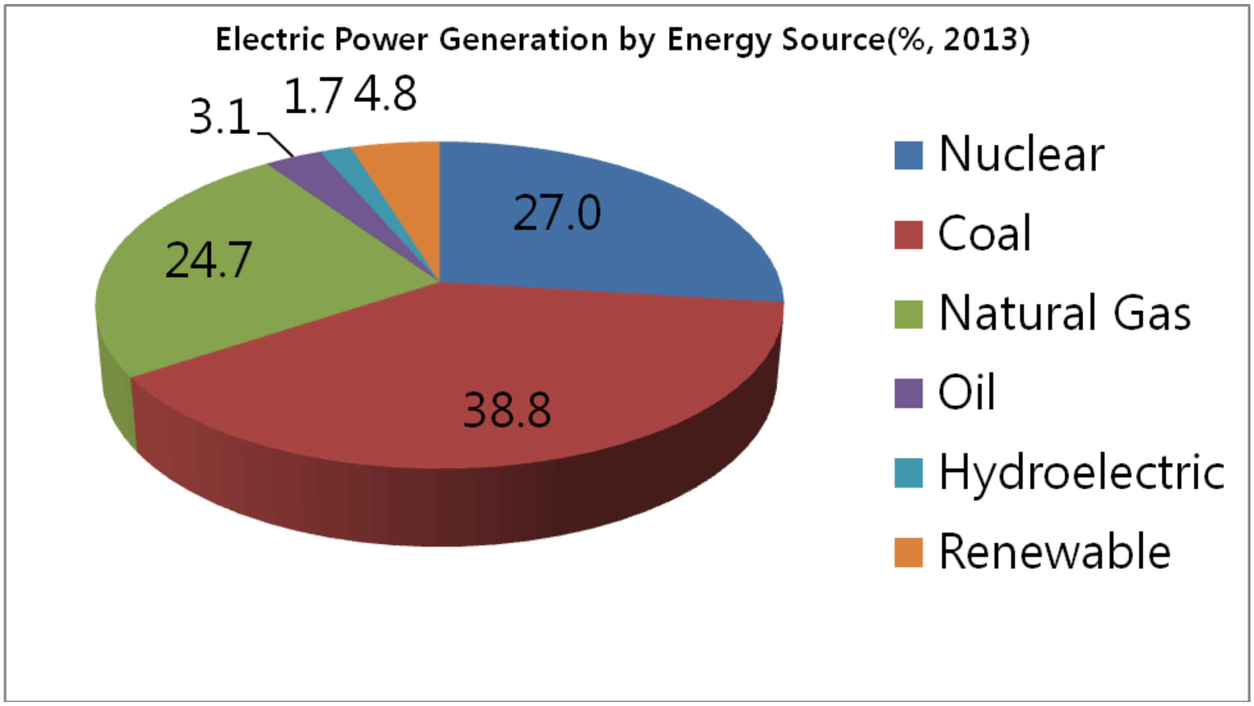
RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

KOREA
[2014]

NATIONAL NUCLEAR ENERGY CONTEXT

The commercial utilization of nuclear power in Korea started in 1978, and there are 23 nuclear power plants (NPPs) in operation as of Dec. 2013. In 2013, NPPs generated 138.8 TWh of electricity, 30.3% of the total electricity generated that year. The 21 NPPs are located at four different sites (Kori, Hanbit, Hanul, and Wolsong). The four NPPs at the Wolsong site are Pressurized Heavy Water Reactor (PHWR, CANDU), while the others are Pressurized Water Reactor (PWR).

Five NPPs are under construction and six NPPs are planned for construction. According to the Basic Plan of Electricity Supply and Demand, 11 more PWRs will be added by 2024, resulting in 31.9% of installation capacity and 48.5% of nuclear share.



Source: http://cyber.kepco.co.kr/kepco/KO/ntcob/list.do?boardCd=BRD_000097&menuCd=FN050301

SOURCES, TYPES, AND QUANTITIES OF WASTE

Under the Nuclear Safety Act, Radioactive waste in Korea is classified into two categories. One is high-level radioactive waste (HLW) arising from nuclear power generation, and the other is low- and intermediate-level radioactive waste (LILW) arising from nuclear power generation and from the use of radioisotopes in medical research and industrial applications. However, In December 2013, the NSSC approved the draft revision of radioactive waste classification system, which specifies the LILW further into the Very Low Level radioactive Waste (VLLW), the Low Level radioactive Waste (LLW) and the Intermediate Level radioactive Waste (ILW), and are now in consideration of amending relevant regulations.

