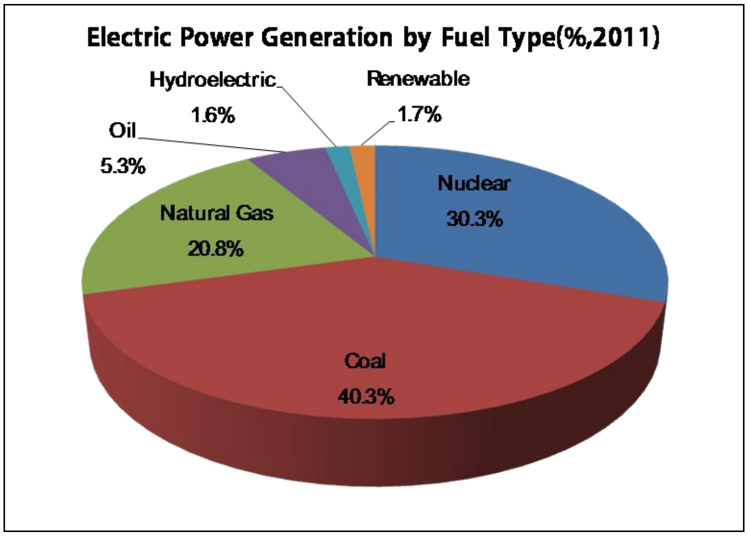
RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

KOREA
[2012]

NATIONAL NUCLEAR ENERGY CONTEXT

The commercial utilization of nuclear power in Korea started in 1978, and there are 21 nuclear power plants (NPPs) in operation as of Dec. 2011. In 2011, NPPs generated 150.2 TWh of electricity, 30.3% of the total electricity generated that year. The 21 NPPs are located at four different sites (Kori, Yonggwang, Ulchin, 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 eight NPPs are planned for construction. According to the Basic Plan of Electricity Supply and Demand, 13 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_new/elec_info/info/statistical_data.jsp

SOURCES, TYPES, AND QUANTITIES OF WASTE

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.

HLW is defined as radioactive waste with specific activity greater than 4,000 Bq/g of alpha-emitting radionuclides 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 357,732 assemblies as of Dec. 2011. Of this, CANDU spent fuel accounts for 344,456 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 2011, 89,422 drums (200 liter/drum) of LILW were generated and stored at four NPPs sites. The amount of HLW and LILW at each NPP site as of Dec. 2011 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 Management Corporation (KRMC). At the end of 2011, 3,160 drums (200 liter/drum) of RI waste were generated and stored.

Table 1. Status of HLW and LILW generated from reactor operations (as of Dec. 2011)

Nuclear Power Station*		HLW (Spent Fuel)		LILW	
Location	Number of Reactors	Storage Capacity (Assemblies)	Cumulative Amount (Assemblies)	Storage Capacity (drums)	Cumulative Amount (drums)
Kori	5	5,971	4,699	60,200	41,138
Yonggwang	6	6,396	4,671	23,300	21,470
Ulchin	6	5,550	3,906	18,929	15,933
Wolsong	4	499,632	344,456	13,240	10,881
Total	21	517,549	357,732	115,669	89,422

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. KRMC launched an alternative spent fuel management study in Dec. 2009 to promote an expert group consensus. KRMC is responsible for interim storage and the final disposal of spent fuel.

The future national policy for spent fuel management will be chosen through the public's participation, taking into consideration the national/international trends on policy and technology development.

Programmes for LILW management

The RI waste is collected and stored by the KRMC. 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 disposal center is under construction. The initial capacity of this center is 100,000 drums. The 1st stage of construction of the disposal center will be completed by June 2014, with a delay of one and half years owing to unexpected water intrusion and host rock property. After a 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. 2011, 1,536 drums of LILW were moved to the Wolsong disposal center for permanent disposal.

Programmes for HLW 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 last year and will be completed by the end of 2012 for Yonggwang units 5 and 6. The same project will be launched for

Ulchin units 5 and 6 in 2012. Through completion of these projects by the end of 2013, the total storage capacity for PWR spent fuels will reach 23,041 assemblies, resulting in a 28.5% increase in storage capacity.

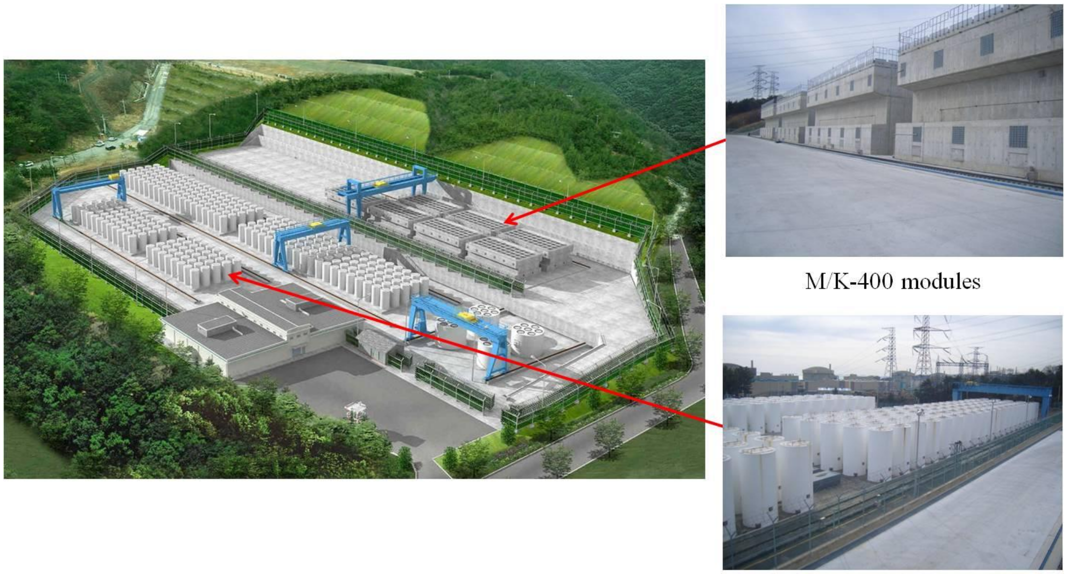


Fig. 1 Dry storage facility for CANDU spent fuel at Wolsong site

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 radionuclides.

