primarily focused on the design, construction, and operation stages of NPPs. However, with the recent approval of the final decommissioning plan for Kori Unit 1 and the anticipated start of full-scale decommissioning, the need for KEPIC development dedicated to decommissioning of NPPs has become increasingly important [3]. To promote standardization in the field of decommissioning of NPPs, the Korea Electric Association is implementing the project, entitled "KEPIC development for the decommissioning of nuclear power plants" [4]. This initiative aims to develop essential decommissioning standards, including those for cost assessment, safety assessment, and dismantling procedures, gradually over time. The project is structured to create a total of 20 decommissioning standards for NPPs in three phases: 8 standards will be developed in the first phase (2023-2025), 6 in the second phase (2026-2027), and 6 in the third phase (2028-2030). Currently, the development of standards for the first phase is underway. This study will analyze the current status of KEPIC development for the decommissioning of NPPs and highlight the necessity of establishing specialized technical standards for each decommissioning stage. The goal is to expand KEPIC's applicability in the decommissioning field, ensure the safety and reliability of the nuclear decommissioning industry, and enhance the competitiveness of Korea's nuclear decommissioning technology.

2. Materials and Methods

Since nuclear-related KEPIC has primarily focused on the construction, design, and operation of NPPs, the approach for developing KEPIC in the field of NPP decommissioning must differ significantly from current methods. The NPP decommissioning process involves more direct handling of higher levels of radioactive materials, such as cutting and dismantling, which present unique challenges compared to construction and operation. To develop KEPIC that is tailored to decommissioning, it is essential to conduct studies that consider the specific characteristics of this process, such as source term evaluation and radiological characterization. Additionally, since this is the first Korean commercial NPP decommissioning initiative and there are no local precedents, it is crucial to conduct comprehensive reviews by comparing and analyzing international experiences in the decommissioning of NPPs. This will help ensure that the development aligns with global standards. Furthermore, a thorough investigation of decommissioning-related tasks and characteristics, along with the establishment of technical standards, is imperative for success in this endeavor.

This study focused on a literature analysis related to the development of KEPIC in the field of NPP decommissioning. The aim was to identify and systematically examine the current status of KEPIC development specifically for the decommissioning of NPPs. The research was limited to KEPIC projects that are currently under development, as well as those scheduled for future development. The literature sources reviewed included workshop materials from the Korea Electric Association, official reports on KEPIC, meeting minutes from the KEPIC decommissioning subcommittees, and other documents related to KEPIC development. In particular, the study focused on the KEPIC development project for NPP decommissioning, promoted by the Korea Electric Association. It involved a review of the step-by-step implementation plan and the detailed development items. The analysis focused on the objectives, necessity, intended use, and applications of the eight types of KEPICs currently being developed in the first stage, as well as those planned for the second and third stages. The study identified the purposes and directions of each development and examined the comprehensive framework of KEPIC development within the decommissioning field.

3. Results and Discussion

3.1. Phase 1 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

The first stage of KEPIC development for NPP decommissioning commenced in 2023 and is scheduled to continue through 2025 [5]. This stage aims to identify key items necessary for KEPIC development in the field of NPP decommissioning and to establish detailed standards for implementation. In terms of decommissioning design, the development of KEPIC focuses on several areas: cost assessment for decommissioning, evaluation of the decommissioning source term, radiological characterization of structures, systems, and components (SSCs), and safety assessments related to decommissioning. For cutting and decontamination, KEPIC development targets methods for metal cutting, dismantling, and system decontamination. In the area of decommissioning waste management, the focus is on developing KEPIC for the clearance of radioactive waste, as well as for the packaging, transport, and disposal of containers. Currently, a total of eight KEPIC development projects are underway in this first stage [6].

The KEPIC project aims to establish a comprehensive methodology for assessing the costs associated with NPP decommissioning. This methodology takes into account the unique characteristics of design, construction, operation, and safety management during the transitional phase following the permanent shutdown of NPPs. It will outline the decommissioning procedures and methods, establish basic assumptions, and create decommissioning plans while considering both domestic and international legal, institutional, and technical requirements. The goal is to quantitatively and objectively evaluate the costs necessary to complete the NPP decommissioning process. The project is currently undertaking an analysis of Korean and international data and regulatory requirements related to the assessment of NPP decommissioning costs. Additionally, it involves developing fundamental assumptions, conceptual design plans, and related strategies, scenarios, schedules, and detailed processes for decommissioning [7].

