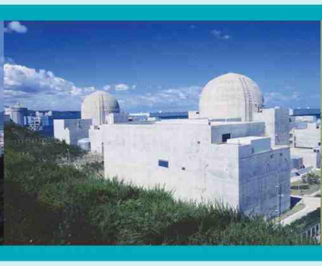
SEVENTH NATIONAL REPORT FOR THE CONVENTION ON NUCLEAR SAFETY

August 2016


THE REPUBLIC OF KOREA

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Preface

This report describes a series of actions carried out by the government of the Republic of Korea (ROK) in order to implement the obligations of Contracting Party imposed by Article 6 - Article 19 of the Convention on Nuclear Safety (CNS), which was adopted on June 17, 1994 and began effective on October 24, 1996. The Republic of Korea, which signed the Convention on September 20, 1994 and deposited the instruments of ratification on September 19, 1995, has faithfully implemented relevant obligations of the Convention since its effectuation date of October 24, 1996.

The nuclear installations covered by this report are limited to “the land-based civil nuclear power plant under its jurisdiction and storage, handling, and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant” in accordance with the CNS, Article 2. Overall various data and status in the report are, unless otherwise specified, measured and confirmed as of December 31, 2015. In addition overall structure of the report follows “Guidelines regarding National Reports under the Convention on Nuclear Safety” and describes the obligation and implementation status following the order of the Articles of the Convention.

For the preparation of the Seventh National Report for the CNS, the Nuclear Safety and Security Commission (NSSC) established and organized the「Working Group for 7th National Report for the CNS」led by the personnel in charge of international cooperation and Korea Institute of Nuclear Safety (KINS) performed major tasks on writing the report. The Working Group also includes Korea Hydro & Nuclear Power Co., Ltd. (KHNP), Doosan Heavy Industries and Construction (DHIC), Korea Atomic Energy Research Institute (KAERI), and KEPCO Engineering and Construction Co. (KEPCO E&C).

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Abbreviations

APPRE	Act on Physical Protection and Radiological Emergency
CP	Construction Permit
EPZ	Emergency Planning Zones
FSAR	Final Safety Analysis Report
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power Co., Ltd.
KINAC	Korea Institute of Nuclear Nonproliferation and Control
KINS	Korea Institute of Nuclear Safety
KoFONS	Korea Foundation of Nuclear Safety
KRMC	Korea Radioactive Waste Management Corporation
NSA	Nuclear Safety Act
NSSC	Nuclear Safety and Security Commission
OL	Operating License
PAZ	Precautionary Action Zone
PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
QA	Quality Assurance
ROK	Republic of Korea
SAR	Safety Analysis Report
SDA	Standards Design Approval
TRM	Top Regulators' Meeting
UPZ	Urgent Protective action Planning Zone

I

Introduction

1. National Nuclear Energy Policy
2. Nuclear Safety Policy
3. Brief Account on the Preparation for the National Report

I Introduction

I.1 National Nuclear Energy Policy

I.1.1 Long-term Nuclear Energy Policy

The Korean government has maintained a consistent national policy for stable energy supply by fostering nuclear power industries, under the circumstances that energy resources are insufficient in the country. Kori Unit 1, the first nuclear power plant in the Republic of Korea, started its commercial operation in 1978. As of December 2015, there are 25 units in operation and three units under construction as shown in Figure I.1-1 and Annex A.

Since the beginning of the 1990's, there has been increasing demands for a more comprehensive and consistent nuclear policy in proportion to the expansion of nuclear industry. In this context, the Atomic Energy Act was amended in January 1995 to include new articles regarding the formulation of a Comprehensive Promotion Plan for Nuclear Energy. Based on this legislation, the 1st Comprehensive Promotion Plan for Nuclear Energy (1997-2001), the 2nd Comprehensive Promotion Plan for Nuclear Energy (2002-2006), the 3rd Comprehensive Promotion Plan for Nuclear Energy (2007-2011), and the 4th Comprehensive Promotion Plan for Nuclear Energy (2012-2016) were formulated in June 1997, July 2001, January 2007, and November 2011, respectively. In 2011, the Atomic Energy Act was divided into the Nuclear Promotion Act and the Nuclear Safety Act (NSA). According to the Nuclear Promotion Act, the Minister of Education, Science and Technology (currently the Minister of Science, ICT, and Future Planning) formulates a Comprehensive Promotion Plan for Nuclear Energy and Ministers of the relevant ministries set up and carry out a specific action plan by each sector. As of December 2015, the 5th Comprehensive Promotion Plan for Nuclear Energy (2017-2021) is being established.

I.1.2 National Nuclear Power Development Program

The government announces the Basic Electricity Supply Plan every two years. According to the 7th Basic Electricity Supply Plan (2015 - 2029) announced in July 2015, the installed capacity of NPPs will increase from 23.5% (2015) to 28.2% (2029) on the basis of peak contribution. As of the end of 2015, 25 units are in operation. With additional nine units whose construction is planned to be completed by 2029, 34 units in total (after considering the permanent shutdown of Kori unit 1 in 2017) are expected to be in operation by 2029.

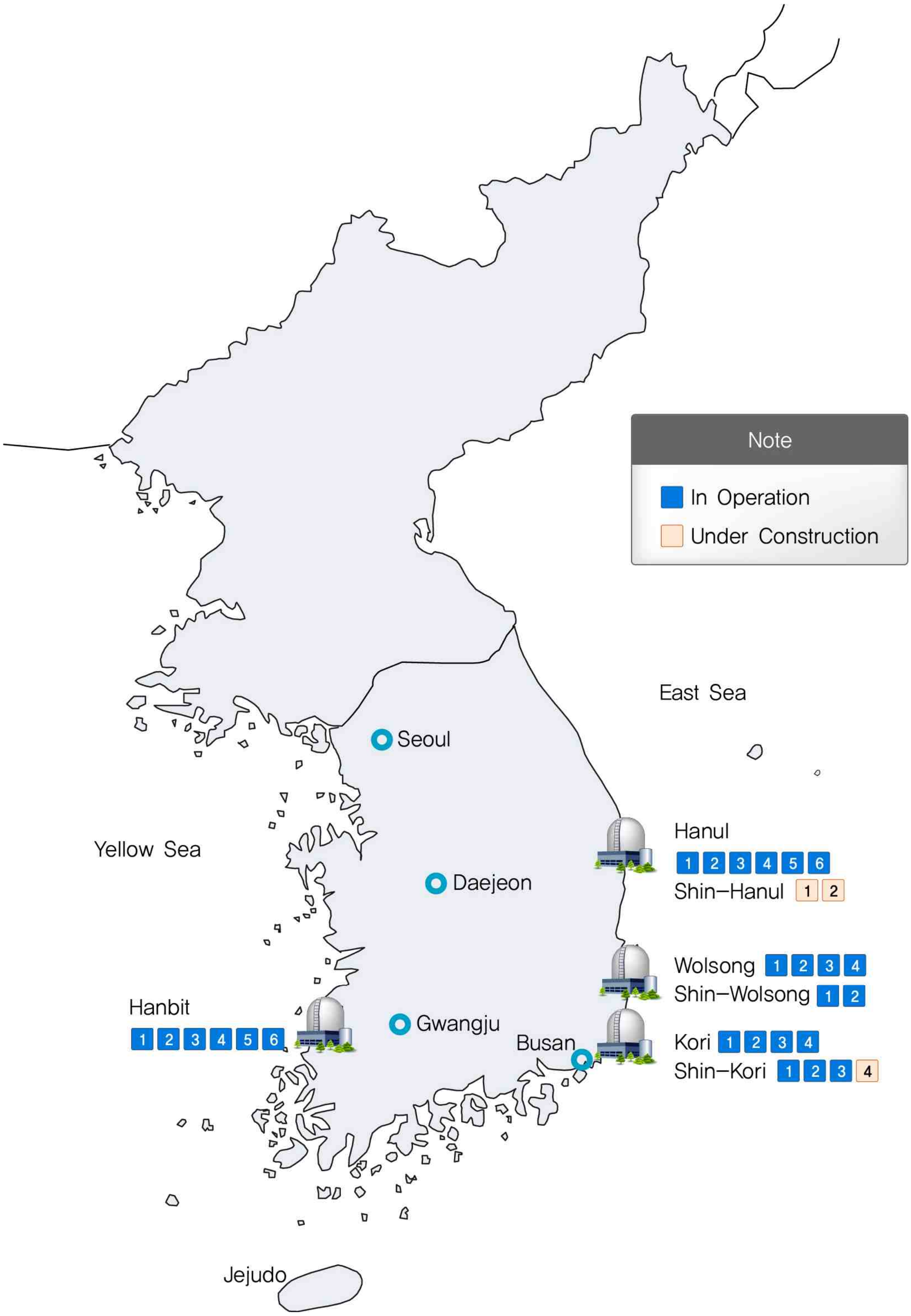


Figure I.1-1 Location of Nuclear Installations (As of December 2015)

I.2 Nuclear Safety Policy

The government established and announced the Nuclear Safety Charter on September 6, 2001. Through the Charter, the government clarified that the nuclear safety is the top priority before the implementation of nuclear power projects, which was to inspire a sense of duty and responsibility to personnel working in the nuclear power industry and also to secure the public confidence on nuclear safety. (Refer to Annex B.)

In September 1994, the government issued the Nuclear Safety Policy Statement to suggest "the five principles" to promote consistency, adequacy, and rationality of nuclear safety related regulatory activities. Along with the principles, "11 items of policy directions for nuclear safety regulation" was presented to help concrete implementation of the principles. (Refer to Annex C.)

In October 2011, Nuclear Safety and Security Commission (NSSC) was established by the government to take the responsibility of the comprehensive nuclear safety management at the national level. In October 2012, based on the NSA Article 3 (Establishment of Comprehensive Nuclear Safety Plan), the NSSC completed the deliberation and resolution of 1st Master Plan for Nuclear Safety (2012-2016), the top notch plan of the nation to guide the mid- and long-term policy direction for better response to the environmental change of domestic and foreign nuclear industries. More details will be discussed in Article 10.

Accordingly, a hierarchy of nuclear safety policy system that consists of Nuclear Safety Charter, Nuclear Safety Policy Statement, Comprehensive Plan for Nuclear Safety, and Annual Action Plan is established as follows:

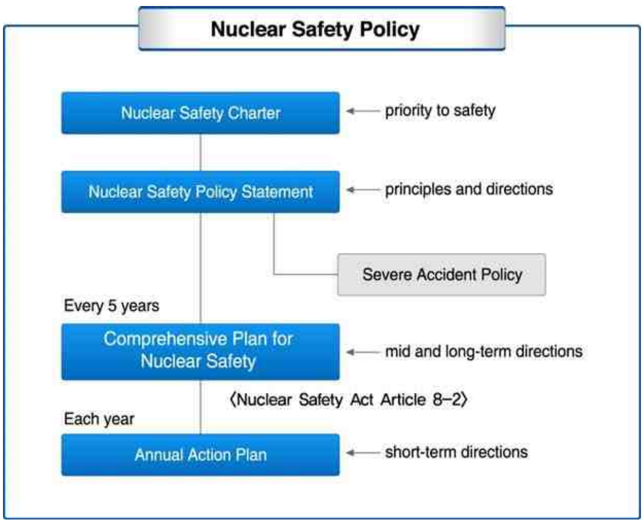


Figure I.2-1 Hierarchy of Nuclear Safety

I.3 Brief Account on the Preparation for the National Report

The Republic of Korea signed the Convention on Nuclear Safety on September 20, 1994 and deposited the ratification instrument on September 19, 1995. Since October 24, 1996 when the Convention came into effect, the Republic of Korea, as a contracting party to the Convention, has faithfully implemented the obligations as stipulated in the Convention.

In accordance with INFCIRC 572, this report is structured as follows:

I. Introduction
II. Summary
III. Article by Article Assessment
Annex

The nuclear installations covered in this report are, as defined in Article 2 of the Convention, limited to land-based civil nuclear power plants under the jurisdiction of the Republic of Korea, including storage, handling, and treatment facilities for radioactive materials on the same site and are directly related to the operation of those nuclear power plants. Unless specified otherwise, all the data and status contained in the report were described as of December 31, 2015.

This report was prepared by the Nuclear Safety and Security Commission (NSSC) and Korea Institute of Nuclear Safety (KINS) of the Republic of Korea in collaboration with: Korea Hydro & Nuclear Power Co. Ltd. (KHNP), the licensee; KEPCO Engineering & Construction Company Inc. (KEPCO E&C), a designer; Doosan Heavy Industries & Construction (DHIC), a manufacturer of key components; and Korea Atomic Energy Research Institute (KAERI), a research institute.

II

Summary

1. Major Safety Issues

2. Follow-up Measures from 6th Review Meeting

3. Implementation of Vienna Declaration

4. Challenges Identified by the Special Rapporteur of Sixth Review Meeting

II Summary

II.1 Major Safety Issues

II.1.1 Approval of the Continued Operation of Wolsong Unit 1

KHNP submitted the application documents for continued operation of Wolsong Unit 1 at the end of December 2009 prior to the expiration of its design lifetime of 30 years (November 2012). The NSSC carried out a thorough review process to verify the adequacy of the continued operation of the Unit. The review contained Periodic Safety Review (PSR), Lifetime Analysis Report on Major Equipment, and Radiological Environmental Impact Assessment Report, which covered 134 detailed review items of 21 different sectors. The review results including the stress test confirmed that the Unit fully satisfied the technical standards prescribed in the nuclear legislations and was capable of coping with extreme natural disasters. In February 2015, in acceptance of such results, the NSSC approved the continued operation of Wolsong Unit 1 and extended its operation period by November 2022. (Refer to Article 6)

II.1.2 Implementation of Stress Test

Kori Unit 1 and Wolsong Unit 1 first carried out the stress test to evaluate their coping capability against extreme natural disasters whose scale goes beyond the design basis. The test was to reaffirm the safety of the NPPs and also to identify items for improvement and complementary measures. Evaluation standards that had already been applied in IAEA, United States, and Japan as well as the recommendations from Greenpeace were rightly and appropriately reflected upon the stress test methodology. By doing so, the test was carried out not only to evaluate NPPs' technical coping capability but also to assess human errors that might arise in decision making process under extreme situation, and operating capability of organization, man power, and available means. Following the stress test results and their verification experience of Wolsong Unit 1 and Kori Unit 1, the NSSC decided to gradually expand the implementation of stress test to all operating NPPs of the nation, starting form 2016. A detailed action plan and guideline (draft) are currently being established. (Refer to Article 6)

II.1.3 Permanent Shutdown of Kori Unit 1

On June 16, 2015, KHNP decided a permanent shutdown of the Kori Unit 1 as recommended by the Minister of Trade, Industry, and Energy based on the deliberation results of the 12th National Energy Committee.

In preparation for safe reactor decommissioning process, the NSA was revised especially in matters related to decommissioning and was promulgated in January 2015. As a result, decommissioning plan needs to be submitted as a part of the application documents for Construction Permit (CP) and Operating License (OL) of an NPP and also be periodically updated. The lower statues including Enforcement Decree and Regulation of the NSA, etc. were promptly revised to reflect decommissioning related requirements and procedures accordingly (Refer to Article 6).

II.1.4 Operating License for Shin-Kori Unit 3

In June 2011, KHNP applied for OL of Shin-Kori Unit 3, the first Advanced Power Reactor (APR1400) with a capacity of 1,400 MWe. The NSSC carried out a comprehensive review to confirm the safety of the Unit: reflection of 33 post-Fukushima items for safety improvements of NPPs under construction, safety response measures against severe accident, quality document review, etc. Following the review and related inspection, the NSSC granted the operation of Shin-Kori Unit 3 in October 2015.

II.1.5 Addition of the factors to the Periodic Safety Review

The Republic of Korea first carried out the Periodic Safety Review (PSR) in 2001. Since then, every 10 years, the NPP operators have carried out the PSR based on 11 evaluation factors as prescribed in the PSR Guidance of IAEA. When IAEA revised the review guide in 2013, therefore, it was deemed necessary for the Republic of Korea to update its PSR standards accordingly. Thus, the Enforcement Decree and Enforcement Regulation of the NSA was revised in April 2014 to add three more factors to existing 11 factors such as design of the nuclear facility, Probabilistic Safety Assessment (PSA), and hazard analysis. (Refer to Article 14)

II.1.6 Expansion of Emergency Planning Zone

In order to provide the local residents with the graded protective actions depending on the distance from the nuclear facility, the Act on Physical Protection and Radiological

Emergency (APPRE) was revised in May 2014 to sub-divide the existing Emergency Planning Zones (EPZ) into Precautionary Action Zone (PAZ) and Urgent Protective action planning Zone (UPZ). The revision was to reflect the latest IAEA standards on protective actions in case of radiological emergency. As a result, the PAZ and UPZ were basically set within the radius of 3-5 km and 20-30 km, respectively from the NPP and related nuclear facility. The relevant laws were also amended to require the licensee to consult with the head of the local government (i. e. Mayors and Governors) and take into account roads, terrain, and other site characteristics first before setting EPZ. (Refer to Article 16)

II.1.7 Legalization of Accident Management Plan

As severe accidents actually took place at Fukushima Daiichi Nuclear Power Plant in March 2011 in Japan, various measures were taken to confirm and improve the safety level of domestic NPPs. A special inspection on domestic nuclear reactor facilities were carried out and 50 Fukushima follow-up actions were identified to improve the safety against severe accidents. In addition, the Republic of Korea invited IAEA Integrated Regulatory Review Service (IRRS) in July 2011, which recommended to legislate the regulation on severe accident and PSA. The recommendation raised the necessity of clear legal basis for the regulation on severe accident.

As a result, in June 2015, the NSA was revised and promulgated to include a firm legal basis for regulatory control of severe accident. The NSSC carried out subsequent rule-making process to support the amendment of the NSA and the process to stipulate all the necessary matters on regulatory control of severe accident including the Enforcement Decree and the Enforcement Regulation of the NSA was completed. (Refer to summary II-3)

II.1.8 IAEA IRRS Follow-up Mission to Korea

The NSSC invited IRRS follow-up mission to the Republic of Korea in December 2014. In addition to the follow-up areas to see the implementation status on the recommendations (10) and suggestions (12) drawn from the initial mission back in July 2011, new areas were added including radiation safety.

The IRRS follow-up mission confirmed that most of the recommendations and suggestions drawn in 2011 were closed. As for the new area of radiation safety, the mission team recognized the safety management on radiation sources licensees and integrated full scope inspections of fuel cycle facilities as good practices. In addition to three good practices, nine recommendations and nine suggestions were identified as the result of 2014 IRRS follow-up mission to the Republic of Korea.

II.2 Follow-up Measures from 6th Review Meeting

The 6th Review Meeting identified six good practices and found eight challenges from the Republic of Korea. Current implementation status on each of challenges are as follows:

Challenges

- Encouragement of reporting corruptive actions at NPPs
- Establishment of robust operator certification system for equipment qualification
- Expanding the scope of vendor inspections (including foreign vendors)
- Strengthening quality assurance inspections
- Establishing tracking and management system of equipment/parts
- Development and implementation of an enhanced regulatory oversight of safety culture
- Reassessment of site safety
- Increase of the number of regulatory experts

Encouragement of Reporting Corruptive Actions at NPPs

Since the falsification case of the test report on the reactor control cables, the NSSC has operated ‘Nuclear Safety Ombudsman’ system starting from June 2013, in which a tip-off by inside/outside informants promptly initiates an investigation on corruptive actions in nuclear industry. The system aims to eradicate and prevent corruptions and wrongdoing in nuclear industry by investigating the corruptive actions on nuclear safety, defects on equipment and parts, unreasonable work practice, and other nuclear safety related actions that violate nuclear legislations on the perspective of nuclear safety.

As for the informants, anonymity and thorough personal protection are guaranteed so as to receive more reports from possible informants. After the reports, investigation and action results are notified and followed by continuous monitoring on corrective actions. In addition, to realize more proactive reports and tip-off, incentives are granted to the informants based on the pre-established incentive standards.

Establishment of Robust Operator Certification System for Equipment Qualification

In accordance with the revised NSA in 2015, performance qualification institutes shall be accredited first in order to carry out quality assurance of facilities. The main idea is that the NSSC designates a performance qualification institute to be responsible for accrediting qualification agencies and post-accreditation management. Currently, Korea Foundation of

Nuclear Safety (KoFONS) is designated as the management institute and in charge of accreditation, post-accreditation management, fact-finding investigations, facility improvement, and education/training. It carries out the review for accreditation and other management works and is planning to complete the development of a comprehensive management system for performance qualification by 2017.

Qualification agencies are able to receive accreditation only when the review confirms that it satisfies the accreditation criteria in areas of specialized personnel, qualification facilities, and quality assurance (QA) system. As of 2016, there is a total of 12 accredited agencies and additional 10 agencies are under accreditation review process. Accredited agencies are also subject to post management including regular check-up. The accreditation may be revoked in case of significant violations or failing to fulfill the corrective actions.

In order to enhance qualification capability, safety, and confidence of the accredited agencies, training of qualification personnel is implemented and major qualification facilities are being improved. The training covers establishment and implementation of QA system for performance qualification and technical training including seismic and environmental qualification.

Expanding Scope of Vendor Inspections (including foreign vendors)

The regulatory inspection on NPPs used to be carried out against the licensees that install and operate NPPs. In 2014, however, inspection on suppliers, etc. was adopted to expand the scope and target of inspection from licensees to designers, manufacturers, and performance verifiers of safety related equipments in order to enhance safety and reliability of NPPs. To this end, the NSA was revised on May 21, 2014 and came into effect on November 22, 2014 after grace period.

“Reporting of contracts on safety-related facilities” and the “inspection of suppliers, etc.” are two major revisions of the laws and the relevant tasks are entrusted to KINS by the NSSC. According to the law, ‘suppliers, etc.’ mean suppliers and performance verifiers and ‘suppliers’ mean designers and manufacturers.

Article 15-2 (Reporting of Contracts on Safety-related Facilities) of the NSA stipulates that after filing an application for permit, a licensee of nuclear power reactor and research reactor shall, when he/she concluded a contract on their safety-related facilities or facilities, report it to the regulatory body within 30 days of the conclusion of the contract. The inspection on suppliers, etc. is carried out against suppliers who reported the contracts on safety-related facilities as prescribed in the Article 16, 22, and 34 of the NSA. More details are prescribed in Article 31-2 of the Enforcement Decree of the NSA and the NSSC Notice (Regulation on Inspection of Suppliers, etc for Safety Related Facilities of Nuclear Installations).

Since the adoption of the inspection of suppliers, etc., in 2015, the inspection was carried out on 14 companies focusing on the suppliers of constructed NPPs and the target of inspection will be gradually expanded from 2016.

Strengthening Quality Assurance Inspections

Quality Assurance (QA) Inspection is carried out to confirm whether or not the QA plan and work established by the licensee are in compliance with the requirements for CP and OL and to verify the validity of the QA plan established by construction or operating licensee of nuclear installations.

To prevent the reoccurrence of falsification of quality certificate and test reports of nuclear parts that took place in 2012, KINS set up a new team to carry out the inspection under the leadership of specialized PM. As for the operating NPPs, the cycle of QA inspection is shortened from every two year to one year per NPP and the inspection to verify the validity of QA system based on 18 QA requirements and the intensive inspection focusing on maintenance issues and vulnerable areas are alternately carried out.

Tracking and Management System of Equipment/Parts

KHNP launched 'Radio frequency identification (RFID) based equipment and material tracking system' in July 2014, enabling history management and monitoring of equipment and materials in different stages. In addition, in January 2015, Integrated Information System of Nuclear Parts was established. Entire information regarding the equipment and parts utilized in NPPs from their design, manufacturing, installation to disposal such as history and person in charge is incorporated and interconnected so as to track and search related information centering on key equipment and parts. The information on equipment and parts can be searched based on keyword or natural language. Search on different subject fields such as purchase, facilities, quality, and installation information as well as their individual equipment and part information is available.

Development and Implementation of an Enhanced Regulatory Oversight of Safety Culture

The NSSC has focused on campaign activities to raise safety awareness of NPP workers rather than directly intervening in the safety culture of the licensee. However, after the licensee intentionally did not report the station blackout incident took place at Kori Unit 1 in February 2012, the NSSC started a regulatory supervision and special inspection on licensee's safety culture. In addition, the NSA was revised in 2014 to institutionalize regulatory supervision on safety culture with adding safety culture to be checked as part of PSR.

Since 2013, KINS has carried out research project on “Development of Regulatory Infrastructure for the Oversight of Safety Culture” and developed a system for practical implementation to regulatory oversight on licensee’s safety culture. (Refer to Article 10)

Reassessment of Site Safety

In the aftermath of the Fukushima Daiichi Accident, the government of the Republic of Korea has made an effort to enhance the coping capability against simultaneous accidents in multiple units through probabilistic approach. Especially in response to the concerns over high regional density of NPPs raised by the National Assembly and environment groups and call for relevant countermeasures, implementation plan for enhanced safety measures along with post-Fukushima measures are in preparation (consideration of disaster in wide area and securing emergency response base). The safety standards regarding safety evaluation on multiple units are also under development through development of and research on PSA methodology for multiple units.

Increase of the Number of Regulatory Experts

The nuclear regulatory workforce of the Republic of Korea is a total of 766 with 140 from the NSSC, 501 from KINS, 83 from KINAC and 42 from Korea Foundation of Nuclear Safety (as of April 2016). The overall size of the regulatory workforce has significantly increased mainly due to the increase in NSSC staff to 140 from 93 in 2013 and also due to the establishment of Korea Foundation of Nuclear Safety with 42 staff.

II.3 Implementation of Vienna Declaration

The Republic of Korea enacted safety regulation on severe accident management by implementing the follow-up actions from TMI accident of the U. S. (December 1983) into domestic NPPs. Since then, with ever increasing necessity for more systematic regulatory control, the severe accident policy statement was issued in August 2001 and following administrative orders to implement the policy has strengthened the regulation on severe accident. Based on the administrative orders, various measures have taken place including securing prevention and mitigation capability against severe accident of new NPPs, PSA on new and operating NPPs, and application of severe accident mitigation guideline.

Many measures to verify and improve the safety have been taken place based on the lessons and experiences learnt from the Fukushima Daiichi Accident in March 2011. Right after the accident, in May 2011, a special inspection on domestic NPPs of the Republic of Korea was carried out and drew up 50 follow-up actions against the Fukushima Daiichi Accident. The licensee was required to perform the follow-up actions to enhance safety against severe accident. Legal basis for the regulation on severe accident became more necessary when the IAEA IRRS Mission to the Republic of Korea in July 2011 recommended that the regulations on severe accident and PSA need to be adopted or amended.

Accordingly, the NSA was revised to clearly stipulate the responsibility for and the regulatory requirements of accident management including severe accident management (promulgated on June 22, 2015 and effective on June 23, 2016). The NSSC promptly promoted follow-up legations and revisions to complete the legalization of what is necessary for regulatory control on severe accident. Here explains key regulatory control whose legalization has recently been completed to lay a legal basis for implementation of Vienna Declaration. In addition, regulatory activities to be performed henceforth based on the new regulations on severe accident are explained in terms of applicable CNS Articles.

Legislation and Revision of the NSA and Subordinate Statues for Regulatory Management of Severe Accident

The NSA and subordinate regulations that stipulate matters related to regulatory control of severe accident came into effect on June 23, 2016. The major contents are as follows:

- To include severe accident into the scope of accident management: accident management is defined as overall actions to: 1)prevent the escalation of the accident; 2)mitigate the consequences of the accident; and 3)achieve a long-term safe and stable state after the accident, which includes severe accident management
- To be included as part of application documents for OL: it is stipulated that accident management

program which includes severe accident management shall be submitted as part of application document for OL. The detailed contents that needs to be included in the accident management program is also prescribed (scope of accident management, equipment used in accident management, strategy and implementation system for accident management, and evaluation of accident management capabilities)

- To expand the scope of Radiological Environmental Impact Assessment to include severe accident
- To carry out periodic inspection on accident management including severe accident against operating NPPs: It is prescribed that the criteria for periodic inspection on NPPs include the criteria for accident management.

Existing Nuclear Power Plants (CNS Article 6)

In accordance with the amendment of the NSA, operating NPPs are required to submit the accident management program by June 23, 2019. It is a basic principle that existing NPPs undergo the assessment process as illustrated in CNS Article 14 (Assessment and Verification of Safety), aiming the same goal with new NPPs, and identify and manage applicable safety improvements to achieve the goal. By doing so, the safety of existing NPPs against severe accident is expected to be practically improved.

What is explained below in CNS Article 19 (Operation) is identically applied to the existing NPPs. That is, the licensee of existing NPPs are required to establish the accident management program by utilizing the structures, systems, and components for severe accident prevention and mitigation that are already in place or additionally purchased as Fukushima Daiichi Accident follow-up measures, and implement the program accordingly.

Assessment and Verification of Safety (CNS Article 14)

Newly adopted severe accident regulation framework strengthens the 5 levels of defense in-depth barriers suggested in INSAG-10 and constitutes defense in-depth levels that divide severe accident into two stages; severe accident prevention and severe accident mitigation.

[Evaluation on Prevention of Severe Accident]

Accidents that need to be considered in the prevention of severe accident can be divided into the accident caused by multiple failures and beyond design basis disasters (natural and man-made). The basic objective for the prevention stage of severe accident is to prevent the nuclear fuel in the reactor or the spent fuel pool from significant damage by managing the accidents considered in the prevention stage. The NSSC Notice stipulates detailed acceptance criteria by accident types.

- Acceptance Criteria of Accident caused by multiple failure
  - Possible significant damage to nuclear fuel in the reactor and the spent fuel pool caused by multiple failure accident need to be prevented at nuclear facilities

- Acceptance Criteria of Beyond Design Basis Disasters (Natural and Man-made)
  - Nuclear facilities are required to be able to recover and maintain the critical safety functions in the case of beyond design basis disasters (nuclear fuel cooling in the reactor and the spent fuel storage facility, integrity of reactor containment)

[Evaluation on Mitigation of Severe Accident]

The basic objective for mitigation stage of severe accident is to prevent radioactive materials from large release to the environment after significant damage to the reactor core (i.e. severe accident). To this end, hydrogen explosion and other threats generated after severe accident should not lead to the loss of containment function.

- Threats to be Considered for Severe Accident Mitigation
  - Combustion or explosion of combustible gas
  - High temperature or overpressure of reactor containment
  - Molten corium and concrete interaction
  - High pressure melt ejection
  - Direct containment heating
  - Fuel coolant interaction
  - Bypass of reactor containment boundary such as creep rupture of steam generator tube
  - Other threats whose frequencies and consequences are evaluated as equivalent to above threats (threats to be additionally considered)

[Assessment of Accident Consequence]

Newly adopted severe accident regulatory framework expanded the scope of accident consequence analysis from existing design basis accident to include severe accident in prevention stage and mitigation stage. The NSSC Notice requires that the accidents newly included in the scope of assessment need to assess the radiation exposure dose on residents in vicinity of the NPPs and meet the acceptance criteria of design basis accident.

[Risk Assessment]

Regarding the prevention and mitigation of severe accident, probabilistic safety assessment needs to be carried out along with deterministic safety assessment and the goals are as follows:

- Early and cancer fatality risk should be less than 0.1% of the total risk, or equivalent performance goal should be met
- The total frequency of the accidents with the release of more than 100TBq of radionuclide Cs-137 should be less than 1.0×10-6/year

Siting (CNS Article 17)

In newly adopted severe accident regulatory framework, siting is related with beyond design basis natural disaster, assessment of accident impact, and probabilistic safety assessment prescribed in CNS Article 14 (Assessment and Verification of Safety) in the above. For each of the assessment, site characteristics are reflected as follows:

Selection of Beyond Design Basis Natural Disasters
- Site characteristics shall be reflected when selecting the specific natural disasters that need to be considered for prevention of severe accident

Assessment of Accident Consequence
- Site characteristics, especially those related with meteorological conditions need to be reflected upon the assessment of accident consequence (radiation exposure dose)

Probabilistic Safety Assessment
- Site characteristics need to be reflected when performing Probabilistic Safety Assessment

Design and Construction (CNS Article 18)

Matters to be considered in the design process of new nuclear installations are directly related to the assessment for the prevention and mitigation of severe accident. Applicants for CP or OL need to carry out various assessments related to severe accident prevention and mitigation as requested in CNS Article 14 (Assessment and Verification of Safety) and design the nuclear installations to be equipped with severe accident prevention and mitigation equipment so as to meet the acceptance criteria of each assessment.

Operation (CNS Article 19)

In accordance with newly adopted regulatory framework of severe accident, the licensee shall properly manage the equipment for severe accident prevention and mitigation, establish and implement the accident management program such as preparation and implementation of guidelines, staffing and organization, and develop and implement training programs.

II.4 Challenges Identified by the Special Rapporteur of Sixth Review Meeting

The president of the 7th CNS Review Meeting requires that contracting parties specify their resolution on the five challenges mentioned in the summary report of the 6th Review Meeting. The objective of five challenges is to ensure continuous endeavors of the contracting parties to achieve high level of nuclear safety in conformity with the goal of the convention and also to minimize the gaps between contracting parties in consideration of findings during the review meeting.

II.4.1 Ways to Minimize Gaps between Contracting Parties' Safety Improvements

KINS established International Nuclear Safety School (INSS) and signed an bilateral agreement with IAEA in 2008 to provide a comprehensive education/training programme of nuclear safety mainly for regulatory personnel from newly emerging nuclear countries. The purpose of the education is to faithfully follow the international norm to support establishment of infrastructure and personnel competence, thereby helping newly emerging nuclear countries secure and enhance nuclear safety and contributing to minimizing gaps in safety improvements.

The KINS-KAIST International Nuclear Safety and Radiation Master's Degree Program generated 76 master degree holders from 24 countries from 2009 to 2015 and, in 2015, 13 nuclear safety education and training courses were provided to about 318 trainees from the regional networks within the framework of Global Nuclear Safety and Security Network (GNSSN) of IAEA, including Asian Nuclear Safety Network (ANSN), Arab Network of Nuclear Regulators (ANNuR), and Forum of Nuclear Regulatory Bodies in Africa (FNRBA).

II.4.2 Ways to Achieve Harmonized Emergency Plans and Response Measures

The Republic of Korea established trilateral information exchange system on nuclear accident with China and Japan under the framework of Top Regulators' Meeting (TRM) since 2008 in order to enhance nuclear safety capability of Northeast Asia and has continued to discuss cooperative methods of three countries including joint radiological emergency preparedness exercise.

The NSSC joined the Response and Assistance Network (RANET) of IAEA in April 2015 to support emergency response between member countries in case of radiological accident. Accordingly when requested to support emergency response that requires international support, the NSSC will strengthen international coordinating activities including dispatch of experts and provision of technical support in collaboration with related organizations (Korea Institute of Radiological and Medical Sciences and Korea Atomic Energy Research Institute).

II.4.3 Ways to Make Better Use of Operating and Regulatory Experience, and International Peer Review Services

The NSSC has been exchanging operating and regulatory experience with China and Japan in the area of online information exchange, education and training, and emergency preparedness including joint emergency exercise under the framework of TRM. In addition, the Republic of Korea invited IAEA IRRS mission from July 10 to 22, 2011 to review areas of power reactor, research reactor, radiation emergency preparedness, and post-Fukushima measures. The IRRS review teem identified 15 good practices, 10 recommendations, and 12 suggestions. The follow-up IRRS mission including new areas such as fuel cycle facilities and radiation safety in December 2014 confirmed that most of the recommendations and suggestions were closed.

KHNP joined INPO and WANO to seek information exchange and cooperation among reactor operators and carried out technical arrangements with major institutes including electric companies overseas to share relevant technologies and experiences.

II.4.4 Ways to Improve Regulators' Independence, Safety Culture, Transparency and Openness

Considering the legal basis of government organization, Ministry of Science, ICT and Future Planning is responsible for research, development, production, and utilization of atomic energy in accordance with Nuclear Promotion Act. Ministry of Trade, Industry and Energy is responsible for nuclear development plan and implementation in accordance with Electricity Business Act and Electric Power Source Development Promotion Act. According to the laws, the function of the NSSC is clearly separated from nuclear energy promotion. Act on Establishment and Operation of the NSSC Article 2 stipulates that NSSC shall maintain independence and impartiality from nuclear development and promotion and Article 3 of the same act prescribes that decision making on the matters related to nuclear regulation shall not be affected by other governmental organizations or external agencies.

The NSSC specified the subject and method of proactive information release in accordance with the NSA 103-2. The NSSC had already opened safety regulation related information to the public including licensing related review report, investigation report on nuclear accident and failure, etc. to meet the right to know of the public, but recently added licensee's application documents for CP and OL to the list of information to be publicly opened. In addition, in accordance with the law, Nuclear Safety Information Center was installed for comprehensive collection and release of safety information and online portal for information center was established so that anyone can access to related information any time.

KINS initiated a research on development of regulatory infrastructure for the oversight of safety culture, through which it developed 16 elements that constitute 5 areas for safety culture implementation (human performance management, reflection of experience and operation improvement, safety first work environment, leadership and organization management, and safety culture management system) and utilizes them in regulation on safety culture of the licensee.

II.4.5 Ways to Engage All Countries to Commit and Participate in International Cooperation

The Republic of Korea has participated in various multilateral and bilateral cooperative activities to enhance international nuclear safety. As a nuclear advanced country, it actively participates in policy decision-making process of international organizations including IAEA and OECD/NEA to better contribute to establishing a global framework of enhanced nuclear safety and has shared nuclear safety regulatory experience with member states through strategic participation in sub-committees of international organizations and technical working groups. The relevant meetings of IAEA and OECD/NEA which the Republic of Korea participates are as follows:

- IAEA
    - Commission on Safety Standards (CSS)
    - Regulatory Cooperation Forum (RCF)
    - Technical and Scientific Support Organization Forum (TSOF)
    - Etc.

- OECD/NEA
    - Committee on Nuclear Regulatory Activities (CNRA)
    - Committee on the Safety of Nuclear Installations (CSNI)
    - Multinational Design Evaluation Programme (MDEP)
    - Etc.

The Republic of Korea has supported the regional networks under the framework of IAEA Global Nuclear Safety and Security Network (GNSSN), namely ANSN, ANNuR, and FNRBA to build infrastructure and nurture competent personnel of newly emerging nuclear countries to secure nuclear safety.

In 2006, the Republic of Korea became a formal member of International Nuclear Regulators' Association (INRA), an international gathering of regulators from nuclear advanced countries, and has been taking part in various occasions including the 37th regular meeting in 2015 to actively share domestic nuclear experience with member states including nuclear safety regulation, radiation protection, and radiological waste management.

In addition, the Republic of Korea is an active member of Top Regulators' Meeting (TRM), a trilateral consultative body between Korea, China, and Japan established to enhance nuclear safety capability of Northeast Asia and to secure a nuclear safety cooperation system. It is to pursue cooperative activities for enhanced nuclear safety capability in Northeast Asia by exchanging good and outstanding nuclear safety experiences and maintaining close information exchange.

For bilateral cooperation in nuclear safety area, the NSSC has entered into various bilateral cooperative agreements and performed diverse cooperative activities. Based on such cooperative agreement between governments, KINS has signed MOU with nuclear safety regulatory bodies overseas for further cooperation (Refer to Annex).

Ⅲ Article-by-Article Assessment

Article 6. Existing Nuclear Installations

Article 7. Legislative and Regulatory Framework

Article 8. Regulatory Body

Article 9. Responsibility of License Holder

Article 10. Priority to Safety

Article 11. Financial and Human Resources

Article 12. Human Factors

Article 13. Quality Assurance

Article 14. Assessment and Verification of Safety

Article 15. Radiation Protection

Article 16. Emergency Preparedness

Article 17. Siting

Article 18. Design and Construction

Article 19. Operation

III Article-by-Article Assessment

III.1 Article 6. Existing Nuclear Installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

III.1.1 Status of Nuclear Installations

The status of construction and operation of nuclear installations in the Republic of Korea is shown in Annex A. Kori Unit 1, the first nuclear power plant in the Republic of Korea, started its commercial operation in April 1978. As of December 2015, there are 25 units of nuclear power plant in operation and three units under construction. Those 25 operating units consist of 21 Pressurized Water Reactors (PWRs) and four Pressurized Heavy Water Reactors (PHWRs), while three units under construction are of PWRs.

