

# Strategic and Technical Aspects in RD&D Program Development for HLW Disposal System in Korea

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## Abstract

This paper is focused on strategic and technical aspects in RD&D Programme for development of HLW disposal system in Korea. As the high-level radioactive waste management basic plan was deliberated and resolved by the final Nuclear Energy Promotion Committee in 2016, the URL for licensing is to be constructed and operated within the permanent disposal site to ensure timely management facilities. In addition to a permanent disposal facility, the research URL(generic) is to be built separately from the management facility so that the programs accounted of strategic and technical aspects to minimize trial-and-error. This paper shows what are strategic and technical factors in preparation of RD&D programme to implement Korean HLW disposal system and a future plans for the elaboration of the site selection process, design, construction and operation of the disposal facility would be materialized in a timely manner. Hence, it is required to develop a RD&D programme for the URL operation for the demonstration of the disposal system considering the site selection schedule and the status and characteristics of domestic high-level radioactive waste. The preconditions for deriving RD&D programme for generic URL are the preferred rock type to be disposed of, the reference disposal system, the type of spent fuel, and the guidelines of regulatory technology. Consequently, the disposal program should be prepared taking into account the associated with RD&D programme.

## 1. Introduction

As the High-Level Radioactive Waste Management Basic Plan was deliberated and discussed by the final Nuclear Energy Promotion Committee (July.25<sup>th</sup>.2016), the URL for licensing was conducted and operated within the permanent disposal site to ensure timely management facilities [1]. In addition to a permanent disposal facility, the generic URL will be constructed separately from the management facility, and the disposal system for the site selection, design, construction and operation of the disposal facility will be established. Therefore, it is required to develop a RD&D program for the URL operation for the demonstration of the disposal system considering the site selection schedule and the status and characteristics of domestic high-level radioactive waste. The preconditions for deriving RD&D programs for research URL are the preferred

rocks to be disposed of, the standard disposal system, the type of spent fuel, and the guidelines of regulatory technology. In addition, the status of Aspo URL's RD&D programme in Sweden, which is similar to the final disposal system considered in Korea, is under investigation. Finally, the URL RD&D programme for research has been drawn. The ultimate goal of the generic URL is to develop a characterization technologies for the disposal site, a technology for applying the site's own disposal system, a safety performance evaluation technology for the site, and to build the confidence of the stakeholders. Nine programmes related to RD&D activities were derived to accomplish with these goals.

## 2. Regulations related to HLW in Korea

Currently, the laws related to the disposal of

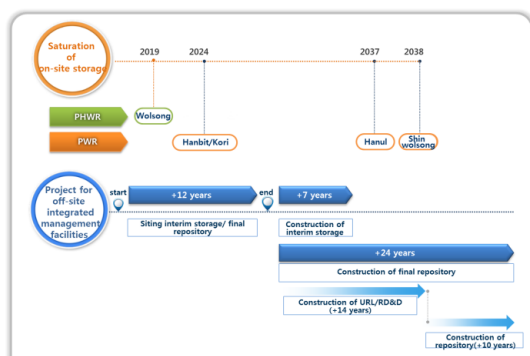
high-level radioactive waste in Korea include Law No. 13545 "Nuclear Safety Act", Nuclear Safety Commission Regulation No. 14 "Rules on Technical Standards such as Radiation Safety Management", and Nuclear Safety Commission Notice No. 2015-21 General Standard for High-Level Radioactive Waste Deep Disposal Facilities."(Fig. 1).

The Nuclear Safety Act stipulates the safety management related to the research, development, production, and use of nuclear energy to prevent radiation-induced disasters and ensure public safety. In relation to the disposal of high-level radioactive waste, Article 63 stipulates that a person who intends to construct and operate a radioactive waste storage, treatment, disposal facility and its associated facilities shall obtain permission from the Commission as prescribed by the Presidential Decree. The location, structure, facilities, and performance of the radioactive waste management facility, etc., as defined in Article 64 (1), "Securing the technical capability necessary for the construction and operation of radioactive waste management facilities, shall be in conformity with the technical standards set forth in the regulations and not interfere with the prevention of public disasters of human bodies and objects due to radioactive materials. According to the legal notice of the regulatory agency(NSSC) are as follows;

The safety of deep disposal facilities should be continuously evaluated based on the latest information for the purpose of step by step throughout the entire disposal system including basic research, site survey, design, construction, operation, closure and post-closure management.