HLW is defined as radioactive waste with specific activity greater than 4,000 Bq/g of alpha-emitting radio nuclides with a half-life of more than 20 years and a heat-generating capacity exceeding 2 kW/m^3. In Korea, HLW consists of only spent fuel. The cumulative amount of spent fuel is 392,784 assemblies as of Dec. 2013. Of this, CANDU spent fuel accounts for 378,104 assemblies. This amount is expected to increase up to 20,000 tons by 2020. These spent fuels are currently stored at four NPP sites, either in spent fuel pools or in dry storage facilities.

LILW is generated from NPPs and radioisotope use in hospitals, industry, and other institutions, and from nuclear fuel manufacturing and R&D activity. LILW from reactor operations consists of dry, active waste; solidified liquid waste; spent resin; and spent filters. At the end of 2013, 94,772 drums (200 liter/drum) of LILW were generated and stored at four NPPs sites. The amount of HLW and LILW generated from each NPP site as of Dec. 2013 is listed in Table 1.

The RI waste generated from domestic RI users and research institutes is collected and stored at Radioisotope Waste Facility of Korea Radioactive Waste Agency (KORAD). At the end of 2013, about 3,190 drums (200 liter/drum) of RI waste were stored.

Table 1. Status of Spent Fuel and LILW generated from reactor operations (as of Dec. 2013)

Nuclear Power Station*		HLW (Spent Fuel)		LILW	
Location	Number of Reactors	Storage Capacity (Assemblies)	Cumulative Amount (Assemblies)	Storage Capacity (drums)	Cumulative Amount (drums)
Kori	6	6,494	5,154	60,200	42,105
Hanbit	6	7,912	5,141	23,300	22,383
Hanul	6	7,066	4,385	18,929	17,989
Wolsong	5	500,155	378,104	13,240	12,295
Total	23	521,627	392,784	115,669	94,772

RADIOACTIVE WASTE MANAGEMENT POLICIES AND PROGRAMMES

Waste management policies

The national policy for radioactive waste management is determined by the Atomic Energy Commission (AEC). The 249th meeting of the AEC, which was held in Sept. 1998, developed a “National Radioactive Waste Management Policy” aiming to construct and operate a LILW disposal facility by 2008 and a centralized spent fuel storage facility by 2016; however, the site selection had not been successful. Therefore, a revision of the policy was made at the 253rd meeting of the AEC held in Dec. 2004. It was decided that an LILW repository should be constructed by 2009. Wolsong was determined to be an LILW repository site, and the 1st stage of construction of the disposal center is ongoing.

The national policy of spent fuel management has not been decided yet. Because the 253th meeting of the Atomic Energy Committee stipulated that a national policy for spent fuel management should be determined later considering domestic and international technologies and a public consensus. Currently, spent fuel is being stored at a reactor site under the KHNP’s responsibility.

After establishing in 2009, KORAD undertook an alternative study on spent fuel management to technically support the policy-making through expert group consensus. The study was finished in 2011. In Nov. 2011, the government established a ‘Forum for Spent Fuel Management Policy’, whose members included experts in various fields, member of NGOs, and local residents of NPP sites. After 10-month review of spent fuel management options and the gathering of public opinions, the Forum submitted a final report to the government in Sept. 2012. The recommendation consisted of 14 agendas including 'construction of the interim storage facility no later than 2024'. Then, in Nov. 2012 the Atomic Energy Promotion Commission decided to proceed with the Public Engagement under the provision of the Radioactive Waste Management Act (RWMA).

Based on this, the public engagement started with the launch of the Public Engagement Commission on SNF management (PECOS) last year. PECOS consists of 15 members, who are experts in human & social science and technical engineering, representatives recommended by NGO and residents in NPP areas. The commission plays a role of deciding principles and methods of the public engagement program, initiating public consultation and discussion, and submitting recommendation to government after in-depth review and analysis on SNF management options.

Main purpose of the public engagement is to draw up the consent-based national plan on SNF management in order to protect people in a safe way. The topic to be discussed during the public engagement is how to manage SNF safely. In fact, all of the management options that could protect people from possible dangers due to SNF could be discussed. And PECOS will collect intensive opinions from all walks of life, such as public, experts, stakeholders, residents in NPP areas and NGOs.