* Refer to Appendix A. List of Nuclear Installations for status of installation and operation of NPPs

III.1.2 Safety Assessment for Nuclear Installations

Safety Assessment and Inspection for Pre-operational Nuclear Installations

The NSA stipulates that an applicant for a CP and an OL, before commencing construction and operation of nuclear installations, shall perform comprehensive and systematic safety assessments and file a Safety Analysis Report (SAR) with the regulatory body for a safety review. According to this provision, all nuclear installations in the Republic of Korea should be constructed and operated through safety assessment first by KHNP as an applicant for CP and OL, and then licensed through safety review and regulatory inspection by the regulatory body of the NSSC.

For enhanced safety of nuclear installations, the inspection of suppliers, etc. is carried out against those suppliers, etc. who perform designing, manufacturing, and performance inspection of nuclear installations. The inspection is based on the annual inspection plan established after considering the relevant NSSC Notice that prescribes the inspection targets. Pre-operational inspection is carried out in accordance with the Enforcement Decree of the NSA which prescribes key tests and time for inspection and also with the NSSC Notice that stipulates each process and detailed inspection items. The period of pre-operational inspection is until the completion of entire commissioning test including power operation.

The details of the stepwise safety review and regulatory inspection and the general licensing procedures for nuclear installations are described in Section III.2.3 and III.2.4, while the details of the comprehensive safety assessment for the construction and operation of nuclear installations are described in Section III.9.1.

Safety Assessment and Inspection for Operational Nuclear Installations

In order to ensure the safety of operating nuclear installations, KHNP carries out an overall safety examination for nuclear installations in every 20 months, and improve the safety of the nuclear installations, if necessary, as a result of the evaluation of safety-related operating experiences and events. KHNP also conducts a periodic assessment for main safety parameters, for example, unplanned reactor scram and safety component availability.

KHNP, the operator of nuclear installations, conducts a safety assessment for the refueled reactor core during a refueling outage. The NSSC approves the criticality of a nuclear installation only when the result of a comprehensive safety and performance evaluation is satisfactory through a systematic regulatory inspection as well as a safety review.

KHNP performs PSR for all nuclear power plants in every 10 years after the date of operating license issuance and submits the reports to the NSSC. The NSSC and KINS review the results of the utility's safety assessment and its plans for enhancing nuclear safety. More details on PSR are described in Section III.9.2.

III.1.3 Status of Nuclear Installation Safety

Post - Fukushima Actions

Since the Fukushima Daiichi Accident in 2011, short- and long-term items for improvements over earthquake, tsunami, and severe accident were identified in order to secure safety in case of beyond design basis natural disasters just as in the nuclear accident in Japan. The NSSC carried out a special safety inspection and identified 60 items for long-term improvement which consisted of 50 items (46 from KHNP, four from Korea Institute of Radiological & Medical Sciences and Korea Atomic Energy Research Institute) and 10 items from licensees' self inspection. Implementation of the identified improvement items are mostly completed except for six items (based on the report received by the NSSC on December 10, 2015) including the installation of vent or depressurization facilities, for which countermeasures will be initiated from 2016 to be completed no later than 2020.

Continued Operation (Wolsong Unit 1)

Wolsong Unit 1 is the first heavy water reactor that operated for 30 years from reaching its first criticality in November 1982 to expiration of design life in November 2012. KHNP submitted application for continued operation back in December 2009 and the NSSC carried out a review to confirm the adequacy of the continued operation on 134 items of 21 areas including ageing degradation and safety performance. Document subject to review includes PSR [55 items of 11 areas plus three areas (new analysis items)], design life evaluation report on major components (59 items of four areas) and radiological environmental impact assessment report (20 items of six areas).

The review results on submitted documents showed that the safety analysis results on 14 evaluation factors such as physical condition of nuclear installation meet the relevant requirements, following which the NSSC approved the continued operation of Wolsong Unit 1 in February 2015. Design life evaluation on safety related components was properly carried out and ageing degradation management plan was established in accordance with related requirements. The radiological environmental impact assessment that reflected changes in environment and site characteristics after OP satisfied relevant requirements.

Stress Test

On April 30, 2013, KHNP received an administrative order to carry out EU's stress test on two of the relatively old NPPs of the Republic of Korea, Kori Unit 1 and Wolsong Unit 1, which was a part of implementation of President's election pledge. It was to see the safety of the NPPs against extreme natural disaster. The recommendation of Greenpeace was included in the evaluation methods and standards together with the evaluation standards of IAEA, the U. S., Japan, etc. The evaluation items contained response capability of each specialized area including: safety of structure, system, component against extreme natural disasters such as earthquake, flood, etc.; coping capabilities against the loss of safety function such as electrical power system; severe accident management capability; and emergency preparedness and response capability. In addition, decision making errors in extreme situation and operational capability (organization, manpower, and available means) were also included as part of the test items.

The result of the stress test found that Wolsong Unit 1 is equipped with response capability in almost all tested items due to its conservative design on safety and regarding the 19 items identified as mid- and long-term safety improvements, follow-up measures are being carried out. Kori Unit 1 was also verified as being equipped with response capability against extreme natural disaster.

22 Units including Shin-Wolsong Unit 2 which started its first commercial operation in July, 2015 are subject to the stress test initiated in 2016. The NSSC is establishing detailed stress test plan and guideline (draft) that are to be applied to the rest of the operating NPPs from 2016 based on the stress test experience in Kori Unit 1 and Wolsong Unit 1 as well as on the international technical and policy trends.

Permanent Reactor Shutdown (Kori Unit 1)

On June 16, 2015, KHNP decided not to submit an application for a continued operation of Kori Unit 1 as recommended by the Ministry of Trade, Industry, and Energy based on the deliberation results of the 12th National Energy Committee on June 12, 2015.

For permanent shutdown of the Unit, KHNP is expected to apply for operation change permit since the NSA recognizes permanent shutdown as one of the operation stage. It is expected that operation change permit will be applied prior to the expiration (June 2017). Currently the detailed regulatory procedure backed by legal basis is being analyzed and the issues to be considered for safety regulation are also being reviewed.

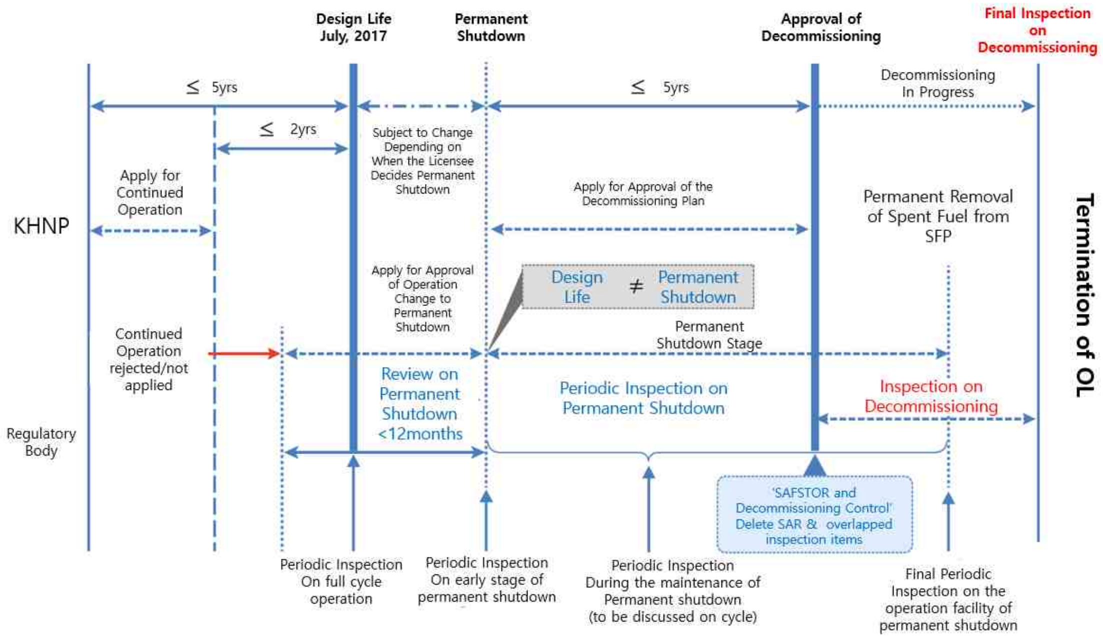


Figure III.1-1 Flowchart on Safety Regulation on Permanent Shutdown

In preparation for the first domestic decommissioning process of the nation, the NSA was revised in January 2015 and taken into effect in July 2015. The revised NSA stipulates that the decommissioning plan should be submitted in advance when applying for CP and OL and be periodically updated. In addition, actual decommissioning procedure should be thoroughly checked up by the NSSC, thereby enhancing nuclear safety. In order to resolve public concerns over the reactor decommissioning, it is legally required that decommissioning plan needs to receive the feedback from the residents living in vicinity of the NPP site.
Accordingly, subordinate statues were revised in 2015 to reflect necessary matters for safety regulation system of decommissioning including the content of decommissioning plan, method for periodic update, approval procedure, etc. as entrusted by the NSA.

Operating License for Shin-Kori Unit 3 (APR 1400)

For the first time in the Republic of Korea, Shin-Kori Unit 3 and 4 adopted standard design of Advanced Power Reactor 1400 MWe (APR 1400) whose electric power output capability is 40 % higher and design life is 60 years longer than existing OPR 1000 reactor and it is equipped with reinforced facilities, which are better in prevention of the reactor core damage in case of accident and in minimized radiational release.

KHNP applied for OL of Shin-Kori Unit 3 back in June, 2011 and 33 safety improvements for constructed NPP drawn from the Fukushima Daiichi Accident were included in the review process. As a result, it was found that among 33 improvements, 23 items that needed to be completed prior to issuance of OL were completed including installation of passive hydrogen recombiner. It was also confirmed that four items including installation of waterproof doors and discharge pumps and six items including research on the maximum potential earthquake for the nuclear sites will be completed prior to commercial operation and post commercial operation (2017), respectively. Based on there review results, the NSSC approved the operation of Shin-Kori Unit 3 in October 2015.

Major Events

Major events that occurred in operating nuclear installations in the Republic of Korea between 2013 and 2015 include “Turbine Manual Stop and Reactor Automatic Trip by Flood in the Circulation Pump Room due to Localized Downpour in Kori Unit 2” in August 2014 and “Automatic Reactor Trip During Power Reduction for the Maintenance of Leaking SG Tube in Hanbit Unit 3” in October 2014. In each case, the licensee took an action to prevent the radiological impact from spreading to general public and the environment and regulatory body also requested proper actions to enhance safety and to prevent the recurrence of the similar events through safety inspection and review as described above. As a result, the nuclear installations safely returned to operation in the same year of the event. Further details can be found in Annex E. Recent Major Events.

III.2 Article 7. Legislative and Regulatory Framework

1. *Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*

2. *The legislative and regulatory framework shall provide for:*
   - *(i) the establishment of applicable national safety requirements and regulations;*
   - *(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence:*
   - *(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;*
   - *(iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.*

III.2.1 Nuclear Legislative Framework

Atomic Energy Related Acts

National laws related to the development, utilization, and safety regulation of nuclear energy are the Atomic Energy Promotion Act and the NSA as well as the Electricity Business Act, the Basic Law of Environmental Policy and others as shown in Table III.2-1. All provisions on nuclear safety regulation and radiation protection are prescribed in the NSA. The NSA is, therefore, the main law concerning safety regulations of nuclear installations.

The legal framework for Nuclear Safety, as shown in Figure III.2-1, consists of four levels: Act (the NSA), Presidential Decree (the Enforcement Decree of the NSA), Ordinance of Prime Minister (the Enforcement Regulations of the NSA), the NSSC Regulation (Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. and Regulations on Technical Standards for Radiation Safety Control, Etc.) and the NSSC Notice. The NSA stipulates fundamental matters concerning the basis of safety regulation, the NSSC, Comprehensive Plan for Nuclear Safety as well as CP and OL of nuclear installations as shown in III.2-2. The Enforcement Decree of the same act (the Presidential Decree) provides the matters entrusted by the NSA and administrative particulars necessary for the implementation (detailed procedure and methods). The Enforcement Regulation of the same act prescribes matters entrusted by the NSA and the Enforcement Decree of the NSA and necessary procedures and documents for its implementation. Two regulations (Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. and Regulations on Technical Standards for Radiation Safety Control, Etc.) provide matters entrusted by the NSA and the Enforcement Decree of the NSA and detailed technical standards to follow for its implementation. The

NSSC Notice prescribes matters entrusted by the NSA, Enforcement Decree and Enforcement Regulation of the NSA, and the detailed technical standards necessary for its implementation. Table III.2-3 lists the NSSC Notices applicable to nuclear installations.

KINS has been developing detailed regulatory standards and guidelines, mainly applicable to new nuclear power plants based on the standards and requirements prescribed in the Act, Decrees, and Notices. KINS, a technical support organization for safety regulation, develops the guidelines on safety reviews and regulatory inspections for new NPPs for its regulatory activities. The industrial standards applicable to nuclear activities are endorsed by the regulatory body and applied to the design and operation of nuclear installations.

Physical Protection and Radiological Emergency Act

To strengthen physical protection system for nuclear material and nuclear facilities and radiological disaster management system, the Act on Physical Protection and Radiological Emergency was legislated in May 2003. Many articles concerning physical protection and radiological disaster prevention in the NSA were moved into this Act and some articles were also newly put into this Act to implement various countermeasures for physical protection and radiological emergency. The details thereof will be described in Section III.11 (Emergency Countermeasures).

Nuclear Liability Related Laws

With regard to the utility's civil liability for any nuclear accident, the Nuclear Liability Act and the Act on Indemnification Agreement for Nuclear Liability were established in 1969 and in 1975, respectively to prescribe general principles concerning the civil liability for nuclear damage. Each of the Act has its Enforcement Decree that stipulates particulars necessary for the implementation of the Act and detailed matters on the conditions of indemnity agreements for nuclear liability are prescribed in the NSSC Notice.

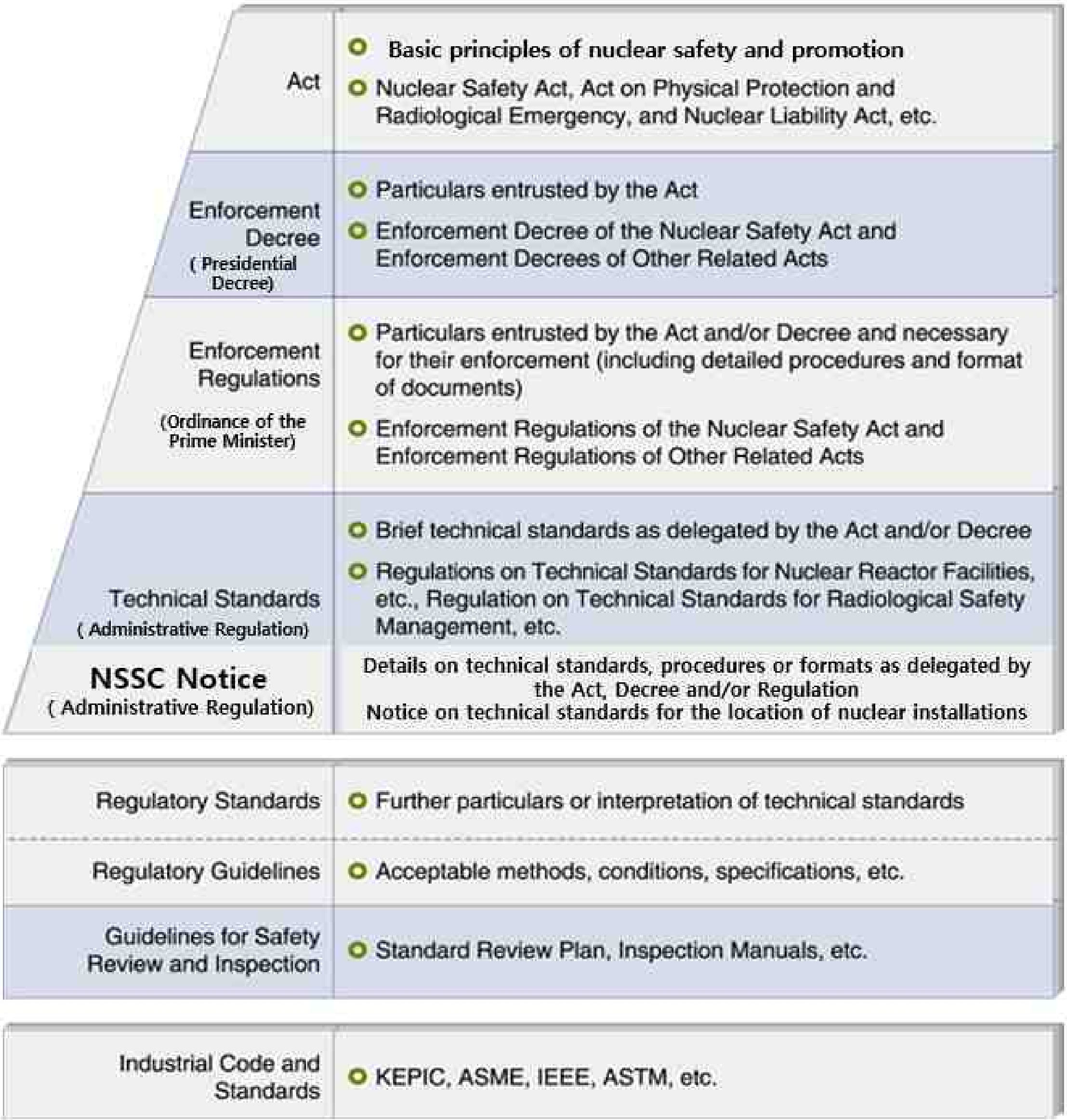


Figure III.2-1 Legal Framework for Nuclear Safety Regulation

Table III.2-1 Laws Concerning Nuclear Regulation

Title	Major Contents	Competent Authorities	Note
Nuclear Safety Act	The highest level of law on nuclear safety regulation	NSSC	-
Korea Institute of Nuclear Safety Act	Provides the establishment and operation of the Korea Institute of Nuclear Safety	NSSC	-
Act on Physical Protection and Radiological Emergency	Establishes effective physical protection system of nuclear materials and nuclear facilities and provides legal and institutional basis for preventing radiological disaster and preparing countermeasures against radiological emergency	NSSC	-
Nuclear Liability Act	Provides the procedures and extent of compensation for any damages which an individual has suffered from a nuclear accident	NSSC	-
Act on Indemnification Agreement for Nuclear Liability	Provides the particulars on a contract between the government and the operator to make up any compensation not covered by insurance	NSSC	-
Act on Establishment and Operation of the NSSC	Provides the particulars on establishment and operation of the NSSC	NSSC	-
Nuclear Promotion Act	Provides the particulars on research, development, production and utilization of atomic energy	Ministry of Science, ICT and Future Planning	Provides the particulars on promotion of atomic energy
Electricity Business Act	Provides the basic system of electricity business	Ministry of Trade, Industry and Energy	Entrusts safety regulations on installation, maintenance, repair, operation and security of nuclear reactor facilities to the NSA
Electric Source Development Promotion Act	Provides special cases relevant to the development of electric sources	Ministry of Trade, Industry and Energy	Provides special cases for the procedure of selecting nuclear installation sites
Framework Act on Environmental Policy	Mother law of the environmental preservation policy	Ministry of Environment	Entrusts the measures for preventing pollution by radioactive substance to the NSA
Act on Environmental Assessment	Provides the extent and procedures to assess environmental impacts according to the Framework Act on Environmental Policy	Ministry of Environment	Assesses environmental impact excluding radiation effects
Framework Act on Fire Services	Provides the general matters on the prevention, precaution and control of fire	National Emergency Management Agency	Provides the requirements for managing inflammables
Building Act	Provides the general matters on construction	Ministry of Land, Infrastructure and Transport	Entrusts the construction permit of reactor facilities to the NSA

Industrial Safety and Health Act	Provides the preservation and enhancement of workers' health and safety	Ministry of Employment and Labor	Entrusts the matters concerning radiation effects to the NSA
Industrial Accident Compensation Insurance Act	Provides insurance to compensate for workers with industrial disaster	Ministry of Employment and Labor	Compensation for the employees in the atomic energy industry is made in accordance with the compensation standard in the NSA
Basic Act on Civil Defense	Provides the general matters on the civil defense system	Ministry of Public Safety and Security	Nuclear disasters are covered in the provisions of the Basic Civil Defense Plan established by this Act
Basic Act on Management of Disasters and Safety	defines basic principles and system of national disaster management	Ministry of Public Safety and Security	As for radiological disasters, management framework prescribed in Act on Physical Protection and Radiological Emergency shall prevail others.

Table III.2-2 Contents of the Nuclear Safety Act

	Title	Major Contents
Chapter 1	General provisions	The purpose of this Act and definitions of the terminology used in this Act
Chapter 2	Establishment and enforcement of Comprehensive Plan for Nuclear Safety	Establishment and enforcement of Comprehensive Plan for Nuclear Safety, Establishment of KINS, Establishment of KINAC, Promotion of safety research and development program, etc.
Chapter 3	Construction and operation of nuclear power reactors and related facilities	Criteria for permit (license), licensing procedures, license application documents to be submitted, regulatory inspection, records and keeping, revocation of license, notification of suspension or disuse of operation, measure for suspension, decommissioning, penalty surcharge, etc.
Section 1	Construction of nuclear power reactors and related facilities	
Section 2	Operation of nuclear power reactors and related facilities	
Section 3	Construction and operation of nuclear research reactors, etc.	
Chapter 4	Nuclear fuel cycle enterprise and use, etc. of nuclear materials	Criteria for permit (license), licensing procedures, and regulatory inspection, etc.
Section 1	Nuclear fuel cycle enterprise	
Section 2	Use of nuclear materials	
Chapter 5	Radioisotopes and radiation generating devices	Criteria for permit (license), licensing procedures, and regulatory inspection
Chapter 6	Disposal and transport	Permit for construction and operation of disposal facilities, and regulatory inspections
Chapter 7	Personnel dosimetry service	Registration of personnel dosimetry service and regulatory inspection
Chapter 8	License and examination	License examination and certificate of license
Chapter 9	Regulation and supervision	Establishment of exclusion area and preventive measures against radiation hazards
Chapter 10	Supplementary provisions	Conditions for permit or designation, approval of report on specific technical subjects, hearing, protection for the individual in charge of safety management, education and training
Chapter 11	Penal provisions	Penal provisions, fine for negligence, and joint penal provisions
Addenda		Enforcement date, transitional measures, and relations with other laws

Table III.2-3 List of NSSC Notices Applicable to Nuclear Installations

No.	Notice No.	Title
1	2013-57	Regulation on Other Facilities related to Safety of Nuclear Reactor
2	2013-58	Regulation on Verification and Calibration of Instrumentation and Radiation Detector for Nuclear Reactor Facilities
3	2014-10	Technical Standards for Locations of Nuclear Reactor Facilities
4	2014-11	Standard Format and Content of Radiation Environmental Report for Nuclear Power Utilization Facilities
5	2014-12	Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities
6	2014-14	Material Surveillance Criteria for Reactor Pressure Vessel
7	2014-15	Regulation on Safety Classification and Applicable Codes and Standards for Nuclear Reactor Facilities
8	2014-16	Regulation on In-Service Inspection of Nuclear Reactor Facilities
9	2014-17	Regulation on Reporting and Public Announcement of Accidents and Incidents for Nuclear Power Utilization Facilities
10	2014-18	Pressure Test Criteria for Major Components of Nuclear Reactor Facilities
11	2014-20	Standards for Safety Valves and Relief Valves of Nuclear Reactor Facilities
12	2014-21	Standards for Performance of Emergency Core Cooling System of Pressurized Light Water Reactor
13	2014-22	Standards for Leakage Rate Tests of Reactor Containment
14	2014-23	Detailed Requirements for Quality Assurance of Nuclear Reactor Facilities
15	2014-24	Regulation on Pre-operational Inspection of Nuclear Reactor Facilities
16	2014-25	Technical Standards for Investigation and Meteorological Condition of Nuclear Reactor Facility Sites
17	2014-26	Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites
18	2014-29	Regulation on In-Service Test of Safety-related Pumps and Valves
19	2014-30	Regulation on Items and Method of Periodic Inspection for Nuclear Reactor Facilities
20	2014-31	Guidelines on Application of Technical Standards for Assessment of Continued Operation of Nuclear Reactor Facilities
21	2014-32	Objects of Consultations due to Installation of Industrial Facilities, etc. around the Nuclear Facilities
22	2014-33	Regulation on Preparation of Technical Ability Description concerning Installation and Operation of Nuclear Reactor Facilities
23	2014-34	Notice on Radiological Emergency Preparedness for Nuclear Licensee
24	2014-71	Regulations on Contents and Calculation Method of Career (including Education and Training) upon Enforcement of Nuclear-related License Examination)
25	2014-72	Notice on Education for Radiological Emergency Preparedness
26	2014-80	Regulation on Reporting of Noncompliance Items
27	2014-82	Notice on Radiological Emergency Preparedness for Nuclear Licensee
28	2015-01	Standard Format and Content of Technical Specifications for Operation
29	2015-07	Regulation on Disposition and Control of Inspection Findings of Nuclear Power Utilization Facilities
30	2015-07	Regulation on Inspection such as Safety Related Equipment Supplier of Nuclear Installation
31	2015-08	Standard Format and Content of Decommissioning Plan for Nuclear Power Utilization Facilities
32	2015-11	Technical Standards for Fire Hazard Analysis
33	2015-12	Regulation on Establishment and Implementation of Fire Protection Program
34	2015-13	Guidelines for Application of Korea Electric Power Industry Code (KEPIC) as Technical Standards of Nuclear Reactor Facilities

International Conventions on Nuclear Safety

The conclusion and ratification of international conventions (treaties) are completed by going through the procedure of: 1) domestic reviews; 2) signature; 3) consent of the National Assembly (where the consent of the National Assembly is necessary in accordance with the Article 60-1 of the Constitution of the Republic of Korea); 4) exchange of ratification instruments; and 5) domestic promulgation (publication in official gazette). International conventions completing aforementioned procedure have the same effect as the domestic laws of the Republic of Korea in accordance with the Article 6-1 of the Constitution, which prescribes "Treaties duly concluded and promulgated under the Constitution and the generally recognized rules of international law shall have the same effect as the domestic laws of the Republic of Korea."

As a contracting party to international conventions on nuclear safety, the Republic of Korea (ROK) has fulfilled its obligations faithfully. The conventions that the ROK joined are shown in Table III.2-4.

Table III.2-4 List of International Conventions on Nuclear Safety that the ROK Joined

Conventions	Joined Date	Effective Date
Convention on Nuclear Safety	September 20, 1994	October 1996
Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	September 16, 2002	December 2002
Convention on Early Notification of a Nuclear Accident	June 8, 1990	July 1990
Convention on Assistance in the. Case of a Nuclear Accident or Radiological Emergency	June 8, 1990	July 1990
Convention on the Physical Protection of Nuclear Material	April 7, 1982	February 1987
Treaty on the Non-Proliferation of Nuclear Weapons	July 1, 1968	April 1975

III.2.2 Current Revision State of Major Laws

The CFSI (Counterfeit, Fraudulent, Suspect Item) case taken place in 2013 raised concerns over nuclear safety. To promptly respond to this, the relevant law was revised in a way that the licensee is required to report or inform matters on safety related facilities and carry out the supplier inspection on the reported matters. Such change is to guarantee the stability of nuclear facilities and performance of the parts, thereby enhancing safety during the construction and operation of NPPs.

In addition, in June 2015, Kori Unit 1 was decided to permanently be shutdown and this is the first case of permanent shutdown of the NPP in the Republic of Korea. Relevant laws were revised to include the definition of 'decommissioning' and mandatory submission of decommissioning plan to the NSSC when applying for CP and OL of power reactor and research reactor, etc. Such legal action was to resolve public concern over the safety issue following decommissioning and also to enhance the level of nuclear safety.

- Definition of decommissioning: all actions or measures taken to exclude any facilities licensed or designated pursuant to this Act from the scope of application of this Act, through removal of the facility and the site or through decontamination thereof after permanent cessation of the operation of the facilities by the power reactor operator, etc.

In addition, the Fukushima Daiichi Accident was a striking example that showed severe accident with extremely low possibility can actually take place and raised awareness on the importance of severe accident management. Therefore, the current accident management for existing design basis accident stipulated in the NSA was revised to add the accident management against severe accident. By doing so, the severe accident management programme can thereby provide guidelines and measures to minimize the on- and off-site release of radioactive materials and to recover the NPP back to safe and stable state. Following revision in the subordinate statues are being underway.

Major revisions of the nuclear safety related laws during 2013 to 2015 are shown in <Table III.2-5>.

Table III.2-5 Major Revisions of Nuclear Safety Related Laws (2013-2015)

Name of the Law	Date of Revision	Major Substance of Revision
Act on Establishment and Operation of the NSSC	March 23, 2013	- Move the NSSC under the Prime Minister
Nuclear Safety Act	May 21, 2014	- Make it mandatory for the licensee to report or inform the reliability of safety related facilities and performance of the parts in nuclear installations - Designation of performance qualification management institute - Increase the ceiling of fines and penalties - Introduce 2 stage permit process and periodic safety review (PSR) on research・education reactor
Enforcement Decree of the Nuclear Safety Act	November 19, 2014	- Prescribe that the NSSC can carry out an inspection on suppliers regarding the reports of safety related facilities - Expand the evaluation factors of PSR
Enforcement Regulation of the Nuclear Safety Act	November 24, 2014	- reduce the scope of minor changes in construction permit of NPPs that can be substituted as report
Act on Physical Protection and Radiological Emergency	May 21, 2014	- Divide the Emergency Planning Zone into precautionary action zone and urgent protective action planning zone
Enforcement Decree of the Act on Indemnity Agreements for Nuclear Liability	December 9, 2014	- increase damages imposed to power reactor not exceeding 300 million Special Drawing Rights (about 500 billion Won)
Nuclear Safety Act	January 20, 2015	- Make it mandatory for the licensee to submit and periodically update the decommissioning plan - In case of decommissioning, the NSSC shall carry out a thorough inspection on the decommissioning procedure. - When deciding continued operation or decommissioning, collect the opinion of the residents regarding the draft of radiological environmental impact assessment report
Enforcement Decree of the Nuclear Safety Act	July 20, 2015	- Provide the case of exception to the PSR on the reactor and related facilities that are permanently shutdown
Enforcement Regulation of the Nuclear Safety Act	July 21, 2015	- Confirm and check on the decommissioning stage of reactor and related facilities and carry out an inspection on the completion of decommissioning
Nuclear Safety Act	June 22, 2015	- Include severe accident into the scope of accident management - Add accident management plan regarding operation as part of documents for OL - Impose and collect charges on nuclear safety management from the nuclear related licensee, ect. and specify the purpose of uses - Active information disclosure on the results of review and inspection on nuclear utilization facilities
Nuclear Safety Act	December 1, 2015	- Include discharge plan of radioactive materials (inclusive of total effluents by nuclide) as part of documents for OL
Act on Physical Protection and Radiological Emergency	December 1, 2015	- Add the definition of “electronic intrusion” - Provide policies and rules for both the Government and nuclear licensee to enhance the security of computer and information system in nuclear installations
Act on Protective Action Guidelines Against Radiation in the Natural Environment	December 1, 2015	- Prescribe that when materials or suspected to exceed radioactive concentration, a recycled a scrap metal handler shall report the matter to the NSSC - Prescribe that the NSSC shall investigate the reported matter

III.2.3 Licensing System and Safety Assessment

The licensing procedures for nuclear installations consist of two steps: the Construction Permit (CP) and the Operating License (OL), pursuant to the NSA. When necessary, licensee may apply for Standard Design Approval and the Early Site Approval (Figure III.2-2).

Standard Design Approval (SDA)

As the design of NPPs with enhanced level of safety could be standardized depending on its demand, a new licensing system, i.e. the Standard Design Approval (SDA) System was issued to improve the regulatory effectiveness. The SDA system ensures the validation of approved standard design without imposing additional regulatory requirements during a certain period of time by the law and basically excludes safety reviews for the portions of NPPs which refer to previously approved standard design.

Early Site Approval

In order to start a limited construction work on a proposed site before the CP is issued, an applicant may apply for an Early Site Approval. The applicant shall submit an application accompanied by a site survey report and a radiological environmental impact assessment report to the NSSC. Based on the results of the safety review by KINS for Early Site Approval, the NSSC will grant an approval. The safety review is to evaluate the adequacy of the proposed nuclear site and the radiological impacts on the environment surrounding the nuclear installation.

Construction Permit (CP)

The applicant for a CP for nuclear installation shall submit an application accompanied by a radiological environmental report, a Preliminary Safety Analysis Report (PSAR), and a construction quality assurance plan and a decommission plan to the NSSC. The NSSC issues a CP after deliberation of the application documents based on the results of the safety review on the application submitted by KINS.

The safety review on the application for a CP is conducted to confirm that the site and the preliminary design of the nuclear installation are in conformity with the relevant regulatory requirements and technical guidelines. It includes safety reviews on the principles and concepts of reactor facility design, the implementation of regulatory criteria in due course, the evaluation of environmental effects resulting from the construction, and a proposal for minimizing those effects.

The radiological environmental impact assessment report submitted for early site approval and CP need to include the opinions of local residents (hold a public hearing if needed). In accordance with the law, in the course of CP application of Shin-Hanul Units 3 & 4 the opinions of local residents on the radiological environmental report were reflected. The CP applicant for nuclear installations wrote up a draft environmental report and submitted it to the NSSC and relevant local authorities for receiving feedback from relevant agencies. Relevant local authorities notified in major daily magazines that the report was now open to public. The same procedure was applied to hold a public hearing on the report the for local residents. The CP applicant reviewed the opinions gathered from the relevant agencies and also from the residents and reflected them upon the final radiological environmental report.

Operating License (OL)

The applicant for an OL for a nuclear installation shall submit to the NSSC an application accompanied by technical specifications for operation, a Final Safety Analysis Report (FSAR), an accident management plan, a quality assurance plan for operation, a radiological environmental report, a decommissioning plan, and a plan to release radiological materials in liquid and gas. The NSSC will issue an OL primarily based on the results of the safety review on the application as well as the results of pre-operational inspections by KINS.

The safety review on the application for an OL is conducted to confirm that the final design of the nuclear installation is in conformity with the relevant regulatory requirements and technical guidelines and that the nuclear installation may continue to operate throughout its lifetime.

For an amendment to the OL such as a change in the technical specifications or in the design that affects or may affect the safety of operating nuclear installations, it is necessary to obtain approval from the NSSC. The approval for an amendment to the OL follows the same procedures as the application for an OL. A safety review is, however, to be conducted to the scope whose safety is affected or may be affected by the amendment to the OL.

Continued Operation

The operators of nuclear installations are required to perform a periodic safety review in every 10 years from the date of operating license issuance and submit the review results to the NSSC. In case, an operator wants to operate a nuclear installation beyond the design life (continued operation), two additional items such as lifetime evaluation for major components and radiological environmental impact assessment are to be incorporated into the periodic safety review. (Refer to III.9.2 for the periodic safety review.) The NSSC deliberates on application documents submitted by the operator and the results of the safety review performed by KINS to approve the continued operation of nuclear installations.

Approval for Decommissioning

In case, an operator intends to decommission a nuclear installation, the operator shall apply for decommissioning and receive an approval from the NSSC. The review on the application of decommissioning includes decommissioning capability of the licensee, adequacy of decommissioning plan, and whether the exposure radiation dose exceeds radiation dose.

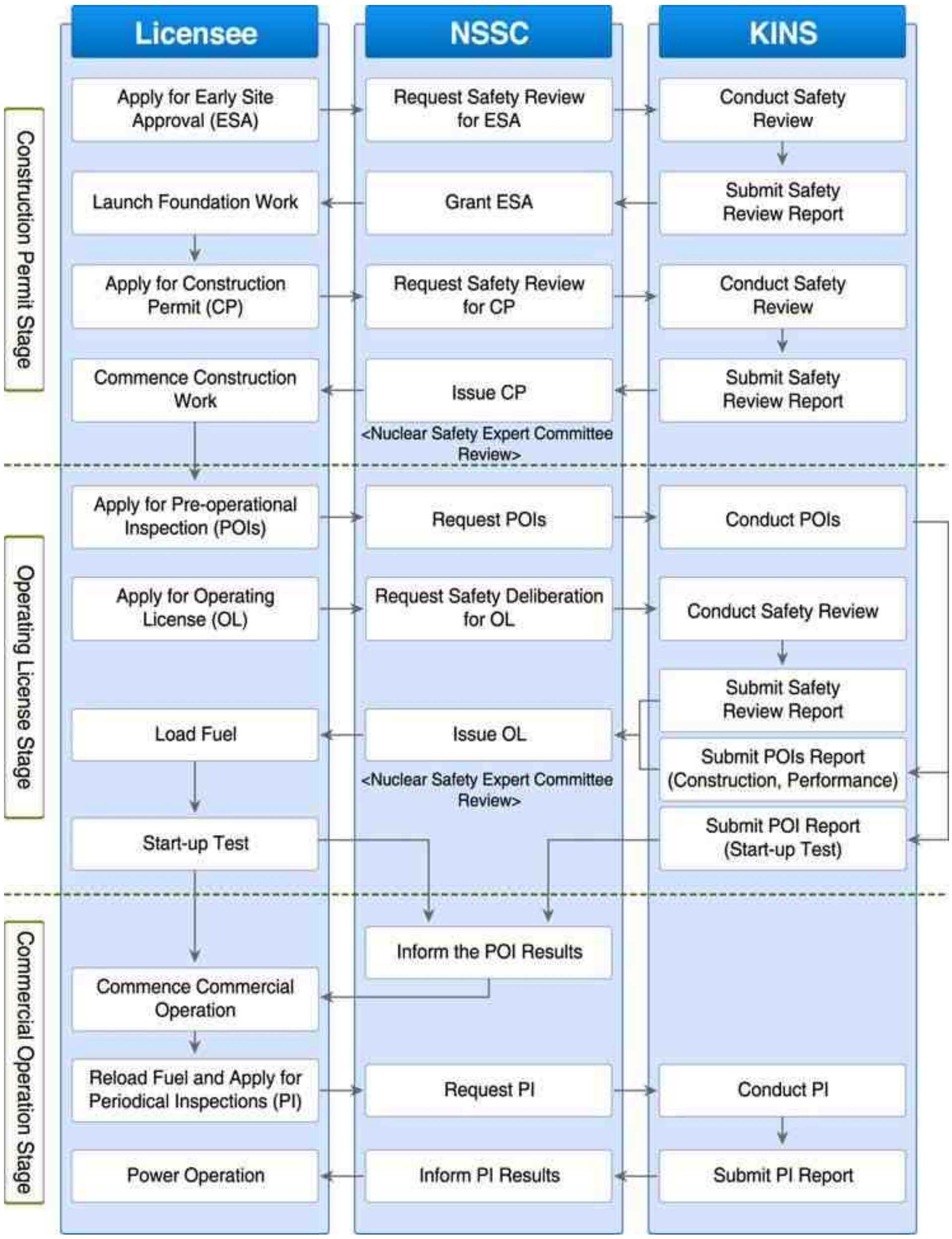


Figure III.2-2 Licensing Process for Nuclear Installations

III.2.4 Regulatory Inspection

Articles 16 (Inspection) and 22 (Inspection) of the NSA stipulates that the authorized parties receive inspection of the regulatory body of NSSC periodically, with respect to construction and operation of a nuclear power reactor and related facilities. And Article 98 (Report and Inspection) of the NSA prescribes that: 1) the regulatory body may order the authorized parties to report their business or submit documents on their business, or to complement the submitted documents; and 2) so as to perform various inspections the inspector may enter the nuclear power facilities, check the records, documents, facilities, or other necessary things, ask any questions to the relevant persons, or collect sampling for a test. These regulatory inspections of the regulatory body are carried out independently from the self-inspections of the authorized parties, and the regulatory inspections are implemented according to the relevant rules and regulations related to nuclear facilities. Where non-compliance with relevant requirements is discovered as results of the regulatory inspection, the regulatory body may order corrective or complementary measures.