The KEPIC project for decommissioning source term evaluation aims to create a comprehensive methodology for determining assumptions and input parameters related to the evaluation of source terms in NPP decommissioning [8]. It considers the

safety management characteristics and the history of the entire lifecycle of NPPs. The project includes stipulations for radiological inventory, evaluation methods, procedures, and basic assumptions. KEPIC seeks to develop comprehensive methods and procedures that can effectively evaluate neutron activation, corrosion, and contamination source terms. The project is currently analyzing both Korean and international data and technical standards related to NPP decommissioning source term evaluation. Additionally, it involves establishing and reviewing standards for evaluating source terms.

The KEPIC for the radiological characterization of SSCs is a technical standard designed to evaluate and outline radiological characteristics such as radionuclides, radioactivity, and contamination levels for permanently shut-down and decommissioned NPPs [9]. Its objective is to create a methodology for assessing the distribution of radiological contamination in structures, systems, and components at each stage of decommissioning. Additionally, it provides insights on how to integrate radiological characterization methods with considerations of decommissioning costs, source terms, safety, and decommissioning technologies. Currently, both Korean and international cases, as well as reference standards for the radiological characterization of SSCs in NPP decommissioning, are under review, with efforts underway to develop methods for their practical application.

The decommissioning safety assessment is divided into two main categories: radiological safety assessment and non-radiological industrial safety assessment. Radiological safety assessment evaluates the radiation doses that workers and residents may receive under normal conditions as well as during design-basis accidents. Non-radiological industrial safety assessment focuses on the impacts on workers from accidents that do not involve radiological factors, such as fires, explosions, falls, and dust. The KEPIC for decommissioning safety assessment aims to provide methodologies and procedures for these evaluations. Currently, efforts are underway to review international standards for decommissioning safety assessments, investigate and analyze general methodologies and procedures, evaluate non-radiological hazards and associated risk levels, and develop procedures for non-radiological safety assessments [10].

The KEPIC also focuses on technologies for cutting and dismantling metals in the decommissioning of NPPs [11]. Depending on the level of radioactive contamination and the size and characteristics of the metal, specific cutting and dismantling technologies are employed. KEPIC is being developed to effectively address various environments and materials. Additionally, to manage the waste generated during the metal cutting and dismantling process, surveys are conducted to assess current conditions and characteristics. KEPIC also aims to establish pre-preparation and post-treatment requirements for the application of these cutting and dismantling technologies. The standard encompasses mechanical, electrical, and thermal cutting methods, incorporating measures for radiation protection and waste management.

The KEPIC for system decontamination focuses on chemical technologies designed to dissolve and remove contaminated oxide films and portions of base metal from the inner surfaces of NPP systems using various chemical agents [12]. The process is categorized based on the characteristics of the oxide film into single-step processes, which utilize a single decontaminant, and multi-step processes, which alternate between oxidants and reductants. Currently, standards are being developed that take into account technical performance factors such as decontamination efficiency and the generation of secondary waste. This involves surveying Korean and international cases, identifying applicable technologies, and reviewing existing standards and regulations. Additionally, evaluation systems are being established to assess safety, effectiveness, and the minimization of secondary waste.

The KEPIC establishes standards for the packaging, transport, and disposal of containers used for radioactive waste. These standards are designed to address the unique characteristics of radioactive waste generated during the decommissioning process, which tends to be more diverse in type and characteristics compared to waste produced during regular operations. Additionally, decommissioning waste is typically heavier and has a larger volume. Due to the complexities of the decommissioning process and its timeline, there is a need for containers specifically designed for decommissioning, in addition to the existing packaging containers used for operational waste [13]. Furthermore, as decommissioning activities may occur simultaneously at multiple sites, it is essential to review various disposal pathways. In response to these needs, efforts are underway to develop standardized containers specifically for NPP decommissioning. A summary of the KEPICs being addressed in the initial phase of KEPIC development for NPP decommissioning is provided in Table 2.