All aspects of disposal facilities, such as site selection, design, construction, operation, closure and post-closure management of deep disposal facilities, should be based on the results of studies conducted in underground research facilities that can characterize deep disposal systems.

Underground facilities should be installed and operated at the site of the disposal facility in order to confirm the characteristics inherent to the disposal



system and to predict the long-term performance.

Fig. 1. Schedule for high-level radioactive waste management

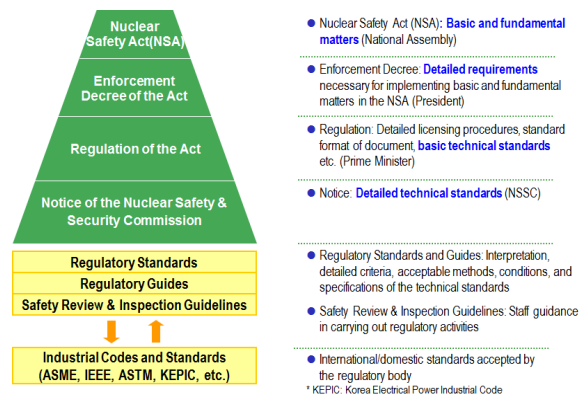


Fig. 2. Nuclear regulations of Korea

### 3. National policy of HLW in Korea

The 'Public Engagement Commission on Spent Nuclear Fuel Management', established in accordance with the 'Radioactive Waste Management Act', recommended the government to establish detailed plans for the development of technology related to spent fuel management facilities through the participation of domestic and international experts, local residents and civic groups ('15).

According to the recommendation of Public Engagement Commission on Spent Nuclear Fuel Management and the Article 6 of the Radioactive Waste Management Act, the government established the "Basic Plan for the Management of High Level Radioactive Waste Management" and published through the deliberation and resolution of the Nuclear Energy Promotion Commission under Article 3 of the Nuclear Energy Promotion Act ('16). The basic plan is the first national plan to deal with high-level radioactive waste. It includes the basic policy of high-level radioactive waste management, the status and prospects of the high-level radioactive waste management, facility planning including site selection, investment planning, public understanding and technology development.

In particular, the basic plan stipulates that URL for licensing, interim storage facility, and permanent disposal facility are to be located in on a single site. According to the basic plan, the site will be selected for about 12 years through scientific research and democratic procedures, and the interim storage facility will be constructed within 7 years after securing the site. Prior to the interim storage, high-level radioactive waste should be inevitably managed within the NPP sites, and empirical studies should be conducted at the URL for licensing. Based on the international cooperation, the strategy of the large-scale framework is to secure timely disposal core technologies aiming at both safety and economic aspect efficiency, to ensure the transparency, public reporting and continuous communication with stakeholders.

The reliability of the disposal project can be enhanced by developing the unique disposal system suitable for the conditions in Korea and by objectively proving its performance and safety assessments.

#### 4. Objective of Generic URL

URLs can be divided into generic URL and site-specific URL according to the schedules of commercial disposal projects (Table 1). The generic URL is a unique disposal system that is developed in consideration of the geological condition, supporting the work performed in preparation stage of the commercial disposal project [2]. The generic URL is mainly based on empirical tests to demonstrate the safety of disposal systems. These projects are carried out at the generic URL located in the distribution area of similar rock type before the candidate site of the final repository is determined. (KORAD, 2012).

Table 1. Comparison of the generic and site-specific URL as a functions of their features and roles

Generic URL	Site-specific URL
<ul style="list-style-type: none"> <li>- Demonstration and performance of NBS's own disposal system (EBS/NBS)</li> <li>- Focus on disposal research and analysis technology development</li> <li>- Development and testing of site environmental monitoring management technology and program</li> <li>- Development of general purpose database system</li> <li>- Appropriateness assessment of preferred rock/site suitability</li> <li>- Test and demonstration of safety evaluation model</li> <li>- Verification and demonstration of construction and operation technology</li> <li>- Development and application of safety case</li> <li>- International cooperation and joint research</li> <li>- Used for (the) technical education and training</li> </ul>	<ul style="list-style-type: none"> <li>- Facilities for supporting construction and operation of commercial disposal facilities</li> <li>- Data collection of rock in site</li> <li>- Evaluation of site characteristics: Deep Environment in near-field</li> <li>- Prove disposal suitability of disposal site</li> <li>- Development and verification of relevant technology</li> <li>- Establishment of baseline conditions of disposal site</li> <li>- Operation of management system for site environment monitoring before construction</li> <li>- Performance and safety evaluation requirements for construction and operation licenses and the application of their related programs</li> <li>- Commercial repository site application program</li> </ul>