Regulatory inspections for nuclear installation under construction or in operation include the pre-operational inspection regarding the nuclear installations, quality assurance inspection, inspection on suppliers, periodic inspection regarding in-service nuclear installation, inspection on the completion of decommissioning, the daily inspection by resident inspector, and the special inspection, pursuant to the NSA. The general procedure for each inspection is schematically described in Figure II.2-8.

Pre-operational Inspection

The pre-operational inspection for nuclear installations under construction is conducted to verify whether the nuclear installation is properly constructed in conformity with the conditions of the CP and whether the constructed nuclear installation may be operated safely throughout its lifetime. It is conducted by means of a document inspection and a field inspection.

Quality Assurance Inspection

The quality assurance inspection is conducted to verify whether all activities that may affect quality at each stage of the design, construction, and operation of a nuclear installation are being performed in conformity with the quality assurance program approved by the regulatory body. It is conducted periodically for nuclear installations in operation and construction.

Inspection on suppliers

Inspection on suppliers is conducted against suppliers (engineers and manufacturers) and performance qualification agencies to confirm the acceptance criteria in accordance with the relevant laws, reports of the contract on safety related equipment, and reports on non-compliances. The NSSC carries out the planned inspection (inspection conducted against selected inspection target entities in accordance with the established annual inspection plan) or the reactive inspection separated from the annual inspection plan to confirm the safety of nuclear installations upon necessity.

Periodic Inspection

The periodic inspection for operational nuclear installation is conducted to verify whether the nuclear installation is being properly operated in conformity with the conditions of the OL; to verify whether the installation can still withstand pressure, radiation, and other operating environments; and whether the performance of the installation maintains license based conditions. It is performed in the forms of a document inspection, field inspection, and interview during the period of refueling outage for PWRs and during periodic maintenance for PHWRs.

The periodic inspection is accompanied with a document inspection and interviews, thereby raising the witness rate and enhancing the effectiveness of the inspection. As a part of such effort, the witness plan is established prior to the inspection and the witness points are notified to the reactor operator in advance. The implementation of the witness plan is also reviewed after the end of the inspection.

Meanwhile, back in November 2012, it was confirmed that the commercial grade dedication reports on parts for nuclear reactors, mainly used for replacement or repair during the periodic inspection were found to be falsified. When it is unable to confirm the falsification of the reports on parts which had already been used, the operator of the nuclear reactor was required to carry out operability evaluation or functional evaluation and to review the results to ensure safety.

Inspection on the Completion of Decommission

Inspection on the completion of decommission is carried out by the NSSC against the nuclear installation after the licensee completes the decommissioning process. The inspection verifies whether: 1) the decommissioning process faithfully follows the decommissioning plan; 2) the state of decommissioning is in conformity with the decommissioning report submitted by the licensee after completing the process; and 3) the content of Final Site Status Report is in conformity with the acceptance criteria for reutilization of the site and its remainder.

Daily Inspection by Resident Inspectors

The main purpose of the daily inspection is to check the nuclear installations under construction or in operation on a daily basis. It includes a witness inspection on periodic inspection, an investigation on the measures taken when the reactor reaches an abnormal state, and check-up on the licensee over the implementation of radiation safety management.

Special Inspection

The special inspection includes an examination of important safety issues, or reportable events such as reactor trips, and a plant walk-down for the prevention of any potential event.

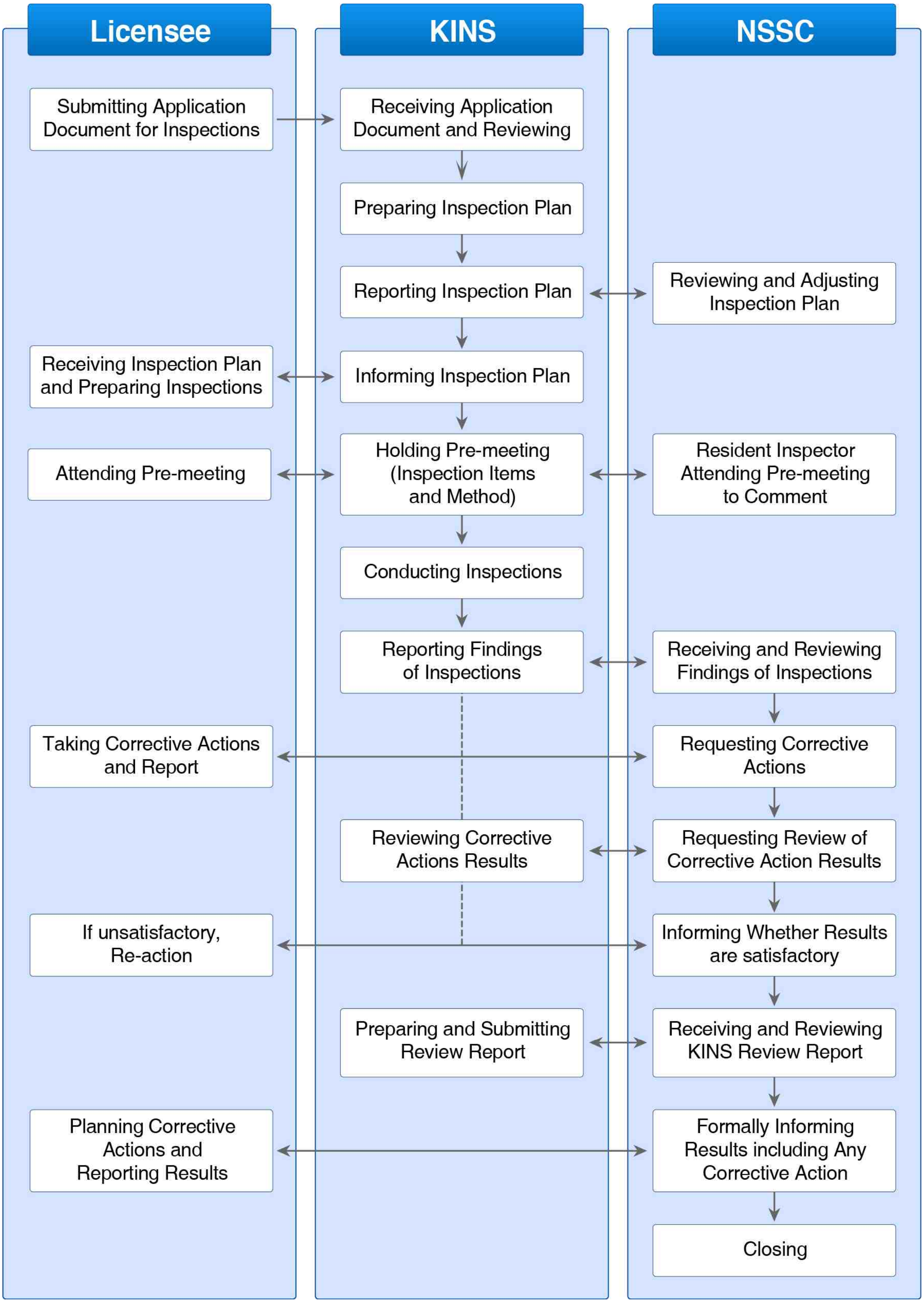


Figure III.2-3 Periodic Inspection Process for Nuclear Installations

III.2.5 Enforcement

When the safety review results of the CP application meet the relevant requirements, the NSSC will issue a CP. The NSSC may impose minimum conditions therein, when judged necessary to ensure safety. If the result of the regulatory inspection complies with technical standards, the NSSC may notify accordingly. If any violation is found as a result of the regulatory inspection, the NSSC may order the license holder to take corrective or complementary measures in accordance with the NSA.

If it is deemed necessary for the enforcement of the regulations, the NSSC is to order the operators to submit the necessary documents on their business and to complement any submitted documents. The NSSC may also conduct a regulatory inspection to verify that the documents are in conformity with field conditions and order the operator to take corrective or complementary measures, when necessary, as a result of the inspection.

The NSSC may order the revocation of the permit (or license) or the suspension of business within a period of no more than one year, in cases where the installer or operator of a nuclear installation falls under one of the followings. For specific cases, surcharge may be imposed instead of suspension of the business pursuant to Article 17 of the NSA.

- where the installer or operator has modified any matters subject to the permit (or license) without approval;
- where the installer or operator has failed to meet the criteria for permit (or license);
- where the installer or operator has violated an order of the NSSC to take corrective or complementary measures as a result of the regulatory inspections for the construction or operation of a nuclear installation and the matters related to measurement control of special nuclear materials; and
- where the installer or operator has violated any of the permit (or license) conditions or regulations on safety measures in the operation of a nuclear installation.

If a licensee whose license was revoked or whose business has been discontinued does not take the necessary actions concerning radioactive materials and radiation generating devices, etc., the NSSC can take necessary actions; furthermore, the licensee will be responsible for the payment of cost of such actions.

In addition, if the operator of NPPs violates obligations prescribed in the NSA, the penal clauses (criminal punishment and fine) may be applied depending on the extent of the violation. Especially those who run nuclear business without the permit (registration or designation included) required by the relevant laws are subject to criminal punishment.

A prime example of regulatory enforcement is the arbitrary change in welding material during the maintenance process of steam generator water box of Hanbit Unit 2. The case was reported to the NSSC back in September 2013, after which the NSSC organized a special investigation committee to further investigate the case and carry out the technical review. The committee temporarily shutdown the unit for investigation and underwent a surface material inspection, non-destructive test, and safety analysis to confirm that the repaired weld zone of the steam generator has no signs of defect and was in sound structure.

Still, it was found as a result of investigation that the welding material was arbitrarily applied without being approved for maintenance activity and therefore due to the violation of the Article 26 of the NSA, fines were imposed as a way of administrative restriction. In addition, based on the investigation result of the committee, the licensee was required to implement preventive measures including improved management system for the in and out of materials during the maintenance activity, video recording of major maintenance procedures, and saving the recorded video clips.

III.3. Article 8. Regulatory Body

> 1. *Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
>
> 2. *Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.*

III.3.1 Regulatory Framework for Nuclear Safety

Prior to the establishment of the NSSC in October 2011, the Ministry of Education, Science and Technology (MEST) was responsible for comprehensive regulation on overall nuclear safety while the Ministry of Knowledge and Economy (MKE) was focusing on promoting nuclear energy.

After the Fukushima Daiichi Accident, however, a discussion started in earnest to establish an independent commission to take care of nuclear safety. As a result, on October 26, 2011, Nuclear Safety and Security Commission (NSSC) was founded as an independent presidential commission and a regulatory body for nuclear safety responsible for nuclear safety, security, and non-proliferation.

When the new administration was inaugurated in the Republic of Korea in February 2013, there was a sweeping change in the government organizational structure. As a part of such change, the NSSC was placed under the Prime Minister's Office from President. Since then, as illustrated in Figure III.3-1, the NSSC has been responsible for nuclear safety regulation including license and permit of nuclear installations and nuclear industry while the Ministry of Industry, Trade and Resources being responsible for the promotion of nuclear industry and the Ministry of Science, ICT and Future Planning for nuclear research and development.

Under the regulatory framework of nuclear safety of the Republic of Korea, in accordance with the Act on Establishment and Operation of the Nuclear Safety and Security Commission, the NSSC takes the responsibility and function on regulatory and administrative activities for nuclear safety, which include the utilization of reactors and related facilities, fuel cycle facilities, radioactive waste management facilities, nuclear materials, and radioisotopes & radiation generating devices. The NSA stipulates that the NSSC has the full authority and responsibility when it comes to the safety regulation on the nuclear installation including the issuance of license and permit of nuclear facilities.

In addition, for effective nuclear safety regulation on technical areas, the government added two provisions in the NSA; Article 5 (Nuclear Safety-Specialized Institution) and Article 6 (Establishment of the Korea Institute of Nuclear Nonproliferation and Control). It also enacted a special act entitled as "Korea Institute of Nuclear Safety Act." These legislative actions became a firm legal basis to establish the Korea Institute of Nuclear Safety (KINS) responsible for nuclear safety regulations including review and inspection as well as the Korea Institute of Nuclear Non-Proliferation and Control (KINAC) for the nuclear security and safeguards.

There is Korea Foundation of Nuclear Safety, specialized in supporting pre-cautionary control for nuclear and radiation safety. In addition, the NSSC operates advisory committees, Nuclear Safety and Security Special Committee and Working-level Review Committee, to paly an advisory role for technical matters and expertise. For the purpose of an effective regulatory function, KINS invites opinions and advice from various external experts through Nuclear Safety Council and Technical Standards Committee.

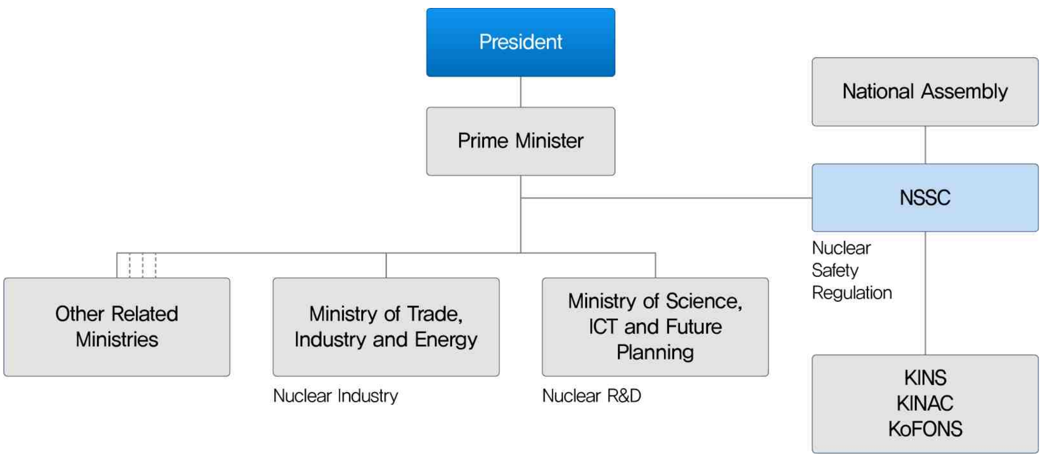


Figure III.3-1 Government Organizations on Nuclear Energy

III.3.2 Structure of Regulatory Organizations

Nuclear Safety and Security Commission (NSSC) and Its Secretariat

The Act on the Establishment and Operation of the Nuclear Safety and Security Commission defines the objectives and duties of the NSSC, the nuclear regulatory body, as follows: the objectives of its establishment are to protect individuals from radiation disasters stemming from the generation and use of nuclear power and to contribute to both the public safety and environmental conservation. The operation principle of the NSSC is to maintain its independence and impartiality, prepare necessary measures for safety management in the research, development, generation, and use of nuclear power and endeavor to enforce such measures. The NSSC is responsible for the deliberation and decision making regarding the matters as follows:

- synthesizing and coordination of matters regarding safety management of nuclear power;
- establishment of the Comprehensive Plan for Nuclear Safety pursuant to Article 3 of the Nuclear Safety Act;
- regulation of nuclear materials and reactors;
- protection against hazards due to radiation exposure;
- granting of permission, renewal of permission, authorization, approval, registration, revocation, etc. related to users of nuclear power;
- measures against prohibited activities of users of nuclear power and the imposition of penalty surcharges;
- estimation and allocation plans for expenses stemming from safety management of nuclear power;
- surveys, tests, research, and development in regard to safety management of nuclear power;
- the education and training of researchers and engineers for safety management of nuclear power;
- safety management of radioactive waste;
- countermeasures against radiation disasters;
- international cooperation in safety of nuclear power;
- the formulation and execution of the budget of the Commission;
- the enactment, amendment, and repeal of relevant Acts, subordinate statutes, and Commission Decree; and
- matters specified by this Act or other Act as matters subject to deliberation and resolution by the Commission.

The NSSC is composed in accordance with the Act on the Establishment and Operation of NSSC and Presidential Decree of Organization of the Nuclear Safety and Security Commission and its Affiliated Bodies. As of April 2016, the NSSC has nine members including the Chairman. The Chairman and one member are standing members.

The members of the NSSC are appointed among those who have in-depth insight and experience in nuclear safety. NSSC is composed of members from various fields that can contribute to nuclear safety such as nuclear energy, the environment, public health, science and technology, public security, law, and social & human sciences. The Chairman is appointed by the President among the nominees referred by the Prime Minister. Four members including the standing member are appointed by the President with the referral of the Chairman of the Commission, while the rest four members are appointed by the President with the referral of the National Assembly. The law prescribes that those who are working or worked as the head or employee of the nuclear operator or the nuclear operator groups within the recent three years; or who are being involved or were involved in the projects performed by the nuclear operator or the nuclear operator groups within recent three years including research and development projects entrusted by the nuclear operator or the nuclear operator groups shall not be appointed as a member of the Commission. The term of office of the commission members shall be three years, and they may be reappointed once.

The NSSC has the Secretariat to deal with the general affairs, with the standing member of the Commission working as the Secretary General. The Secretariat consists of one office, two bureaus and 13 divisions with 140 staff in total and there are four site offices (Kori, Wolsong, Hanbit, and Hanul) as shown in Figure III.3-2.

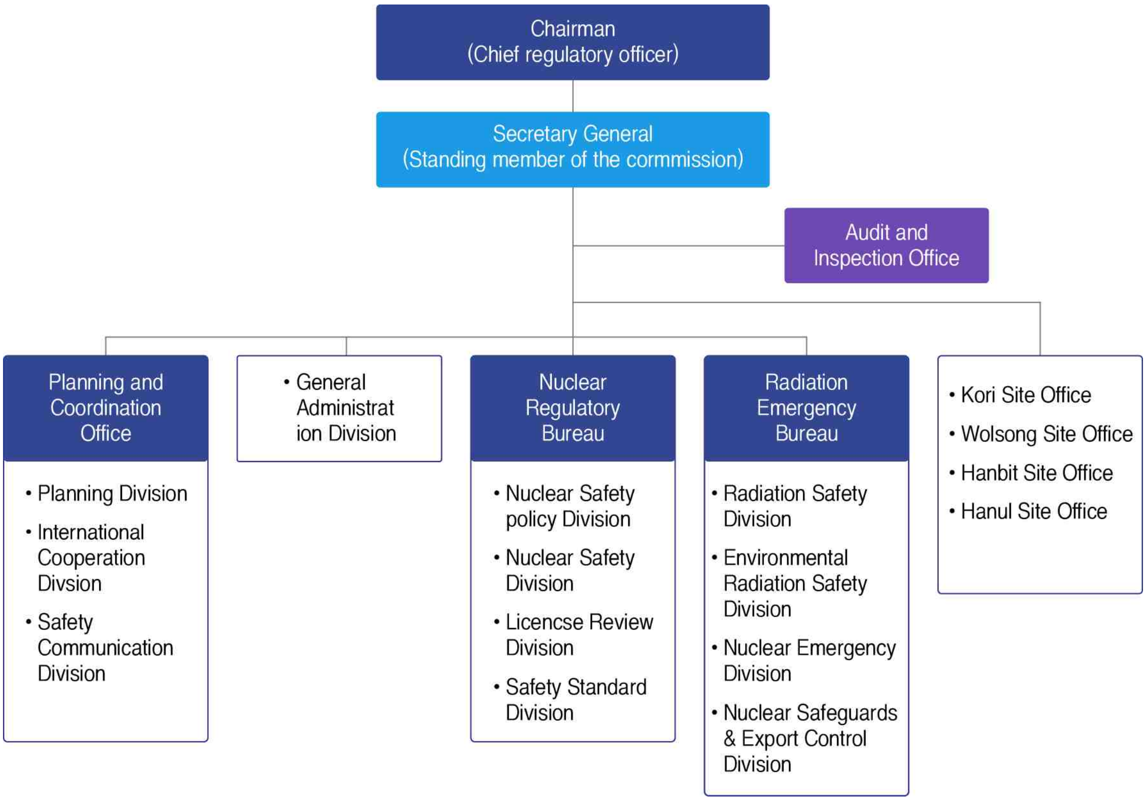


Figure III.3-2 Organization Chart for NSSC Secretariat

Korea Institute of Nuclear Safety

KINS was established as an independent technical support organization in February 1990 under the legal basis of the Korea Institute of Nuclear Safety Act. It has conducted the technical regulatory activities for nuclear safety pursuant to the first paragraph of the NSA, Article 111 (Delegation of Authority) and the Act on Physical Protection and Radiological Emergency, Article 45 (Entrustment of Duties).

- Nuclear Reactors
  Safety assessment for licensing and approval of nuclear reactor facilities
  Inspection of safety regulations for the manufacturing, construction and operation of nuclear reactor facilities
  R&D on technical criteria regarding safety regulations for nuclear reactor facilities
  Management of license examination for operating nuclear reactor facilities and handling nuclear materials or radioisotopes
  Processing of licensing reports
  Quality assurance review and inspection

- Fuel Cycle Facilities
  Safety assessment for licensing for fuel cycle facility business
  Pre-operational inspection of fuel cycle facilities
  Regular inspections of the functions of fuel cycle facilities
  Quality assurance inspection on the equipment, parts and devices of fuel cycle facilities

- Radiation Sources and Transportation
  Safety assessment for licensing of radiation sources
  Inspection of the sale, use, storage, transportation, and disposal of radiation sources
  Safety assessment for design certificate of radiation devices and packages
  Inspection for manufacturing of radiation devices and packages

- Radioactive Waste Management Facilities
  Safety assessment for the design, construction and operation of radioactive waste management facilities
  Pre-operational inspection of the structure, equipment and function of radioactive waste management facilities during construction
  Periodic inspection of radioactive waste management facilities
  Disposal inspection of radioactive waste

- Radiation around Living Environment
  Installation and operation of radiation detection instrument at airport and port
  Registration to handle materials that contain natural radioactive nuclides, report on export and import, and submission and inspection of current circulation status
  Establishment and operation of national information network for radiation around living environment
  Fact-finding survey and analysis on safety management of radiation around living environment

As of June 2016, KINS is composed of the Executive Vice President, one bureau, nine divisions (including one school) and 41 departments/teams/centers as in <Figure III.3-3>. By grouping or separating departments based on relevancy and independence in function, KINS has efficiently operated its regulatory structure, focusing on nuclear safety regulation.

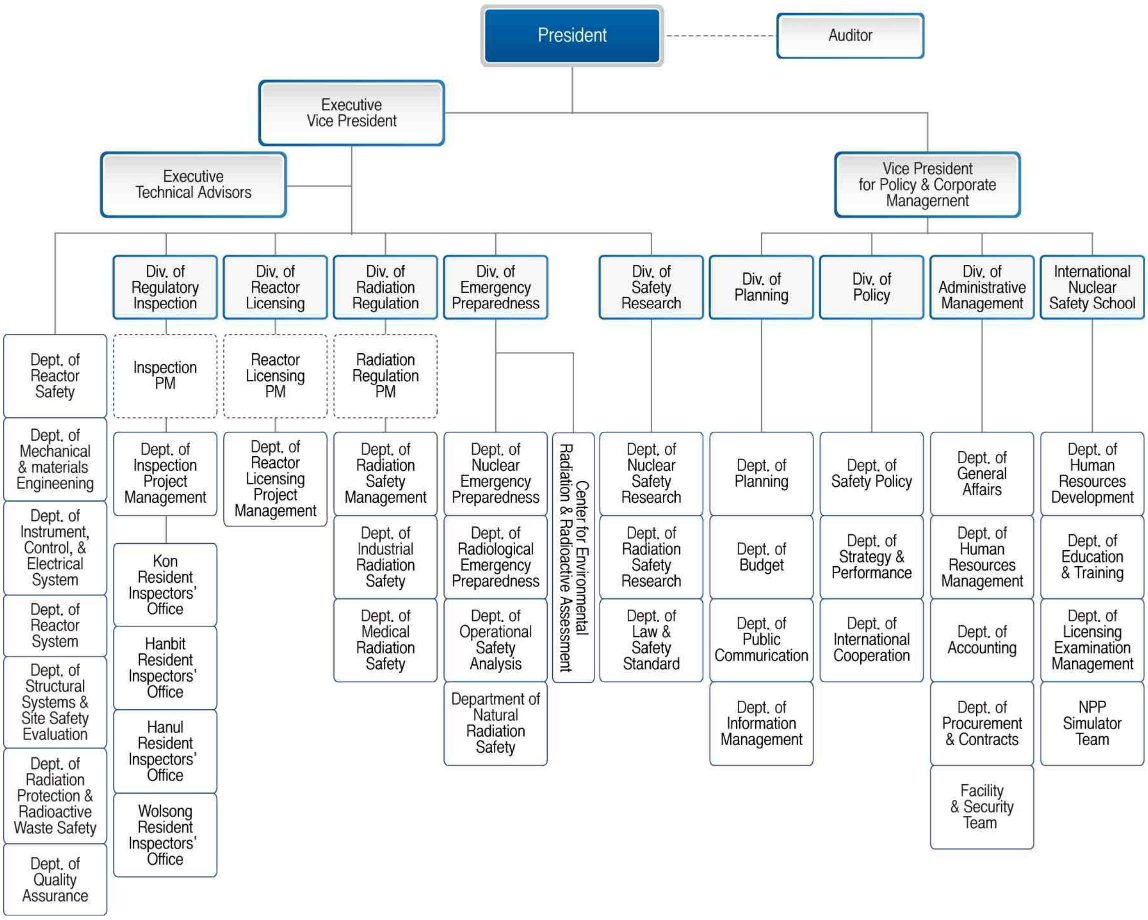


Figure III.3-3 Organization Chart for KINS

Korea Institute of Nuclear Non-Proliferation and Control (KINAC)

KINAC performs the tasks of safeguards, imports and exports control, physical protection, and research & development of nuclear facilities and materials pursuant to the NSA Article 6 (Establishment of the Korea Institute of Nuclear Nonproliferation and Control) and Article 7. KINAC is composed of one office, two centers, one department, and eight divisions as illustrated in <Figure III.3-4> and has major duties as follows:

- Supporting of establishment and implementation of a system for execution of the IAEA Statement on Full-Scope Safeguards and the Additional Protocol
- Screening and examination of the State System of Accounting for and Control of Nuclear Material
- Imports and exports control of internationally regulated materials such as nuclear

materials and relevant technology
- Support of the establishment of physical protection against nuclear materials and nuclear facilities and cyber security systems
- Screening and examination of physical protection against nuclear materials and nuclear facilities and cyber security systems
- Cooperating with international nonproliferation system and the IAEA
- Education and training, research and technical development related to nuclear control
- Collection, analysis and evaluation of information related to neighboring states' nuclear activities and support for urgent measures in case of emergency
- Research and development of nonproliferation and nuclear security policy

Performing these tasks, KINAC has contributed to: 1) the use of nuclear power for nothing but the peaceful purposes; 2) the compliance with the international standards for nonproliferation; 3) enhanced international cooperation on transparency of nuclear power; and 4) the expansion on peaceful use of nuclear power for the purpose of strong confidence in the international community.

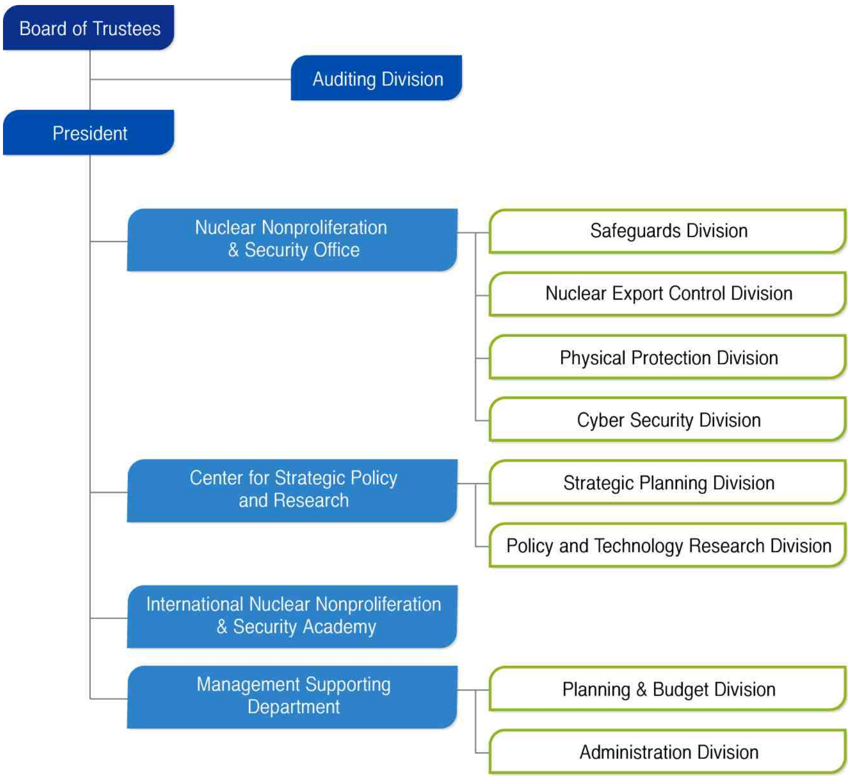


Figure III.3-4 Organization Chart for KINAC

Korea Foundation of Nuclear Safety

Korea Foundation of Nuclear Safety (formerly Korea Radiation Safety Foundation) was established in November 2012 to support administrative and policy work of the NSSC including planning and supervising nuclear safety R&D, management on performance qualification agencies for reactor components, radiation worker management (radiation exposure and safety training), and operation of nuclear safety regulation funds.

Established under the clear legal basis prescribed in the NSA, Korea Foundation of Nuclear Safety, as of April 2016, has 42 staff and organizational structure shown as <Figure. III.3-5>. In accordance with the NSA, Article 7-2 (Establishment of Korea Foundation of Nuclear Safety), it carries out main duties as follows:

- Basic data investigation and research to support the nuclear safety related policy making process of the NSSC
- Fact-finding investigation on nuclear safety to help efficient promotion of nuclear safety policy
- Planning, management, and evaluation of R&D projects on nuclear safety
- Education and training for radiation workers
- Management on radiation workers (radiation exposure dose and medical records)
- Reports on imports and exports of the radioisotopes
- International cooperation to promote nuclear safety and non-proliferation

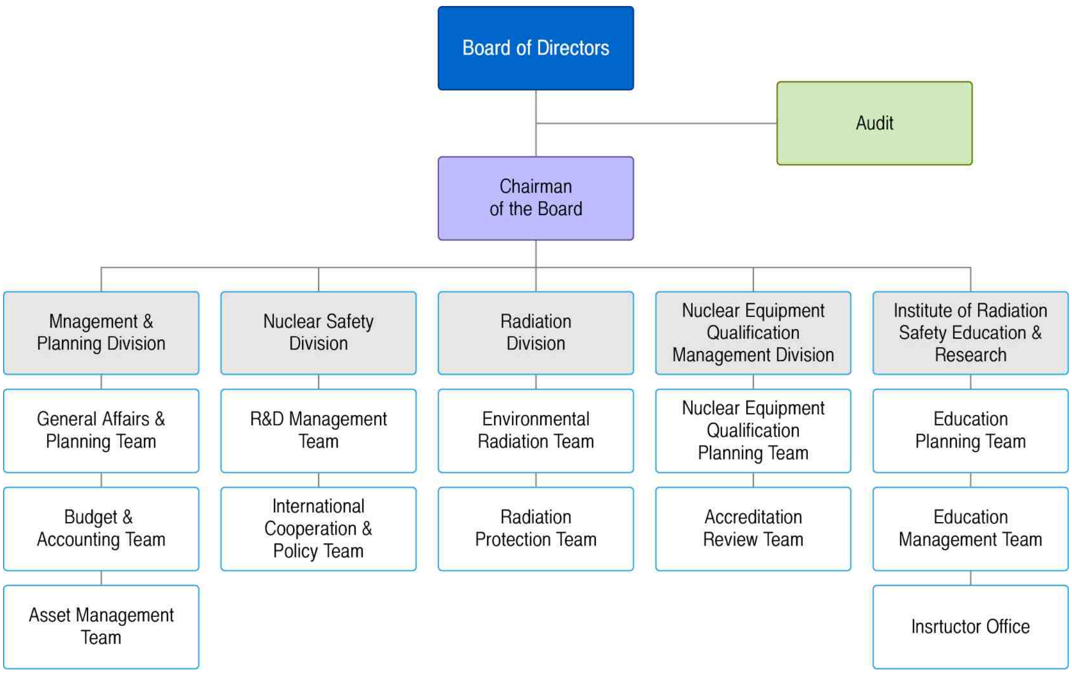


Figure III.3-5 Organization Chart for Korea Foundation of Nuclear Safety

Advisory Committee and Support Organization

The NSSC operates a special committee as prescribed in the Act on Establishment and operation of NSSC and the Enforcement Decree of the same Act and the Regulations on the Operation of NSSC Meetings in order to seek working-level advice on administrative affairs and a preliminary review on matters subject to deliberation and resolution. The special committee shall be composed of experts in various fields related to nuclear safety, such as reactor, safety analysis, instrumentation and control (I&C), radiation protection, radiation disaster prevention, control, etc.
In any of the following cases, the NSSC may organize a separate special committee to investigate relevant issues:

- where a critical accident occurs in the safety system of a facility related to nuclear power;
- where environmental pollution from a radiation accident occurs;
- where a grave accident with radiation exposure occurs; and
- where an overseas radiation related accident corresponding to cases.

Nuclear Safety and Security Special Committee

The Nuclear Safety and Security Special Committee was newly organized back in May 2013 based on the changes in the composition of the members of the NSSC, following the reshuffling of the government structure in 2013. The Special Committee consists of 15 experts from various fields and has five specialized departments (Reactor System, Radiation Protection, Site and Structure, Policy and system, and radiation disaster prevention & Environment) to ensure efficient deliberation on technical matters. In case of a nuclear or radiation accident, the Committee may form and run a Special Investigation Committee. The Special Committee also provides advice for: 1) major decisions on licensing or permit such as construction permit, operating license, change permit, permit for continued operation of nuclear facilities, and reviews on the periodic safety review (PSR) results; 2) solutions to major safety issues arising from licensing reviews for nuclear facilities and regular or special inspections; and 3) the establishment of coping measures to an accident that has already caused or is likely to cause radiation risks, etc.

Working-level Review Committee

To perform an in-depth review on the tasks in charge, members of the Nuclear Safety and Security Special Committee can temporarily establish and operate a Working-level Review Committee composed of less than 10 members.

KINS invites opinions and advice from various external experts with the goal of improving efficiency and effectiveness of its regulatory activities pursuant to the KINS Rule 08-18, “Rules for Expert Utilization.” The typical KINS mechanism for utilizing the opinions or advice of external experts is to have external experts with wide experience and high level of expertise as members of the following advisory committees: the Nuclear Safety Council and the Technical Standards Committee.

Nuclear Safety Council

Nuclear Safety Council is composed of maximum 20 external and internal experts from relevant areas. The primary responsibility of the Council is deliberation and resolution on matters regarding: 1) safety test review and inspection, regulation process, and major current issues when comprehensive deliberation deemed necessary; 2) establishment and adjustment of safety regulation related policy and plan; 3) mid- and long-term policy of study on nuclear safety regulation; 4) comprehensive plan for domestic and international safety regulation education and training; and 5) qualification evaluation and management of regulation inspector. The committee also operates its subcommittees in professional areas for investigating and reviewing the concerned matters of the Nuclear Safety Council.

Technical Standards Committee

The committee consists of internal and external experts and deliberates and decides: 1) matters regarding technical standards of nuclear facilities and radiation utilization or radioactive wastes-related facilities; 2) major technical matters regarding standards and guide for performing regulatory activities on nuclear facilities and radiation utilization or radioactive wastes-related facilities; 3) important matters for establishment and implementation of the technical standards and the regulatory criteria; and 4) important matters relevant to the operation of the specialized subcommittees and their meeting results. The committee also operates its subcommittees by specialized areas in order to investigate and review the concerned matters of the Technical Standards Committee.

In addition, KINS obtains informal short-term consultation services from external experts to use as references or guides for research and development projects or the deliberation on pending regulatory issues. When a long-term consultation is deemed necessary, it invites qualified experts as researchers or asks for their advice in the form of entrusted tasks. In case of nuclear or radiation accidents, KINS sets up and operates special temporary consulting organizations for investigating causes of the accident and for establishing regulatory response measures.

III.3.3 Regulatory Resource

Regulatory Workforce

The NSSC has continuously expanded the organizational structure of Secretariat and its human resources since its establishment in order to strengthen its nuclear safety function and to enhance the coordination and management of nuclear safety policies. In July 2012, the NSSC carried out its first organization expansion to beef up its human resources especially for enhanced safety at the site of nuclear power plants (NPPs). In September 2013, the NSSC has made effort to carry out a stricter on-site regulation for nuclear safety by placing site offices, first at Kori Nuclear Power Plant followed by Hanbit, Hanul, and Wolsong NPPs. By increasing the number of resident officers, it was able to strengthen on-site management and supervision of NPPs. The human resource for safety function has also increased such as for the quality assurance of NPP components and safety management for radiation around living environment.

KINS established and implemented a mid- and long-term human resource supply and demand plan. The plan is to secure the sufficient number of regulatory personnel every year corresponding to ever increasing regulatory demands and modified and complemented the plan every three years. In December 2012, KINS formulated a mid- and long-term human resource management plan for 2013 to 2022, which was implemented after the deliberation of the board of directors. According to the plan, KINS is set to increase the number of its staff to 612 by 2022.

As of April 2016, KINS has 501 employees. Technical workforce is allocated for the safety regulation on reactor and related facilities and radiation and radioactive waste (RI and disaster prevention tasks included). The size of workforce allocated is graded based on the nature and scale of regulation target facilities and the necessary regulatory activities. KINS enhances efficiency of job performance by a matrix organization operation system, standardization of tasks and utilization of IT infrastructures, and hiring competent staff as temporary commissioned experts after retirement, thereby successfully coping with its lack of manpower issue.

KINS operates an open hiring system to recruit not only experienced competent experts from various fields such as academia and research institutes but also those with doctorates, masters and/or bachelor degrees in areas necessary for regulatory activities. It is to secure competent regulatory workforce with qualifications and sufficient expertise to carry out regulatory tasks and to take the responsibility according to the nature and size of regulation target facilities and regulatory activities.

KINAC has also prepared and implemented a plan for manpower supply and demand in order to secure enough staff corresponding to the expansion of the tasks related to nuclear control. As of April 2016, KINAC has a total of 83 employees and arranges the manpower resource in different departments and divisions considering the urgency and importance of the tasks they are in charge of. In addition, due to the changes in external environment and government policy as well as new legislations, KINAC faced with the expansion of the existing task scope and new task areas, resulting in lack of manpower. It has strived to reinforce the employees' capabilities by reassigning manpower and adjusting the tasks based on the analysis on duties and workload in 2013.

As a research institute specialized in nonproliferation and nuclear security, KINAC, in order to secure competent talents, conducts an open hiring process to recruit experienced workers from various fields such as schools and research institutes, not to mention those with doctorates, masters and/or bachelor degrees in areas of relevant fields necessary to conduct tasks for safety control.

The NSSC, KINS, and KINAC have successfully fulfilled the specific responsibilities and functions of their own by properly recruiting, assigning, and transferring qualified and competent regulatory staff in proportion to the nature and size of nuclear facilities subject to regulation and the necessary regulatory activities. In addition, they operate various training programs and the qualification system for regulatory inspection personnel to improve the level of job-performance.