The future national policy for spent fuel management will be chosen based on the result of the public engagement, taking into consideration the national/international trends on policy and technology development.

KORAD is responsible for interim storage and the final disposal of spent fuel.

Programmes for LILW management

The RI waste is collected and stored by the KORAD. Most LILWs generated from NPPs are treated at gaseous, liquid, and solid waste treatment facilities and stored at on-site storage facilities.

For permanent disposal of LILW, the Wolsong LILW Disposal Center(WLDC) is under construction. The initial capacity of this center is 100,000 drums. Overall construction progress is about 98.75% as of the end of Dec. 2013. The construction of the 1st stage of WLDC is scheduled to be completed by June 2014. After stepwise expansion, the final disposal capacity will be 800,000 drums. The basic plan on the 2nd stage of construction of the disposal center was set up in 2011. The Wolsong LILW Disposal Center started operation of surface facilities to take in LILW in Dec. 2010. By the end of Dec. 2013, 2,712 drums of LILW were moved to the WLDC, and are waiting for permanent disposal in a waste inspection & interim storage building.

Programmes for Spent Fuel management

Active nuclear energy utilization causes a significant amount of spent fuel accumulation. Owing to the difficulty in the site selection, most spent fuels are stored at each reactor site.

For CANDUs, spent fuel is first placed in wet storage bays to allow for cooling and radioactive decay. After at least 6 years of cooling in the storage bays, spent fuel is put into stainless steel fuel baskets and transported to above ground on-site dry storage facilities. Two kinds of dry storage facilities of 300 concrete silos and 7 MACSTOR/KN-400 (M/K-400) concrete storage modules are currently used for on-site storage of CANDU spent fuels, as shown in Fig. 1. The total storage capacity for CANDU spent fuel in dry storage facilities is 3,062 metric tons (one bundle accounts for 19.1KgU) of uranium for concrete silos and 3,175 metric tons of uranium for M/K-400 modules, respectively. Although the two types of dry storage facilities and wet storage bays are operated, it is expected that the storage capacity will be saturated by the end of 2018.

For PWRs, spent fuels are now stored at NPP pools, but all storage pools are expected to reach their full capacity in several years. To expand the insufficient storage space at the plant sites, re-racking and transshipment to neighboring plants are utilized as a short-term solution until a national spent fuel management policy is determined. A project to install a compact storage rack was launched in 2010 and was completed by the end of 2012 for Hanbit units 5 and 6. The same project will be launched for Hanul units 5 and 6 in 2012. Through completion of these projects by the end of 2013, the total storage capacity for PWR spent fuels reached 21,995 assemblies, resulting in a 22.8% increase in storage capacity.

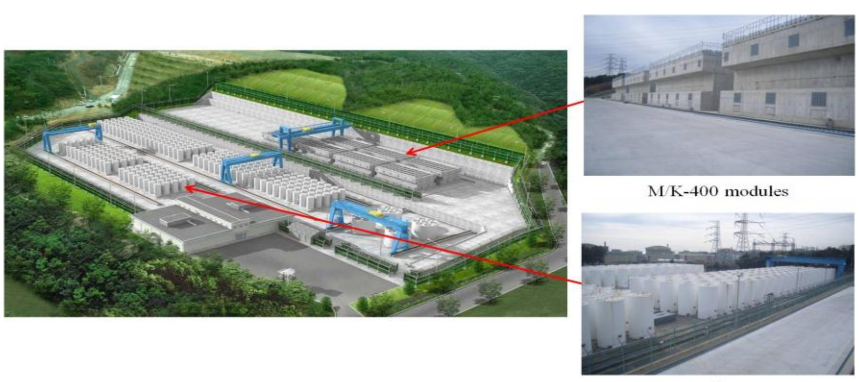


Fig. 1 Dry storage facility for CANDU spent fuel at Wolsong site

RESEARCH AND DEVELOPMENT

R&D programmes for HLW disposal

The spent fuel management program in Korea maintains a long-term perspective strategy in that it progresses the program in consideration of the national policy and worldwide radioactive waste disposal technology development. The R&D program on the disposal technology of HLW was initiated in 1997. After 10 years into the research program, a reference disposal system called the Korea reference disposal system (KRS) was proposed in 2006 based on the results of the R&D program, which included a performance and safety assessment, as well as studies on the geo-environmental conditions in Korea, an engineered barrier system, and the migration of radio nuclides.