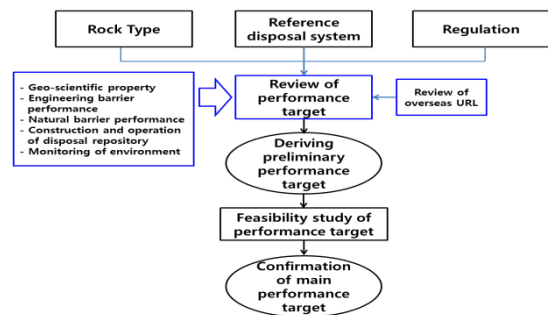
#### 5. Procedure of RD&D program of generic URL

Considerations for developing a generic URL RD&D program are as follows;

1) concept of a unique disposal system reflecting domestic circumstances, 2) preferred rock species for disposal, and 3) regulatory requirements (Fig. 3).

A generic URL RD&D programme for proving the performance of a disposal system should include all the detailed research items that need to be carried out in a series of URL business processes leading to site selection and site investigation, construction and operation [3].

Fig. 3. Procedure of developing the RD&D programme  
Prior to developing the RD&D programme of a



generic URL, it is necessary to review the preferred rock type for the disposal reflecting the domestic geological condition, and single or multiple rock types may be determined depending on the situation. The most important component in a disposal system is multiple barriers (engineered barriers + natural barriers). Engineered barriers prevent the outflow of the RN spills leaking from high-level radioactive waste, and the natural barriers serve to delay the diffusion of RN into the ecosystem through engineered barriers. The URL RD&D programme should consider how this multi-barrier system can prove that it can maintain safety performance in compliance with regulatory requirements [4]. Hence, in the development process of generic URL RD&D programme, the expected performance items are determined by taking the above items into consideration and the RD&D programme of the budget is derived by being compared with the overseas situation. The resulting RD&D programme is finalized by reflecting the status and conditions of the research in the country.

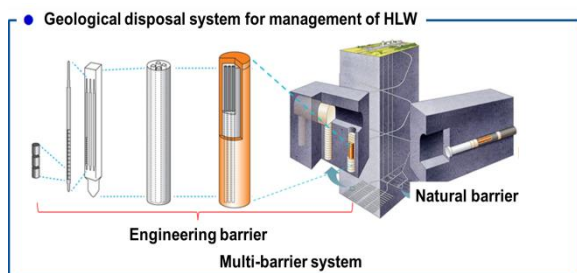


Fig. 4. Concept of Korean reference disposal system (KRS)

On July 25, 2016, South Korea finalized the 'Basic Plan for High-Level Radioactive Waste Management'(Draft) [1]. The site selection stage is aimed at the operation of a permanent disposal facility which consists of excluding non-conforming areas, collecting opinions from the public, conducting basic site conformity survey and in-depth site survey. The site selection period is expected to take about 12 years. It is necessary to secure an underground research facility (Generic URL) before the disposal site is determined in order to effectively carry out site investigation method, demonstration of the disposal system, and promotion to the public. An underground research facility (Site-specific URL) is set up in the final repository site derived from the site selection stage, which is distinguished from the generic URL, and an empirical study of the disposal system is planned. The schedule for securing the generic URL is expected to be about 10 years from site acquisition to construction as shown (Fig. 5). The site will be selected in 2019, and investigated until 2021, and the disposal repository will be constructed from 2023 to 2026, with the goal of operating from 2026 to 2053. but due to the nature of NWMO and uncertainties about the future, the schedule can be changed any time.