The qualifications for inspectors of regulatory body are stipulated in Article 139 (Qualification of Inspector) of the Enforcement Decree of the NSA, NSSC regional Office Operational Regulations, and NSSC Instruction No. 47. Under the legal basis of the Act on the Education and Training of Public Officials and the Enforcement Decree of the same Act, the NSSC establishes an inspector training plan every year for its public officials to complete at least 80 hours of training, thereby enhancing their expertise. No less than 40 percent of the training hours are dedicated to the subjects designed to better understand the national policy agenda and current issues as well as to enhance their expertise. Based on the training plan, the NSSC runs various courses, including specialized training in regulation by composing lecturers with the experts in regulation fields such as professors, NSSC employees at the deputy director level, etc.

KINS and KINAC provide refresher and new (where necessary) training courses relating to inspector qualification every year, and open various training courses on a variety of regulatory technology to improve core capabilities of the inspectors. The instructors for these courses mostly consist of experts with considerable regulatory experience. For some courses including continued operation, KINS invites high quality experts from outside of Korea, such as IAEA.

KINS also operates intensive training programs, as well as the qualification system for KINS regulatory inspectors to improve their job-competence. The International Nuclear Safety School (INSS) provides training courses mainly for the philosophy and basic principles of nuclear and radiation safety regulation, focusing on knowledge and technologies required for efficient job-performance skills for new employees either with or without having careers in the nuclear power industries as well as for the inexperienced employees. The training program includes development of nuclear energy utilization, concepts of nuclear safety, nuclear power plant systems, safety regulation framework, nuclear safety policies and legislation, regulatory procedure for licensing and permit, concepts of radiation safety, national radiation disaster prevention measures, nuclear quality assurance, nuclear and radiation accident, and integrity and leadership. Furthermore, KINS develops and operates regular and special training programs to educate the KINS regulatory staff in new technologies and techniques required for improving their job-competence.

KINS has significantly intensified qualification requirements of the nuclear regulatory inspectors to promote tighter inspection of the nuclear facilities, and adopted newer and more rigid requirements since January 2003. KINS classifies the qualifications of nuclear regulatory inspectors into six fields: facility management, radiation management, quality assurance, radiation disaster prevention, material accountancy, and physical protection. Those who have working experience as assistant inspectors for more than two years and have completed the required training courses are qualified to become inspectors.

In addition, it is mandatory for KINS regulatory staff to be dispatched to one of the regional offices at the site of nuclear power plant for the period of more than two years. KINS implements staff rotation system between regulation department and research department and strives to enhance regulatory competence and to create synergy effect between departments with different nature. In addition, KINS regularly dispatches some regulatory personnel to work in the international institutions such as the IAEA, OECD/NEA, and ITER and foreign regulatory bodies such as US NRC in order to globalize Korean regulatory technology and to enhance the capability for international regulatory cooperation.

KINAC encourages field work experience by providing resident workers at site with incentives to personal career records. It has long promoted a working environment where regulatory tasks and research tasks can be implemented in a single department, which now becomes a sound foundation to achieve practical research and development with high level of on-site utilization.

Finance

The finance of regulatory body consists of government contribution, regulatory fees, R&D project expenses, etc. Since 2015, the regulatory fees collected from the licensee has been used as a source of funding, which was a change in execution system for more transparent execution process. The NSSC imposes on and collects the regulatory fees from the licensees which used to be imposed, collected, and executed by KINS. The collected fees are incorporated into the fund for integrated expense execution. Based on the secured financing source of the fund, the NSSC has established independent safety regulation projects and improved operation process to allocate the expense based on the purposes elaborated as follows:

- Licensing, review, and inspection carried out in accordance with the NSA and radiation disaster prevention project such as emergency drill against radiation accident as prescribed in the Act on Physical Protection and Radiological Emergency; and
- Establishment of regulatory infrastructure such as R&D, basic infrastructure, nurturing workforce and investing in specialized institute as prescribed in the NSA and the Act on Physical Protection and Radiological Emergency.

III.3.4 Policy Direction of the Regulatory Body

Independence of the Regulatory Body

Independence of nuclear safety regulation is clearly stated in the Act on Establishment and Operation of the Nuclear Safety and Security Commission. Article 2 (Principles of Operation) of the Act stipulates that the NSSC shall maintain independence and impartiality. According to the Article 3 (Establishment of Commission) of the same Act, the NSSC shall be directed and supervised by the Prime Minister of the Republic of Korea under the Government Organization Act. However, it is also prescribed that the Commission shall not be directed by the Prime Minister in matters such as those regarding: the permit, re-permit, authorization, approval, registration, and revocation of permits of users of nuclear energy; the establishment of a comprehensive plan for nuclear safety; and decision-making in respect to safety control such as corrective orders. Article 10 (Disqualifications) of the same Act stipulates that no person who meets any of the following criterion shall be qualified as a commissioner: 1) a person who has worked or has been working as the head or an employee of a nuclear energy users' group or an organization of users of nuclear energy during the preceding three years; and 2) a person who has been commissioned to, or involved in, a project entrusted as a research and development task by a user of nuclear energy or an organization of users of nuclear energy, or a project carried out by a user of nuclear energy or an organization of users of nuclear energy during the preceding three years. Article 14 (Recusal, Challenge and Evasion of Commission Members) states if a commissioner has an interest in a matter, he/she shall not be involved in the decision-making around that matter so that segregation of functions is guaranteed between the Commission and institutions with a vested interest.

On the other hand, in accordance with the Nuclear Promotion Act, the Ministry of Science, ICT and Future Planning (MSIP) is charged with the responsibility of promoting industries related to research, development, production, and the use of nuclear energy (hereinafter referred to as "use of nuclear energy"). Pursuant to the Electric Power Source Development Promotion Act and the Electric Utility Act, the Ministry of Trade, Industry and Energy (MOTIE) holds responsibility to secure stability of power supply and demand as well as to establish and implement nuclear energy development plans to promote competition amongst electric utilities. In other words, the duties of the NSSC encompass regulations while the MSIP and the MOTIE are charged with focusing on and promoting nuclear power generation and in these aspects of their functions, they are legally separated.

Since KINS and KINAC are involved in regulatory activities relating to nuclear safety and nonproliferation, respectively as entrusted by the NSSC in accordance with the NSA and related laws, their technical works and their decision making processes under their jurisdictions are not influenced by the interested parties. KINS is entrusted with the tasks related to nuclear safety regulation by the NSSC and established as an independent organization to carry out professional and technical tasks under the KINS Act. Article 23 of the Articles of Association of KINS states that any person who has worked or has been working as the head or an employee of a user of nuclear energy or an organization of users of nuclear energy during the preceding three years, or who has been involved in or is being involved in a project entrusted as a research and development task by a user of nuclear energy or an organization of users of nuclear energy, or is involved in a project carried out by a user of nuclear energy or an organization of users of nuclear energy during the preceding three years shall not be a member of the executive board, hence ensuring that there is no opportunity for the board to be influenced by an institution with a vested interest during the process of decision-making.

Most of the external members of the NSSC (and its subcommittee as well as the consulting committees of KINS) are affiliated with the institutions or organizations that have no interests among themselves with the licensees. Thus they independently provide their advice and service to the regulatory bodies not as the representatives of their institutions or organizations, but in a personal capacity. In cases where it is not possible to exclude interested stakeholder, the stakeholder still needs to be excluded from the decision-making processes to prevent interest intervention in the regulation decision courses. The regulatory body makes the final regulatory decisions by referring to these advice and services, and takes the full responsibility of the decisions it makes. In addition, regulatory enforcement and decisions are performed pursuant to the related legislative provisions and official procedures, and undergo a series of multiple deliberations and confirmations from the KINS regulatory experts through the NSSC regulatory officers, so as to minimize the possibility of challenging the independence and objectivity of the regulatory activities, even if advice or support is obtained from organizations with potential conflicts of interest in the intermediate stages of the process of decision making.

Openness and Transparency of the Regulatory Body

KINS has enhanced public confidence on nuclear safety regulatory activities by setting up Nuclear Safety Information Center back in November 2002 to open nuclear safety information to the public and also to invite public opinion. On June 11, 2003, the Nuclear Safety Information Center started cyber information system to ensure that anyone can access and utilize nuclear safety information regardless of time and space.

After collecting and analyzing the information on safety performance analysis results from NPPs, NPP operation data, accidents and failures record, data for radiation disaster prevention, and environmental radiation/activity data through the supporting system for regulatory activities and other informants, KINS sends the information to the Nuclear Safety Information Center. The Center opens the information to the public after carrying out the procedure of data processing, establishment of the database for open information and data processing dedicated to external release. Recently, the NSA was revised to include the provision on active information disclosure which will come into effect on June 23, 2016. Following the change in the law, a mid- and long-term plan will be established to gradually expand the operation of Nuclear Safety Information Center starting from 2016.

III.4 Article 9 Responsibility of License Holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

III.4.1 Legal Basis

The legal basis for the construction permit (CP) and permit standards is the NSA Article 10 (Construction Permit) and Article 11 (Standards for Permit), respectively.

The legal basis for the operating license (OL) and license standards is the NSA Article 20 (Operating License) and Article 21 (Standards for License), respectively.

III.4.2 Responsibility of the License Holder

The construction permit (CP) holder assumes the responsibility to construct a nuclear installation as approved at the time when the CP was issued. The permit holder also assumes the responsibility to comply with the conditions imposed on the CP by the regulatory body.
The operating license (OL) holder assumes the responsibility to operate a nuclear installation as approved at the time when the OL was issued. The licensee also assumes the responsibility to comply with the conditions imposed on the OL by the regulatory body.

According to the "Nuclear Safety Policy Statement," the ultimate responsibility for the safety of a nuclear installation rests with the operating organization and is in no way diluted by the separate activities and responsibilities of designers, suppliers, constructors, and regulators.

III.4.3 Verification from the Regulatory Body

In accordance with the NSA, the NSSC, the regulatory body, assumes the responsibility to verify, by means of regulatory inspections described in Section III.2.4, that the installer or operator of nuclear installations comply with the permit or license conditions during construction or throughout the lifetime of the installations. If a violation takes place, the NSSC immediately orders the installer or operator to take corrective or supplementary measures so as to secure the safety of the nuclear installation.

The installer of a nuclear installation shall undergo pre-operational inspections from the NSSC to verify that the nuclear installation is constructed as previously approved. After passing the inspections, the installer can commence operation. The operator of a nuclear installation shall undergo periodic inspections from the NSSC to assure that the performance of the nuclear installation maintains conformity with the technical standards as prescribed in the relevant provisions, and that other performances including the resistance to pressure and radiation maintain the same state as they were when passing the pre-operational inspection.

If the installer or operator of a nuclear installation has failed to meet the permit or license conditions, the NSSC may order the revocation of the permit or license or the suspension of the business for a given period. If the performance of the nuclear installation does not meet the standards or if safety measures for the operation of the nuclear installation are unsatisfactory, the NSSC may order the operator to take corrective actions or to suspend the operation of the nuclear installation.

III.4.4. Mechanism for Continuous Communication with the Public

KHNP has established a company image that always puts safety first by airing public advertisement with safety concept, holding CEO Talk Concert for better communication with university students to send a message that KHNP supports energy and dream of Korea. In addition, it has operated Energy Farm, an emotional communication channel in Seoul, which is always open to the public and provides hands-on experience in order to fulfill its social responsibility. By launching integrated communication body that consists of both external and internal members and promoting better communication with the stakeholder, KHNP has made a proactive effort for enhanced communication.

KHNP opened an integrated online homepage to enhance transparency of information release for each stakeholder. It helps users more easily access to the web and maximize the effect of information release by utilizing diagrams and charts instead of text based lists. It also promotes open communication through Social Networking Site (Facebook, blogs, etc.), holds participatory contests and organizes journalist team mainly composed of university students and web-bloggers, by which KHNP enhances online based communication on nuclear safety and provides catered information.

The publicity media center was launched for the convenience of about 80 major media outlets. It integrates and provides various real time information such as press release, media data, etc. It has not only improved the satisfaction of media outlets but also helped prevent distorted and misled media coverage in advance, thereby enabling prompt and effective responses. To ensure the understanding of media outlets on nuclear issues on site, KHNP has supported journalists' site visits to NPPs and media coverage. It also has made an all out effort to deliver the correct information by holding press meetings.

III.4.5. Mitigation Measures and Securing Support on Accident and the Consequence

Regarding nuclear accident, prevention should basically be put first rather than mitigation. In case of core damage, however, MCR and TSC workforce in NPPs need to carry out the procedure prescribed in Severe Accident Management Guideline (SAMG) as part of mitigation measures in order to prevent an escalation of the accident. In addition, emergency organization is arranged and operated in accordance with the radiological emergency plan.

As for the operation of accident management plan, it is legal responsibility for those who are planning to operate NPPs and related facilities to submit an accident management plan when applying for OL. Those who already hold OL need to submit the accident management plan by June 2019 to meet the legal requirement.

III.5 Article 10. Priority to Safety

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

III.5.1 Safety Policy

The government issued Nuclear Safety Policy Statement in 1994 to emphasize a fundamental philosophy of "safety first" in use of nuclear energy, and the importance of accounting for international trends in the nuclear safety arena. Through this Statement, the government has clearly pointed out its firm intention regarding nuclear safety with emphasis on establishing nuclear safety culture. Eleven policy directions for safety regulation have been provided along with the following five principles of nuclear safety regulation: Independence, Openness, Clarity, Efficiency, and Reliability.

Moreover, the government reaffirmed that nuclear safety is the highest objective in pushing forward nuclear power application by proclaiming the Nuclear Safety Charter in 2001. The Charter suggests among others the following resolutions that those people who are involved in nuclear power related activities need to make: 1) maintenance of the highest safety standard; 2) prompt and transparent dissemination of safety information; 3) public consensus on safety policies; 4) assurance of independence and fairness in safety regulation; 5) intensification of safety research and technology development; 6) faithful implementation of safety related laws and international conventions; 7) persistent improvement of rules and regulations; and 8) enhancement of safety culture.

The government implements long-term and systematic policies and strategies related to nuclear safety in accordance with the NSA. For effective implementation of nuclear safety laws and various policies for safety regulation, a mid- and long-term comprehensive nuclear safety plan is established and implemented every five years along with detailed implementation plan being established every year. The regulatory body checks the implementation status every year in order to ensure its practical implementation. The Comprehensive Plan for Nuclear Safety is at the pinnacle of national nuclear safety plan and decides mid- and long-term policy direction for nuclear safety. The "First Comprehensive Plan for Nuclear Safety (2012-2016)" was formulated in October 2012 after deliberation and decision-making by the NSSC.

The 1st Comprehensive Plan for Nuclear Safety (2012-2016) states that the basic direction of its establishment is to "Achieve Nuclear Safety at the Highest Possible Level for the People to Feel Safe." Accordingly, "Building Nuclear Safety Systems that the People and the World Trust" was adopted as the vision and "Achieving Nuclear Safety for the People to Feel Safe" was defined as one of mid- to long-term policy objectives. To that end, seven action strategies were set out as follows:

- Strengthen Nuclear Safety with Feedback of Lessons Learned from the Fukushima Daiichi Accident
- Promote Safety Culture and Strengthen Public Communication
- Build an Integrated Radiation Safety Management System
- Establish a System for Nuclear Nonproliferation and Nuclear Security
- Upgrade Nuclear Regulatory Capabilities through Active Investment in Research and Development and Human Resources
- Expand Contributions to Global Nuclear Safety Regime
- Innovate National Laws and Systems for Nuclear Safety

Meanwhile, it is stated in the KINS Mission Statement announced on February 11, 2000 that 'KINS will strive for nuclear safety culture to firmly take root so that the people in the nuclear industry can perform their work giving the highest priority to safety.'

KHNP also declared in its “Policy Statement for the Safety of NPP” announced in December 2003, that the safety goals in the operation of nuclear power plants are to protect the public health from radiation hazards and to preserve the environment. The management also made clear of its commitment to safety with an aim to achieve and maintain safety at the highest possible level that the people feel assured, which has been established as one of the most important management policies. To implement the safety first policy, the KHNP has continuously improved its business environment by setting operational goals and performance indicators for nuclear power plants with the focus on safety so as to ensure that nuclear safety comes first before power production or generation plan or other processes and costs.

III.5.2 Licensee’s Activities to Strengthen Safety Culture

Development and Implementation of Safety Culture Program

In order to reflect the lesson learnt from the Kori Unit 1 station blackout (SBO) and subsequent cover-up which occurred due to the lack of safety culture in February 2012, KHNP created a division dedicated to safety culture in 2012 and has established and implemented measures to improve

nuclear safety culture every year to help safety culture to take firm root and spread further.
KHNP developed an objective safety culture evaluation indicator through research on ways to promote safety culture and first applied it to the workers at NPP sites in 2006. Since then, the staff in operating NPPs has been subject to the evaluation every two years. In addition, by applying international standards in June 2014, licensees set the specific definition of safety culture and spreaded eight principles and 32 characteristics to encourage its workers to internalize safety culture. In 2011, the KHNP developed a new assessment method for nuclear safety culture and carried out pilot evaluation in November 2011 to verify the practicality of the evaluation method. The evaluation has been continuously carried out in 2012 (four NPP units), 2013 (six NPP units), 2014 (six NPP units) and 2015 (six including Hanbit Unit 2). The yearly safety culture evaluation is expected to continue in order to monitor the safety culture awareness of nuclear workers and identify issues for improvements, thereby improving safety culture continuously.

Institutional Mechanism for Safety Management and Implementation

To enhance the safety of nuclear power plants, KHNP carries out a quality assurance program by developing quality assurance requirements and systems that should be followed in stages of design, construction, fabrication, building, commissioning, and operation of the nuclear power plants through a quality assurance organization independent from construction and operation organizations. With an aim to continuously improve the safety of nuclear power plants, a self-assessment program was developed so as to identify areas for improvement through comparison and analysis of current performance level and the best performance goals, and to monitor and manage the progress for improvement. This program has been applied to all of the power plants and other power generation facilities since 2008. Furthermore, the operator has conducted technical exchanges with national and international organizations including the IAEA and WANO in the form of peer reviews and technical support missions.

KHNP established and operated committees for deliberating and deciding on matters on nuclear safety at NPPs (Plant Nuclear Safety Committee or PNSC) and the HQ (KHNP Nuclear Review Board or KNRB). Nuclear safety related policies, significant issues, and operating license are deliberated and decided in the PNSCs or KNRB. After the Kori Unit 1 SBO event, the operator established a nuclear safety oversight organization that works at each nuclear power site but reports directly to the head office, in May 2012. The nuclear safety oversight team monitors the operational status of the plants around the clock and ensures that any significant issues that occur at the plants are reported to the head office without ommission or cover-up. The safety oversight team also monitors safety compliance of station employees as well as contractor workers continuously.

Monitoring and Self-Assessment of Safety Performance

KHNP has analyzed the operational performance of its NPPs on a quarterly basis with WANO's 10 safety and performance indicators. The analysis is aimed to identify and improve vulnerabilities in comparison with the performance of overseas nuclear power plants or nuclear operating nations. In addition, in conformity with relevant laws, periodic safety reviews (PSRs) have been conducted for operating NPPs to complement their weak points caused by ageing degradation of components and to assure safety to be equivalent to that of newly constructed plants. The PSR results are reviewed by the regulatory body. Since the first PSR was conducted for Kori Unit 1 in May 2000, PSRs have been performed for each one of 18 operating power plants, as of December 2015. The PSR for Kori Unit 2 and Hanul Units 5 & 6 were commenced in June 2013 and as of the end of 2015, the review is being underway by the regulatory body.

III.5.3 Regulatory Oversight of Licensees' Safety Culture

Development of Regulatory Infrastructure for the Oversight of Safety Culture

Regarding the SBO at Kori Unit 1 and subsequent cover-up that occurred in February 2012, the NSSC and KINS have set new policy directions for the licensees' safety culture. Before the case, the regulatory body had concentrated its efforts on campaigns to raise the safety awareness of workers at NPPs, rather than on intervening in the licensees' safety culture. However, the event was considered by the regulatory body as a typical case of compromised integrity of defense-in-depth barriers caused by organizational and cultural factors, and so it was taken as an opportunity to reconsider the regulatory supervision of safety culture.

Hence, the NSSC carried out a special inspection on licensees' safety culture as a way of regulatory oversight of safety culture. In addition, the NSA was revised in 2014 to establish a firm institutional basis for safety culture regulation by adding safety culture items to be checked during PSR.

KINS has performed the research project of development of regulatory infrastructure for the oversight of safety culture since 2013 to lay a firm foundation for regulatory body to carry out regulatory oversight of safety culture and to develop a system to implement the regulation. KINS defines nuclear safety culture as “the assembly of behavior patterns, core values, and basic beliefs shared by individuals in organization with regard to the importance of safety” and developed 16 factors that constitute five areas for implementation of nuclear safety (human performance management, management for improvement, safety conscious work environment, leadership and organizational control, and safety culture management system) for safety culture regulation against licensees.

Pilot Inspection and Special Inspection on Licensees' Safety Culture

As part of follow-up measures for SBO event in Kori Unit 1, the NSSC and KINS carried out pilot inspection and special inspection on safety culture for each NPP unit.

During the periodic inspection in 2013, Hanbit Unit 4 & 5 were subject to a pilot inspection on safety culture implementation system, through which the regulatory body aimed to confirm the adequacy of the system established for the promotion of safety culture and its implementation. The results showed that the safety culture management system was adequately established and implemented with the harmony between the promotion plan led by the NPP and the plan and procedures led by the headquarters (HQ). On the other hand, Hanbit Unit 3 was required to improve the expertise of the personnel dedicated to safety culture activities, actively employ safety culture evaluation results, improve the implementation system for industrial safety, and finally review and utilize overseas case on organizational change management.

In 2014, a special inspection team for safety culture carried out a special inspection on safety culture against KHNP HQ, Kori Unit 3 & 4 and Hanul Unit 3 & 4. The inspection was meaningful in that the NSSC was able to confirm necessary matters for policy making in the process of establishing comprehensive measures to promote and maintain safety culture of the licensee. The following needs were identified as a result of the inspection: 1) development of legal and institutional foundation on safety culture inspection for future regulation; 2) consideration of establishment of the authority to impose restrictive measures on intentional violators for the establishment of justice culture; and 3) establishment of a common ground for licensee and regulatory body to better understand safety culture.

In 2015, special inspection was carried out on Hanbit Unit 1 & 2, Wolsong Unit 1 & 2, Kori Unit 1 & 2, and KHNP HQ. The special inspection in 2015 was to see how far safety culture has improved and spreaded since the special inspection results in 2014 and to identify additional issues for improvement by carrying out the inspection on three NPPs that were not included in the inspection in 2014. In terms of implementation system for safety culture, KHNP showed that it has gradually been equipped with necessary institution and procedures. Regarding the capability, detailed endeavors, attention from the management, and the understanding of the workers to promote and maintain safety culture in practice, some issues to be improved were identified from direction setting stage.

III.6 Article 11. Financial and Human Resources

1. *Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*

2. *Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.*

III.6.1 Regulatory Requirements for Human Resources and Financial Status of the Operator

The operator who wants to obtain a construction permit and an operating license for a power reactor should secure the technical capability for construction and operation in accordance with the NSA, and submit relevant technical capability specifications to the NSSC. The NSSC Notice (Regulation on Preparation of Technical Ability Description concerning Installation and Operation of Nuclear Reactor Facilities) prescribes the particulars that should be contained in the technical capability specifications. They include the organization, responsibility and authority, and qualification and experience of the operator who applies for a construction permit or operating license. The regulatory body examines the suitability of the technical capability based on the results of pre-operational inspections for the construction permit holder, and on the results of periodic inspections for the operating licensee.

The KHNP is the only NPP operator in the Republic of Korea, and it is designated as a public institution by the Law on Management of Public Bodies. Under the Law, it is controlled by the government on such matters as management objectives, budget, business management plan, mid- to long-term financial management plan, and use of reserve fund. The KHNP is required to make public key performance indicators such as management performance and operating status.

Therefore, financing of the fund necessary for maintaining the safety and stability of nuclear power plants is not interrupted by pursuit of profit. The KHNP has invested in the replacement and reinforcement of facilities based upon the mid- to long-term plant refurbishment plan to guarantee the safe operation of nuclear power plants.

The KHNP pays the cost for radioactive waste management and the charge for spent fuel management to Korea Radioactive Waste Management Corporation (KRMC) which operates radioactive waste management facilities and the Ministry of Industry, Trade and Energy, respectively. In addition, the KHNP has accumulated a separate reserve fund for nuclear decommissioning of the NPPs every year.

III.6.2 Organization of the Operator

Korea Electric Power Corporation (KEPCO) transacted the reorganization of electric power industrial structure in April 2001, in view of promoting efficiency in electric power business and maximizing the effect of services for the people with the introduction of a competitive system. Currently the electric power sector is divided into six power generation companies: five thermal power companies (KOSEP, KOMIPO, WP, KOSPO, EWP) and one hydro and nuclear power company (KHNP).

The KHNP, a company which took all nuclear power-related installations and employees of KEPCO, is composed of the head office with seven divisions and 26 departments/offices, four nuclear power sites, one hydro power site, six pumped storage power plants, and eight special institutes. With assets worth about KRW 51.2 trillion, the operator hires approximately 11,100 persons and among them, approximately 7,800 persons are involved in construction and operation of nuclear power plants (Figure III.6-1).

As shown in Figure III.6-2, each nuclear power site of the KHNP consists of Quality Assurance Team, Quality Engineering Team, Training Center, General Administration Department, and Director Generals of Nuclear Power Plants. There are Safety Engineering and Support Team, Operation Office, and Maintenance & Engineering Office under the Director General of a Nuclear Power Plant. Safety Engineering and Support Team, responsible for general affairs on safety directly reports to the Director General. Operation Office consists of Operation Team, Radiation Safety Team, and Chemical Engineering Team, and Maintenance and Engineering Office is composed of System Engineering Team, Program Engineering Team, Mechanical Engineering Team, Electrical engineering Team, and I&C Team.

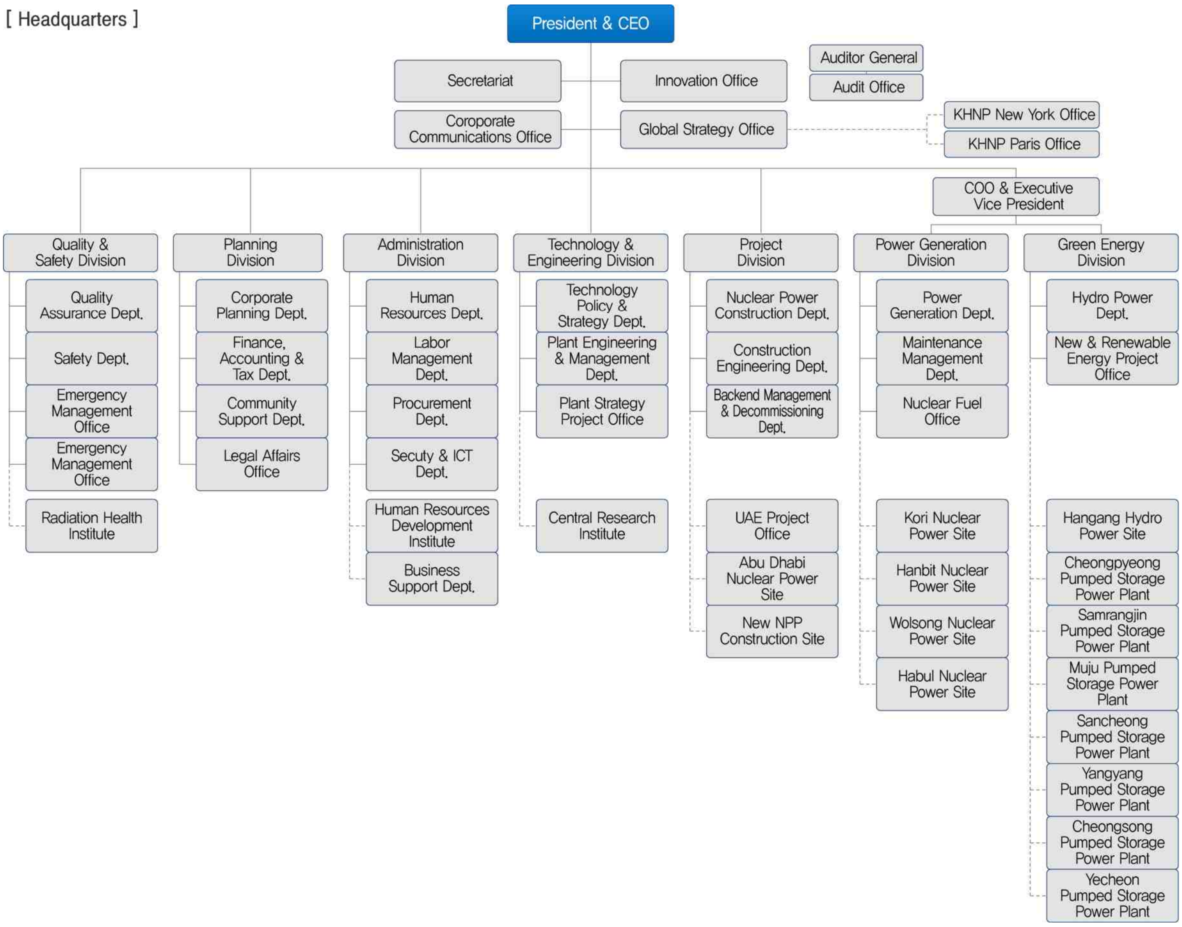


Figure III.6-1 Organization Chart for Korea Hydro & Nuclear Power Co., Ltd

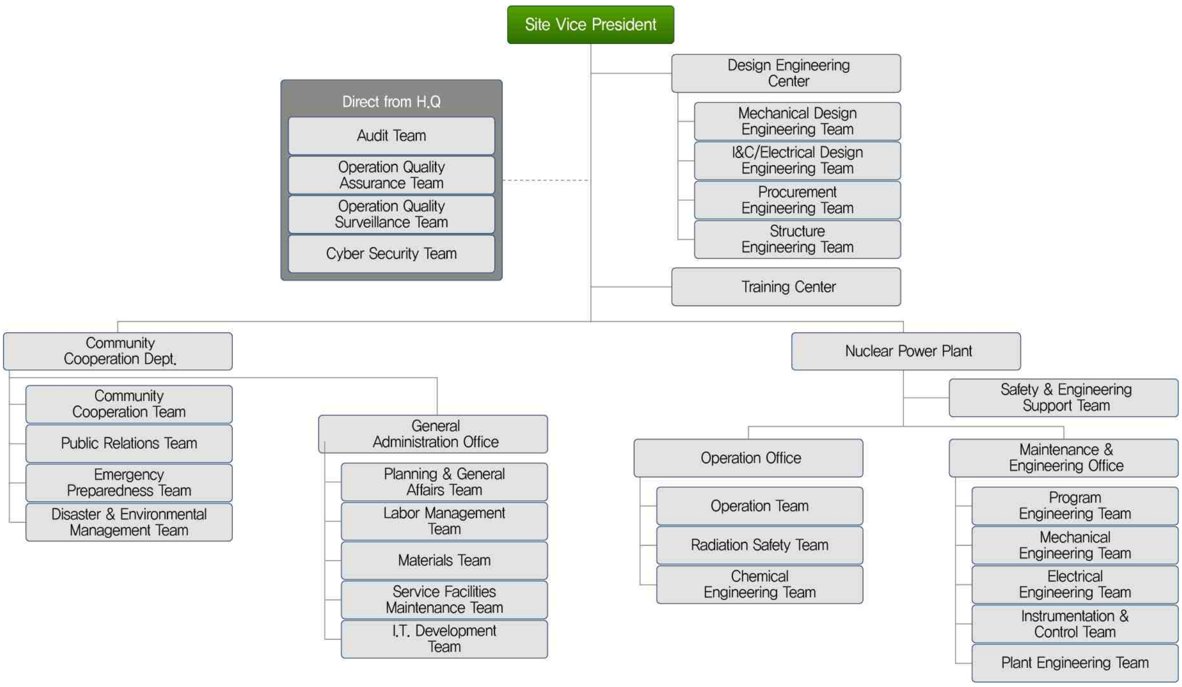


Figure III.6-2 Operating Organization Chart for Nuclear Power Plants of KHNP

III.6.3 Financing of Safety Improvements

Research & Development (R&D)

The government performs research and development to enhance safety as part of the Long-term Nuclear Energy Research and Development Program for the purpose of maintaining safe operation of nuclear installations and preparing for changes in regulatory standards reflecting the advancement of nuclear technology and environmental changes. To continuously perform research and development and to secure financial resources, the Atomic Energy Promotion Act stipulates specifics on the promotion of nuclear research and development programs and on the foundation of a nuclear research and development fund.

The nuclear research and development fund consists of the fee borne by the operator of nuclear installations. The fee is fixed at KRW 1.20 per kWh of nuclear power generation. According to the 4th Comprehensive Promotion Plan for Nuclear Energy (2012 – 2016) the total budget to be invested into the research and development programs during the period from 2012 to 2016 amounts to approximately KRW 1.814 trillion. It is also planned to gradually expand the research on nuclear safety, considering its ever increasing importance after the Fukushima Daiichi Accident.

In December 2012, the Nuclear Technology Road Map 'Nu-Tech 2030' was announced as a plan for developing future nuclear technology. It was established to meet the growing demands for nuclear safety at home and abroad after the Fukushima Daiichi Accident with the aim of securing higher level of safety and strengthening the international competitive edge of Korean nuclear technology. The road map contains four areas: safety of nuclear power plants in operation and under construction, high reliability nuclear fuel & components, and radioactive waste disposal & decommissioning. According to the road map, a total of KRW 5.6 trillion is planned to be invested until 2030 with an average annual investment of KRW 330 billion.

Facility Investment

As a public organization, the KHNP is replacing and/or reinforcing its facilities under the Mid- to Long-term Plant Investment Plan to ensure the safe operation of nuclear power plants.

As post-Fukushima measures, KHNP completed 56 items for improvement including building up the coastal barrier for Kori site and installing injection flow paths for emergency cooling water in spent fuel pool by 2015 and is set to complete seven additional items for improvement such as installing containment filtered venting system (CFVS) by 2020.

III.6.4 Financial and Human Provisions for Decommissioning Program and Radioactive Waste Management

The cost for treatment, transportation, and on-site storage of radioactive waste generated from nuclear installations is included in the maintenance cost of nuclear installations.
The KHNP establishes Radiation Safety Team under the Safety & Environment Department in its head office as well as each nuclear power plant to take charge of the safe treatment and storage management of radioactive waste. Contractors including KEPCO KPS provide the required support for treatment of radioactive waste as well as maintenance & management of treatment facilities. The KRMC is currently constructing a permanent disposal facility for low and intermediate level radioactive waste.

The Radioactive Waste Management Act stipulates that the radioactive waste generator shall pay the cost for radioactive waste management to the operator of radioactive waste management facilities and the operator of nuclear installations shall pay the charge for spent fuel management to the Minister of Industry, Trade and Energy and accumulate a separate reserve fund for nuclear decommissioning every year.

Accordingly, the KHNP, a radioactive waste generator and nuclear operator, pays the cost for radioactive waste management and the charge for spent fuel management to KRMC which operates radioactive waste management facilities as entrusted by and to the Ministry of Industry, Trade and Energy, respectively. Separately, the KHNP has accumulated a separate reserve fund for nuclear decommissioning every year.

III.6.5 Qualification and Training of Personnel

Articles 54 (Operational Organization) and Article 55 (Qualification and Training) of the Regulation on Technical Standards for Nuclear Installations stipulate that the operator of a nuclear installation shall comply with the requirements for the organization, departments, responsibility & authority, qualification, and education & training needed for operation of the installation and the regulatory body shall check on the adequacy of their compliance through periodic inspections.

The NSA stipulates that only person who has obtained a license from the Commission (including professional engineer of radiation control under the National Technical Qualifications Act) is allowed to operate a nuclear reactor and handle nuclear fuel material as well as radioisotope, etc. Provided that, the same can be applied to the case a person who has undergone education and training or handles such material under the direction and supervision of a person who has obtained a license. The NSA classifies the licenses as follows:

- a license for senior reactor operator,
- a license for reactor operator,
- a license for senior nuclear fuel material supervisor,
- a license for nuclear fuel material supervisor,
- a general license for radioisotope supervisor,
- a special license for radioisotope supervisor,
- a license for radiation handling supervisor, and
- a professional engineer of radiation control under the National Technical Qualification Act.

Licenses are issued to applicants who have engaged in the relevant fields with sufficient experience and successfully passed an examination administered by the NSSC. The number of license holders employed by the KHNP are a total of 3,250 (including double licenses) as shown in Table III.6-1. At regular intervals, the license holder must take a refresher course held by KAERI, the KHNP, or KRIA according to the type of license. Technical specifications for each nuclear power plant specify the qualification requirements for positions necessary for NPPs and prescribe that plant employee shall meet the specified qualifications.

Table III.6-1 License Holders Employed in Reactor Facilities

(As of December 31, 2015)

Field \ Category	Type of License	Number of Holders
Reactor	Senior Reactor Operator	1,354 (1,175)
	Reactor Operator	1,415 (1,482)
	Subtotal	2,769 (2,657)
Nuclear Fuel Materials	Senior Nuclear Fuel Material Supervisor	72 (53)
	Nuclear Fuel Material Supervisor	21 (7)
	Subtotal	93 (60)
Radioisotope	Senior Radiation Safety Supervisor	6,951 (468)
	Radioisotope Supervisor	896 (0)
	Radioisotope Supervisor in Medical Use	920 (65)
	Subtotal	8,767 (533)
Total		11,629 (3,250)

※ Figures in parentheses correspond to the number of license holders employed by the KHNP.

In accordance with Regulations on Technical Standards for Nuclear Reactor Facilities, Etc., Article 55 (Qualifications and Training), improved training programs are established every year to provide the plant personnel with sufficient knowledge and experience. Employees are required to complete mandatory training courses as defined according to their respective

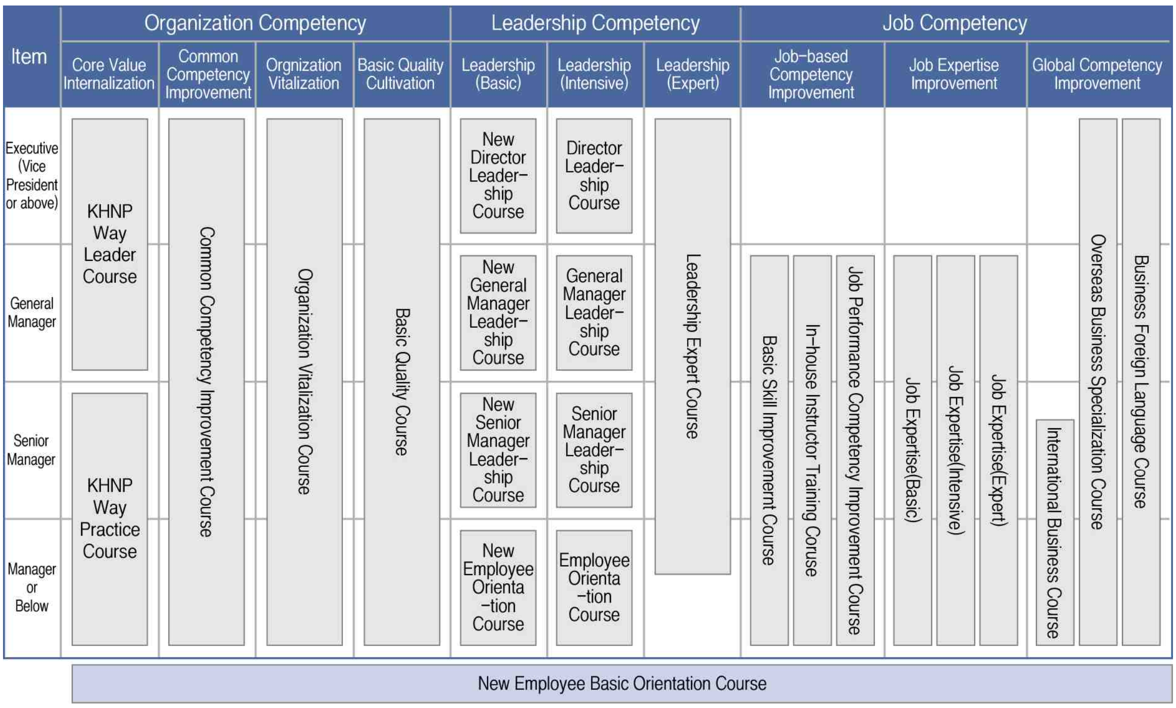
hierarchy levels and positions, as shown in Table III.6-2.
The KHNP provides a three week Operator Re-qualification Training Program, three times a year for operators in shift work where six operation teams rotate; three teams on shift, one team in simulator & local training, one team in training, and one team off duty. The major contents of the program consist of nuclear safety culture, simulator training, technical specifications, and operating experiences.