For validation of the KRS, a project for constructing a generic underground research tunnel in a crystalline rock called the KAERI (Korea Atomic Energy Research Institute) Underground Research Tunnel (KURT) started in 2003. Following the site characterization study, the tunnel design, and the construction licensing, the construction of KURT, which is located at the KAERI site, started in May 2005. Controlled drilling and blasting techniques were applied to excavate a 6m wide, 6m high and 255m long horseshoe-shaped tunnel with a 10% downward slope. After completion of this construction of KURT in Nov. 2006, various in-situ tests are being carried out for the validation of HLW disposal techniques. Important in-situ tests, currently underway at KURT, include tests related to (a) the fluid flow through discontinuities, (b) groundwater chemistry, (c) the thermal behavior of the rock mass, (d) the evaluation of an excavation-damaged zone, and (e) the migration of ions and colloids in an underground environment.

In 2007, an expert committee convened by the Ministry of Education, Science and Technology (MEST) drafted a comprehensive R&D action plan for the technical verification of the spent fuel management scheme for the future nuclear energy system in Korea. This may become a basis in the process of establishing a national long-term nuclear R&D program after public consultation through forums, public hearings, and so on. The draft R&D action plan, a measure to promote the long-term safety of spent fuel management, was prepared in such a way to contribute to the sustainable use of nuclear energy, protect public health, and minimize environmental burden to the next generation by maximizing the environmental friendliness of a HLW disposal system through the reuse of spent fuel in an appropriate manner.

The drafted R&D action plan mainly consists of the development and verification of a pyroprocess and a sodium-cooled fast reactor, which are highly proliferation-resistant, through the design and construction of an engineering-scale mock-up equipment and facility (PRIDE, PyRoprocess Inactive integrated Demonstration facility) by 2012, the design and construction of the pilot facility (Korea Advanced Pyroprocess Facility, KAPF) by 2025. According to the proposed action plan, the volume of spent fuel is expected to be reduced by recovering U and TRU, and the efficiency of the final repository increased by separating out and storing heat generating isotopes. It is also expected that the time needed for the radiological toxicity of spent fuel to be reduced to that of natural uranium can be shortened to hundreds of years, through the burning of the recovered TRU elements in the fast reactors.

DECOMMISSIONING AND DISMANTLING POLICIES AND PROJECTS

D&D project of KRR-1 & 2 and R&D program

While decommissioning of KRR-2 was completed in 2009, decommissioning of the reactor structures and internals of KRR-1 was newly launched in the middle of 2011. KRR-1, a research reactor with a thermal power of 250 kW, faced a permanent shutdown in Jan. 1995, after reaching first criticality in Mar. 1962, and was chosen to be preserved as a monument after a free-release of the building and site. This project is scheduled to be carried out from 2011 to 2014, with a budget of 0.3 million USD. Radioactive wastes from the decommissioning of KRR-1 (except reactor core) and KRR-2 were classified according to their characteristics and radioactivity levels, packed into 200-liter drums or 4 m^3 containers, and stored in the reactor hall of KRR-2.

The database system, called DECOMMIS (DECOMMissioning Information management System), was developed and has been operated to collect all of the relevant information related to the decommissioning waste, including its generation, decontamination, packing, and storage. It enables managing the decommissioning waste in a systematic way and reporting safety information to the WACID, which is a DB system developed and operated by the Korea Institute of Nuclear Safety (KINS) for managing nationwide safety information on radioactive waste management. Continuous recording resulted in 3,123,410 items of the 376,434 lists from the KRR decommissioning activities and 1,925,888 items of the 230,599 lists from the uranium conversion plant decommissioning activities in DECOMMIS. DECOMMIS is very helpful for the public to understand the safety and management of decommissioning work and radioactive waste from the decommissioning site. It will also be very useful for the decommissioning of other nuclear facilities.

After the nuclear accident in Fukushima, to be prepared for the upcoming decommissioning of NPPs, Korea is now actively developing decommissioning technologies for the nuclear facilities which are no longer in use as well as during the operation to enhance the radiation safety. Korea will develop decommissioning key technologies for NPP by 2016 and eventually secure commercial DD&R technologies by 2021. Our development scope for DD&R technologies can be summarized as follows:

- High performance decontamination technologies
- Economically improved remote dismantling technologies
- High volume reduction decommissioning waste treatment technologies
- Safe & effective site remediation technologies

All these technologies have a unique direction to enhance technical performance and safety at the same time.