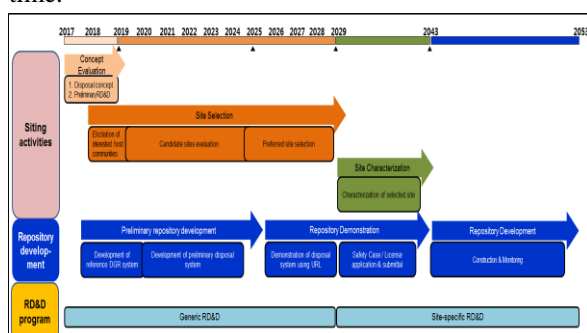


Fig. 5. Timetable for high-level radioactive waste management (Draft)

## 6. Development of generic URL RD&D programme

The roadmap approach is a common way to develop RD&D programme for deep geological disposal and the guideline should include principles of flexibility, step-by-step approaches to disposal, long-term verification of disposal plans and uncertainty. Through the execution of the generic

URL RD&D programme for research, it is possible to identify the natural barriers target characteristic of the disposal system and the performance goal of the engineering method, and to identify the design factor of the unique disposal system reflecting the site characteristics in the short term and develop the final disposal system will be used as a core factors. The final goals of generic URL RD&D programme is timely secure and demonstrate core technologies needed for the construction and operation of the deep geological repository (DGR) considering various site evaluation tests and verification for securing the safety of DGR and for evaluating characteristics of host rock of disposal for optimization of construction. In order to examine the applicability of the disposal system that reflects the site characteristics, it is necessary to verify the performance of the disposal system, to complement and demonstrate the construction and operation of DGR, and finally to secure the acceptance of the public. Prior to site selection, we will focus on the site investigation and assessment technologies, the development of the concept of disposal system, and the production of safety assessment input data for site selection confirmation. For the purpose of securing the operation license until the operation of the DGR, the objective is to secure the safety assessment of the disposal system, the long-term demonstration test, the disposal facility handling method and equipment, and construction and operation methodology of DGR.

The ultimate goal of the generic URL is to develop a characterization technology for the disposal site, a technology for applying the site's own disposal system, a safety performance evaluation technology for the site, and to build the confidence of public. Nine program related to RD&D activities were derived to accomplish with these goals.

- 1) RD&D technical management program
- 2) Site investigation program
- 3) Rock mechanic investigation program
- 4) Natural barrier evaluation program
- 5) Engineering barrier evaluation program
- 6) Disposal operation program
- 7) Information transparency and monitoring system program
- 8) International cooperation program
- 9) Personal training program (2018 - 2052 years)

A total of 9 categories of RD&D programme were selected and detailed in research projects proposed within individual RD&D programme that is based on IAEA's recommendation (Fig. 6).

The data derived through the execution of the URL RD&D program for research can be utilized for the construction licensing of permanent disposal facilities in 2043 and the licensing of permanent disposal facilities in 2052.

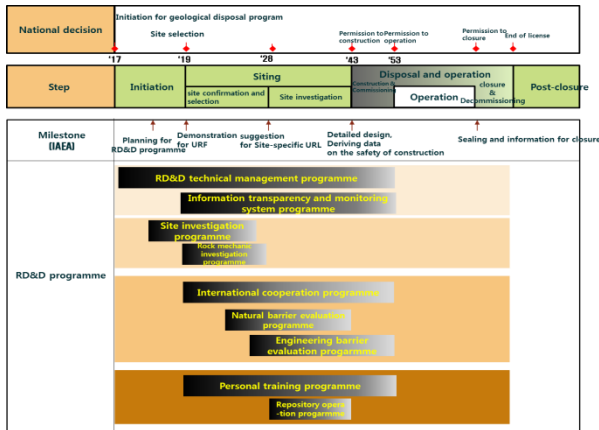


Fig. 6. RD&D programme related to goals (Draft)

### 7. Development of generic URL RD&D programme

Development and updating of RD & D programs are required for obtaining research URLs and for long-term operation. We will publish technical reports every year, analyze RD & D results every two years, and set future directions. This behavior can be also used directly in the construction of a safety case.

Quality assurance is an act to ensure that all work items are performed under the premises of quality pursuit. In order to achieve these goals, it is necessary to carry out task management for sectors such as manpower, purchasing, quality, safety and environment according to a reasonable operating system. The structure of the quality assurance system consists of procedures, guidelines, training, traceability of verification / certification and quality audits. General guidance on pending issues relating to management, quality and environment should be prepared.

The total execution period is expected to take 36 years from '18 to '52 (Fig. 7). The final result is the development of a quality assurance system that reflects the operator management system and operator requirements for long-term URL operation. It will be used as a basic system and will be used immediately as regulatory agency license application documents. It consists of five detailed projects linked to two detailed programs.