The KHNP has periodically utilized outside professional organization for evaluation of the adequacy of its personnel management and organizational structure. In 2009, a diagnosis of management of operation teams at nuclear power plants was conducted to analyze the status of management, to research on overseas cases, and to assess the adequacy of management of operations teams. Based upon the results, proper manpower and organizational structure were identified and applied to improve the management of operation teams.

For the diagnosis of safe operating capacity of nuclear power plants conducted in 2011, job analysis was performed for organizations of nuclear power plant in operation or at each stage of pre-startup operation. Based upon the results, areas for improvement concerning the proper staffing level and human resource planning for nuclear power plants were identified and improvements were made in the standard job classification system, the calculation of proper manpower, and the establishment of human resource planning for nuclear power plants. Additionally, a 'Power Generation Personnel Management' system was constructed to prevent the dilution of expertise and knowledge of the staff due to the growing number of new and inexperienced employees at the plants and to provide quantitative criteria to determine the proper ratio of experienced personnel for each power plant. The system helps the KHNP determine the adequacy of manpower and assign personnel to each nuclear power plant.

Table III.6-2 Training System of Employees in Nuclear Installation

Type of Capability	Type of Training	Overview
Common Competency	Core Value Internalization	Training course on vision, strategy, and core value of KHNP
	Common Competency Improvement	Training course on common competency of KHNP (ethics, communication, and safety control)
	Organization Culture Vitalization	Training course on establishing desired organizational culture and vitalizing the organization
	Basic Quality Course	Training course on basic quality that employees must have as a person working for KHNP, public corporation
Leadership Competency	Leadership (Basic)	Training course to understand the role and duty as new director and senior/general manager and to obtain the leadership competency specific to KHNP
	Leadership (Intensive)	Training course to identify items for improvement while performing current position and prepare what is required for upper position
	Leadership (Expert)	Training course to acquire leadership competency and business expertises that one must have as a leader of KHNP, public corporation
Job Competency	Job-based competency Improvement	Training course to enhance employees' job-performance in a comprehensive manner
	Job-expertise Improvement	Training course to enhance job-expertise (knowledge/techniques)
	Global Competency Improvement	Training course to enhance international business competency



III.7 Article 12. Human Factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

III.7.1 Regulatory Requirements and Implementation System for Human and Organizational Factors

Human and organizational factors of nuclear facilities refer to various factors that can directly or indirectly affect individual or collective task performance of NPP personnel. These factors are addressed through human factor engineering (HFE) design and technical capabilities for operation. HFE design is applied to human-system interface equipments or facilities such as main control room (MCR), remote shutdown room, emergency response facilities, and local control panels. HFE design should comply with detailed regulatory requirements described in the Chapter 15 of regulatory standard for LWR, “Human Factors Engineering” (Doc. No. KINS/RS-N15.00) and related regulatory guidelines under the legal basis of Article 25 (Control Room, etc.) and Article 45 (Human Factors) of ‘Regulations on Technical Standards for Nuclear Reactor Facilities, etc.’ Technical capabilities for operation refers to operational aspects of nuclear facilities, such as organizations, training, procedures, and human performance management, which influence human error occurrence or task performance of NPP personnel. Technical capabilities for operation should comply with detailed regulatory requirements described in the Chapter 17 of regulatory standard for LWR, “Operation and Quality Assurance” (Doc. No. KINS/RS-N17.00) and related regulatory guidelines under the legal basis of the Article 54 (Operational Organization), Article 55 (Qualifications and Training), Article 56 (Operational Procedures), Article 57 (Management of Human Factors), and Article 58 (Reflection of Operating Experience) of ‘Regulations on Technical Standards for Nuclear Reactor Facilities, etc.’

In the case of NPPs under construction, in order to apply HFE design principles in a systematic way from an early stage in the design process, HFE design organization was established with the participation of KHNP (the license applicant) and KEPCO E&C (the architect engineer). In addition, the applicant for CP and OL are required to submit the SAR, implementation plans, and result summary reports, which describe HFE plan, analysis, design, and evaluation. KINS conducts a safety review for the SAR and related licensing documents submitted by the applicant for CP an OL, and field inspection to verify whether HFE design principles and requirements are properly integrated into HFE design of nuclear facilities.

In the case of operating NPPs, in order to improve human performance of NPP personnel and to prevent human errors, the headquarter office of KHNP has established a management system for human performance. Each operating organization of an NPP analyzes the cause of human error induced events and reflects lessons learned from the events using K-HPES, and manages human factors such as design changes during operation. The Central Research Institute of KHNP manages operating experience feedback system, performs trend analysis periodically, and reflects the results to improve human performance. In 2001, new provisions on "Technical Capabilities for Operation" was added to the nuclear related laws to institutionalize a system where nuclear operators manage technical capabilities for operation of nuclear power plants in operation. Based on such provisions, KINS conducts the inspection on technical capabilities for operation as a part of periodic inspection during the period of refueling outage to inspect operational organizations, qualifications and training, management of human factors, emergency operating procedures, and operating experience feedback. Based upon the results, corrective actions are taken to improve the safety of operating nuclear power plants.

III.7.2 Human Factor Engineering Design for Nuclear Installations

HFE design for NPPs under construction is implemented systematically by HFE program throughout entire design stages such as planning, analysis, design, verification and validation, and design implementation and human performance monitoring described in the SAR based on HFE regulatory standard and guidelines which were accepted at the time when HFE program was planned for CP application. In the case of design changes in operating NPPs, HFE design principles and standards described in the FSAR shall be consistently applied and HFE program is conducted in a graded manner depending on the scope of the design change.

HFE design process shall comply with the Chapter 15 of regulatory standard for LWR, "Human Factors Engineering" (Doc. No. KINS/RS-N15.00). The process consists of planning stage, analysis stage, design stage, verification and validation stage, and design implementation and human performance monitoring stage. The regulatory body conducts safety reviews to verify whether implementation plans and the results of 12 HFE activities are appropriate for HFE design. In order to comply with Section 15.1 of regulatory guideline for LWR, "Human Factors Engineering Plan" (Doc. No. KINS/RG-N15.01), the planning stage should address the following topics: 1) applicable HFE scope; 2) HFE design organizations; 3) HFE design process and activities; and 4) HFE issues tracking system. In accordance with Section 15.2 of regulatory guideline for LWR, "Human Factors Engineering Analysis" (Doc. No. KINS/RG-N15.02), the analysis stage contains operation experience review, functional requirements analysis and function allocation, task analysis, staffing and qualifications, and human reliability analysis. The results in analysis stage are provided as input of HFE design. At design stage, human-system interface design, procedure development, and training program development shall be systematically implemented based on related regulatory requirements and HFE analysis results in order to comply with Section 15.3 of regulatory guideline for LWR, “Human Factors Engineering Design” (Doc. No. KINS/RG-N15.03). In addition, verification and validation stage and design implementation and human performance monitoring stage should comply with Section 15.4, “Human Factor Engineering Verification and Validation” (Doc. No. KNS/RG-N15.04) and Section 15.5, “Design Implementation and Human Performance Monitoring” (Doc. No. KINS/RG-N15.05) of regulatory guideline for LWR.

III.7.3 Measures to Minimize Human Error in Nuclear Installations

The regulatory body consistently pushes ahead with human error prevention policies to ensure safety of nuclear installations and foster the public trust. KHNP developed a Korean version of Human Performance Enhancement System (K-HPES) based upon INPO-HPES and has systematically analyzed the causes of human error-related events and applied lessons learned from the events since 1993. KHNP also keeps enhancing human performance of NPP personnel by utilizing corrective action program (CAP), human performance tools, and Management Observation.

As more unplanned reactor scrams are caused by human errors in 2007, the regulatory body launched a task force team which composed of experts from industry and academia to reduce human errors and established suitable action items to address human error issues in nuclear installations. From 2007 to 2008, KHNP implemented short-term action items for the issues required to be addressed urgently, such as management of operators’ fitness for duty, management of maintenance contractor workers' qualification, and configuration management of training simulators. For the long-term issues to be addressed, KHNP established comprehensive action plans to reduce human errors, and the action plans were conducted through joint research by experts from the industry, academia, and research institutes from 2009 to 2012. Besides, after the human error-related event at Hanul Unit 5 in 2013, the regulatory body demanded the effectiveness evaluation on licensee’s human error prevention system as a condition for restarting the reactor. In response to this, KHNP formed a task force team that consisted of internal and external experts, and conducted comprehensive inspection on organization and manpower related to human error prevention, human performance programs, and human error prevention techniques in 2014. In addition, since 2015, KHNP has proceeded follow-up measures such as human performance enhancement working group, unification of departments dedicated to tasks to prevent human errors, and fostering HFE and human error experts.

III.7.4 Current Issues and Management of Human and Organizational Factors of Nuclear Installations

Following the Kori Unit 1 SBO cover-up in 2012 and the corruption scandal linked with its parts supplier, the KHNP has been carrying out various organizational reforms including measures to transform its organizational culture and workers' safety awareness, job rotation, etc. Besides, the KHNP set up a new safety oversight organization in each NPP site which works independently to monitor the safety-related matters of the plant and report them directly to the headquarter office. Moreover, it created a procurement engineering team in each NPP site and a supply chain management (SCM) team in the headquarter office to improve objectivity in the procurement process and strengthen the procurement document review.

Recently, there has been an increase in the number of new employees in safety-related departments such as operating crews, maintenance team, etc. due to the dispatch of NPP personnel to support the construction and operation of UAE Barakah nuclear power plant, the implementation of job rotation, etc. To address this challenge, the KHNP has built additional operator training simulators and carried out various change management measures for the key maintenance teams such as instrumentation and control team, etc. including the improvement in job rotation system, hiring experienced maintenance workers and having them serve in the maintenance team for the mandatory 5 years, etc.

In addition, the KHNP evaluated the effectiveness of its entire human error prevention system following the human error-related event at Hanul Unit 5 in 2013. As a follow-up measure, it has made overall adjustment to how the system works by consolidating human error prevention functions in each NPP into a single department to be responsible for the operating experience feedback and K-HPES. Besides, the human error prevention system has been continuously improved through periodic working group activities which facilitate the exchange of relevant experiences and requests of human error practitioners.

III.7.5 A System for Learning from Operating Experiences Caused by Human and Organizational Factors

The KHNP has established and implemented a procedure for sharing the important domestic and overseas operating and maintenance experiences and reflecting the lessons learnt in its own operation of nuclear installations. Since 1999 when it introduced the KHNP Nuclear Information System (KONIS), the company has complied not just domestic operating experiences, but also foreign operating experiences through IAEA, INPO, WANO, etc. to learn from the lessons in a systematic manner. Furthermore, it has published and distributed the operating experience reports which include the events, failures, and near misses of a plant, and held a regular workshop to disseminate the lessons from operating experiences and perform follow-up measures. For more systematic management of follow-up actions of NPP events, it has established the Management System for Action Plans on NPP Events (MAP) and has been working to prevent recurrence of similar events by making sure the follow-up actions are implemented in a fast and correct manner.

Apart from the retrospective approach to human and organizational factor-related events, KHNP is also engaged in identifying and addressing areas for improvement in the overall operations of a plant in a prospective way through the biennial safety culture assessment and by ensuring that important tests and maintenance work are performed under the supervisory observation. Areas for improvement identified from this process have been collected and corresponding follow-up measures have been managed through the CAP system.

III.7.6 Regulatory Issues on Human and Organizational Factors and Compliance Status

The regulatory body has continuously promoted policies to improve human performance of NPP personnel and encouraged the licensee to identify and address issues related to human and organizational factors through licensing and regulatory oversight of nuclear installations. From the Shin-kori Units 3 & 4, the advanced control room design concepts such as large display panel, operator console, safety console, etc. were introduced based on the APR 1400 reactor design. During the construction phase of the Units, HFE issues were identified and addressed through the systematic implementation of HFE program. Meanwhile, for the continued operation of the Kori Unit 1, overall improvements of main control room had to be made. In this process of design change, the regulatory body required KHNP to apply the 10 elements of the HFE program and confirmed its compliance with the requirement during the safety review.

Responding to the public concerns over nuclear safety in the Republic of Korea, the regulatory body decided to conduct stress tests for Wolsong Unit 1 and Kori Unit 1, which have been operating more than 30 years. The safety margin of a NPP depends on human and organizational factors as well as on technical factors. Thus, HFE assessment was carried out as one of evaluation areas for stress tests. HFE assessment of a stress test is to comprehensively evaluate the resilience of NPPs from the human and organizational factor perspective against beyond design basis event (BDBE) conditions caused by large scale natural hazards. The main objective is to verify if the emergency response organization of the NPPs can successfully cope with BDBE situations using available equipment and procedures. Various areas for improvement have been identified and addressed including the accident management organization, procedures, human-system interface, environment, etc. The regulatory body plans to expand the applicability of stress test on all nuclear installations and perform the HFE assessment during the stress test. Based on the lessons learned from the Fukushima Daiichi Accident and experiences in stress tests, the regulatory body will develop the regulatory basis and requirements on human factors engineering and related areas considering BDBE situations. A research project was launched for this purpose in 2014, and the results will be reflected in the licensing process of new NPPs under construction. Through implementation of such regulatory activities, the regulatory body expects the level of safety to be raised and safety culture to be fully established in the nuclear installations so as to gain more public trust.

III.8 Article 13. Quality Assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

III.8.1 Regulatory Approach and Requirements for Quality Assurance System of Licensee

With regard to quality assurance (QA) system, the applicant for a CP shall file a Quality Assurance Program (QAP) Manual for Construction together with a PSAR and the applicant for an OL shall file a QAP Manual for Operation together with a FSAR in accordance with the NSA Article 10 (Construction Permit) and Article 20 (Operating License).

The licensee needs to prepare a QAP to satisfy the QA technical standards prescribed in Section 4 (Quality Assurance regarding Construction and Operation of Reactor Facilities of Regulations) on Technical Standards for Nuclear Reactor Facilities, Etc. As for the main contractor involving in construction and operating license, a description on the QAP of main contractors shall be included in the SAR in accordance with the standard prescribed in the safety review guideline of KINS.

Regulatory body carries out a safety review to verify that the QAP of the licensee and a description on QAP of main contractors meet the acceptance criteria stipulated nuclear safety related laws.

The licensee has the responsibility to abide by the approved QAP in construction and operation of nuclear installations, and the regulatory body shall audit the status and effectiveness of the QAP implemented by the licensee and its main contractors in accordance with the NSA.

III.8.2 Implementation of Integrated Quality Management Systems

The KHNP, an installer and operator of nuclear installations, requires all contractors who participate in safety related work to prepare and implement a QAP in accordance with the NSA and SAR. The KHNP is responsible for establishing and maintaining an integrated QA system for NPPs and also for making all subcontractors implement its own QAP.

All contractors involved in quality related work including design, construction, operation, and maintenance in a form of contract perform QA activities in order to meet the certain requirements of each contractor. Their adequacy is inspected by the KHNP as well as through regulatory inspections by the regulatory body.

III.8.3 Main Elements of Quality Assurance Program

Section 4 (Quality Assurance regarding Construction and Operation of Reactor Facilities) of Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. stipulates 18 criteria for the QAP as follows: (1) organization; (2) quality assurance program; (3) design control; (4) procurement document control; (5) instructions, procedures, and drawings; (6) document control; (7) control of purchased items and services; (8) identification and control of items; (9) control of special processes; (10) inspection; (11) test control; (12) control of measuring and test equipment; (13) handling, storage, and shipping; (14) inspection, test, and operating status; (15) nonconforming items; (16) corrective action; (17) quality assurance records; and (18) audits.

In order to meet the aforementioned 18 standards prescribed in nuclear safety related laws, the licensee applies KEPIC QAP (2000 Edition) developed by Korea Electric Association and the regulatory body allows for the application of KEPIC QAP (2000 Editions) as prescribed in the NSSC Notice Detailed Requirements for Quality Assurance of Nuclear Reactor Facilities (reactor.26) and Guidelines for Application of Korea Electric Power Industry Code (KEPIC) as Technical Standards of Nuclear Reactor Facilities (reactor. 21).

In addition, the licensee applies ANSI/ANS 3.2 (1994 Edition) as detailed requirements for administrative management and QA in operation phase, which is also required by the NSSC Notice as mentioned above.

III.8.4 Audit Programs of the Operator

In accordance with Article 85 (Audits) of the Enforcement Regulation Concerning the Technical Standards of Reactor Facilities, etc. and KEPIC QAP applied as detailed QA requirements by the NSSC Notice, the licensee should conduct audits more than once a year for the construction plant and once every two years for the operating plant in order to verify whether quality activities of each QAP-related branch have been performed according to the requirements of the program, and also to assess the effectiveness of the program.

The audit shall be conducted by a qualified auditor according to the prescribed procedure or checklist, the results shall be documented and reported to the management, and a corrective action request (CAR) shall be issued for non-conformities identified by the audit.

The audit organization shall also verify the suitability of corrective actions and shall conduct a follow-up audit, if necessary.

III.8.5 Audit of Vendors and Suppliers by the Operator

The quality assurance audit is conducted in order to verify whether quality-related activities have been performed properly according to requirements of the QAP and to assess the effectiveness of the QAP. The audit is conducted annually for the activities related with capstone design, reactor facilities, turbine generator, construction, and commissioning, and conducted every three years or once during the term of a contract if shorter than three years for the activities related with auxiliary equipment.

The QA inspection is conducted in the form of direct inspection such as test, measurement, or inspection at each work process. As for the work process where direct inspection on inspection target items is impossible, quality surveillance is conducted to monitor or observe a process, equipment, and workers. Quality surveillance is also conducted periodically for the task or the place in which the same quality characteristics are repeated.

The QA inspection is conducted by a qualified inspector on the basis of the pre-established inspection plan. The inspector selects the inspection points (hold points and witness points) considering work characteristics. The work process set as a hold point can move onto the next stage only when the appointed inspector completes the field inspection, except in the case of getting a written approval from the appointed inspector in advance.

The quality document review is to verify whether the contents of all the quality documents related with purchase, design, manufacturing, maintenance, and operation are complied with requirements of the relevant regulations, specifications, technical standards, QAP and guideline, etc. The review is conducted by the QA organization.

During construction and operation of an NPP, KHNP assesses the adequacy of the QAP of suppliers of safety items and safety-affected items necessary for replacement of the equipment, and makes the qualified suppliers be registered on a qualification list and then each supplier is re-evaluated every three years to determine if it can be re-registered.

III.8.6 Regulatory Review and Control Activities

The regulatory review and inspection activities concerning QA are conducted by KINS, as entrusted by the NSSC. These activities are performed based on the NSA as well as on the safety review guidelines and the QA inspection guidelines developed by KINS.

QA Review

The safety review of QA is to verify that the QAP is properly established in accordance with the nuclear safety related laws and safety review guidelines as well as to confirm that the QAP can be implemented as planned.

The licensee who applies for CP needs to submit QAP regarding construction separately from PSAR and PSAR shall include a description on the QAP of main contractors including NSSS supplier, architect engineer, construction company, and fuel supplier in conformity with the Enforcement Regulation of the NSA and safety review guideline. Likewise, the licensee who applies for OL, needs to submit QAP on operation separately from FSAR and FSAR shall include a description on the QAP of the contractors.

The regulatory body carries out a safety review on QAP of the applicant and the description on QAP of main contractors to verify that the QA systems of the applicant and main contractors are in accordance with the criteria stipulated in nuclear safety related laws and the requirements prescribed in the safety review guidelines.

It is stipulated in the nuclear safety related laws that in case a QAP is to be modified after issuance of CP or OL, the licensee should report the modification to the regulatory body for its approval, except for changes in general organization, not QA related organization. In such case, KINS reviews the adequacy of the change and submit the review results to the NSSC.

Quality Inspection

The objectives of regulatory inspection of QA activities are to verify whether each licensee participating in the design, manufacturing, construction, and operation of nuclear installations has performed QA activities in accordance with the QA requirements, and whether an effective QA system has been implemented so as to ensure the safety of nuclear installations.

Regulatory inspection on QA is performed for each NPP every year in accordance with the Quality Assurance Inspection Procedure for Construction and Operation of Nuclear Reactor Utilization Facilities (KINS-GI-N013). Operating NPPs carry out two QA inspections alternately every year; one is validity inspection to see effectiveness of the QA system based on 18 QA requirements and the other is intensive inspection focusing on each NPP's specific maintenance issues and weakness areas. NPPs under construction carry out validity inspection which includes the QA system of main contractors who perform construction and building work.

As for NSSS supplier and A/E, inspection on QA system and its implementation status is carried out in accordance with ‘the inspection on suppliers, etc.’ newly legalized provision back in November 2014. The inspection on suppliers, etc. consists of the validity inspection on QA system and the direct inspection on the items and service supplied by the main contractors.

III.9 Article 14. Assessment and Verification of Safety

Each Contracting Party shall take the appropriate steps to ensure that:

1. *comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;*

2. *verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.*

III.9.1 Licensing Procedure and Safety Analysis Report

Pursuant to the NSA, the licensing procedure for nuclear installations, as described in Section III.2.3, consists of two stages: the CP and the OL. If the applicant intends to construct reactors of the same design, it can obtain a Standard Design Approval (SDA), which would substantially reduce the CP and OL review process by exempting the scopes already reviewed in the process.

Prior to commencement of construction or operation, the applicant for an SDA, CP, or OL shall conduct comprehensive and systematic safety assessments in conformity with the stipulations in the NSA to ensure that the public and the environment are protected from potential radiation hazards which may accompany the construction or operation of nuclear installations. The results of those assessments shall be documented as follows: Standard Safety Analysis Report for an SDA; PSAR and Radiological Environment Impact Assessment Report for a CP; and FSAR and Radiological Environment Impact Assessment Report for an OL. These reports are to be submitted to the NSSC.

The SAR includes the results of the safety assessment of nuclear installations, such as design features of structures, systems and components, structural integrity and performance evaluation by component and human factor engineering, coping capability of design basis accidents, radiation protection, and site characteristics. The contents of the SARs are prescribed in Article 4 of the Enforcement Regulation of the NSA and shall be applied to all types of reactors, as shown in Table III.9-1.
As for new NPPs, the licensee needs to submit the decommissioning plan in advance when applying for CP and OL, after which the plan should be periodically updated as required

by the Ordinance of the Prime Minister and reported to the NSSC. The residents in areas as near as defined by the NSSC should be given full access to the decommissioning plan (draft) and be able to attend a hearing so that their opinions are collected and reflected when preparing the final version of the decommissioning plan. In such case, a hearing should be held when requested by residents within the scope designated by Presidential Decree or by the head of the local government having the area under its jurisdiction.

In order to manage a severe accident which exceeds design basis and causes significant damage to the reactor core, an accident management plan which includes severe accident management program needs to be submitted to the NSSC. Accident management plan contains relevant actions taken to prevent an escalation of the accident, mitigate the consequence of the accident, and recover to a safe stable state in case of an accident in nuclear installations.

The Radiological Environmental Impact Assessment Report includes an assessment of the radiological effects on the public and environment and, as prescribed in the Enforcement Regulation of the NSA, contains the following items:

- environmental state of all areas around the nuclear installation and its site;
- estimation of radiological impacts on surroundings due to the construction and operation of nuclear installations;
- radiological environmental monitoring program to be implemented during the construction and operation of nuclear installations; and
- radiological environmental impacts resulting from accidents which may occur during the operation of nuclear installations.

Further details are described in the NSSC Notice No.2014-11 (Regulation on Preparation of Evaluation Statement of Environmental Impact by Radiation at Nuclear Facilities).

Table III.9-1 Contents of SAR of Nuclear Installations

1. Introduction and General Plant Description
2. Site Characteristics
3. Design of Structures, Components, Equipment, and Systems
4. Reactor
5. Reactor Coolant System and Connected Systems
6. Engineered Safety Features
7. Instrumentation and Controls
8. Electric Power
9. Auxiliary Systems
10. Steam and Power Conversion System
11. Radioactive Waste Management
12. Radiation Protection
13. Conduct of Operations
14. Initial Test Program
15. Accident Analyses
16. Technical Specifications
17. Quality Assurance Program
18. Human Factor Engineering

III.9.2 Continued Monitoring and Periodic Safety Review

Periodic Inspections and Assessments for Nuclear Installations

To assess the safety and continuous operability of nuclear installations, the KHNP carries out comprehensive safety inspections including in-service test (IST) and in-service inspection (ISI).

The KHNP conducts a safety evaluation for the reload core of all PWR installations during a refueling outage. The reload safety evaluation includes the design of reload core, power performance, accident analysis, modification to technical specifications, and acceptability of reactivity coefficient. KINS, as entrusted by the NSSC, conducts regulatory inspections to ensure the safety of reload core.

Independently from and in parallel with the safety inspections conducted by the KHNP, KINS conducts a periodic regulatory inspection for operating nuclear installations and since April 2005, KINS has included the secondary system into its inspection scope. The NSSC determines whether to allow the reactor to reach its criticality by comprehensively assessing the safety and performance of nuclear installations based on the result of the regulatory inspection.

KHNP carries out zero power/power physics test after recriticality to confirm the feasibility of the design and effectiveness of the safety limits. During the respective operation cycle, KHNP periodically confirms safety until the reactor shutdown.

Periodic Safety Review (PSR)

In order to implement a mandatory clause taken effective in October 1996, the NSSC decided to introduce the PSR system in the 11th committee meeting of December 21, 1999 and completed a pilot PSR against Kori Unit 1 for the first time in May 2000. Accordingly, the legislation for PSR was followed suit through the revision of the NSA in January 2001 as well as the revision of Enforcement Decree and Enforcement Regulation of the NSA in July 2001. As a result, the operator of NPPs shall comprehensively assess the safety of each NPP and related facilities every 10 years after an OL is issued, and report the assessment results thereof to the NSSC. The assessment scope was originally based on 11 safety factors such as physical condition of the NPP, safety analysis, and equipment qualification. In November 2011, however, three more factors (design of a power plant, probabilistic safety assessment, and hazard evaluation) were included, following the revision of the law.

In accordance with the law, as of December 2015, 18 operating NPPs completed PSRs more than once and currently the regulatory body is carrying out the safety review on the PSR results of Kori Unit 2 (2nd PSR) and Hanul Unit 5 & 6 (1st PSR). Such reviews are improving nuclear safety. In addition, PSR review guideline was revised to include 3 more evaluation factors and the format of the review report was enhanced. The review is carried out by not only evaluating 14 evaluation factors individually but also by analysing cross-cutting items, after which the evaluation results and the safety actions based on the evaluation are considered to draw up comprehensive review results. Effective technical standard of the respective NPP at the time of review is utilized as the review standards.

The KHNP conducted periodic safety reviews for all NPPs every 10 years after OL and the regulatory body periodically confirms the implementation status of the improvement items identified by the licensee or the regulatory personnel during the PSR.

Monitoring and Assessment of Safety-related Indicators

The KHNP conducts a continued monitoring and assessment for the safety-related indicators listed below, and the data on unplanned reactor scram and unit capacity factor during the past 10 years are shown in Table III.9-2:

- Unplanned reactor scram,
- Actuation and failure of safety-related systems,

- Human performance of all events involving human errors, and
- Trend and practice of all maintenance including periodic maintenance.

In order to minimize the radiological impacts on nearby residents and the surrounding environment following operation of nuclear installations, the KHNP sets the limits of radioactive effluent release and records and controls the releases to the environment, in addition to continuous monitoring of the effect on the environment. According to the environmental radiation monitoring program, the KHNP periodically collects and analyzes environmental samples, continuously checking the environmental radiation level with the environmental radiation monitoring system. Based on the data, the KHNP evaluates the off-site dose to the population every month. The details of the radioactive material release and the environmental radiation monitoring system are described in Sections III.10.2 and III.11.3.

Table III.9-2 Current State of Unit Capacity Factor

(Unit: %)

Category		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Kori	1	90.2	92.2	91.9	96.5	98.0	87.9	51.0	49.9	85.2	82.5
	2	91.4	89.7	88.3	93.0	90.3	98.8	84.5	80.9	91.5	78.9
	3	88.4	96.4	88.7	89.3	100.1	90.7	78.1	100.1	83.5	80.9
	4	88.8	88.0	97.4	91.8	93.6	92.9	100.1	75.5	86.3	97.0
Shin-kori	1	-	-	-	-	-	100	81.2	26.6	84.8	86.3
	2	-	-	-	-	-	-	98.5	40.8	95.1	84.9
Hanbit	1	91.1	77.6	101.0	89.0	93.5	101.1	92.9	82.4	103.5	82.3
	2	99.6	85.0	90.1	101.3	90.2	92.0	101.7	75.2	77.8	92.1
	3	87.5	89.5	90.3	100.8	91.8	91.6	80.1	54.1	78.8	57.6
	4	99.9	88.1	91.7	88.6	100.9	91.2	88.8	86.6	77.9	62.9
	5	88.9	99.5	90.1	90.9	97.8	94.6	72.1	94.1	79.5	80.4
	6	91.8	90.6	91.0	98.0	91.7	93.2	83.1	98.1	81.8	92.1
Hanul	1	87.7	88.1	98.9	90.9	90.3	99.7	80.1	85.8	91.9	88.1
	2	96.0	90.0	88.2	100.5	91.5	80.0	98.7	88.2	84.6	99.6
	3	96.8	90.8	92.0	93.5	100.3	90.4	69.4	100	41.4	99.9
	4	90.7	91.2	100.6	91.4	93.4	69.4	0	37.8	98.1	83.7
	5	90.6	92.2	100.3	91.0	93.6	92.4	100.4	85.5	84.2	99.4
	6	85.2	91.0	92.9	99.9	91.8	92.9	88.2	99.8	88.7	74.2
Wolsong	1	91.4	89.8	93.0	23.3	0	49.3	81.0	-	-	95.8
	2	99.7	90.9	92.2	94.8	93.7	99.6	94.4	83.7	91.3	92.9
	3	94.0	94.3	93.0	95.3	97.1	97.5	90.7	92.6	85.6	94.7
	4	100.4	93.2	94.5	92.5	94.3	94.3	100.2	90.3	85.1	87.7
Shin-Wolsong	1	-	-	-	-	-	-	95.7	38.1	99.3	71.4
	2	-	-	-	-	-	-	-	-	-	100.3
Weighted Average		92.3	90.3	93.4	91.7	91.2	90.7	82.3	75.5	85.0	85.3

Safety Performance Indicators

In the Republic of Korea, the Safety Performance Indicators (SPIs) system was developed by the regulatory body and applied first to the operating NPPs in 1995 to analyze performance trend, to monitor long-term safety status of NPP operation, to allocate regulatory resources properly, and to improve public confidence in nuclear safety by providing operational information. The Korean SPI system has been constantly improved by reflecting SPIs developed by the IAEA and US Nuclear Regulatory Commission (USNRC) and was restructured in 2002 by adopting graphic display model. The quarterly evaluation result of SPIs is posted on the web-site (http://opis.kins.re.kr).

The SPI system is composed of two safety areas, five categories, and 11 indicators as shown in Table III.9-3.

Table III.9-3 Structure of Safety Performance Indicator (SPI) System

Area	Category	Safety Performance Indicator
Reactor Safety	Operational Safety	▪ Unplanned Reactor Scram ▪ Unplanned Power Reduction
	Safety System	▪ SI System Unavailability ▪ EDG System Unavailability ▪ AFW System Unavailability
	Multiple Barrier	▪ Fuel Reliability ▪ Reactor Coolant System Integrity ▪ Containment Reliability ▪ Emergency Preparedness
Radiation Safety	On-site Rad. Safety	▪ On-site Radiation Dose
	Off-site Rad. Safety	▪ Off-site Radiation Level

The four colors representing the performance grades are green, cyan, yellow, and orange, each of which stands for excellent, good, normal, and warning grade, respectively. Quantitative values to decide performance grades are set considering operation margin, regulatory limits, and severity levels when exceeding the limits.

III.9.3 Verification Program

Preventive Maintenance

The KHNP carries out preventive maintenance in accordance with the provisions defined in the technical specifications of each NPP in order to prevent any failure by preserving the operating condition and performance of NPPs within the design limits. By adopting equipment reliability process, the preventive maintenance is being operated systematically and preemptively to select preventive maintenance targets based on the functional importance of equipment, to standardize the preventive maintenance task based on the PM template, to perform the predictive maintenance based on the condition monitoring, and to introduce online status monitoring and early alarm, thereby enhancing equipment reliability and safety of NPPs.

In-Service Inspection (ISI) and In-Service Test (IST)

Pursuant to the Enforcement Decree of the NSA and the NSSC Notices, the KHNP submits to the NSSC a long-term ISI Plan for each nuclear installation in 10-year intervals and performs in-service inspections according to the plan. The NSSC Notice (Regulation on In-Service Inspection of Reactor Facilities) stipulates that the ISIs shall be conducted in accordance with KEPIC (Korea Electric Power Industry Code) MI section or its equivalent of Code Section XI, Rules for In-service Inspection of Nuclear Power Plant Components of the American Society of Mechanical Engineers (ASME) for PWR, and in accordance with CAN/CSA-N285.4 (Periodic Inspection of CANDU Nuclear Power Plant Components) and CAN/CSA-N285.5 (Periodic Inspection of CANDU Nuclear Power Plant Containment Component) for PHWR.

The NSSC Notice (Regulation on In-Service Inspection of the Safety-related Pump and Valve) prescribes that KEPIC MO section or the Section IST of the ASME Operation and Maintenance (OM) Code shall be applied to both PWR and PHWR during the IST. Pumps must undergo several tests for pressure, flow rate, and vibration, and any change in reference values of the parameters needs to be analyzed in accordance with the provisions specified in KEPIC MOB section or Subsection ISTB of Section IST. As for valves, KEPIC MOC section or Subsection ISTC of ASME OM Codes Sec. IST shall be applied to carry out the leakage test, the actuation test, and the position indicating test and fail-safe test and also analyze any change in reference values of the parameters.

III.9.4 Regulatory Management Activity

Implementation Status of Post-Fukushima Actions

Implementation of Post–Fukushima Actions Conducted by KHNP

After the Fukushima Daiichi Accident, KHNP identified short- and long-term action items for safety improvement to assure safety against natural disasters such as earthquakes and tsunami, and severe accidents that exceed the design basis as is the case with the Fukushima Daiichi Accident. KHNP enhanced its preventive and mitigatory capabilities against the early stage of natural disasters by: 1) investigating and researching the maximum potential earthquakes for nuclear sites and sea water levels; 2) improving seismic function of nuclear installations; 3) installing waterproof doors and discharge pumps; and 4) enhancing cooling sea water intake capability. KHNP also strengthened its safety functions and accident management capabilities by: 1) improving reliability of electric power system, core cooling function, and spent fuel pool cooling function; 2) securing cooling water sources, fire fighting water sources, and integrity of containment building; 3) mitigating the release of effluent radioactive material to the environment; and 4) building up capabilities to respond to fire, management of severe accidents, and extensive damage. In addition, KHNP enhanced emergency preparedness and radiation emergency medical system by 1) securing additional inventory of potassium iodide tablets for residents in vicinity of NPPs; 2) procuring emergency equipment to prepare for a prolonged emergency; and 3) reinforcing emergency notifying system.

Matters Related to Licensing

After the Fukushima Daiichi Accident on March 11, 2011, the Korean government formed an safety inspection team consisting of experts from relevant fields and from KINS and carried out a safety inspection for domestic nuclear installations including operating NPPs, research reactors, nuclear fuel cycle facilities, and radiological emergency medical centers from March 21 to April 30, 2011. The safety inspection was conducted for six areas: safety of structure and components against earthquakes and tsunami; safety of electric power, cooling and fire protection systems against flooding; emergency preparedness system; NPPs in operation for long period of time and new NPPs; research reactors/nuclear fuel cycle facilities; and radiological emergency medical center.

As a result of the safety inspection, the inspection team identified a total of 50 action items for safety improvement and required them to be implemented; 46 from KHNP, one from Korea Institute of Radiological and Medical Sciences (KIRAMS) and three from Korea Atomic Energy Research Institute. Together with the 10 additional items identified by KHNP from its self-assessment in February 2012, the inspection team finalized 60 action items for safety improvement and has selected and reviewed items that need to be addressed by each year. For each NPP unit, the regulatory body has received reports of minor changes or approved operation change and also carried out technical review to verify safety of actions for improvement suggested by the licensee. Periodic inspection and other field activities are also being used as a way to confirm the adequacy of corrective measures for each NPP unit. In addition, the result of each item's corrective action is confirmed when the licensee completes the corrective actions and its self-inspection process.

As of the end of 2015, regarding 69 items on four NPP sites, the safety review through Q&A process on 69 items including reports on minor changes, approval on operation change, etc. is in progress and the review on 117 items regarding licensing were completed. The status of safety review for each NPP site is shown in Figure III.11-2.

Table III.9-4. Status of Review on Post-Fukushima Items as of end of 2015

	Kori NPPs			**Wolsong NPPs**			**Hanbit NPPs**			**Hanul NPPs**			Total
Unit	1	2	3	1	2	3	1	2	3	1	2	3	
In-Progress	6	7	5	12	6	3	6	4	5	5	5	5	69
Closed	16	7	7	14	6	23	7	7	7	7	9	7	117

III.10 Article 15. Radiation Protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

III.10.1 Laws, Regulations and Requirements Concerning Radiation Protection of Nuclear Installations

The NSA prescribes the basic matters on radiation protection to be applied to nuclear installations, as follows:

- provisions on protective measures against radiation hazards that keep the radioactive material release and the occupational radiation exposure to be as low as reasonably achievable (ALARA),
- provisions on safety measures relating to operations stipulating the necessary actions to be taken for protecting human bodies, materials, the public, and the environment from radiation hazards which may accompany the operation of nuclear installations,
- criteria for the registration of a business related to the personnel dosimetry service for any person who is employed in, or who has access to nuclear installations, and
- training requirements for radiation workers.

The Enforcement Decree of the NSA specifies the detailed requirements for implementing the basic matters on radiation protection referred to in the Act, while the Enforcement Regulations of the NSA, the Regulations on Technical Standards for Nuclear Reactor Facilities, etc., and the Regulations on Technical Standards for Radiation Safety Management, etc. include the detailed procedures and methods for executing the NSA and its Enforcement Decree as follows:

- radiation dose limits related to radiation protection (The dose limits defined by this regulation are as shown in Table III.10-1);
- detailed regulations to minimize the radiation exposure of the workers engaged in radiation work, the persons who have frequent access to nuclear installations, and the population living around the said installations;
- detailed provisions necessary for implementing protective measures against radiation hazards, such as the action to be taken for the radiation overexposure accident, and relevant reporting;
- detailed provisions necessary for implementing the radiological control measures such as criteria and access control of radiologically controlled area;

- detailed provisions on the criteria for the registration related to a license for personnel dosimetry service;
- detailed provisions on the peculiar radiation workers, such as damaging or losing the personal;
- dosimeter and those whose radiation dose measurement is more than the specified limits; and
- provisions on the legal dosimeters for radiation workers.