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 system by 2011, the construction of an engineering-scale verification facility (Engineering Scale Pyroprocess Facility, ESPF) by 2016, design of a pilot pyroprocess plant by 2020, and the completion and operation 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 and 2

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 control from the decommissioning site. It will also be very useful for the decommissioning of other nuclear facilities.

TRANSPORT

Transport of radioactive materials is regulated by the Nuclear Safety Act and its associated Enforcement Decree and Enforcement Regulations. The requirements are specified in the NSSC Notice entitled "Regulations on the Packaging and Transport of Radioactive Materials" and in "Technical Standards of Radiation Safety Management." 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. The NSSC Notices also include 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 1,536 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 KRMC. 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

The government established the Nuclear Safety and Security Commission (NSSC), an independent nuclear safety regulation agency directly responsible to the President, on Oct. 26, 2011, for the separation and independence of nuclear safety operations. In June 2011, the National Assembly resolved the revision of the Atomic Energy Act (AEA) in relation to the establishment of the NSSC and the establishment and revision of related laws such as the Act on the Establishment and Operation of NSSC, the Act on the establishment of the Korea Institute of Nuclear Safety, the Nuclear Safety Act, and the Act on Measures for the Protection of Nuclear Facilities, Etc. and Prevention of Radiation Disasters. Accordingly, the government announced legislative bills for the establishment and revision of related laws in Aug. 2011 through the revision of enforcement decrees, and established the NSSC as directly responsible to the President on Oct. 26, 2011.

NSSC will be exclusively in charge of overall safety regulations in nuclear areas such as the construction and operation of NPPs, disposal and transportation of RI and radiation generating devices, and the licensing of nuclear fuel cycle management businesses. The commission consists of 9 members, including one chairman and one vice chairman. Experts from various parts of society such as nuclear power and environment and health participate in the commission. The establishment of the NSSC's independence from the MEST and the Ministry of Knowledge Economy (MKE), which had been in charge of research and development of nuclear safety operations and the utilization of nuclear power, is expected to make great contributions to the independence of nuclear safety and intensify professionalism. The organization of NSSC is described in Fig. 2.

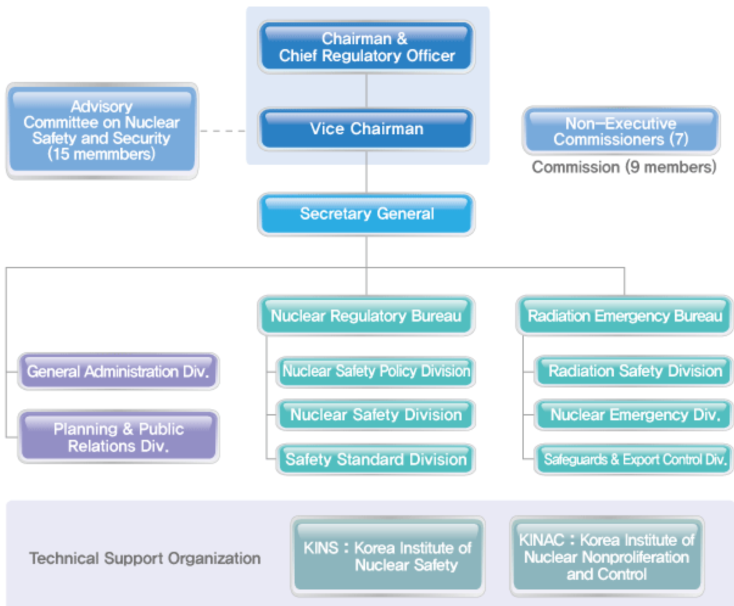


Fig. 2 Organization of Nuclear Safety and Security Commission

The Korea Institute of Nuclear Safety (KINS) is a group of experts who perform regulatory inspections, review licenses, execute technical support, and make recommendations to NSSC on nuclear safety matters.

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.

KRMC 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. KRMC is responsible for the transport, storage, and disposal of radioactive waste and spent fuel including R&D activities, as well as sitting, 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 KRMC.

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 is converted into the Radioactive Waste Management Fund and Management as of Jan. 1, 2009. According to the RWMA, those who have generated radioactive waste shall transfer the cost of maintaining radioactive waste to the KRMC, 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 will be 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, KRMC, 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 Industry

Nuclear Safety and Security Commission (NSSC)
Website: www.nssc.go.kr
Ministry of Education, Science and Technology (MEST)
Website: www.mest.go.kr
Ministry of Knowledge Economy (MKE)
Website: www.mke.go.kr

Research Institute

Korea Institute of Nuclear Safety (KINS)
Website: www.kins.re.kr
Korea Atomic Energy Research Institute (KAERI)
Website: www.kaeri.re.kr
KHNP-Central Research Institute
Website: www.khnp.co.kr/tech

Industry

Korea Hydro & Nuclear Power Co., LTD (KHNP)
Website: www.khnp.co.kr
Korea Radioactive Waste Management (KRMC)
Website: www.krmc.or.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

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