3.2. Phase 2 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

The second stage of KEPIC development for NPP decommissioning is scheduled to take place from 2026 to 2027 [5].

Table 2. Phase 1 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

No.	KEPIC	Category	Details
1	Decommissioning Cost Assessment	Objective	Quantitative assessment of the costs associated with the complete decommissioning of nuclear facilities
		Main Contents	- Investigation of detailed methodologies for assessing decommissioning costs, along with case studies to estimate waste generation from decommissioning activities - Review of decommissioning strategies, scenarios, schedules, and detailed processes, including measures for effective project management - Collection of expert opinions on cost evaluation that takes into account socio-economic impacts
		Application	Developing a standard for assessing the costs of decommissioning nuclear power plants
2	Decommissioning Source Term Evaluation	Objective	Development of methodology and input parameters for evaluating the radiological inventory and contamination source term during decommissioning
		Main Contents	- Investigation of evaluation methodologies, computational codes, and input & output methods - Collection of Korean and international data and technical standards for source term evaluation - Analysis of evaluation criteria and factors influencing decommissioning source terms
		Application	Establishing a standard for evaluating the source term during decommissioning
3	Radiological Characterization of SSCs (Structures, Systems, and Components)	Objective	Assessment of the radiological characteristics of structures, systems, and components (SSCs) in permanently shut-down NPPs during the decommissioning stages
		Main Contents	- Investigate evaluation methodologies for assessing the distribution of contamination in SSCs during different decommissioning stages - Review optimal methodologies, including operational history analysis, radiological surveys, and final status surveys - Evaluate the best approaches that utilize operational history, calculations, and direct measurements
		Application	Establishing standards for the radiological characterization of SSCs
4	Decommissioning Safety Assessment	Objective	Investigation of methods to assess overall safety during the decommissioning process
		Main Contents	- Review of safety assessment methodologies and procedures - Case studies on considerations such as defense-in-depth, safety functions, and optimization of protection - Investigation of post-decommissioning scenarios, including residual radioactivity, exposure pathways, and safety requirements
		Application	Development of a standard for assessing safety during decommissioning

Table 2. Continued

No.	KEPIC	Category	Details
5	Clearance of Decommissioning Radioactive Waste	Objective	Establishing standards for the clearance of waste generated during the decommissioning of nuclear facilities
		Main Contents	- Investigation of optimal clearance methods for decommissioning waste - Review of characteristics of clearance waste and acceptance criteria at disposal sites - Case studies on clearance methods to promote Korean clearance
		Application	Establishing standards for the disposal of decommissioned radioactive waste
6	Metal Cutting and Dismantling	Objective	Development of standards for selecting optimal cutting and dismantling technologies applicable to various environments and materials
		Main Contents	- Survey of cutting and dismantling technologies - Review of current status, characteristics, and applicable technologies for metal dismantling in the decommissioning of NPPs - Investigation of requirements for pre-preparation and post-treatment for cutting and dismantling
		Application	Technical basis for the development of standards for metal cutting and dismantling
7	System Decontamination	Objective	Investigation of application methods for reference standards, considering decontamination factor and secondary waste generation
		Main Contents	- Review of reference standards, including guidelines for decontamination technologies and performance evaluation - Survey of Korean and international cases, applicable technologies, and reference standards - Comparative analysis of performance, advantages, and disadvantages of different decontamination technologies
		Application	Development of standards for system decontamination using reference standards
8	Packaging, Transport, and Disposal Containers for Radioactive Waste	Objective	Development of standards for packaging, transport, and disposal containers for radioactive waste generated during decommissioning
		Main Contents	- Review of container specifications, taking into account Korean regulations - Case studies comparing container practices in operating and decommissioned NPPs - Investigation of container standards linked to national regulations on radioactive waste management and transport
		Application	Development of standards for packaging, transport, and disposal containers for radioactive waste in the decommissioning of NPPs

During this stage, pilot applications will be conducted at the field level to verify the applicability of the results from the first stage, with subsequent improvements made based on feedback received. Additionally, there will be a promotion of the international standardization of KEPIC in the field of NPP decommissioning [6]. A total of six KEPICs are scheduled to be developed during this second stage, covering the following areas [5]. Decommissioning design includes site radiological characterization. Cutting and decontamination encompass the cutting and dismantling of calandria and pressure tubes, as well as the dismantling of bio-shield concrete structures. Furthermore, it includes decontamination methods for metal and concrete. Decommissioning waste management will develop KEPICs for the management of liquid, gaseous, and solid radioactive waste.