TRANSPORT

Transport of radioactive material is regulated by the Nuclear Safety Act and its associated Enforcement Decree and Enforcement Regulations. The major technical standards are specified in the NSSC regulation entitled “Regulations concerning the Technical Standards of Radiological Safety Management, etc." and the NSSC Notice entitled “Regulation for the Packing and Transport of Radioactive Materials, etc.”. These domestic regulations are based on “Regulations for the Safe Transport of Radioactive Materials,” published by the International Atomic Energy Agency and given effect by the Nuclear Safety Act. Another NSSC Notice ‘Regulations for Manufacture and Periodical Inspections of Packagings for Radioactive Amterials” also includes regulations for the inspection of transport containers during manufacturing and while in service.

Most LILW from NPPs is currently stored at the sites where it was created, and 3,536 drums of LILW were moved to the Wolsong disposal center for permanent disposal by the end of Dec. 2011. When the disposal facility is available for LILW, it is expected that transport of LILW to the repository will be by sea. LILW generated by domestic RI users is undertaken by KORAD. In general, radioisotope wastes are transported by road.

Some shipments of spent fuel from reactor sites have been carried out for R&D and inspection purposes. At first, these shipments used a cask (KSC-1) developed by KAERI. A large amount of spent fuel is moved between reactors on the same nuclear site owing to a lack of storage capacity in some older reactors, and the frequency of this is expected to increase in the future. Up to 2001, KHNP used another cask (KSC-4) developed by KAERI for the movement of spent fuel at the Kori site. In addition, the KN-12 cask developed by KHNP has been used to improve the transport efficiency since 2002. The KN-18 cask was also developed and planned for manufacturing to improve transport efficiency and accommodate various types of fuel.

COMPETENT AUTHORITIES

Before the Nuclear Safety and Security Commission (NSSC) was newly established in October 2011, the Ministry of Education, Science and Technology (MEST) was in charge of national nuclear safety and regulatory matters including licensing of nuclear installations and businesses. The Fukushima accident created momentum to set up the NSSC as a national mandate and it was formally established on 26 October, 2011 as a presidential commission on nuclear safety as well as security and non-proliferation. Following the inauguration of the new government and subsequent restructuring of government organizations in February 2013, however, the NSSC was now placed under the Prime Minister's Office. Accordingly, relevant laws and regulations were amended to reflect the changes under the new government organizations.

Today, the NSSC is in charge of nuclear safety regulation including nuclear installations and licensing matters; the Ministry of Industry, Trade and Energy (MOTIE) is responsible for promotion of nuclear industry; and the Ministry of Science, ICT and Future Planning (MSIP) is mainly charged with nuclear research and development.

More specifically, the nuclear safety and regulatory system of Korea is composed of the NSSC as a regulatory authority, Korea Institute of Nuclear Safety (KINS) as an expert organization for nuclear safety, and Korea Institute of Nuclear Non-proliferation and Control (KINAC) for nuclear control.

As of June, 2013, the NSSC is composed of nine members including the Chairman. The Chairman and one member are standing members. The standing member holds an additional position of the Secretary General. The Secretariat, which deals with the general affairs of the Commission, consists of two bureaus and nine divisions as shown in Fig. 2.