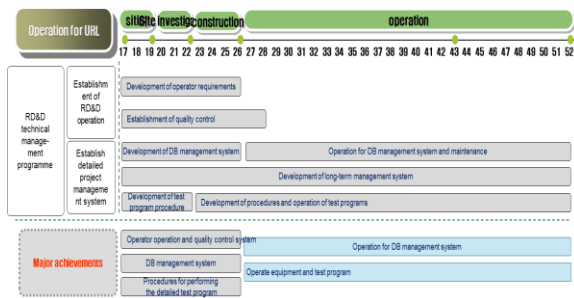


Fig. 7. Roadmap of RD&D technical management programme goals (Draft)

### 8. Strategy to implement generic URL RD&D programme

In case of overseas cases, R&D strategy (R&D planning, implementation strategy, budget management, etc.) and management systems are directly managed by the disposal program of each country.

The R&D's how it works is divided into fields according to the characteristics of the project and is carried out through collaboration with industry, university and institute.

The radioactive waste management agency will focus on planning and arranging the overall project (combination of R&D results), promoting low-cost R&D (development of disposal container), and safety related activities (including URL operation).

Implementation of international cooperation focuses on performance assessment of repositories through URL operation and is conducted through demonstration programs elements in associated with disposal system.

The basic research is carried out by academia in order to maintain human resources and the highest level of technology to support radioactive waste management agency.

The government-funded/government-contributed research institute reflects the plans for disposal projects into the national R&D policy and conducts domestic R&D. The results of the research are directly used by the radioactive waste management agency.

The company conducts machinery, equipment, and systems related to the construction and operation of repositories that reflect the operator's R&D plans. And also strive to secure the reliability and acceptability of disposal projects.

As for the framework for implementing R&D programme, all the duties such as the technology and knowledge developed through URL RD & D for research, secured site data, and information on building a safety case are essential for the operation of the geological repository and construction permits. Therefore, for the effective progress of implementing the geological repository, we aim to enter the middle of the leading technology through joint research with domestic industry, academia and government, and international cooperation.

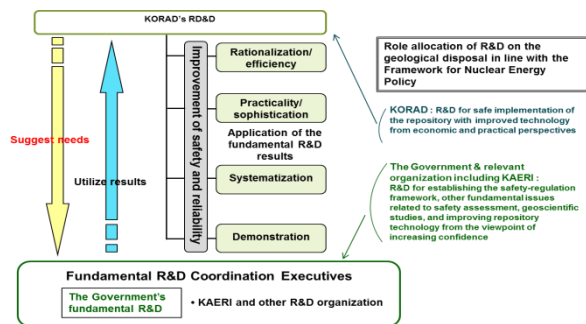


Fig. 8. Framework for implementing the RD&D programme

However, taking into account the efficiency and licensing aspects of the project, it is the principle that the responsible organization of the radioactive waste should take the initiative (Fig. 8). Therefore, a dedicated agency is required to perform the integrated performance evaluation and safety evaluation, development of safety case, the disposal facility design, and the operation of the input data management system, which are required for the construction and operation of disposal facilities.

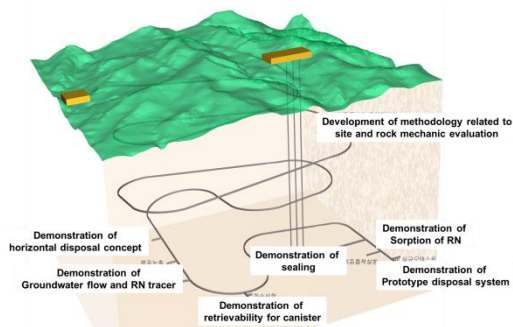


Fig. 9. Concept of KORAD generic URL (Draft)

The preliminary layout of KORAD generic URL is based on overseas case (Fig. 9). Future plans will be revised and supplemented through further research and consultation.

## 9. Conclusions

In Korea, KORAD is responsible for the SNF management in the short and long-term, i.e. the transport, the interim storage and the geologic disposal program. To follow government's basic national plan for SNF management, KORAD is carrying out development of a RD&D programme taking into account of political and technical aspects in deep geological repository. The preconditions for deriving RD&D programme for generic URL are the preferred rocks to be disposed of, the standard disposal system, the type of spent fuel, and the regulatory technology guidelines. Consequently, RD&D programme in associated with disposal program is in the middle of preparation and documented also updated until its first official publication as a leading program for Korean deep geological repository study.

## 10. Reference

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