The initial phase of site radiological characterization involves investigating the residual radionuclides and the distribution of radioactivity at the location. This process will facilitate the development of KEPIC to establish evaluation methods for radionuclides, contamination levels, and the distribution of radioactivity at NPP sites. Next, KEPIC will focus on the cutting and dismantling of calandria and pressure tubes in pressurized heavy water reactors (PHWRs). This will involve selecting appropriate technologies for cutting and dismantling reactors that are applicable to various environments and materials. The technologies necessary for cutting and dismantling reactors in CANDU NPPs will be emphasized. Depending on the degree of radioactive contamination, the equipment is classified into highly activated and low-radioactivity. Each category requires specific cutting and dismantling techniques based on the size and characteristics of the metal involved. Additionally, management measures for the waste generated from metal cutting and dismantling in PHWRs will include packaging, transportation, on-site storage, and disposal. The third focus of KEPIC development will be on dismantling the bio-shield concrete structures surrounding reactor vessels, which may be volumetrically contaminated due to neutron activation. This aspect of development will explore applicable surface decontamination technologies, remote cutting methods, and the current status of bio-shield concrete dismantling technologies. Fourth, the KEPIC for metal and concrete decontamination will address technologies for decontaminating metallic debris and contaminated concrete generated during the decommissioning process. Guidelines and technical evaluation requirements for these decontamination technologies will be created, along with an analysis of their current applications and status. Fifth, KEPIC will also focus on managing liquid and gaseous radioactive wastes. This initiative will encompass the management of various forms of radioactive waste generated during decommissioning. Requirements for the technical evaluation of this waste management will be established, which will include estimating the volume of decommissioning waste, treating secondary waste, and evaluating the connections between solid and mixed waste. Finally, the KEPIC for solid radioactive waste management will also be developed. Solid radioactive waste will be classified based on its characteristics, including contaminated or activated metallic waste, concrete waste, and soil waste. Technologies for the effective management of these wastes will be developed, particularly in connection with waste treatment facilities used in decommissioning processes. Depending on the levels of contamination, scale, condition, and treatment capacity, appropriate management strategies will be implemented. The KEPIC will be designed to connect liquid, gaseous, and mixed waste management, ensuring compliance with acceptance criteria for radioactive waste disposal. The specific areas to be emphasized in the second stage of NPP decommissioning KEPIC development are summarized in Table 3.

3.3. Phase 3 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

The third stage of the KEPIC development for NPP decommissioning is scheduled to take place from 2028 to 2030, during which the KEPIC for NPP decommissioning will be completed [5]. In this stage, a total of ten KEPICs will be proposed for international standardization. These KEPICs include decommissioning source term evaluation, radiological characterization of SSCs, decommissioning safety assessment, site radiological characterization, cutting and dismantling of calandria and pressure tubes, management of liquid and gaseous radioactive waste, management of solid radioactive waste, decommissioning waste management for PHWRs, site reuse, and restoration and decontamination of the decommissioned site [6]. The final version of these KEPICs will be completed by incorporating feedback from field pilot applications, resulting in a total of 20 standardized KEPICs, with an additional six standards to be developed. In the area of decommissioning design, KEPIC will focus on knowledge management and quality assurance. In terms of decommissioning waste management, KEPIC will also address the measurement and verification of radioactivity in decommissioning waste, management of decommissioning waste in PHWRs, mixed waste management, site reuse, and the restoration and decontamination of decommissioned sites [5].