Article 2, Subparagraph 4 and Table 1 in the Enforcement Decree of the NSA specify the dose limits, while the NSSC Notice of Standard on Radiation Protection, etc. prescribes technical requirements such as effluent control limits.

Table III.10-1 Radiation Dose Limit

(Unit: mSv)

Classification	Effective Dose Limit	Equivalent Dose Limit	
		Crystalline	Hands, Feet and Skin
1. Radiation Worker	100 mSv for five years within the scope not exceeding 50 mSv per annum	150 mSv per annum	500 mSv per annum
2. Persons with occasional access, personnel engaging in Transport and persons under 18 with the purpose of education and training, etc. as recognized by the Commission	6 mSv per annum	15 mSv per annum	50 mSv per annum
3. Persons other than those in No1&2	1 mSv per annum	15 mSv per annum	50 mSv per annum

Note

1. Dose limit refers to the accumulative radiation dose from January 1 to December 31 (1year).
2. Despite the dose limit prescribed in the table herein, as for radiation workers subject to No. 1 & 2 and identified to be pregnant as well as those subject to No. 3 and those who use radioactive isotopes temporarily or for a limited time period shall be governed by the dose limits determined and publicly announced by the NSSC.
3. “Persons engaging in transport” in No. 2 refers to the personnel, other than those radiation workers, who transports radioactive materials outside the radiation controlled area in accordance with Article 2-12.
4. For those subject to No. 3, in case where the NSSC recognizes the exposure dose of more than 1mSv per annum, effective dose limits, despite being specified in the table above, shall be set to exceed 1mSv per annum to the extent that an average of 5 years of exposure dose does not exceed 1 mSv.
5. Five-year in effective dose in No. 1 in the table and Note No. 4 refers to the period of every five-year that begins January 1998.

※ The effective dose of the personnel of occasional access in the table was revised from 12 mSv per annum to 6mSv per annum on April 12, 2016 and the revised dose limit will be effective from January 1, 2017.

Regarding the training of radiation workers, in accordance with the nuclear safety related laws revised in August 2013, from the year of 2014, a basic training system was adopted in which a specialized institute is in charge of the education and training of radiation workers and aims at an enhanced education management, thereby preventing safety accidents from taking place. The training of radiation workers are divided into basic training and on-the-job training.

Korea Foundation of Nuclear Safety was designated as an institute dedicated to basic training in October 2013 and has carried out the basic training since 2014 in accordance with nuclear safety related laws. The basic training course is divided into two courses; one is for radiation workers and the other is for radiation safety controller. Each course is further divided into common area and radiography examination area. The training course for radiation workers are also be divided into new training and regular training. Meanwhile, on-the-job training is carried out by in-house training or by Korean Association for Radiation Application and Korea Academy of Nuclear Safety, as designated and announced as entrusted education institutes by the NSSC.

The curriculums, training hours and institutions-in-charge for basic education course and on-the job training are as follows:

Table III.10-2 Education of The Radiation Worker

Courses	Training Target	Training Areas	New/Regular	Duration of training	Training Institute
Basic Training	Radiation Workers	Common areas	New training	8	Korea Foundation of Nuclear Safety (basic education institute)
			Regular training	3	
		Radiographic examination area	New training	12	
			Regular training	5	
	Radiation safety officer	Common areas	New training	3	
		Radiography examination area	Regular training	5	
On-the-job Training	Radiation Workers	Common areas	New training	4	In-house education or entrusted education institute (Korean Association for Radiation Application, Korea Academy of Nuclear Safety)
			Regular training	3	
		Radiography examination area	New training	6	
			Regular training	5	

The government promulgated a revised NSA back in January 2015 which modified safety regulatory system of decommissioning in preparation for the decommissioning of Kori Unit 1. According to the revised act, for the purpose of safety regulation for decommissioning of nuclear facilities, decommissioning needs to be considered from the planning stage of nuclear facilities and a modified regulatory framework was formulated for different stages of nuclear facilities from permanent shutdown stage, transient stage, decommissioning stage, to end of license. In addition, when applying for CP of power reactor and research reactor, decommissioning plan should also be submitted and in case of modification of the decommissioning plan, such changes should also be reported to the regulatory body. For the approval of decommissioning, it is mandatory to submit a final decommissioning plan and matters on licensee's duty and inspection of regulatory body are already specified. Accordingly preliminary decommissioning plan is submitted and is being reviewed in the course of license review of new NPPs. Operating NPPs are also planning to submit the decommissioning plan by 2018 and receive approvals.

Kori Unit 1 is to be permanently shutdown in 2017 and KHNP, the nuclear power plant operating company, will request for an operation change for a permanent shutdown and the regulatory body is in preparation for related matters for regulation on permanent shutdown including setting the review direction for an operation change permit.

III.10.2 Implementation of Laws, Regulations and Requirements Concerning Radiation Protection of Nuclear Installations

Radiation Exposure Control and Dose Reduction

Implementation of ALARA in the Design and Construction of Nuclear Installations

The KHNP incorporates the below multifaceted radiation protection means in the design and construction of nuclear installations, for achieving ALARA and keeping the radiation doses to workers and the general public below the applicable limits.

- Radioactive equipment to be installed separately in the shielded room with a partition,
- Installation of shields to fully attenuate radiation from pipes and equipment containing large amounts of radioactivity,
- Use of remote controlled equipment and automatic equipment,
- Installation of ventilation facilities in areas of potential air contamination,
- Installation of a continuously operating radiation monitoring system in nuclear installations, and
- Appropriate zone classification and access control.

KHNP reflects the following ALARA design features in the design and construction of nuclear installation in order to facilitate the decommissioning process and to minimize radiation exposure of the decommissioning workers:

- to secure work space to facilitate the work and to provide easy access to the components during the decommissioning process;
- to install skids on integral component for easy removal during the decommissioning process;
- to utilize reliable and simple components in radioactive system and components to minimize the amount of wastes during the decommissioning process;
- to design in a way that minimizes the release of radioactive flow from radioactive components and pipes and that the leak flow is collected in the sump and processed through waste management system; and
- to arrange site connection pipe through pipe tunnel and to design in a way that leak liquid is collected in the floor drain sump and processed through liquid waste management system.

Criteria for and Operation of Radiation Exposure Control

The KHNP establishes a target dose limit for radiation workers at 80% (16 mSv) of the legal limit, as shown in Table III.10-1, and controls radiation doses to maintain within the target dose limit. It is prescribed in the procedures that any person whose annual dose reaches the target value shall not perform any more radiation work during which they are expected to be additionally exposed above the target value, unless the approval of the plant manager is given or any proper measure is taken.

Management of Radiation Work

The KHNP prescribes in the procedures that any person who intends to have access to controlled areas and to perform radiation work should obtain approval in advance in the form of a radiation work permit. The radiation work permit is prepared differently in consideration of the radiation work type, the radiation level, and the working area conditions.

For issuance of the radiation work permit, the radiation safety officer is to evaluate the expected dose in consideration of the working environment and conditions, and if necessary, to further impose any special conditions on the worker.

The KHNP has established the Radiation Safety Management (RAM) system linked with its ERP (Enterprise Resource Planning) system in 2003 to improve the efficiency and reliability of radiation management in NPPs. The computerized system is designed to manage the enrollments of workers, the access to controlled zone, the work permit, the personal dose exposure data, and the radiation level management. As a result, the KHNP can collect and manage various statistical data and hence, improve the efficiency of radiation safety management.
Additionally, remote monitoring cameras are installed in the radiation controlled area to ensure safety management in the workplace.

Dose Reduction

The KHNP sets the target values for annual collective dose, collective dose during the period of refueling outage, and the job-specific collective dose in efforts to reduce occupational radiation exposure. The KHNP prescribes in the procedures that any radiation work shall be conducted following the plan, as established before undertaking the work.

It is also prescribed that the ALARA Committee shall be held from the planning stage to estimate and evaluate the radiation level and the expected collective dose, and to further evaluate ALARA performance more than once a year, in respect of major maintenance work, design modification, and replacement of equipment. When conducting radiation work, the technique for reducing doses shall be described in the radiation work procedure or the radiation work permit. It is required for radiation workers to utilize the technique after evaluating the application result of the technique to any past work.

* Trends of radiation exposure of radiation workers in nuclear installations are shown in Table III.10-3.

Requirements for Radioactive Effluent Release during operation

KHNP removes radioactive materials by utilizing processing facility before the discharge of gaseous or liquid effluents into the environment and analyzes the sample of radioactive material before the discharge so as to release the effluents less than the prescribed effluents control limits.

In addition, it installed a monitoring device on drain or vent facilities to release effluents into the environment under a monitored and controlled condition.

Read and Verification on TLDs

KHNP, registered in NSSC to read the TLDs of radiation workers and personal radiation exposure, distributes, collects, and reads thermo-luminescence dosimeters (TLDs) and the result should be notified to the government. The calibration of the reader is conducted every six months and QA test items are implemented every year in order to verify the performance.

In accordance with the NSA, the dosimetry service providers undergo an annual regulatory inspection of quality assurance system for dosimetry facility and its management and also an annual performance inspection to verify technical ability to perform dosimetry service so as to secure objectivity and reliability in the personnel dosimetry.

Table III.10-3 Exposure Dose of Radiation Workers in Nuclear Installations

Unit: Collective Dose (man-Sv), Average Individual dose(mSv)

Dose by Unit / Year		2007	2008	2009	2010	2011	2012	2013	2014	2015
Kori Units 1&2	Collective Dose	1.92	1.46	1.05	0.76	0.42	0.86	1.10	0.48	0.86
	Average Individual dose	0.74	0.66	0.54	0.38	0.25	0.41	0.52	0.33	0.45
Kori Units 3&4	Collective Dose	0.91	1.21	1.98	0.82	1.79	1.15	1.41	1.62	1.03
	Average Individual dose	0.59	0.65	1.00	0.52	0.78	0.61	0.78	0.82	0.58
Shin-Kori Units 1&2	Collective Dose	-	-	-	0.03	0.02	0.23	0.41	0.03	0.54
	Average Individual dose	-	-	-	0.02	0.01	0.13	0.20	0.02	0.28
Hanbit Units 1&2	Collective Dose	1.96	0.94	0.88	1.38	1.20	0.69	3.34	0.83	0.85
	Average Individual dose	1.13	0.66	0.57	0.75	0.68	0.45	1.69	0.57	0.56
Hanbit Units 3&4	Collective Dose	1.19	1.62	0.77	0.79	1.50	1.19	1.22	0.79	0.77
	Average Individual dose	0.74	0.91	0.49	0.53	0.79	0.57	0.64	0.39	0.36
Hanbit Units 5&6	Collective Dose	0.38	0.78	0.58	0.60	0.71	0.98	0.36	0.79	0.78
	Average Individual dose	0.29	0.46	0.41	0.37	0.40	0.52	0.23	0.35	0.40
Wolsong Units 1&2	Collective Dose	1.84	0.89	7.51	7.64	1.22	1.42	0.80	0.52	0.92
	Average Individual dose	1.03	0.58	2.61	2.33	0.63	0.74	0.49	0.31	0.51
Wolsong Units 3&4	Collective Dose	1.36	1.48	1.32	1.08	0.85	1.13	1.16	0.98	0.80
	Average Individual dose	0.89	0.99	0.84	0.72	0.55	0.76	0.71	0.59	0.45
Shin-Wolsong Units 1&2	Collective Dose	-	-	-	-	-	0.01	0.20	0.02	0.42
	Average Individual dose	-	-	-	-	-	0.01	0.10	0.01	0.24
Hanul Units 1,2	Collective Dose	1.81	0.92	0.76	1.28	1.38	1.69	1.47	0.88	0.63
	Average Individual dose	1.14	0.61	0.47	0.66	0.63	0.81	0.87	0.60	0.43
Hanul Units 3&4	Collective Dose	0.96	0.63	1.22	1.09	1.60	0.83	0.34	0.93	0.96
	Average Individual dose	0.55	0.43	0.65	0.73	0.73	0.43	0.19	0.39	0.52
Hanul Units 5&6	Collective Dose	0.49	0.23	0.26	0.40	0.48	0.29	0.30	0.45	0.29
	Average Individual dose	0.28	0.16	0.18	0.24	0.26	0.20	0.23	0.25	0.16

Radiation Protection Training

Radiation workers having access to radiation controlled areas shall take appropriate radiation protection training courses in order to enhance individual radiation protection capability and to comply with radiation protection rules. Access to the radiation controlled area is allowed only for those who pass the evaluation of radiation protection training course to ensure their full awareness of the code of conduct when facing abnormal condition of the NPP.

In accordance with the nuclear safety related laws, there are two mandatory education courses; one is a basic education course conducted by a basic education institute designated by the NSSC and the other is on-the-job education performed as an in house training course.

National Safety Management Center for Radiation Workers

As the number of radiation workers continuously increases with the expansion of nuclear facilities and radiation related industries in the Republic of Korea, it has become necessary to systematically control occupational exposures with the ALARA principle. Thus, KINS established the National Safety Management Center for Radiation Workers, on November 27, 2002 with the support of the NSSC.

The center operates the Korea Information System on Occupational Exposure (KISOE), which is a computerized database system that enables analysis and evaluation of occupational exposures and lifetime tracking of individual worker dose. The main functions of the KISOE are as follows:

- management of radiation safety of radiation workers through analysis of individual dose,
- support of safety regulatory activities based upon radiation risk information,
- calculation of quantitative indicators for radiation safety management and for verification of the effectiveness of radiation safety regulation,
- creation of basic data for managing radiation exposure of radiation workers, and
- establishment of an information network system related with international databases such as ICRP, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and Information System on Occupational Exposure (ISOE) of OECD/NEA.

The MEST (then regulatory body) has authorized the Korea Radioisotopes Association (KRIA) to establish and operate the Radiation Workers Information System (RIS) since August 2005. The RIS can synthetically and perpetually manage the radiation exposure, health medical examination, and education & training. In 2013, the business performed by the KRIA was transferred to Korea Foundation of Nuclear Safety, which has operated Radiation Worker Information Service System (RAWIS) since February 2016. Compared to RIS, RAWIS provides significantly improved function and user convenience with information including real-time exposure dose of radiation workers and SMS alarm service to those workers whose exposure does are reaching to the dose limits.

The NSSC has strengthened safety management of radiation workers through close connection with KISOE controlled by the KINS.

Discharge of Radiological Material

The Enforcement Decree of the NSA and the NSSC Notice (Standards for Radiation Protection, etc.) prescribe effluents control limits of gaseous and liquid radioactive effluents to be released from nuclear installations into the environment, along with the annual dose constraints of the population living around nuclear installations.

The dose constraints for gaseous effluent on the exclusion area boundary by a unit of nuclear power plant, which are specified in the NSSC Notice, are as follows:

- air absorbed dose by gamma rays : 0.1 mGy/yr
- air absorbed dose by beta rays : 0.2 mGy/yr
- effective dose from external exposure : 0.05 mSv/yr
- skin equivalent dose : 0.15 mSv/yr
- organ equivalent dose from internal exposure to particulate radioactive substance, H-3, C-14, and radioiodine : 0.15 mSv/yr

The dose constraints for liquid effluents on the exclusion area boundary by a unit of nuclear power plant are as follows:

- effective dose : 0.03 mSv/yr
- organ equivalent dose from internal exposure : 0.1 mSv/yr

The annual dose constraints on the exclusion area boundary per site in operating multiple units within the same site are as follows:

- effective dose : 0.25 mSv/yr
- thyroidal equivalent dose : 0.75 mSv/yr

According to this, the KHNP discharges gaseous or liquid effluents into the environment after confirming that the released effluents is less than the prescribed effluent control limits through sample analysis. The trend of annual release of liquid and gaseous effluents per site and off-site dose is shown in Table III.10-4.

Table III.10-4 Trend of Annual Release of Liquid and Gaseous Effluents per Site and Off-site Dose

Unit : TBq

Site	Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Kori	Liquid	1.77E+01	2.82E+01	3.20E+01	3.28E+01	4.94E+01	6.19E+01	3.87E+01	3.97E+01	6.88E+01
	Gaseous	3.17E+01	1.75E+01	1.48E+01	1.37E+01	1.48E+01	1.74E+01	2.15E+01	2.08E+01	2.33E+01
	Off-site Dose (mSv)	1.51E-02	4.60E-03	2.26E-03	1.52E-03	1.71E-03	4.18E-03	4.55E-03	2.68E-03	6.68E-03
Hanbit	Liquid	5.09E+01	8.95E+01	7.58E+01	7.03E+01	5.70E+01	7.81E+01	3.54E+01	3.71E+01	4.52E+01
	Gaseous	2.67E+01	4.64E+01	1.71E+01	1.24E+01	1.11E+01	1.08E+01	1.80E+01	1.86E+01	1.44E+01
	Off-site Dose (mSv)	6.04E-03	9.57E-03	4.33E-03	2.74E-03	2.71E-03	1.61E-02	5.84E-03	8.01E-03	8.34E-03
Hanul	Liquid	5.61E+01	3.92E+01	4.48E+01	4.89E+01	5.84E+01	4.45E+01	3.41E+01	5.39E+01	5.10E+01
	Gaseous	6.66E+00	5.63E+00	8.78E+00	1.03E+01	1.10E+01	1.27E+01	1.31E+01	1.27E+01	1.36E+01
	Off-site Dose (mSv)	2.09E-03	1.90E-03	2.09E-03	3.33E-03	3.33E-03	1.57E-02	1.21E-02	2.61E-02	2.10E-02
Wolsong	Liquid	1.38E+02	1.15E+02	1.64E+02	1.43E+02	9.21E+01	1.23E+02	6.92E+01	4.84E+01	2.57E+01
	Gaseous	3.87E+02	3.64E+02	2.89E+02	2.16E+02	1.93E+02	1.64E+02	1.48E+02	1.53E+02	1.45E+02
	Off-site Dose (mSv)	5.79E-03	8.31E-03	7.07E-03	6.96E-03	4.85E-03	2.24E-02	2.86E-02	1.05E-01	4.46E-02
Total	Liquid	2.62E+02	2.72E+02	3.16E+02	2.95E+02	2.57E+02	3.08E+02	1.77E+02	1.79E+02	1.91E+02
	Gaseous	4.52E+02	4.34E+02	3.30E+02	2.52E+02	2.29E+02	2.05E+02	2.00E+02	2.05E+02	1.96E+02

*Source: Report of Survey for Environmental Radiation around NPPs, etc.

▶▶ Assessment of Radiation Doses to the Population around Nuclear Installations

The KHNP assesses the radiation dose and its effect on the population around nuclear installations using the Off-site Dose Calculation Manual (ODCM) based upon the amount of released liquid and gaseous effluents by type, atmospheric conditions, human body metabolism, as well as the daily life data such as the amount of agricultural, livestock and maritime products intakes in the local community in the radius of 80km. It reports the assessment results to the NSSC in conformity with the NSSC Notice (Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities).

The NSSC is reviewing the reports on survey of radiation environment and assessment of radiological impact on environment for the first half and the entire year that were submitted in conformity with Article 10 (Reporting) of the aforementioned NSSC Notice.

III.10.3 Regulatory Control Activities

The regulatory activities for radiation protection are classified into safety reviews, regulatory inspections, and development of technical standards. In the safety review, items are examined regarding ALARA assurance of radiation exposure to workers, source term assessment, characteristics of radiation protection design, occupational dose assessment, health physics program, the appropriateness of radiation protection equipment and radiation (radioactivity) monitoring equipment, and assessment of the impact of radioactive effluents on environment. The regulatory inspection confirms whether or not the radiation monitoring system in nuclear installations is appropriately operated. It also confirms that any personal exposure to radiation is maintained as low as reasonably achievable by checking the health physics program, the procedures for the radiation exposure control, the ALARA program, and the radiation work management.

In November 2015, an amendment of the NSA, Article 20 (Operating License) was passed in the plenary session of the National Assembly to add discharge plan on liquid and gaseous radioactive materials to the application documents for OL and will be effective from December 2016. The discharge plan needs to include total amount of effluents by period and nuclides and the operator of the NPP shall operate the facility not to exceed the total amount of effluents specified in the discharge plan. Following the revision of the law, it is expected that the control on liquid and gaseous radioactive materials will be strengthened.

III.11 Article 16. Emergency Preparedness

1. *Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.*

2. *Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.*

3. *Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.*

III.11.1 Laws, Regulations, and Requirements

Radiological emergency preparedness is based on the Act on Physical Protection and Radiological Emergency of Nuclear Installations, etc. (APPRE), which stipulates the system of managing radiological emergency, as well as Framework Act on Civil Defense and the Basic Act of Disasters and Safety Control, which stipulate the system of national response against disasters of various kinds. Especially, APPRE, legislated in May 2003 and came into force in February 2004, stipulates overall radiological emergency management affairs including: prevention of, preparedness for, and response to radiological emergency; radiological emergency medical treatment; and international cooperation.

Pursuant to APPRE, the NSSC formulates a National Radiological Emergency Plan every five years, which is interlinked with Basic Plan for National Safety Management established based on the Basic Act of Disasters and Safety Control. Each year the NSSC prepares a National Radiological Preparedness Plan which is an yearly implementation plan for radiological preparedness, and local governments with relevant jurisdiction over all or a part of an emergency planning zone make their own radiological preparedness plan every year in accordance with the Basic Plan for National Safety Management and the National Radiological Preparedness Plan. The Nuclear licensee also establishes Radiological Emergency Plan and obtain an approval of its plan from the NSSC for operation.

For preparation against radiological emergency, the Enforcement Decree of APPRE prescribes that a nuclear licensee shall submit a radiological emergency plan containing the items as below. The detailed standards for each of the item are specified in the NSSC Notice 2014-82 (Radiological Emergency Preparedness for Nuclear Licensee). The Notice was formulated in 1996 and revised in August 1998, August 2003, June 2004, April 2008, September 2009, November 2011, and January 2012, and November, 2014. With recent revision, the Notice reflected modification and expansion of radiation emergency plan zones and changes in cycle of Radiological Emergency Exercise.

It contains the following:

- the emergency planning zone and general provisions,
- the duties and organization of emergency preparedness organizations,
- the criteria for announcement of radiological emergency,
- the emergency response facilities,
- the response activities for emergency, and
- the maintenance and management of emergency response capabilities.

APPRE defines nuclear facilities as a nuclear power reactor, nuclear reactor for research, nuclear fuel cycling facilities, storage/processing/disposal facilities of radioactive wastes, utilization facilities of nuclear materials and other facilities related with the use of nuclear energy and those who obtain CP and OL of the nuclear facilities as nuclear licensee. Hence, nuclear licensees such as operators of NPPs and of facilities related to spent fuel and radioactive wastes are required to perform emergency response activities in case of radiation emergency or disasters in accordance with the Radiological Emergency Plan rightly approved by the rules and requirements mentioned above.

The NSSC carries out an inspection on the licensee's duties, facilities and equipment to respond to radiological disaster, radiological emergency education and radiological emergency exercise in accordance with the NSSC Notice (Regulation on Inspection for Radiological Emergency of Nuclear Licensee). The scope of inspection is as follows:

- Checking/verifying the nuclear licensee's performance of obligations,
- Checking/verifying the nuclear licensee's provision of facilities or equipment for responding to radiological emergency,
- Checking/verifying the nuclear licensee's radiological emergency education, and
- Checking/verifying the nuclear licensee's radiological emergency exercise.

Where major content of radiological emergency plan is modified and its implementation needs to be confirmed and verified or where radiation emergency is highly likely to occur due to an accident and failure, the NSSC may carry out an additional inspection against the relevant nuclear licensee.

In order to carry out effective resident protective measures based on their distance from the nuclear installations, APPRE was revised in May 2014 to divide radiation emergency plan zone (EPZ) into precautionary action zone (PAZ) and urgent action planning zone (UPZ) by reflecting upon IAEA standard. Centering on power reactor and related facility, EPZ was set in a radius of 3-5 km and UPZ in a radius of 20-30 km. Subordinate statues were also revised to set EPZ considering regional characteristics such as roads and topography.

III.11.2 Implementation of Emergency Preparedness Measures

In order to confirm emergency response capability of the nuclear licensee, central government and local government in case of radiation emergency, radiological emergency exercise is carried out every year based on National Radiological Preparedness Plan backed by National Radiological Emergency Plan. The exercise planned by the National Radiological Preparedness Plan is to confirm the management framework against radiological disasters and to evaluate the category of emergency and the response, resident protective measures, disaster protective facilities, obtainments and availability of equipment, and training and exercise.

Classification of Emergency Situation

Radiological emergencies at a nuclear installation site are classified into white emergency (alert), blue emergency (site area emergency), and red emergency (general emergency) according to the severity of accident. The NSSC is, however, pushing forward to change from the current color based classification into facility emergency, on-site emergency and off-site emergency considering the international terminology and the meaning of emergency in order to ensure explicit delivery of their meaning.

- **Facility Emergency(Alert)** : Events are in progress or have occurred which involve actual or potential substantial degradation of the safety level of nuclear installations. The release of radioactive material is expected to be limited within the structures of the nuclear installation.

- **On-site Emergency(Site Area Emergency)** : Events are in progress or have occurred which involve actual or likely failures of major safety functions due to the degradation of the recovering function to safety condition. The release of radioactive material is expected to be limited within the boundary of the nuclear installation.

- **Off-site Emergency(General Emergency)** : Events are in progress or have occurred which involve actual or substantial core degradation or melting with the potential for loss of the last barrier integrity, thus anticipating a large release of radioactive material beyond the boundary of the nuclear installation.

It is stipulated in the APPRE that, in case of radiological emergency subject to Facility Emergency (Alert)/ On-site Emergency (Site Area Emergency)/ Off-site Emergency (General Emergency) in nuclear installations, the operator shall report the emergency situation to the NSSC and local governments, in accordance with the procedure defined in the Radiological Emergency Plan (method, time and content of the report) which is approved by the NSSC.

Radiological Emergency Response Scheme

The radiological emergency response scheme is composed of National Emergency Management Committee which is chaired by the Chairman of the NSSC, Off-site Emergency Management Center (OEMC), Local Emergency Management Center (LEMC), Radiological Emergency Technical Advisory Center of KINS, National Radiation Emergency Medical Center of Korea Institute of Radiological and Medical Sciences (KIRAMS), and Emergency Operations facility of the nuclear operator as shown in Figure III.11-3.

The NSSC has a responsibility to control and coordinate the countermeasures against radiological disaster. When a radiological emergency occurs (on-site emergency and above), the NSSC operates Central Safety Management Committee in which 18 central government offices and two specialized institute participate as members of the committee meeting to initiate a practical pan-governmental response system. The NSSC installs and operates the OEMC, which is chaired by the standing member (Secretary General) of the NSSC. It consists of experts from the central government; local governments; local military and police; fire-fighting and educational institutes; nuclear safety expert organizations, radiological medical service institutes; and the personnel dispatched by the licensees. The OEMC has a responsibility to perform coordination and management of radiological emergency response such as accident analysis, radiation (radioactivity) detection, and decision-making on public protective actions (sheltering, evacuation, food restriction, distribution of thyroid protection medicine, and control of carrying-out or consumption of agricultural, live stock and fishery products). OEMC is composed of six working divisions and Joint Emergency Preparedness Consultative Body is installed as an advisory organization to facilitate the decision-making process of the leader. Meanwhile Joint Information Center is also operated to ensure that the information is delivered in a clear and consistent way.
The LEMC, established by the local governments concerned, implements the OEMC's

decision on protective measures for residents. It also takes charge of coordination and control of emergency relief activities utilizing local fire stations, police stations and military units.

When an accident occurs, the KHNP, the licensee of nuclear installation, is responsible for organizing an Emergency Operation Center and for taking measures to mitigate the consequences of the accident, to restore installations, and to protect the on-site personnel. The central government established and has operated the national radiological emergency medical treatment system for coordination and control of radiological medical services. The national radiological emergency medical treatment system consists of KIRAMS' Radiological Emergency Medical Center and 23 primary/secondary radiological emergency medical centers.

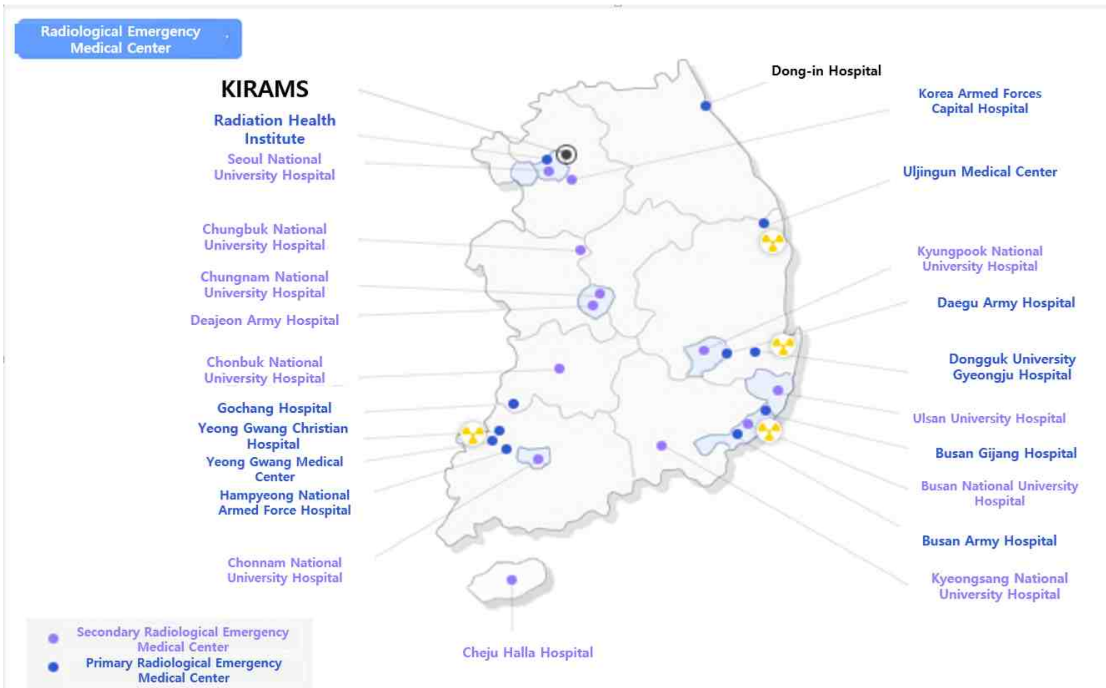


Figure III.11-1 List of Radiological Emergency Medical Centers

KIRAMS establishes National Radiation Emergency Medical Center in case of radiological disaster to take an overall management in radiation emergency medical activities including advice on medical relief, technical support and medical treatment on those who have radiation damage or are likely to have radiation damage. The national Radiation Emergency Medical Center dispatches a field medical support team to establish and operate a joint radiation emergency medical center and support the installation and operation of field radiation emergency medical clinics. For effective medical response and interactive support during a disaster, various cooperative treaties were singed and came into effect with competent entities including chemical, biological, and radiological protection command (CBRPC), armed forces medical command (AFMC), National 119 Rescue Services, Radiation Health

Institute, and National Medical Center domestically and internationally with NIRP (National Institute of Radiological Protection) of China, NIRS (National Institute of Radiological Sciences) of Japan, FMBA (Federal Medical and Biological Agency) of Russia, IRSN (Institute for Radiological Protection and Nuclear Safety) of France, RCRM (Research Center for Radiation Medicine) of Ukraina, and Hirosaki University of Japan.

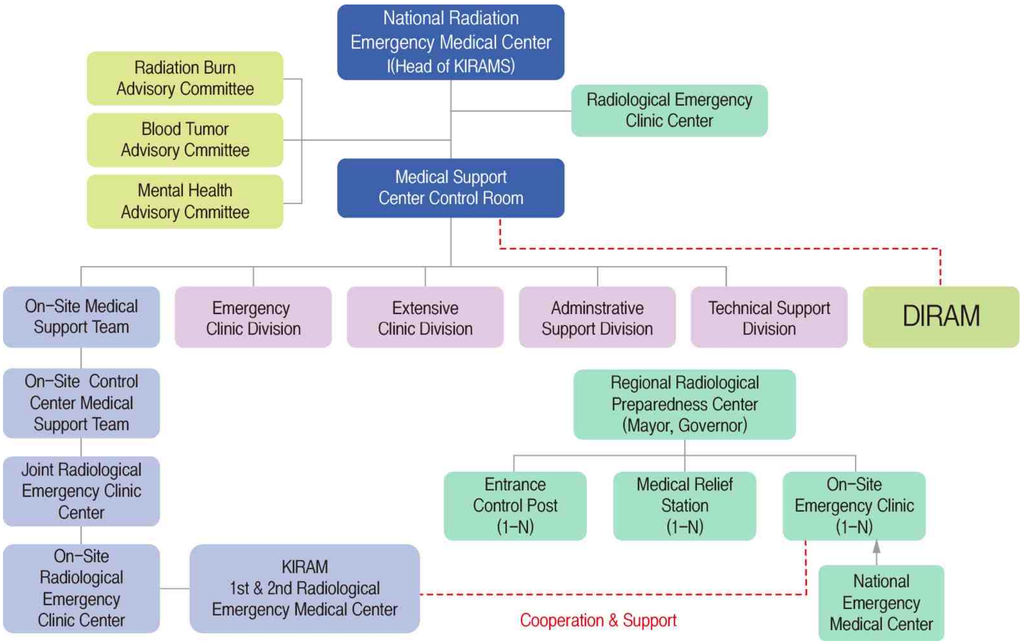


Figure III.11-2 Radiation Emergency Medical Response Framework

KINS organizes Radiological Emergency Technical Advisory Center, which is in charge of providing technical advice on radiological emergency response, analysis and assessment of accident, dispatching technical advisory teams to the affected site, initiating emergency operation of 134 nation-wide environmental radioactivity monitoring stations, assessment on environmental radiation/radiological and radiation impact. KINS has an agreement with the Nuclear/Biological/Chemical Defence Command for prompt response in the initial phase of a radiological emergency. IT also developed the Atomic Computerized Technical Advisory System for a Radiological Emergency (AtomCARE). Currently the system is operated in order to effectively provide various technical supports for the public and environment protection in radiological emergencies. The AtomCARE enables not only the rapid analysis and evaluation of radiological emergencies and radiation impacts but also the comprehensive management of information about several measures to protect the public. Its configuration is represented in Figure III.11-4.

AtomCARE receives key operation parameters of NPPs from Safety Information Display System (SIDS), weather information from Radiological Emergency Management Data Acquisition System (REMDAS) and environmental radiological information from Integrated Environmental Radiation Network (IERNet). Based on the information provided, Automatic

Information Notification System (AINS) provides emergency personnel in emergency preparedness area with information and alarm in case of emergency. When core damage occurs, Source Term Evaluation System (STES) estimates source terms by calculating the severity of core damage, discharge path, and the amount of discharge. Accident Dose Assessment Model (ADAMO) which is enhanced model than the existing one (FADAS) assesses the radiation exposure impact within a radius of 100Km. To effectively support resident preventive measures, Geographic Information System (GIS) provides information with relevant organizations including wind flow by site, resident evacuation path, evacuation status, disaster protective facilities by region, and the spread of population and cars. Meanwhile, in case of accident, nuclear licensee, local government, and regulatory body utilize Emergency Response Information exchange system (EPIX) for prompt response to the accident and also for effective information exchange.

Following the Fukushima Daiichi Accident, it was required that radiation emergency planning zone needed to be expanded and assessment on nation-wide exposure dose became necessary in case of an radiation leakage accident. As a result, Accident Dose Assessment Model (ADAMO) was developed in 2015 and started its operation in 2016.

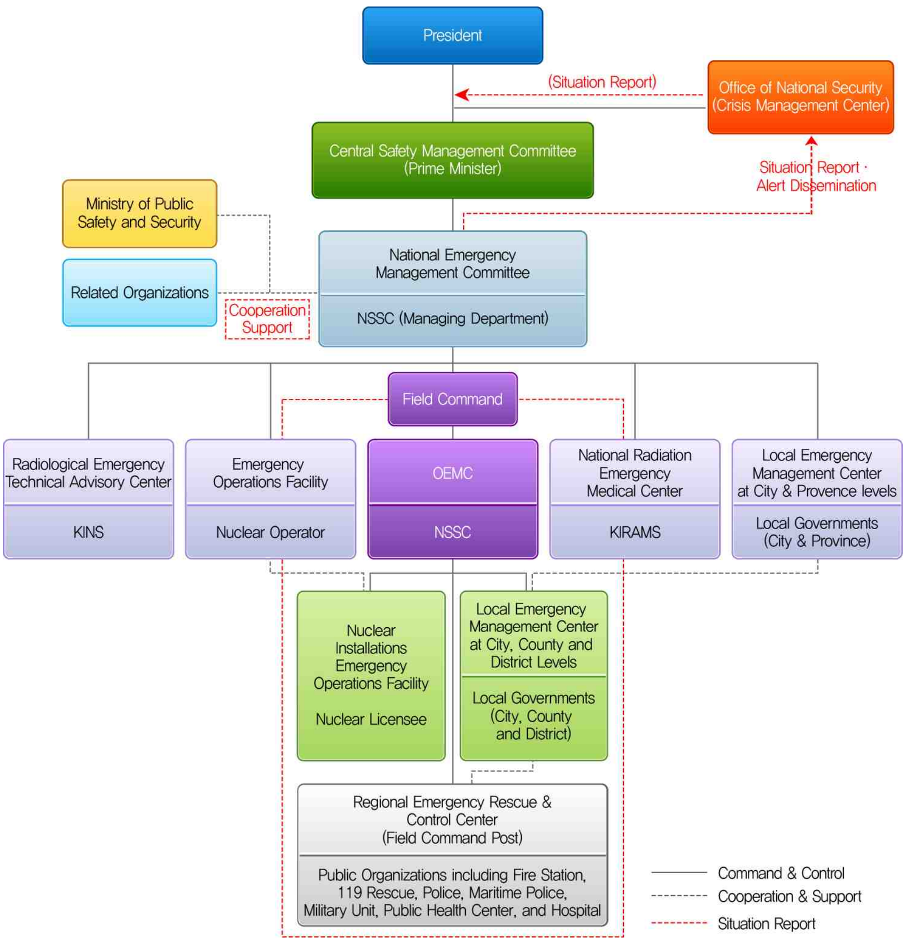


Figure III.11-3 National Radiological Emergency Preparedness Scheme

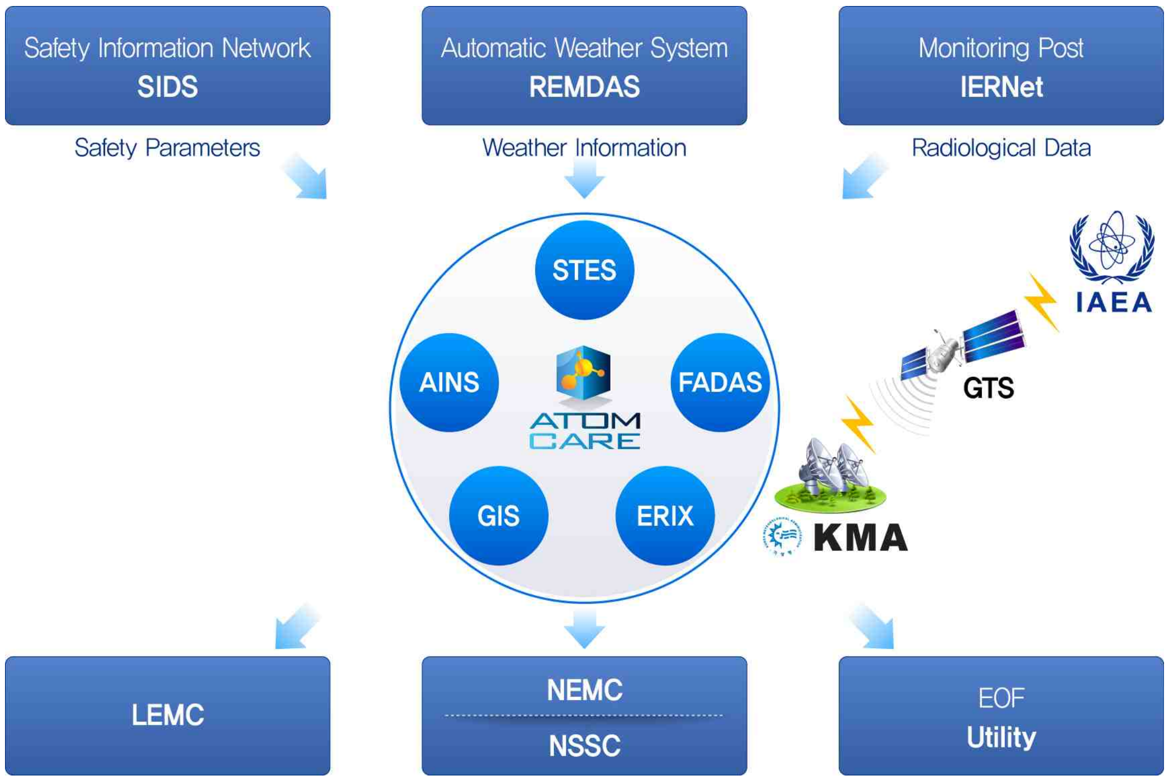


Figure III.11-4 Atomic Computerized Technical Advisory System for the Radiological Emergency (AtomCARE)

- SIDS : Safety Information Display System
- IERNet : Integrated Environmental Radiation Network
- REMDAS : Radiological Emergency Management Data Acquisition System
- AINS : Automatic Information Notification System
- STES : Source Term Evaluation System
- ADAMO : Accident Dose Assessment Model
- GIS : Geographic Information System
- ERIX : Emergency Response Information eXchange system
- KMA : Korea Meteorological Administration
- GTS : Global Telecommunication System
- LEMC : Local Emergency Management Center
- NEMC : National Emergency Management Committee
- EOF : Emergency Operations Facility
- NSSC : Nuclear Safety and Security Commission

Protective Measures

In order to carry out effective resident protective measures radiation, emergency plan zone (EPZ) was expanded from 8-10 km to 20-30 km and further divided into precautionary action zone (PAZ) and urgent action planning zone (UPZ). As a result, the residents living PAZs can be provided with prompt and effective protective measures when radioactive materials are released. Local government designates public buildings in different regions as aid stations in advance, considering estimated population of evacuation, estimated time, and distance for evacuation of the residents living in PAZ. In case of an accident, relevant actions of sheltering and evacuation are carried out based on the decision of the OEMC.