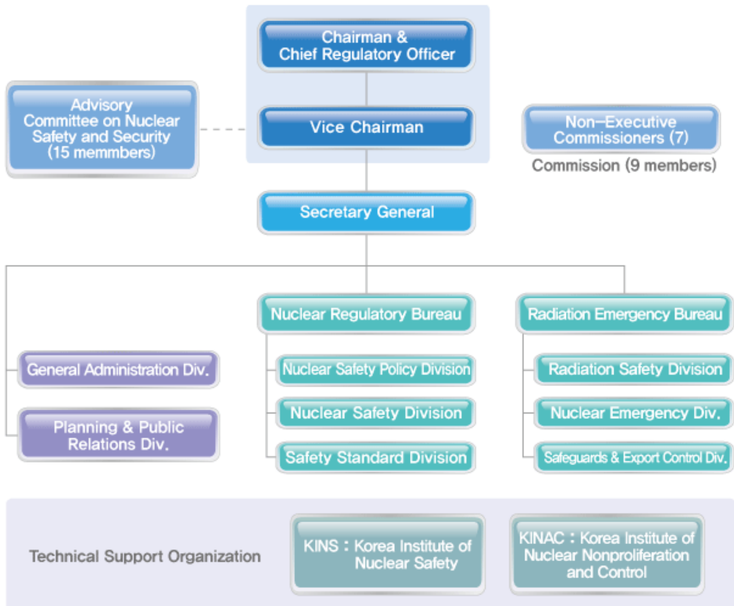


Fig. 2 Organization Chart for the Nuclear Safety and Security Commission

The Korea Institute of Nuclear Safety (KINS) was established as an expert organization for nuclear safety in February 1990, according to the enactment of the Korea Institute of Nuclear Safety Act to conduct nuclear safety regulation as entrusted by the Nuclear Safety Act and the Act on Physical Protection and Radiological Emergency. Its major functions relevant to nuclear safety regulation are regulatory review, inspection, research and development, and technical support for nuclear safety regulation, and so on.

The Korea Institute of Nuclear Non-proliferation and Control (KINAC) was established in June 2006 to perform the tasks of safeguards, control of export and import of nuclear materials, physical protection, and research and development concerning nuclear facilities and nuclear material.

The Korea Radioactive Waste Agency (KORAD) was established in Jan. 2009 to build a structure of mutual control and balance by differentiating the producers of radioactive waste from their disposal operators, which follows the IAEA recommendations and global standards for safe and effective management of radioactive waste, based on the “Radioactive Waste Management Act” legislated on Mar. 28, 2008. KORAD is responsible for the transport, storage, and disposal of radioactive waste and spent fuel including R&D activities, as well as siting, construction, and operation of related facilities. Administration of a radioactive waste management fund and public relations for radioactive waste management are also important missions of KORAD.

The Korea Hydro and Nuclear Power Co., Ltd (KHNP), an electricity utility, is responsible for the safe and economic construction and operation of NPPs, and for securing financial resources for radioactive waste management.

The Korea Atomic Energy Research Institute (KAERI), a national institute for nuclear research, carries out a R&D project for the treatment and disposal of HLW.

FINANCING

Since 1983, NPP licensees have deposited the cost required for the disposal of LILW, spent fuel generated in NPP decommissioning and operation processes on a yearly basis and have accumulated this cost as in-house liability in accordance with the provisions of Electricity Business Act.

As per the RWMA legislated in 2008, however, such in-house liability has been converted into the Radioactive Waste Management Fund since Jan. 1, 2009. According to the RWMA, those who have generated radioactive waste shall transfer the cost of maintaining radioactive waste to the KORAD, and the corporations will pay this maintenance cost to the fund. However, as for the spent fuel generated by NPP licensees, to implement projects related to the management of spent fuel smoothly, the cost of managing such fuel has been imposed on NPP licensees as the spent fuel management costs and reverted to the fund.

The appropriate cost is determined every two years by government, KORAD, KHNP, etc, by applying an annual escalator to the costs for disposal of LILW, interim storage and disposal of spent fuel, and decommissioning of NPP.

PUBLIC INFORMATION

For more information, the websites of the relevant authorities and organizations are listed below.

Government

Nuclear Safety and Security Commission (NSSC)
Website: www.nssc.go.kr
Ministry of Science, ICT and Future Planning(MSIP)
Website: www.misp.go.kr
Ministry of Trade, Industry and Energy (MOTIE)
Website: www.motie.go.kr

Regulation-related

Korea Institute of Nuclear Safety (KINS)
Website: www.kins.re.kr
Korea Institute of Nuclear Non-proliferation and Control (KINAC)
Website: www.kinac.re.kr

Research Institute

Korea Atomic Energy Research Institute (KAERI)
Website: www.kaeri.re.kr

Industry

Korea Radioactive Waste Agency(KORAD)
Website: www.korad.or.kr
Korea Hydro & Nuclear Power Co., LTD (KHNP)
Website: www.khnp.co.kr
KEPCO Engineering & Construction Co., INC (KEPCO-E&C)
Website: www.kepco-enc.com
KEPCO Nuclear Fuel (KEPCO-NF)
Website: www.knfc.co.kr

Others

Korean Radioactive Waste Society
Website: www.krws.or.kr
Korean Nuclear Society
Website: www.nuclear.or.kr
Korean Association for Radiation Protection
Website: www.karp.or.kr
Korea Atomic Industry Forum
Website: www.kaif.or.kr
Korea Nuclear Energy foundation
Website: www.knef.or.kr
Korean Association for Radiation Protection
Website: www.karp.or.kr