Table 3. Phase 2 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

No.	KEPICs	Category	Details
1	Site Radiological Characterization	Objective	Development of KEPIC on methods to continuously measure residual radioactivity levels at sites in comparison with natural background levels, ensuring compliance with site reuse criteria
		Main Contents	- Investigation of site radionuclide species, contamination levels, and radioactivity distribution evaluation methods - Review of Korean and international cases and reference standards for site radiological characterization - Surveys on input parameters, evaluation methodologies, and baseline data for site radiological characterization
		Application	Utilization of standards for site radiological characterization
2	Calandria and Pressure Tube Cutting and Dismantling (PHWRs)	Objective	Development of KEPIC for the optimal selection of technologies related to the dismantling of calandria and pressure tubes in PHWRs, and management of dismantling waste
		Main Contents	- Survey of dismantling technologies for calandria and pressure tubes - Investigation of current status, characteristics, and applicable technologies - Review of dismantling technologies for activated components and large metallic equipment in PHWRs
		Application	Development of standards for calandria and pressure tube cutting and dismantling
3	Bio-shield Concrete Dismantling	Objective	Development of KEPIC for dismantling technologies applicable to bio-shield concrete generated during decommissioning
		Main Contents	- Case studies and technical evaluations on dismantling bio-shield concrete - Investigation of current status and applicability of dismantling technologies - Definition of technical requirements for remote cutting and surface decontamination
		Application	Development of standards for dismantling bio-shield concrete
4	Metal and Concrete Decontamination	Objective	Development of KEPIC for decontamination technologies applicable to metallic debris and contaminated concrete generated during decommissioning
		Main Contents	- Survey of decontamination technologies and related Korean reference standards - Investigation of characteristics and effectiveness of various technologies - Comparative analysis of the advantages and limitations of metal and concrete decontamination methods
		Application	Development of standards for metal and concrete decontamination
5	Liquid and Gaseous Radioactive Waste Management	Objective	Development of KEPIC for the management of liquid and gaseous radioactive waste generated during NPP decommissioning
		Main Contents	- Survey and evaluation of management technologies for liquid and gaseous radioactive waste - Review of Korean reference standards and regulatory frameworks - Identification of applicable treatment technologies, such as ion exchange resins and filters
		Application	Development of standards for the management of liquid and gaseous radioactive waste
6	Solid Radioactive Waste Management	Objective	Development of KEPIC for the management of solid radioactive waste generated during NPP decommissioning
		Main Contents	- Survey and evaluation of solid waste management technologies - Review of Korean and international standards and practices - Technical evaluation of solid waste classification and estimation of waste volumes
		Application	Development of standards for the management of solid radioactive waste

The KEPIC for the development of decommissioning knowledge management and quality assurance aims to establish standards that connect configuration management and records management programs from the design stage of an NPP through to its permanent shutdown and subsequent decommissioning. The goal is to create systematic management methods for the data generated during the decommissioning phase following permanent shutdown. This involves linking records management and quality assurance practices prior to permanent shutdown, as well as managing records and quality assurance during the decommissioning phase following shutdown. To achieve this, both Korean and international regulatory requirements regarding NPP decommissioning knowledge management and quality assurance will be analyzed. A knowledge management system tailored for decommissioning and quality assurance will be developed, utilizing the configuration management system that spans from design to permanent shutdown.

Secondly, KEPIC will focus on measuring and verifying radioactivity in decommissioning waste. The objective here is to establish a methodology that accurately measures and verifies radionuclide radioactivity, aiding in the safe disposal of waste generated during the decommissioning process. Through this methodology, waste will be classified based on radiation and radioactivity measurement results, with appropriate management measures proposed. Additionally, methodologies from international NPP decommissioning cases will be explored to assess the applicability and effectiveness of KEPIC.

Thirdly, the development of KEPIC for managing decommissioning waste from PHWRs aims to establish a monitoring system for hard-to-detect radionuclides. Given that PHWRs typically generate more hard-to-detect radionuclides compared to light water reactors, it is essential to monitor radioactive nuclides before, during, and after dismantling. This will also include verification procedures for the disposal of decommissioning waste, as these factors directly impact the safety and economic efficiency of PHWR decommissioning. Therefore, there is a need to develop KEPIC that establishes optimal management technologies and strategies.

Fourth, the development of KEPIC for managing mixed waste focuses on the mixed waste produced during NPP decommissioning, which contains both radioactive materials and industrial hazardous waste. Management standards must be established to ensure safety, effectiveness, and economic feasibility. To this end, relevant Korean and international laws and regulations will be examined, with key objectives being the minimization of mixed waste generation and the establishment of appropriate treatment methods.