Considering the special aspects of radiological accident, the local government and the nuclear installation operator must jointly alert the population living within a radius of 5 km from the nuclear installation. The operators of nuclear installations are responsible not only to report emergency situations to the organizations concerned, but also to provide the local government with advice and consultation on protective measures at the early phase of the accident.

When an emergency situation occurs, to prevent the thyroid exposure from radioactive iodines, the local government retains potassium-iodide for emergencies and maintains a distribution system. The KHNP has made agreements with designated hospitals near the site of nuclear installations for prompt medical service in case of radiological accident, and established the Radiation Health Research Institute which conducts research activities and incorporate the results into radiation and health physics. The institute also provides the radiological emergency medical service and the medical examination for nuclear workers.

The Director of the OEMC has a responsibility to decide on the measures to control the ingestion of contaminated foodstuffs. The Director of the NEMC and the operator of the nuclear installation shall give utmost support to the Director of the LEMC in making decisions on relevant measures. In order to secure a stable life of the population, it is necessary for the central government and the local governments to devise short-term food substitute, secure an emergency water supply system, and take long-term response against a prolonged emergency.

Measures for Publicity

The central government and the local governments have provided information to the public in the vicinity of the nuclear installation on nuclear disasters, evacuation routes, evacuation centers, emergency communication, and protective action guides through pamphlets, video materials, various publicity materials, and civil defense education.

Emergency Facilities and Equipment

The operator of nuclear installations must prepare emergency response facilities such as the Emergency Operations Facility (EOF), the Technical Support Center (TSC) and the Operational Support Center (OSC). The operator is also required to set up the Plant Data Acquisition System through which information is provided to the NSSC and KINS.

The operator of nuclear installations shall keep and manage equipment required by each emergency organization for the measurement and analysis of radioactivity. The operator also provides off-site emergency organizations with radioactivity measuring and analyzing equipment to perform an emergency response.

The emergency response capability and the radiological emergency response facilities of nuclear power plant are continuously checked through the periodic inspections by regulatory body and, if necessary, they are complemented.

III.11.3 Environmental Radiation Monitoring

The KHNP conducts environmental radiation monitoring activities including the environmental impact assessment based on the environmental survey plan which establishes the quality control, guideline of environmental survey and the handling of survey data. These activities are in accordance with the NSSC Notice No. 2013-04, Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in vicinity of Nuclear Power Utilization Facilities.

The environmental radiation monitors are installed at about 10 stations within a 30 km radius of nuclear installations, in consideration of topography, population distribution, and atmospheric dispersion factors, and continuously monitor the gamma exposure dose rate 1 meter above the ground. The monitoring system status and the radiation dose levels can be confirmed, on real time basis, in the environmental radiological laboratory and the main control room where the monitors are connected on-line. TLDs are installed at 26 to 41 posts at each NPP site for measuring and assessing quarterly the cumulative gamma radiation dose within a 30 km area around nuclear installations. The sampling points in the neighboring environment are selected with due consideration of population distribution, meteorological condition, and geographical features of the area within 30 km. The samples are, inter alia, airborne particles, land samples (soil, pine needles), water samples (seawater, underground water, precipitation), seabed samples (sediment, benthos), and food samples (milk, fishes and shellfish, cereal, seaweed). The sampling intervals are indicated in Table III.11-2.

Meanwhile, KINS has separately performed environmental monitoring activities for quality control and verification of environmental monitoring activities of the operator. The environmental samples, analyzed items, analysis frequency and number of sampling locations are shown in Table III.11-3.

Table III.11-1 Environmental Radiation Monitoring in the Vicinity of NPPs

Items				Frequency		No. of locations (samples)							
Sample	Media		Monitoring Item	Sampling	Analysis	Kori		Wolsong		Hanbit		Hanul	
Air	Air dose rate		Gamma ray dose rate (ERMS)	Continuous	Monthly	16		16		10		13	
			Gamma ray dose rate (TLD)	Continuous	Quarterly	41	(164)	37	(148)	26	(104)	35	(140)
Land	Air	Dust	Gross β	Continuous	Weekly	10	(520)	10	(520)	10	(520)	10	(520)
		Particles, Gas	^{131}I		Weekly	10	(520)	10	(520)	10	(520)	10	(520)
		Dust	γ radionuclides		Monthly	10	(120)	10	(520)	10	(120)	10	(120)
		CO2	^{14}C		Monthly		-	3	(36)		-		-
		Moisture	^{3}H		Semimonthly		-	10	(240)		-		-
	Drinking Water		^{3}H, γ radionuclides	Quarterly	Quarterly	4	(16)	4	(16)	2	(8)	3	(12)
	Ground water		^{3}H, γ radionuclides	Quarterly	Quarterly	3	(12)	4	(16)	2	(8)	3	(12)
	Surface Water		^{3}H, γ radionuclides	Monthly	Monthly	4	(48)	5	(60)	2	(24)	3	(36)
	Rainfall		Gross β, ^{3}H, γ radionuclides	Monthly	Monthly	5	(60)	8	(96)	4	(48)	5	(60)
	River Sediments		γ radionuclides	Quarterly	Quarterly	5	(20)	3	(12)	2	(8)	3	(12)
	Soil		γ radionuclides(including ^{131}I)	Semi-annual	Semi-annual	5	(10)	4	(8))	5	(10)	6	(12)
			^{90}Sr			2	(4)	2	(4)	2	(4)	2	(4)
	Milk		γ radionuclides(including ^{131}I)	Monthly	Monthly	2	(24)	2	(24)	2	(24)	1	(12)
			^{90}Sr	Monthly	Quarterly	2	(8)	2	(8)	2	(8)	1	(4)
			^{14}C, ^{3}H	Monthly	Quarterly		-	2	(8)		-		-
	Farm Products		γ radionuclides	The harvesting season	Once or twice a year	11	(14)	11	(14)	12	(12)	8	(10)
			^{90}Sr			6	(8)	6	(8)	8	(8)	8	(10)
			^{14}C, ^{3}H3)				-	8	(10)		-		-
	Surface Organism		γ radionuclides(including ^{131}I)	Semi-annual	Semi-annual	7	(14)	8	(16)	8	(16)	6	(12)
			^{90}Sr			2	(4)	3	(6)	2	(4)	2	(4)
	Meat		γ radionuclides	Semi-annual	Semi-annual	2	(4)	2	(4)	2	(4)	2	(4)
			^{14}C, ^{3}H3)				-	2	(4)		-		-
Sea	Seawater		Gross β	Weekly2)	Monthly	11	(132)	6	(72)	3	(36)	5	(60)
			^{3}H			13	(156)	6	(72)	4	(48)	5	(60)
			γ radionuclides		Quarterly	13	(52)	6	(24)	4	(16)	5	(20)
			90Sr			3	(12)	3	(12)	2	(8)	3	(12)
	Marine Sediments		γ radionuclides	Semi-annual	Semi-annual	11	(22)	8	(22)	4	(8)	5	(10)
			^{90}Sr			3	(6)	3	(6)	2	(4)	3	(6)
	Fish and Invertebrates		γ radionuclides(including ^{131}I)	Semi-annual	Semi-annual	12	(24)	15	(40)	9	(18)	10	(20)
			^{90}Sr			6	(12)	6	(12)	4	(8)	6	(12)
	Benthos		γ radionuclides	Semi-annual	Semi-annual	7	(14)	5	(10)	3	(6)	5	(10)
	Seaweeds		γ radionuclides(including ^{131}I)	Semi-annual	Semi-annual	8	(16)	7	(18)	4	(8)	5	(10)
			^{90}Sr			3	(6)	3	(6)	2	(4)	3	(6)

Table III.11-2 KINS Plan to Investigate Environmental Radiation in the Vicinity of Atomic Energy Facilities

Sample			Item	Frequency	No. of Locations
Radiation Monitoring	Gamma ray dose rate (ERMS)		Gamma ray dose rate (ERMS)	Continuos	1 around each NPP
	Gamma ray dose rate (TLD)		Gamma ray dose rate (TLD)	Quarterly	12 for each site
Radiation Analysis	Enviro nment	Soil	γ radionuclides, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, $^{240Pu/239}$Pu atomic percent U radionuclides	Semi-annual Semi-annual Annual	5 for each site for each site at Daedeok
		Marine sediments River sediments	γ radionuclides, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{240}Pu/^{239}Pu atomic percent U radionuclides	Semi-annual Annual Annual	2 to 6 for each site 2 to 6 for each site 2 at Daedeok
		Air	^{3}H, ^{14}C	Monthly	2 around Wolsong NPP
		Pine needles	^{3}H, ^{14}C	Monthly	2 around Wolsong NPP
	Water	Seawater	γ radionuclides, ^{3}H, ^{90}Sr, $^{239+240}$Pu, ^{240}Pu/^{239}Pu atomic percent	Quarterly Semi-annual	3 to 8 around intake and drainage (excluding Daedeok)
		Ground water	γ radionuclides, ^{3}H	Semi-annual	2 for each site
		Surface water	γ radionuclides	Quarterly	1 at Daedeok
		Rainfall	γ radionuclides, ^{3}H	Monthly	2 at Daedeok Meteorological observatory at each NPP (for Wolsong, 6 at intervals)
	Food	Milk	γ radionuclides γ radionuclides ^{90}Sr ^{3}H, ^{14}C	Quarterly Monthly Semi-annual Monthly	1 stock farm for each NPP site 1 stock farm at Daedeok 1 stock farm at each site 1 stock farm around Wolsong NPP
		Cabbage	γ radionuclides	Annual	2 for each site
		Rice	γ radionuclides	Annual	2 for each site
	Sea	Fish	γ radionuclides	Semi-annual	2 to 3 for each site (excluding Daedeok)
		Seaweeds	γ radionuclides	Semi-annual	2 to 3 for each site (excluding Daedeok)

KINS is continuously monitoring nationwide environmental radiation and dose rates and also it monitors routinely the radiation contamination of airborne particles, fallouts, rain, farm products, soil, water and milk for early detection of abnormal situation or symptoms and also for a timely response to them. KINS has also been operating Automated National Environmental Monitoring Network since 1997. A total of 134 radiation monitoring stations are interconnected to the central monitoring station at KINS on this network (Figure III.11-3). KINS annually provides training and education program to the technicians working at local radiation monitoring stations and conducts inter-comparison analysis with foreign institutes periodically for improving the quality of radiation monitoring.

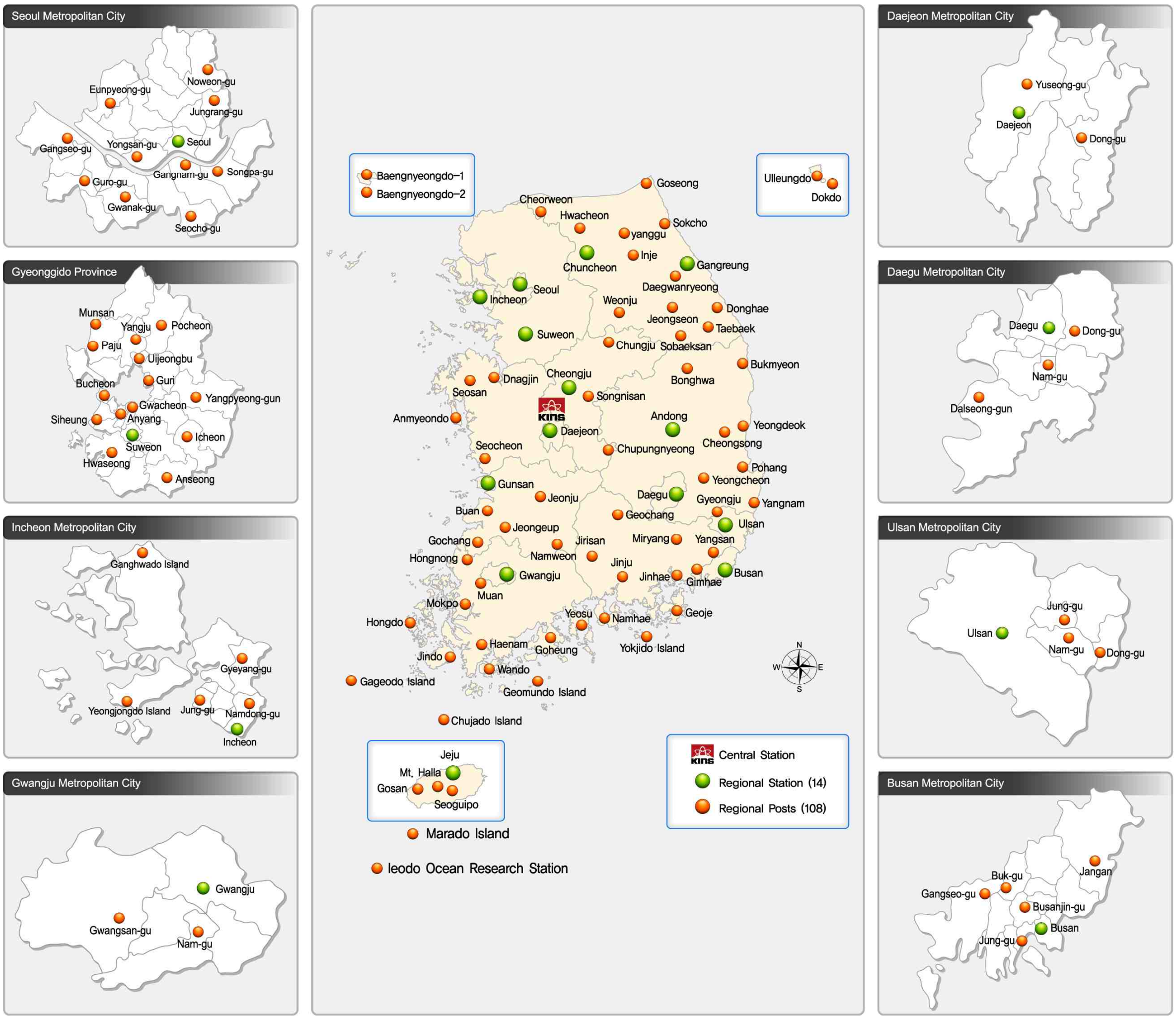


Figure III.11-5 National Environmental Radiation Monitoring Network

KINS conducts radiation analysis for ^{137}Cs, ^{3}H, ^{90}Sr, and $^{239+240}Pu$ after taking surface seawater samples at 21 designated points (eight points at the East Sea, seven at the South Sea and six at the West Sea) four times a year as shown in Figure III.11-6. At some points, seawater from different depth, maritime organism (fish, shells and seaweeds) and seabed sediments are also analyzed.

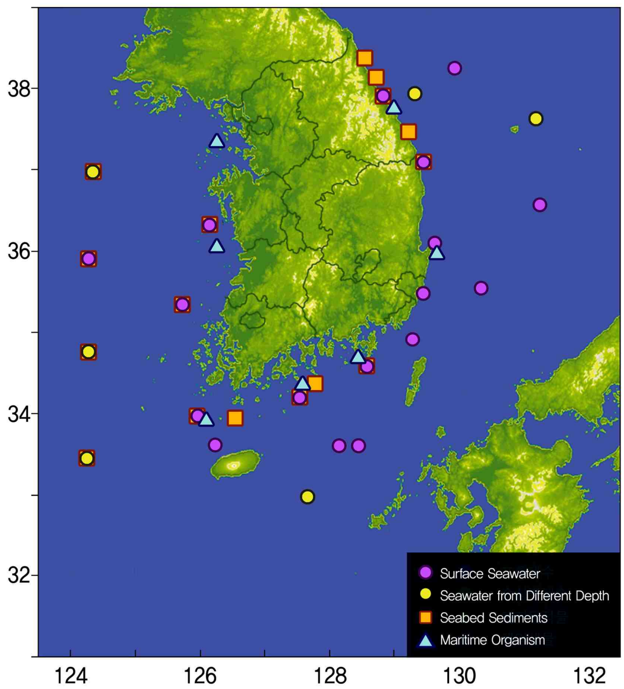


Figure III.11-6 Maritime Radiation Monitoring Network

TLDs are installed at 26 to 41 posts at each NPP site for measuring and assessing quarterly the cumulative gamma radiation dose within a 30 km area around nuclear installations. The sampling points in the neighboring environment are selected with due consideration of population distribution, meteorological condition, and geographical features of the area within 30 km. The samples are, inter alia, airborne particles, land samples (soil, pine needles), water samples (seawater, underground water, precipitation), seabed samples (sediment, benthos), and food samples (milk, fishes and shellfish, cereal, seaweed).

Mostly, the measurement results of environmental radiation are similar to those of background radiation in the Republic of Korea. In measuring environmental radiation, due to the consequence of nuclear test in the past and nuclear accident in neighboring country, ^{137}Cs and ^{90}Sr were detected within normal variation range across the nation including the areas in vicinity of NPPs.

III.11.4 Training and Exercises

The operator of nuclear installations shall periodically conduct repeated training and exercises for emergency personnel to qualify them by providing thorough knowledge of emergency duties. International Nuclear Safety School of KINS, Nuclear Training Center of KAERI and Human Resource Development Institute of the KHNP operate training courses on emergency preparedness for personnel involved in an emergency response.

KIRAM operates and implements the training and exercise for radiological emergency medical treatment on emergency medical personnel designated by the heads of 23 primary/secondary radiological emergency medical centers.

Radiological emergency medical treatment training which divides into new training and refresher training instructs matters on laws concerning radiological preparedness, general matters, radiation protective actions and radiological emergency medical treatment.

In addition, the personnel from KIRAM and radiological emergency medical centers are required to participate in a combined exercise as well as a joint exercise organized by local government. Those personnel have made effort to improve their emergency response capability by taking part in intensive exercise for emergency medical treatment and for enhanced response against radiological accident organized by regions and organizations.

According to the APPRE, radiological emergency training is comprehensively managed at a national level. In that sense, KINS has conducted the regulatory inspection of radiological emergency training programs in radiological emergency educational institutes. To support the implementation of comprehensive and systematic radiological emergency training, the NSSC Notice on Education for Radiological Emergency Preparedness specifies the designation and notification of radiological emergency staff, establishment of training programs, method of training and other necessary details.

After the expansion of EPZ in May 2014 in accordance with the revised APPRE, the NSSC pushed forward its follow-up measures by revising Enforcement Decree in November 2014, in which the joint exercise of radiological preparedness organized by local governments shall take place by NPP site once in two years instead of once in four years and intensive exercise shall be newly introduced including resident protective measures by sector. In addition, emergency preparedness exercise has been further strengthened by initiating a massive combined exercise participated by central government once a year instead of once in five years.

Emergency exercises are held, in which on-site and off-site emergency preparedness organizations must participate, as follows:

- unified exercises, in which the emergency organizations of nuclear installations, off-site emergency organizations, and central and local governments shall participate, are held under the supervision of the NSSC on a national level once every five years;
- integrated emergency exercises, in which all on-site and off-site emergency organizations shall participate, are held at the nuclear installation site once every four years;
- on-site emergency exercises, in which all emergency units in nuclear power stations of two units shall participate, are held every year;
- drills, in which each emergency unit in a nuclear installation shall participate, are held every quarter; and
- for newly constructed nuclear installations, an initial exercise is held to demonstrate the ability of emergency response before the rated thermal output reaches 5%.

III.11.5 International Cooperation including conventions with neighboring countries

Notice of an accident and request for support to international organizations and countries in cooperation follow the procedures prescribed in IAEA “Convention on Early Notification of a Nuclear Accident” and “Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.”

As for bilateral cooperation, the NSSC and U.S. NRC have developed emergency cooperation system in accordance with the Arrangement on cooperation of regulatory and safety research and exchange of technical information. Korea and Japan signed into a treaty to maintain early contact network for nuclear safety with a view to early notification of nuclear accident between the NSSC of Korea and Nuclear Regulation Authority of Japan.

KINS made an agreement with National Nuclear Safety Administration (NNSA) of China for cooperation in area of radiological emergency preparedness to be prepared for nuclear accident. In November 2015, it entered into an MOU with Nuclear and Radiation Safety Center (NNSA/NSC) and Chinese Atomic Energy Authority-National Nuclear Emergency Response Technical Assistance Centre (CAEA-NNERTAC) of China for continued support in area of radiological emergency preparedness. KINS has also maintain an emergency cooperation system with China Institute for Radiation Protection (CIRP) through an technical cooperation agreement of nuclear safety and radiation protection. It also made an agreement with Atomic Energy Council, INER, Institute of Nuclear Energy Research (AEC) of neighboring Taiwan over expert exchange for sophistication of radiological emergency preparedness exercise system and completed first information exchange meeting at Taiwan.

Meanwhile, the Republic of Korea, China, and Japan signed the Memorandum of Cooperation (MOC) concerning Top Regulatory Meeting (TRM) for enhanced nuclear safety capability of Northeast area. Through TRM, three countries have established a framework for information exchange on nuclear accident and continuously discussed on ways of interactive cooperation including joint radiological emergency preparedness exercise. Back in August 2014, 7th meeting was held in Japan and in November 2014, first trilateral TRM joint exercise of emergency preparedness was kicked in, followed by the same exercise implemented in Japan back in November 2015.

III.11.6 Response to the Fukushima Daiichi Accident

Due to an earthquake and tsunami beyond expectation, a severe accident occurred at multiple units at the Fukushima nuclear site in Japan, causing severe damage to the nuclear site and adjacent infrastructure. Many lessons are learned from the nuclear accident with regard to emergency response and post-accident management.

Considering that situation, a safety inspection led by the regulatory body was conducted to prepare a plan to improve domestic emergency response and the emergency medical service system. The areas inspected were:

- Emergency preparedness plan related to procedures and organization, including Emergency Action Level (EAL),
- Emergency response facilities and equipment,
- System operating status for protecting residents in case of emergency,
- Emergency medical system,
- Exercises to test emergency response capabilities, and
- Response system to simultaneous emergencies at multi-units on the same site.

As a result, it was verified that emergency response and the emergency medical system based on existing design and accident concept are appropriate. However, action items to respond to a natural disaster beyond the design basis and simultaneous emergencies at multiple units were identified as follows:

- Securing additional thyroid blocking agent for protecting residents near a nuclear power plant,
- Amending the radiological emergency plan to include such events as the simultaneously issuing an emergency alert at multiple units,
- Securing additional equipment in preparation for an event where in the emergency is prolonged,
- Expanding equipment of emergency medical treatment organizations,
- Reinforcing radiation emergency exercise,
- Devising a means for securing necessary information in case of a prolonged loss of electrical power,

- Securing countermeasures for protecting maintenance workers,
- Improving emergency response facilities,
- Amending the information disclosure procedure in the event of a radiation emergency,
- Evaluating protective measures for residents who live beyond the emergency plan area, and
- Reinforcing the performance of emergency alarm equipment.

The KHNP which is the operator of nuclear power plants, the research reactor, the nuclear cycle facility operator, and KIRAMS which is the emergency medical institution, prepared and have implemented a detailed action plan with regard to emergency response and medical service at the request of the regulatory body in May 2011.

- Amending the radiological emergency plan to include such events as the simultaneous declaring of an emergency at multiple units

The radiological emergency organizations were structured to cope with a radiological emergency at a single-unit. Now, the radiological emergency organizations are restructured based on three scenarios: first, a radiological emergency at single unit, second, simultaneous emergencies at two units on the same site, and third, simultaneous emergencies at all units on the same site, and the revision of the radiological emergency plan to incorporate the plan for establishing a radiation emergency organization based on three scenarios has been already completed in December 2011.

In the revised radiological emergency plan, the magnitude of tsunami is added to the criteria for declaring an emergency with respect to a natural disaster. In addition, the revised radiological emergency plan defines the target time for emergency response: issuing a radiation emergency alert within 15 minutes after detection, initiating radiation emergency organizations within one hour after the declaration of a radiation emergency and putting the emergency organizations into operation within two hours

- Securing additional equipment to prepare for a prolonged emergency
  Before the Fukushima Daiichi Accident, pursuant to the radiological emergency plan, the KHNP kept approximately 350 units of seven different types of radiation (radioactivity) instruments including high-level beta-gamma dose rate meters, 8,600 pieces of radiation production equipment including protective clothing, 166,000 tablets (130g) of thyroid protection medicine. In response to a prolonged emergency like the nuclear accident in Fukushima, the KHNP has additionally secured 440 units of radiation (radioactivity) instruments and 20,000 radiation protection gears to increase inventory 200% of the previous level.

- Increasing the equipment of emergency medical treatment institutions
  To effectively respond to a sudden increase in patients due to a radiological disaster,

Seoul National University Hospital and 22 others designated for radiological emergency medical service have been continuously provided with medical facilities, equipment and medical products. As of now 740,000 tablets of thyroid protection medicine are secured.

- Reinforcing radiation emergency exercise
  Under the recommendation of the NSSC, the KHNP has conducted an unannounced radiation emergency exercise at each nuclear power site once a year. Unannounced means the personnel participating in the exercise must not be advised in advance, of the exact date, time and scenario of the exercise. Therefore, it is believed that the unannounced exercise contributes to strengthening emergency response capabilities of radiological emergency staff. Furthermore, research was conducted to develop exercise scenarios based on earthquake and tsunami. The newly developed scenarios have already been applied in the unified emergency exercise

- Devising a means for securing necessary information in case of a prolonged loss of electrical power
  The power supply to emergency response facilities as well as the main computer is essential for acquisition of key plant parameters in case of a prolonged loss of power. The EDG together with the UPS is secured to prepare for the loss of power to emergency response facilities, however the UPS alone is not sufficient in case of a long-term loss of power. To resolve the issue, the licensee completed additional deployment of mobile power generating equipment to ensure continued power supply to the main computer in 2015.

The Fukushima Daiichi Accident showed that when massive earthquake and tsunami cause prolonged on- and off-site power outage, flooding and damages in facilities, Environmental Radiation Monitoring System (ERMS) installed in on-site EPZ might experience unrecoverable damage. To prepare for such case, mobile environmental radiation monitoring facility (seven instrumentation equipment and one operating server) was adopted to ensure the environmental monitoring in case of emergency.

- Improving emergency response facilities
  A plan to improve the habitability and scale of emergency response facilities including Technical Support Center (TSC) and Operation Support Center (OSC) and to prevent inundation of emergency facilities due to a large tsunami is continuously in progress by improving TSC and OSC.

- Securing countermeasures for protecting emergency workers
  The standard Procedure for Protecting Emergency Workers, which describes procedures for input of emergency workers for accident prevention and emergency measures, was developed in August 2011. This is a procedure that standardizes the decision and approval of emergency work to avoid confusion of radiation protection during a radiation

emergency. It will enable emergency workers to perform emergency work promptly.
Since contract workers are also important in an radiological emergency, they are mandated to take the same training for radiation emergency preparedness as KHNP employees do and to participate in the emergency preparedness exercise.

- Amending the information disclosure procedure in the event of a radiological emergency
  With respect to improvement of the national radiation disaster management system after the nuclear accident in Fukushima, the operator had a discussion with the NSSC and the KINS regarding dealing with the media. Based on that, the government manual for crisis management and the operator's radiation emergency plan was revised to raise the transparency and promptness of disclosing the information to be provided to the media, the public and residents near nuclear plants by specifying the details of information (list of information released real time, information on radiological contamination, and the protection of residents).

- Evaluating protective measures for residents who live beyond an emergency planning zone
  Pursuant to the APPRE, the emergency planning zone for a nuclear installation can be defined as an area within the radius of eight to 10 km from a nuclear installation. A research to identify items to protect residents who live beyond an emergency planning zone based on lessons learned from the Fukushima Daiichi Accident was completed. In this research, the dispersal pattern and distance of radioactive materials and their impact on residents beyond an emergency panning zone was able to be evaluated taking into consideration environmental conditions around a nuclear power plant such as wind direction and speed to identify necessary measures to protect local residents.

- Reinforcing the performance of emergency notifying system
  The operator has established an emergency alerting system (Amplifier and Speaker) for the local residents who live within the radius of 2 km from the outside boundary of a nuclear power plant and with the expansion of EPZ, the radius of emergency alerting system was also expanded to the maximum radius of 5 Km in December 2015. The integrity of the system has been maintained via self-inspection and joint inspection attended by the local and central governments. The joint inspection has been conducted to check the status of sound and the operation of the system on a quarterly basis.
  As a need to improve the emergency notifying system rises after the nuclear accident in Fukushima, an emergency power source for alerting system and wireless communications system were secured in preparation of power loss caused by earthquake and tsunami.

The KHNP identified the below action items additionally in consideration of lessons learned from the Fukushima Daiichi Accident and prepared a detailed action plan.

- Improving a cooperation system with relevant organizations

The KHNP strives to establish a close cooperation with relevant organizations, and based on which, respond to an accident promptly and prevent the expansion of an accident in case of a radiation emergency or disaster. One example is the Agreement on Prompt Response and Cooperation in Case of a Nuclear Emergency that KHNP and National Emergency Management Agency (NEMA, currently fire-fighting division of Ministry of Public Safety and Security) signed in September 2011. It deals with helicopter support in the event of a radiological accident and an emergency medical airlift. According the agreement, in the event of a radiation disaster accident, NEMA (currently fire-fighting division of Ministry of Public Safety and Security) will allow National 119 Rescue Services to provide a helicopter for rescues, patient transfers, and transporting experts while the KHNP provides nuclear facility experts and radiation protection equipment to NEMA (currently fire-fighting division of Ministry of Public Safety and Security).

In addition, with the expansion and redefinition of EPZ, the role of local metropolitan government has increased. Hence, Kori Headquarters (HQ) made an agreement with relevant organizations in the city of Busan and its region over metropolitan based cooperation agreement for nuclear safety and emergency preparedness related work on August 12, 2015. Hanbit HQ signed the consultative agreement in the southwestern metropolitan area with the city of Gwangju and regions of Jeonnam and Jeonbuk to provide manpower, resource and technical support in case of radiation release accident.

- Operating an assessment program for public protective actions

  The APPRE requires the nuclear operator to assess the estimated dose to residents and take protective measures in case of a radiation emergency. To this end, the KHNP has developed and operated KHNP Radiological Emergency Dose Assessment Program (K-REDAP). The reliability of the program has been secured through emergency preparedness drills at a nuclear power plant.

  In the past, real-time meteorological data was not considered to calculate the estimated dose to public in the system, which undermined data accuracy. Therefore, KHNP developed Smart Radiological Emergency Dose Assessment Program (S-REDAP) that enables real-time meteorological and environmental radiation data to assess the impact on residents and has applied it to NPPs. The system was configured by comparing calculated estimates with environmental radiation monitoring data and then evaluating the difference repeatedly to arrive at the most accurate expected exposure dose.

The regulatory body has reinforced a radiological/radioactive environment monitoring system across the country to ensure prompt and effective protective measures for residents, and completed the revision of laws and systems to adopt the concepts of the precautionary action zone (PAZ) and the urgent protective action planning zone (UPZ) instead of the emergency planning zone (EPZ).

- Environment Monitoring

  As part of post-Fukushima actions, KINS has also increased regional radioactive monitoring station from 12 to 15, and Integrated Environmental Radiation Monitoring Networks (IER-Net) from 71 to 134 so as to strengthen the capability for early detection of radiation (radioactivity) abnormalcy following nuclear accidents at home and abroad.

- Reforming EPZ

  For more prompt and effective protection of public in case of radiological emergency, the revision of the radiological emergency planning zone was completed to divide the existing single emergency planning zone (EPZ) into the precautionary action zone (PAZ) and the urgent protective action planning zone (UPZ). Relevant laws were revised in 2014 and currently Radiation emergency plan is in revising process to be in compliance with the expansion of EPZ to 20-30 km and subdivided EPZ.

III.12 Article 17. Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

III.12.1 Licensing Process and Regulatory Requirements

Regulatory Requirements of Site

It is stipulated in the NSA Article 11 (Standards for Permit) related to construction and Article 21 (Standards for License) related to operation that the siting of nuclear installations shall conform to the technical requirements prescribed by the NSSC in such a way that it does not present any impediment to the protection of people, properties and the environment against radiation hazards. As for technical standards entrusted by the same Act, the Enforcement Regulation Concerning the Technical Standards of Reactor Facilities, etc. provides seven Articles: Article 4 (Geological Features and Earthquakes), Article 5 (Limitations on Location), Article 6 (Meteorological Conditions), Article 7 (Hydrological and Oceanographic Condition), Article 8 (Impact of Man-made Accident), Article 9 (Feasibility of Emergency Plans), and Article 10 (Construction of Multiple Units).

With regard to siting, detailed regulation requirements by areas are as follows:

- Technical Standards for Investigation and Evaluation of Meteorological Conditions of

Nuclear Reactor Facility Sites: NSSC Notice 2014-25;

- Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites: NSSC Notice 2014-26;

- Objects of Consultations due to Installation of Industrial Facilities, etc. around the Nuclear Facilities: NSSC Notice 2014-32;

- Standard Format and Content of Radiation Environmental Report for Nuclear Power Utilization Facilities: NSSC Notice 2014-11; and

- Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities: NSSC Notice 2014-12.

Provided that, Guidelines for Investigating and Evaluating Seismic and Geologic Characteristics of Nuclear Reactor Facilities Site, Guidelines for Location Restrictions of Nuclear Reactor Facilities, and Guidelines for Investigating and Evaluating Man-made Incidents for Site Selection shall apply the relevant requirements developed by U.S. NRC in accordance with NSSC Notice (Technical Standards for Locations of Nuclear Reactor Facilities). Specific technical standards considering domestic reactor facility site and environmental characteristics are being developed through mid- and long-term R&D projects. In addition, KINS has developed and applied regulatory standards and regulatory guidelines applied to PWR reactor facilities and continued revising works are also being underway to reflect upon latest technical trends on siting and environment at home and abroad.

Site Selection Procedure

The installer and operator of nuclear facilities performs safety assessments, under the provisions of the NSA, including the preliminary site surveys and the detailed site surveys for a proposed site.

When applying for early site approval, the installer and operator of nuclear facilities must prepare a radiation environmental report (RER) and a site characterization report, and other necessary documents specified by the Ordinance of Prime Minister and submit them to the NSSC. The NSSC can issue an early site approval on the basis of the results of the safety review conducted by KINS. However, the KHNP has an option to apply for the construction permit package with evaluation of the site safety without the procedure of an early site approval. The operator has relied on the latter option of construction permits rather than of early site approval for the last 10 years. In this case, the site characterization report is not prepared separately, but included in Chapter 2 of the PSAR.

III.12.2 Assessment on Site Characterization and Radiological Environmental Impact

Site Characterization Assessment

- Geography and Population

To confirm the suitability of a site, the applicant for the construction permit of a nuclear reactor installation should conduct a site survey and an assessment regarding the geographical and geomorphological conditions, the population density estimates for the period of NPP operation, and public facilities in low population zone. The applicant should also perform assessment regarding the adequacy of the exclusion area boundary, the low population zone, the population center distance, and the feasibility to take proper protective actions in an emergency.

In accordance with the NSA, the installer and operator of nuclear reactor facilities establish an exclusion area within a specified radius from the site. In establishing the exclusion area boundary distance, 700 m was applied to a site with PWRs, at the initial stage, to be consistent with the exclusion area boundary distance applied to Kori Unit 1 on the basis of dose calculations. In the case of the site with PHWRs introduced from Canada, 914 m (1,000 yards) was established as the exclusion area boundary distance in accordance with Canadian practices. However, a boundary distance of 560 m has been adopted on the basis of a comprehensive review including dose calculations for Hanbit Units 5 & 6, Hanul Units 5 & 6, and Shin-Kori Units 1, 2, 3 & 4, Shin-Wolsong Units 1 & 2 and Shin-Hanul Units 1 & 2. The exclusion area boundary distance has to be set up in such a way that an individual located at any point on the exclusion area boundary for 2 hours immediately following onset of the radioactive material release would not receive a total radiation dose to the whole body in excess of 0.25 Sv or a total radiation dose in excess of 3 Sv to the thyroid from iodine exposure.

- Nearby Industrial, Transportation and Military facilities,

The installer and operator of nuclear reactor facilities should investigate and evaluate the site for installation, and the distribution of industrial, transportation and military facilities around the site, and assess the probability of man-made hazards that can occur at those facilities and their distance from the nuclear installations so that they may not affect the safety of the nuclear reactor installation. The NSSC Notice on Consultations due to Installation of Industrial Facilities, etc. around the Nuclear Facilities stipulates that the heads of administrative agencies concerned should, at the time of permission, authorization and approval, consult with the NSSC for the facilities, which are deemed to cause a serious trouble to the safety of a nuclear reactor and related facilities under construction or in operation. The installation of such facilities can be limited, if necessary.

▶▶ Meteorology, Hydrology and Oceanography

The installer and operator of nuclear reactor facilities should investigate and evaluate regional climate conditions (typhoon, heavy snow, rain, and tornado), local meterological conditions, on-site meterological conditions, and atmospheric transport and dilution of gaseous effluents in case of radioactive release, which are needed for the siting and safety design of the nuclear reactor installation, in conformity with the NSSC Notices of Technical Standards for Investigation and Evaluation of Meteorological Conditions of Nuclear Reactor Facility Sites and also of Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites. The applicant should also establish and implement a site meteorological observation plan for safe operation of the installation.