Fifth, the development of KEPIC for site reuse aims to establish standards for measuring and inspecting residual radioactivity, thereby facilitating the reuse of NPP sites after decommissioning. This process involves investigating residual radionuclides on the site, determining site reuse scenarios, identifying exposure pathways, and assessing relevant input parameters. Such methodologies require systematic preparation over an extended period and should be planned from the early stages of decommissioning.

Lastly, the development of KEPIC for decommissioning site restoration and decontamination focuses on establishing measures to remediate soil and groundwater contamination at sites following decommissioning. This involves generating strategies for restoring and decontaminating sites after decommissioning, developing site restoration plans, and examining Korean and international reuse cases to outline the technical requirements for effective site restoration. Ultimately, this initiative aims to establish practical standards for post-decommissioning site restoration and decontamination. The specific KEPICs to be prioritized in the third stage of KEPIC development for NPP decommissioning are summarized in Table 4.

4. Conclusion

This study examines the current status of KEPIC development for NPP decommissioning and outlines step-by-step implementation plans. As there has been no experience with the decommissioning of commercial NPPs in Korea, there are currently no specialized technical standards for the decommissioning process. KEPIC has been developed to support the design, construction, and operation stages of NPPs; however, decommissioning presents unique technical challenges and complex procedures that differ from these earlier stages. The lack of standards for decommissioning-specific processes, such as cutting and dismantling, radioactive waste management, and radiological characterization, not only compromises safety in the field but also hinders coordination with regulatory authorities and weakens industrial competitiveness. Therefore, the development of KEPIC for NPP decommissioning is essential as we commence the decommissioning of commercial NPPs.

The ongoing KEPIC development project for NPP decommissioning was initiated out of necessity and is significant as it represents the first attempt of its kind in the world. The Korea

Table 4. Phase 2 of the KEPIC Development for the Decommissioning of Nuclear Power Plants

No.	KEPICs	Category	Details
1	Decommissioning Knowledge Management and Quality Assurance	Objective	Investigation of systematic methods for managing knowledge and quality assurance programs, taking into account NPP characteristics throughout the decommissioning period
		Main Contents	- Surveys on records management, quality assurance linkage, and systematic knowledge management from design to permanent shutdown - Review of Korean regulations and requirements for records and QA in NPP decommissioning - Investigation of measures for quality assurance under abnormal situations
		Application	Development of standards for decommissioning knowledge management, and quality assurance
2	Measurement and Verification of Radioactivity in Decommissioning Waste	Objective	Development of KEPIC for the measurement and verification of radioactivity in decommissioning waste to ensure safe disposal
		Main Contents	- Survey of methodologies for measuring and verifying radionuclide radioactivity - Investigation of classification methods for decommissioning waste based on measurement results - Review of international cases of radioactivity measurement and verification
		Application	Development of standards for the measurement and verification of radioactivity in decommissioning waste
3	PHWR Decommissioning Waste Management (Additional)	Objective	Development of KEPIC for managing decommissioning waste from pressurized heavy water reactors (PHWRs)
		Main Contents	- Surveys of PHWR-specific monitoring and management technologies - Analysis of the current status of PHWR waste management, including spent fuel and mixed waste - Investigation of radiological characterization and monitoring methods
		Application	Development of standards for PHWR decommissioning waste management
4	Mixed Waste Management	Objective	Development of KEPIC for managing mixed waste generated during NPP decommissioning
		Main Contents	- Surveys on management technologies and technical performance evaluations for mixed waste - Review of Korean and international regulations and standards for mixed waste management - Investigation of treatment, packaging, and disposal measures for mixed waste
		Application	Development of standards for mixed waste management
5	Site Reuse	Objective	Development of KEPIC for the measurement and inspection of residual radioactivity to support site reuse after decommissioning.
		Main Contents	- Survey of methodologies for site reuse, including radioactivity monitoring and inspection - Case studies on site reuse scenarios, exposure pathways, and parameter selection - Investigation of background radiation and residual radioactivity assessment methods
		Application	Development of standards for site reuse
6	Site Restoration and Decontamination after Decommissioning	Objective	Development of KEPIC for restoring and decontaminating soil and groundwater at NPP sites after decommissioning.
		Main Contents	- Case studies on site restoration and contamination removal technologies - Surveys on restoration methods for soil and groundwater - Investigation of international cases of site reuse and restoration
		Application	Development of standards for site restoration and decontamination after decommissioning

Electric Association plans to develop a total of 20 KEPICs in three stages from 2023 to 2030. In the first stage, eight standards are being developed, which include decommissioning cost assessment, source term evaluation, and radiological characterization of SSCs. The second stage will involve the development of six standards, including site radiological characterization as well as the cutting and dismantling of calandria and pressure tubes. Finally, the third stage will focus on six additional standards, covering areas such as knowledge management, quality assurance, and the measurement and verification of radioactivity in decommissioning waste.

The development of the KEPIC for NPP decommissioning marks the first effort to establish technical standards in a field that previously lacked them. This initiative aims to enhance the safety and economic efficiency of the decommissioning process while also strengthening the international competitiveness of Korean nuclear decommissioning technology. Additionally, by promoting the international standardization of ten KEPICs, it is expected that Korean standards will be broadened to a global level, thus allowing Korea to establish a foundation for a leading role in the global nuclear decommissioning industry.

Acknowledgments

This work was supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (RS-2023-00240856, Development of KEPIC for NPP Decommissioning).

References

1. Korea Electric Association. Definition of KEPIC, Accessed July 29, 2025, Available at https://www.kepic.org:444/sub_intro/overview_defi.php (in Korean)
2. Korea Hydro & Nuclear Power. Status of Nuclear Power Plant Operation, Permanent Shutdown, and Decommissioning (as of June 30, 2025). Updated July 1, 2025. Accessed August 8, 2025. Available at https://www.khnp.co.kr/main/selectWebDisoffView.do?key=154&siteId=&seq=14402
3. Nuclear Safety and Security Commission. Final Approval of Kori Unit 1 Decommissioning Plan. Press Release. August 4, 2025. Available at https://www.nssc.go.kr/ko/cms/FR_BBS_CON/BoardView.do?pageNo=2&pagePerCnt=15&MENU_ID=190&-CONTENTS_NO=&SITE_NO=2&BOARD_SEQ=5&BBS_SEQ=46772&USER_NAME=&TEL_NO=&WRITER_DI=&_csrf=&SEARCH_FLD=&SEARCH=
4. Korea Electric Association. Foundation for Strengthening the Competitiveness of the Domestic Nuclear Decommissioning Industry. Business Agreement with Korea Hydro & Nuclear Power. Updated July 4, 2024. Accessed August 6, 2025. Available at https://www.khnp.co.kr/main/selectBbsNttView.do;WCN_EXHP=QSvm6_mFTXnop2IAs9JS7gdA80JMRmObwU0AGEDwyvmn8hXvx2tY!-570597537?key=2289&bbsNo=71&nttNo=55602&searchCtgry=&searchCnd=all&searchKrwd=&integrDeptCode=&pageIndex=33
5. Kim KH. Development and Future Plans of KEPIC for Nuclear Decommissioning. Proceedings of the Korean Nuclear Society, May 21, 2025. Available at https://share.google/QzSmekIh4YZFbHT1j
6. Joo HJ. Development of KEPIC in the Field of Nuclear Decommissioning. Proceedings of 2024 KEPIC WEEK, September 4, 2024. Available at https://www.kepic.org:444/kepic_week/sub2/2_2.php?cate=0570_&ysy=2024
7. Kim HG. Development of KEPIC for Nuclear Decommissioning Cost Assessment. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
8. Kwon KN. Current Status of Standardization for Decommissioning Source Term Evaluation. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
9. Kim KP. Current Status of Standardization for Decommissioning Safety Assessment. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
10. Yang HY. Reference Standards and Methodology Survey for System Decontamination. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
11. Kwon KN. Current Status of Standardization for Clearance of Decommissioning Waste. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
12. Kim HW. Current Status of Standardization for Metal Cutting and Dismantling. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
13. Han KW. Current Status of Standardization for Packaging, Transport, and Disposal Containers of Radioactive Waste. Proceedings of 2025 KEPIC WEEK, August 13, 2025.
14. Kim HG. Development of KEPIC for Radiological Characterization of SSCs. Proceedings of 2025 KEPIC WEEK, August 13, 2025.