Appropriate evaluations and analyses are conducted concerning hydrological features of the site that might affect safety-related structures and the behavior of released radioactive materials in conformity with the NSSC Notices of technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites. These features include floods, ground water systems, surges, tsunami, and dam failure. The results are then reflected in the design of the nuclear installation. The flood history and the maximum flooding of streams and rivers are surveyed. Based on the survey results, assessments are conducted regarding any potential effects from flooding or heavy rainfall, and any potential water disaster that might affect safety-related structures in the nuclear installation due to dam failures near the site. In addition, the minimum water level and flow also are evaluated to check the capacity of cooling water supply for validating the source of the ultimate heat sink and reflected in the design of the cooling water intake structures and the cooling system.

▶▶ Geology, Earthquake and Geotechnical Engineering

The installer and operator of nuclear reactor facilities conduct investigation and safety evaluation for the area within a radius of 320 km from a nuclear installation in such fields as topography, geology, geological structure, stratigraphy, historical geology, geological tectonics and seismology in conformity with the NSSC Notice (Technical Standards for Locations of Nuclear Reactor Facilities). As for the area within a radius of 8 km from the nuclear installation, a more detailed investigation should be conducted. Through such investigations, the maximum earthquake ground motion expected to occur at the site of the nuclear reactor installation should be analyzed and evaluated, and the result should be fully incorporated into the design of the installation. In case a geological phenomenon for which clear judgement cannot be made due to lack of relevant data or uncertainties in natural phenomena, additional detailed investigation is to be demanded to verify that the standard for site location is satisfied.

The installer and operator of nuclear reactor facilities investigate whether any geological disaster, for example, settlement or collapse has occurred at the site. The applicant should also evaluate whether the foundation holds a sufficient bearing capacity within the allowable extent of subsidence of each structure by investigating and analyzing the stability of the foundation under static and dynamic load conditions. If needed, the applicant should reinforce the foundation to maintain its stability. As for the stability of the foundation of nuclear installation site, KINS re-confirms the stability of the whole foundation through the pre-operational inspection concerning the foundation excavation and reinforcement, which are implemented after the issue of construction permit, and finally confirms, for the area including unsuitable foundation materials that needs reinforcement works, whether the design criteria are satisfied through such reinforcement works.

Areas of Radiological Environmental Impact Assessment

When applying for a CP and an OL of an NPP, the operator must conduct a radiological environmental impact assessment on the site where nuclear facilities will be located in accordance with the NSSC Notice on Regulations on the Preparation, etc. of Radiological Environmental Impact Report of Nuclear Facility. The key areas of assessment include: the data on the use of land within a radius of 80 km of nuclear facilities, the use of the sea; data sets which demonstrate the site characteristics including meteorological data, atmospheric dispersion factors, oceanic conditions and dispersion factors, and distribution of population. The owner conducts the survey on aforementioned data sets as well as current status of environmental radiation and radioactivity in surrounding areas and submits the results. Moreover, the impact of radiation from NPP operation must be assessed by first estimating the expected release of radiation source term and then the exposure dose of workers from the construction and public from operations of an NPP. Also, if there are the operating nuclear facilities within the site planned for the construction of NPPs, an environmental impact assessment on multiple nuclear facilities must be conducted and the result must meet the Article 16 of the Standards for Protection Against Radiation (NSSC Notice).

The operator of an NPP is required to submit environmental impact monitoring plans for both before and during operations of the NPP as prescribed in the NSSC Notice on Regulations on the Preparation, etc. of Radiological Environmental Impact Report of Nuclear Facility. The plans must be prepared based on the results of Environmental Radioactivity Survey on areas surrounding the NPP and the NSSC Notice on Regulations on Environmental Impact Assessment. KINS verifies if the environmental impact monitoring plan, etc. submitted by the operator satisfies the regulations.

III.12.3 Reassessment of Factors Related to Site Characteristics

As it was mentioned in the sixth report, the NSSC carried out an all-round safety inspection of all nuclear power plants in the Republic of Korea following the 2011 Great East Japan Earthquake and the disastrous Fukushima Daiichi Accident. During the inspection, the need for reassessing the maximum earthquake ground motion at NPP site and the design basis sea level was identified. NSSC requested the Korea Nuclear and Hydro Power Co. (KHNP), the operator and installer of NPPs, to conduct the survey and research on the subjects with the purpose of improving the site selection and safety of an NPP. The following is the summary of the results of the study and NSSC's review, etc.

Survey · Research on Maximum Earthquake Ground Motion at the NPP Site

- Background and Purpose

  KHNP conducted the "Survey·Research on Maximum Earthquake Ground Motion at NPP Site" from October 2011 to December 2013 in order to completely reassess the estimated maximum earthquake ground motion of NPP sites in the Republic of Korea.

- Key Findings and Results

  Analyzing the seismic hazard posed to NPPs for the reassessment of design earthquake ground motion requires an objective evaluation of a wide range of earth science information including seismic sources, earthquake ground motion, site response characteristics, etc. To conduct the analysis, KHNP adopted the suggestions from the US Senior Seismic Hazard Analysis Committee (SSHAC) and basically applied the Level 2 and adopted some elements of Level 3 (the collection of input data through workshops, etc) to the analysis.

  For the seismic hazard analysis of NPPs in the Republic of Korea, KHNP estimated the maximum earthquake ground motion at the sites based on the Technical Standards for the Locations of Nuclear Installations (NSSC Notice) and the Section 1.7 of Regulatory Guide for Light Water Reactors, “Determination of Design Earthquake Ground Motion at Site”, and used the deterministic method to determine the design earthquake ground motion, and then verified the validity of the determined value using a probabilistic method. The analysis found that the estimated maximum earthquake ground motion at sites was lower than the design earthquake ground motion of 0.2g (or 0.3g for newly built NPPs) and the mean annual rate of exceedance of the design earthquake ground motion was less than 1.0×10-3/year, thereby satisfying review criteria.

Reassessment of Design Basis Sea Level

Background and Purpose

NSSC requested KHNP to conduct a survey and research to improve the safety of NPPs by protecting them from beyond design basis flood that induced by tsunami or storm. Accepting the request, KHNP conducted the "Survey·Research on Design Basis Sea Level of NPP Site" from October 2011 to September 2015.

Key Findings and Results

With the purpose of ensuring safety of nuclear power plants from beyond design basis flood, KHNP used a deterministic method to reassess the validity of design basis sea level that was set under the consideration of typhoon, tsunami, swell-like wave, and meteorological tsunami posed to NPP sites. The reassessment was based on Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites (NSSC Notice) and the review criteria in Section 1.5 "Hydrology", and Section 1.4 "Survey and Assessment for Flood, and Water Supply in NPP Site and Surrounding Area" of Regulatory Guidelines for Light Water Reactors.

The reassessment of design basis sea level of NPPs in the Republic of Korea found that there was no risk of site flooding by the probable maximum sea level and no probability of component cooling sea water (CCSW) intake loss due to the probable minimum sea level. However, in the case of Kori Units 3 & 4, there is a possibility of high waves overtopping breakwaters and flooding at intake structure areas where 10 m (above the mean sea level) high sea wall are not in place. Therefore, KNHP plans to place more flood protection facilities in that area.

III.13 Article 18. Design and Construction

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defense in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;

(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;

(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

III.13.1 Licensing Procedure and Regulatory Requirements

The licensing procedure for the design and construction of nuclear installations is described in Section III.2.3. The criteria for a CP of nuclear installations are specified in the NSA as follows:

- technical capability necessary for the construction of nuclear installations shall be secured;

- the location, structures, and components of nuclear installations shall conform to the technical standards provided in the Regulation of the NSSC in such a way that there may not be any impediment to the protection of human bodies, materials, and the public against radiation hazards caused by radioactive materials, etc.;

- the criteria set in the Presidential Decree to prevent hazards to public health and environment due to radioactive materials which may accompany the construction of nuclear installations shall be satisfied;

- the Quality Assurance program shall be in compliance with standards specified in the Regulation of the NSSC; and

- the decommissioning plan shall be in compliance with standards specified in the Regulation of the NSSC.

The technical requirements for the location, structure, and equipment of reactor facilities are specified in the Enforcement Regulation Concerning the Technical Standards of Reactor Facilities, etc. The more specific regulatory requirements, if necessary, are prescribed in the NSSC Notices.

III.13.2 Implementation of Defense-in-depth Concept

In order to prevent and mitigate accidents at nuclear installations, the regulatory body requires the application of the defense-in-depth principle including the multi-barrier concept to the design and construction of nuclear installations through the NSA, etc. In response to such requirements, the KHNP applies a multi-barrier concept based on the defense-in-depth principle to assure the safety of nuclear installations. The following basic concepts are considered in the design in order to implement the defense-in-depth principle:

- securing sufficient design margins,
- securing independency, redundancy, and diversity,
- multiple barriers concept,
- fail-safe concept,
- interlock concept, and
- in-service testability.

Irrespective of the reactor type, systems, structures, and components (SSCs) of a nuclear installation are designed in consideration of the following internal and external events at the stage of selecting the site, as specified in the Atomic Energy Laws:

Internal events: Loss of coolant accident, main steam and high energy line breaks, internal scattered material (missile) caused by a rotor, fire, flooding, and so on.

External events: Earthquakes, floods, typhoons, inflammables, poisonous gas, other anticipated man-made disasters, and so on.

The nuclear installation is designed by applying the defense-in-depth principle as a safety design concept against internal and external events as mentioned above. Its major contents are as follows:

- A sufficient safety margin is secured in the design so that the probability of any design basis accident is minimized. Safety facilities are designed in terms of independency, redundancy, and diversity so that the consequences of accidents are minimized.

- Nuclear installations are designed so that even if any abnormal state occurs in the nuclear installation due to any failures of equipment, operator errors, or combination thereof, the reactor protection system operates automatically by detecting the abnormal state and initiates the operation of the reactor shutdown system in order to prevent the abnormal state to proceed into a severe accident.

- Nuclear installations are designed so that the nuclear installation has multiple barriers, such as the fuel pellet, the fuel clad, the reactor vessel, the reactor coolant pressure boundary, and the containment building to prevent the release of any radioactive materials into the environment.

III.13.3 Prevention and Mitigation of Accidents

Design and Provisions for Accident Prevention

The followings are reflected in the design of nuclear installations to prevent any accident from occurring:

- The reactor core is designed so that in the power operating range, the net effect of the prompt inherent nuclear reactivity characteristics tends to compensate for a rapid increase in reactivity. The reactor core is also designed to assure that power oscillations which can result in conditions exceeding specified acceptable design limits are not possible or can be readily suppressed (in PWR).

- The reactor protection system is installed to sense accident conditions and maintain the reactor in a safe state by automatically initiating the operation of the reactor shutdown system and the engineered safety features. The reactor protection system is designed with redundancy, diversity, and independency to assure that no single failure of any equipment or channel of the system results in loss of the intended safety functions.

- The reactor coolant pressure boundary is designed to have an extremely low probability of abnormal leakage and gross rupture. If any leakage of the reactor coolant takes place, it is promptly detected to prevent against proceeding to a severe accident. It is also designed to permit periodic inspection and testing to assess the structural integrity and leak-tightness.

- The emergency core cooling system is designed to automatically provide abundant emergency core cooling following any loss of reactor coolant at a rate such that any fuel damage that could interfere with continued effective core cooling is prevented. Even if the off-site power is lost, the necessary power is to be supplied from emergency diesel generators installed in the nuclear installation. The residual heat removal system is also installed to remove the core decay heat.

- The Probabilistic Safety Assessment (PSA) has been conducted to minimize the risk of fuel damage. For the scenarios identified to have relatively high possibility of fuel damage, the relevant design and operating procedures are assessed and modified considering the cost and benefit so as to enhance the capability of accident prevention.

KHNP has conducted probabilistic safety assessments for operational nuclear installations in compliance with the Severe Accident Policy declared by regulatory body. On the basis of the results, several examples of safety enhancement achieved by reflecting the results of PSA are given as follows:

- to enhance the capability of coping with station blackout, the KHNP completed the installation of additional Alternate Alternating Current (AAC) for each PWR plant groups: Kori Units 1, 2, 3 & 4, Hanbit Units 3, 4, 5 & 6, Hanul Units 3, 4, 5 & 6, Hanbit Units 1 & 2, Hanul Units 1 & 2, Shin-Kori Units 1 & 2 and Shin-Wolsong Units 1 & 2;
- through a design change which enables the Kori Units 1 & 2 to share their instrument air systems, there has been an enhancement in the reliability of pressurizer relief valve actuation;
- the risk drawn from an external-event PSA has been reduced at Wolsong Unit 1 through design changes to seal the opening at the fire areas boundary and to be alerted by an alarm in case of flooding of the turbine building;
- for the purpose of risk reduction, Shin-Kori Unit 1 & 2 installed cross-tie pipe among auxiliary feedwater systems and secured redundant power sources for auxiliary feedwater regulating valves; and
- installation of PAR to all NPPs in operation and under construction was completed in March 2015, significantly reducing hydrogen risk of containment building in case of power loss.

The regulatory body, as a follow-up action to the regulatory review on PSA, has recommended the licensee to extend the scope of PSA to the low power and shutdown operation mode and the results were reflected upon low-power shutdown severe accident management guidelines (December 2015). In addition, as part of considerations for accident mitigation, mobile electric power generators and batteries are about to be or have already been introduced to better cope with a prolonged power loss or loss of heat sink.

Design and Provisions for Accident Mitigation

Facilities dedicated to cope with severe accident are reflected in the design of APR 1400 reactor, which is in construction, including hydrogen control system, emergency spray system, safety depressurization system and reactor cavity flooding system for enhanced response capability against severe accident.

In case of core damage, Main Control Room (MCR) and Technical Support Center (TSC) team at site carries out mitigation measures following the procedure in accordance with the SAMG in order to prevent an escalation of the accident. Emergency organization is also arranged according to the radiation emergency plan.

With respect to the operation of accident management plan, it is legalized that those who are to operate power reactor and related facilities shall submit accident management plan when applying for OL and those OL holders shall submit the accident management plan by June 22, 2019.

Post-Fukushima Action

The following six items for safety improvement in the area of severe accident were identified through the safety check conducted for domestic nuclear reactor installations after the Fukushima Daiichi Accident in 2011. They have been implemented for most of the domestic NPPs except the installation of vent or depressurization facilities in containment building, which will be completed by 2020.

- Installation of passive hydrogen removal equipment
- Installation of filtered vent system or depressurizing facilities in the containment buildings
- Installation of reactor injection flow paths for emergency cooling water injection from external sources
- Reinforcing education and training for severe accidents
- Revision of the Severe Accident Management Guidelines to enhance effectiveness
- Development of Low-power Shutdown Severe Accident Management Guidelines

III.13.4 Application of Proven Technologies

Under the basic principle that technologies incorporated in the design of a nuclear installation shall be duly proven by experience or qualified by testing or analysis, the regulatory body requires "prove the adequacy of design" and "use the performance qualified components" Accordingly, the KHNP has designed the nuclear installations under construction or in operation in the Republic of Korea with technologies proven by operating experiences or qualified by testing or analysis inside or outside of the country.

New designs with enhanced safety were adopted after verifying their performance for improved safety. For example, the newly constructed APR1400 adopted the design of direct vessel injection of emergency cooling water. The performance of the design was already proven by verification tests conducted for several years at the Korea Atomic Energy Research Institute using the thermal hydraulic test facility. In addition, passive auxiliarly feedwater system was tested to verify cooling performance of the components in the system by conducting the unit base effect test on a small scale and a large scale comprehensive test to verify overall performance in a gradual manner. After its performance being verified, it was applied to the design of Advanced Power Reactor Plus (APR+), a reactor design upgrading the APR 1400.

III.13.5 Operation in Consideration of Human Factors and Man-Machine Interface

The NSA stipulates that the main control room and the remote shutdown room shall be designed so that the analysis and evaluation results on the human factors engineering are reflected therein in order to maximize the safety and effectiveness of nuclear facility. According to this provision, the contents of analyzing the feasibility and suitability of the human factors engineering design are included in the PSAR and in the FSAR accompanying an application for a CP and an OL, respectively. The major contents of the analysis are as follows:

- in the design of the main control room, human factors engineering are considered so that the man-machine interface is suitable for the safe operation of nuclear facility. The major factors are: working space in the main control room, environment around the working space, alarm and control equipment, visual indicating equipment, auditory signal equipment, nameplates and their positioning, and layout of control board.

In particular, the APR-1400 NPP features an advanced control room and distributed digital control system based integrated network to control and monitor the major plant equipment. The operation console, large display panel (LDP) and the mini-LDP of safety console provide continuously the important information of safety and plant operation to enable operating crew to use the information. also, all systems are designed following Human Factors Engineering requirements from the design stage.

- the man-machine interface system of remote shutdown room is designed following human factors engineering guidelines just as same as the MCR to enable safely shutdown the plant when impossible to reside the main control room

III.14 Article 19. Operation

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;

(ii) operating condition and limiting condition for operation derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;

(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;

(iv) procedures are established for responding to anticipated operational occurrences and to accidents;

(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;

(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;

(vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;

(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

III.14.1 Licensing Procedure and Regulatory Requirements

The licensing procedures for operating nuclear installations are referred to in Section III.2.3.

The criteria for an OL for a nuclear installation are specified in the NSA as follows:
- technical capability necessary for the operation of the nuclear power reactors and related

facilities shall be secured;

- the performance of the nuclear power reactors and related facilities shall conform to the technical requirements, as prescribed by the Regulation of the NSSC, in such a way that there may not be any impediment to the protection of human bodies, materials and the public against radiation hazards caused by the radioactive materials;

- there shall not be any impediment to the protection of the public health and the environment against danger and injury due to radioactive materials which may accompany the operation of the nuclear reactors and related facilities, according to the Presidential Decree; and

- the substance of a QA program, decommissioning plan, accident management plan is to meet the criteria provided in the Regulation of the NSSC.

The technical standards entrusted by the NSA are prescribed in Regulations on Technical Standards for Nuclear Reactor Facilities, Etc.; six articles regarding the technical capability on operation; 38 articles regarding the technical standards for the performance of nuclear installations; and 18 articles regarding the technical standards for the QAP. Regarding reactor operation, NSSC Notice (Standard Format and Content of Technical Specifications for Operation) specifies detailed regulatory requirements of Technical Specifications for Operation.

The NSSC approved the operation of Shin-Wolsong Unit 2 in July 2015 after verifying that the Unit satisfies the design and safety requirements through the pre-operational inspection and the review of FSAR, Technical Specifications for Operation, Quality Assurance Manual, and Operational Technical Capability Specifications. The operations of Shin-Kori Unit 3 were approved in October 2015.

III.14.2 Safety Analysis and Commissioning Program for Authorization of Initial Operation of Nuclear Installations

In order to obtain initial authorization to operate a nuclear installation, the operator shall obtain a CP and an OL from the regulatory body according to the licensing procedure provided in the NSA. Following this, the KHNP conducts comprehensive and systematic safety assessments of nuclear installations and prepares a PSAR and a FSAR from the results of the safety assessments. The reports are reviewed by KINS. KINS conducts a pre-operational inspection to verify whether or not the nuclear installation is constructed in conformity with the permit conditions. The SARs, the safety assessments and the pre-operational inspection for issuing the CP and the OL are described in detail in Sections III.2.3, III.2.4, and III.9.1.

KHNP formulates and implements a commissioning program to verify that the instruments and components of the reactor coolant system can be operated in compliance with the design. The commissioning program includes the following tests: cold functional test, hot functional test prior to fuel loading, initial fuel loading test, hot functional test after fuel loading, initial criticality test, low power reactor physics test, and power ascension test.

III.14.3 Limiting Conditions for Operation

The NSA stipulates that the operator of a nuclear installation shall submit a Technical Specifications for Operation accompanying the application for an OL, so as to establish requisite conditions for the safe operation, and the technical specifications prescribe the details on technical guidelines. In the specifications, operational limits and conditions for the safety operation of nuclear installations, limiting safety system settings, and surveillance requirements are specified with a classification according to operational modes and systems. The technical background for each operational limits and conditions are also included in this specification. The Standard Technical Specifications for the Korean Standard Nuclear Plant type, Westinghouse type, Framatome type, and CANDU type reactors have been developed and applied in all reactors.

The content of the Standard Technical Specifications for Operation is outlined in Table III.14-1.

The safety limits and limiting conditions for operation are established with sufficient safety margins through the accident analysis in the SAR, as stated above.

III.14.4 Operation, Maintenance, Inspection and Testing Procedures

In accordance with the Enforcement Regulation Concerning the Technical Standards of Reactor, etc., KHNP, an operator of nuclear installations, prescribes in the Technical Specifications for Operation that the written procedures listed below should be prepared, observed, managed and periodically examined, and conducts the operation, maintenance, inspection and testing of nuclear installation, based on the relevant specifications.

- Administrative Procedure
- General Operating Procedure
- System Operating Procedure
- Test and Inspection Procedure
- Maintenance Procedure

- Chemistry and Radio-chemistry Control Procedure
- Radiation Protection and Control Procedure
- Refueling, Emergency Planning, Off-site Dose Calculation Manual (ODCM) and Fire Protection Procedure

The procedures related to the safety of nuclear installations are to be deliberated by the PNSC and implemented after obtaining approval from the plant manager. The Technical Specifications for Operation prescribes that the same process shall apply in case that any change is to be made to the approved procedures. KHNP staff can release latest procedures through information management system.

Table III.14-1 Major Contents of Standard Technical Specification for Operation

Part	Items	Major Contents
Part 1. Operation of Nuclear Installation	Use and Application	- Definition of Terminology, Logical Connect, Limiting Conditions, Surveillance Frequency, etc.
	Safety Limits	- Safety Limits and Measures in Case of Exceeding Limit
	Limiting Conditions for Operation and Surveillance Requirements	Reactivity Control Systems Power Distribution Limits Instrumentation Reactor Coolant System Emergency Core Cooling Systems Containment Systems Plant Systems Electrical Power Systems Refueling Operations
	Design Features	- Site location, Reactor core, Fuel Storage, etc
Part 2. Radiation and Environment Control of Reactor Facilities	Radiation Protection	Reactor Installation Protection Radiation Safety Control Radiation Detection Instrumentation Management
	Management of Radioactive Materials, etc	Radioactive Waste Management Gaseous and Liquid Effluents Monitoring System Transportation, Storage, Handling, and Security of Nuclear Materials Use of Radioisotope, etc.
	Environmental Protection from Reactor Facilities	- Environmental Monitoring
Part 3. Management Control of Reactor Facilities	-	Organization and Responsibility Patrol and Check of Reactor Facilities Emergency Operator's Action Programs and Manuals Reporting Requirement

III.14.5 Procedures Responding to Anticipated Operational Occurrences and Accidents

The plant conditions and initiating events are classified based on those developed by the American Nuclear Society and Reg. Guide 1.70 of the United States Nuclear Regulatory Commission. The classifications are as follows:

- Condition I (Normal Operation)
- Condition II (Incidents of Moderate Frequency)
- Condition III (Infrequent Incidents)
- Condition IV (Limiting Faults)

Incident response procedures based on plant operational conditions and initiating events are classified as follows:

- Alarm Response Procedure: procedure describing the measures suited to an alarm on main control board
- Abnormal Operating Procedure: procedure responding to Condition I and II events
- Emergency Operating Procedure: event-based and symptom-oriented procedure to cope with Condition III and IV, and design basis accidents
- Severe Accident Management Guideline: accident management guide to link the Emergency Operating Procedure with the Emergency Plan

II.14.6 Engineering and Technical Support

There are organizations that provide engineering and technical support to the KHNP, the operator of nuclear facilities, in order to secure the safety of nuclear facilities during their lifetime. Their names and respective roles are as follows:

- KEPCO Engineering and Construction Co. (KEPCO E&C): comprehensive design engineering works including design of nuclear installations, project management, and a whole range of engineering services;
- KEPCO Nuclear Fuel Co. (KEPCO NF): design and fabrication of nuclear fuel and relevant research and development activities;
- Korea Plant Service and Engineering Co. (KPS): maintenance of main nuclear installations and electric power installations, general activities on relevant research and development, labor service, and equipment development;
- Doosan Heavy Industries and Construction (DHIC): construction of various power generating facilities including nuclear installations; and
- Korea Atomic Energy Research Institute (KAERI): research and development on nuclear energy and nuclear safety technology, and establishment of policies and related work.

Additionally, the KHNP have internal technical support organizations and systems under their control. The Central Research Institute under the KHNP is responsible for the support of the operation and the construction of the nuclear facilities, the advanced light-water reactor construction, the survey and analysis of nuclear technical information, the R&D for the management of the radioactive wastes.

Under the contract of emergency recovery services with Westinghouse Electric Co., ABB CE, Siemens, Alstom Power, CANDU Energy, DOOSAN Heavy Industry, the KHNP receives international technical support and consultation for field works and safety issues of nuclear installations introduced from abroad.

III.14.7 System of Reporting Incidents to Regulatory Body

The NSA stipulates that the organizations concerned in nuclear activities shall immediately take all necessary safety actions and report such actions to the NSSC for the following cases:

- if radiation hazards occur,
- if any failure occurs in nuclear installations,
- if there is any danger in nuclear installations or radioactive materials due to earthquakes, fire or other disasters
- if Radiation Generating Devices and the radioactive material under possession is stolen, lost, or destroyed by a fire or any other incidents, or
- if the radioactive material in transportation or packing leaks or is destroyed by a fire or any other incidents.

The NSSC Notice (Regulation on the Reporting and Disclosure of the Incidents and Accidents of Nuclear Facilities) stipulates the detailed facts on the objects, methods, and procedures of the reporting and the classifications of the incident reporting system. The Notice was revised in 2013 to extend the scope of incidents subject to reporting from 57 to 66 and once again in 2014 to reflect upon some organizational change. The classification of incidents is based on the International Nuclear Event Scale (INES) of the IAEA. The incidents and accidents response system of utility and regulatory body are shown in Figure III.14-1. If an incident or accident occurs, then utility must report it to the NSSC within a specified time limit and posts the related information on the internet. The NSSC dispatches a special inspection team composed of KINS experts to the plant and requires the complementary corrective measures from the utility to prevent recurrence, based on the inspection report. Among 26 events that occurred and reported during three years from 2013 to 2015, nine events were classified as Level 1, and the rest 17 events as Level 0 (minor failure, deviation). The result of the INES classification for events that occurred during past 10 years (2006-2015) is summarized in Table III.14-2.

Table III.14-2 Result of INES Classification (2006-2015)

Scale \ Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	total
Level 0 (Below Scale)	15	19	14	9	13	11	15	5	8	4	113
Level 1 (Anomaly)	3			1		2	1	4	4	1	16
Level 2 & above (>incident)					1		1				2
total	18	19	14	10	14	13	17	9	12	5	131

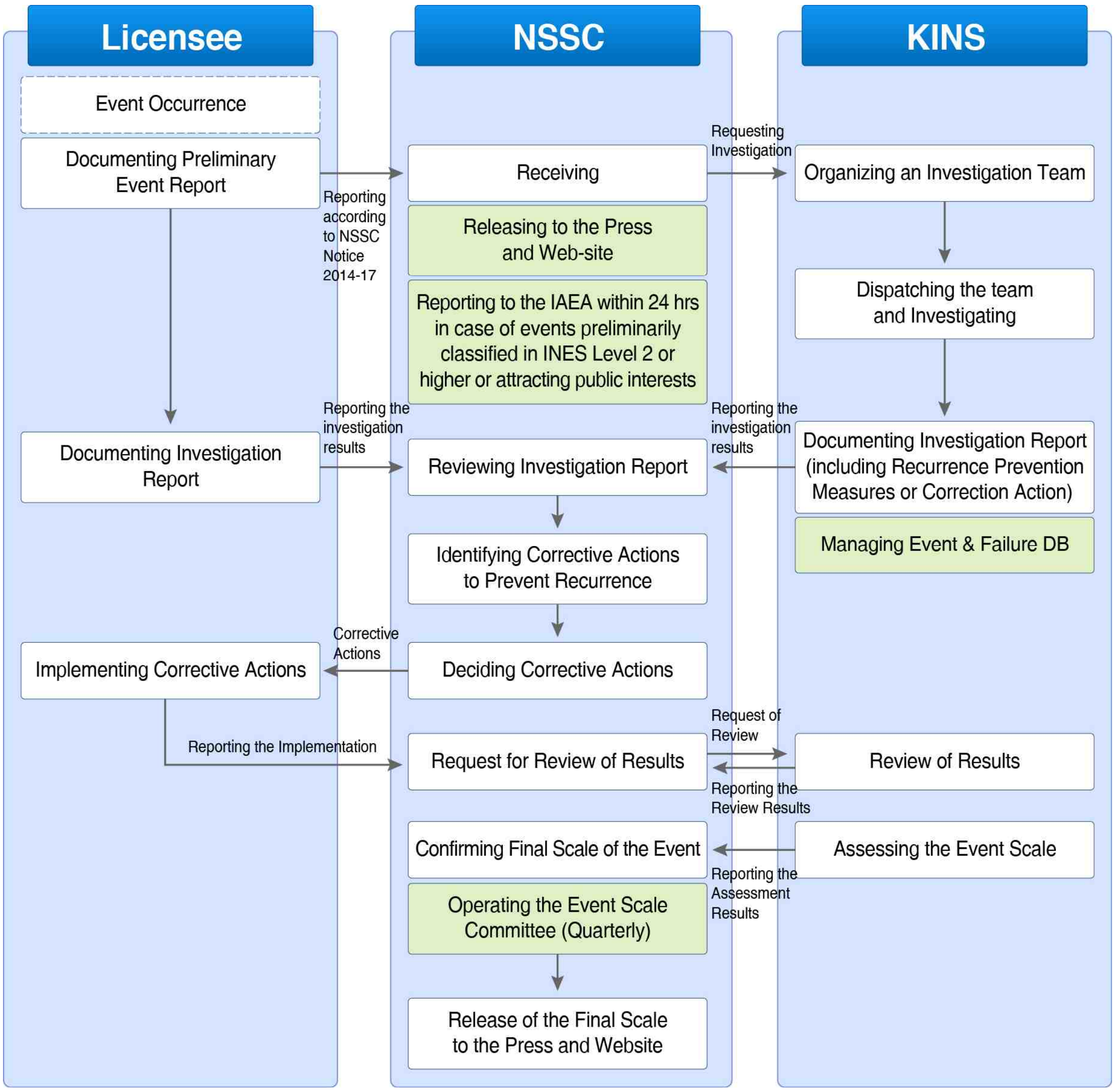


Figure III.14-1 Incidents and Accidents Response System

III.14.8 Collection, Analysis and Exchange of Operating Experience

Domestic and foreign operating experiences related to safety, cases of incidents, and the results of safety-related research are to be reflected in the operation and construction of nuclear installations through an administrative order of the NSSC, or through recommendations made during regulatory inspections by resident inspectors or inspectors of KINS. The KHNP is required to submit a report of the results on the implementation of the administrative orders or the recommendations to the NSSC for review of its suitability. Typical examples are the post-TMI action items, lessons-learned from the damages at reactor vessel head of Davis-Besse nuclear power plant, a loss of feedwater accident at Mihama nuclear power plants in Japan and loss of off-site power at Forsmark nuclear power plant in Sweden which have been ordered to be reflected in all domestic nuclear installations.

In cases that it is found necessary to modify nuclear installations or to change organizations or administrative matters on the basis of the results of self-assessments of domestic and foreign operating experiences, The KHNP files with the NSSC a safety assessment report related to the modifications and changes. Entrusted by the NSSC, KINS reviews the report. All procedures necessary for the operation of nuclear installations must be deliberated by the PNSC and approved by the plant manager. To incorporate new technology, operating experiences and necessary information, the procedures are examined and supplemented at least every two years.

The Nuclear Power Plant Event Scale Evaluation Committee was organized by the NSSC and it has been in operation for systematic assessment and feedback of safety related assessment of incidents and accidents and operating experiences. In addition, the KINS developed the OPIS (Operational Performance Information System for Nuclear Power Plants) to synthetically manage the data related to the incidents and accidents in operating nuclear facilities, event evaluation results and safety performance indicators. The OPIS can provide the foundation and means to give feedback to the operating experience. The information in OPIS (http://opis.kins.re.kr) is composed of the date, title, power level of reactor and turbine generator before shutdown, outline, watch code and field report, which are the input items for Incident Report System (IRS) of the IAEA.

KHNP also formulates and implements the Procedures for Utilization and Control of Technological Information to efficiently utilize the operating experience of foreign nuclear installations.

KHNP joined the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) to promote information exchange and cooperation among operators of nuclear installations. The KHNP has also become a member of PWR Owner's Group, Framatome Owner's Group, CANDU Owner's Group. The KHNP concluded technical agreements with foreign electric power companies to exchange relevant technologies and experience. KINS continuously improves the e-FAST (electronic Functional Analysis & Simulation Tool) the nuclear plant analyzer which permits the qualitative and quantitative analysis of operating events collected to establish and enforce the nuclear plant operating experience feedback system on a national scale. The e-FAST, a tool of analyzing the status and operational progress of any nuclear power plants under normal operation, abnormal operation, transients and accidental circumstances, is the nuclear plant simulator designed to make the interactive manipulation of equipments possible through the Graphic User Interface. The E-Fast was developed from 2001 to 2005 and has regularly been improved for the five types of reactors operating in the Republic of Korea, namely, OPR-1000, CANDU, Framatome, W/H 3 Loop, and W/H 2 Loop.

To share and spread the information on foreign and domestic operating experiences, The Workshop on the Operating Experiences Feedback has been annually held at KINS with the government and other organizations since 2003.

III.14.9 Minimization, Treatment, and Storage of Radioactive Waste

Article 66 (Radioactive Waste Management Program) of Regulations on Technical Standards for Nuclear Reactor Facilities, Etc. stipulates that the operator of a nuclear power reactor shall establish a radioactive waste management program and minimize the amount of radioactive wastes and effluents. Solid waste generated from facilities include dry active wastes (component parts, decontamination paper, radiation protective clothing, gloves, shoes, etc.) created in the maintenance process as well as concentrated liquid wastes, spent resin and spent filter produced while processing liquid and gaseous radioactive wastes.

Dry active wastes are packed after being compressed by general compressor (30 tons of capacity). In case of Hanul Unit 5 & 6, vitrification facility is used for low and intermediate level radioactive wastes to process vitrifiable combustible dry active waste, resulting in an advantage of 90% of volume reduction. Concentrated liquid wastes are packed in high integrity container and spent resin is first dried in dry equipment to be packed in high integrity container or its equivalent. Meanwhile, spent filter is stored after being packed in proper shielded container. Radioactive wastes are stored in temporary storages in each of NPP sites until they verify disposal suitability and transported to disposal facility. Further details can be found in National Report on joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.

Annex

A. Data on Korea Nuclear Installation

B. Nuclear Safety Charter

C. Nuclear Safety Policy Statement

D. Policy on Severe Accident of Nuclear Power Plants

E. Recent Major Events (2013~2015)

F. List of Agreements and MOU

Annex A. Data on Korea Nuclear Installation

Table A-1 Nuclear Power Plant in Operation

(As of December 2015)

Station Name	Reactor Type	Capacity (MWe)	Operator	NSSS Supplier	Connected to Grid	Commercial Operation
Kori Unit 1	PWR	587	KHNP	WH	1971. 8	1978. 4.29
Kori Unit 2	PWR	650	KHNP	WH	1978. 7	1983. 7.25
Kori Unit 3	PWR	950	KHNP	WH	1979. 6	1985. 9.30
Kori Unit 4	PWR	950	KHNP	WH	1979. 6	1986. 4.29
Wolsong Unit 1	PHWR	678.7	KHNP	AECL	1977. 6	1983. 4.22
Wolsong Unit 2	PHWR	700	KHNP	KHIC/KAERI/AECL	1991.10	1997. 6.30
Wolsong Unit 3	PHWR	700	KHNP	KHIC/KEPCO E&C/AECL	1993. 8	1998. 7. 1
Wolsong Unit 4	PHWR	700	KHNP	KHIC/KEPCO E&C/AECL	1994. 2	1999.10. 1
Hanbit Unit 1	PWR	950	KHNP	WH	1980.10	1986. 8.25
Hanbit Unit 2	PWR	950	KHNP	WH	1980.10	1987. 6.10
Hanbit Unit 3	PWR	1,000	KHNP	KHIC/KAERI/ABB-CE	1989. 6	1995. 3.31
Hanbit Unit 4	PWR	1,000	KHNP	KHIC/KAERI/ABB-CE	1989. 6	1996. 1. 1
Hanbit Unit 5	PWR	1,000	KHNP	DHIC/KEPCO E&C	1996. 9	2002. 5.21
Hanbit Unit 6	PWR	1,000	KHNP	DHIC/KEPCO E&C	1996. 9	2002.12.24
Hanul Unit 1	PWR	950	KHNP	FRAMATOME	1981. 1	1988. 9.10
Hanul Unit 2	PWR	950	KHNP	FRAMATOME	1981. 1	1989. 9.30
Hanul Unit 3	PWR	1,000	KHNP	KHIC/ABB-CE	1992. 5	1998. 8.11
Hanul Unit 4	PWR	1,000	KHNP	KHIC/ABB-CE	1993. 7	1999.12.31
Hanul Unit 5	PWR	1,000	KHNP	DHIC/KEPCO E&C	1999. 1	2004. 7.29
Hanul Unit 6	PWR	1,000	KHNP	DHIC/KEPCO E&C	1999. 1	2005. 4.22
Shin-Kori Unit 1	PWR	1,000	KHNP	DHIC/KEPCO E&C	2005.1	2011. 2.28
Shin-Kori Unit 2	PWR	1,000	KHNP	DHIC/KEPCO E&C	2005.1	2012. 7.20
Shin-Wolsong Unit 1	PWR	1,000	KHNP	DHIC/KEPCO E&C	2005.9	2012. 7.31
Shin-Wolsong Unit 2	PWR	1,000	KHNP	DHIC/KEPCO E&C	2005.9	2015. 7. 24
Shin-Kori Unit 3	PWR	1,400	KHNP	DHIC/KEPCO E&C	2007.9	2015.10 (Approval of Operating License)

Table A-2 Nuclear Power Plant in Operation

(As of December 2015)

Station Name	Reactor Type	Capacity (MWe)	Operator	NSSS Supplier	Start of Construction		Approval of Operating License
Shin-Kori Unit 4	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2007.9	2011.6	-
Shin-Hanul Unit 1	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2010.4	2014.12	-
Shin-Hanul Unit 2	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2010.4	2014.12	-

Note) Glossary of Terms

- ABB-CE : Asea Brown Boveri-Combustion Engineering
- AECL : Atomic Energy of Canada, Limited
- KAERI : Korea Atomic Energy Research Institute
- KHIC : Korea Heavy Industries Co.
- DHIC : Doosan Heavy Industries Co.
- KHNP : Korea Hydro & Nuclear Power Co.
- KOPEC : Korea Power Engineering Co.
- WH : Westinghouse Electric Co.
- KEPCO : Korea Electric Power Co.
- KEPCO E&C : KEPCO Engineering & Construction Co.

Annex B. Nuclear Safety Charter

Recognizing that the peaceful use of nuclear energy contributes to national development and improvement of the quality of the people's life, and confirming that protection of the people and preservation of the environment through safe control of nuclear energy have the first and foremost priority over others, we pledge ourselves:

1. To maintain the highest standards of safety in the use of nuclear energy;
2. To release information regarding nuclear safety promptly and transparently;
3. To reflect the public opinion in formulating nuclear safety policies;
4. To assure the independence and fairness in nuclear safety regulation;
5. To strengthen research and development of technologies on nuclear safety;
6. To abide sincerely by national laws and international agreements on nuclear safety;
7. To complement and improve the nuclear safety-related legal system continuously; and
8. To promote nuclear safety culture and incorporate it in our workplace.

September 6, 2001

ANNEX C. Nuclear Safety Policy Statement

1. Introduction

The following declares the NSSC's major policies for the assurance of nuclear safety through the settlement of nuclear regulatory goals and principles to meet the growing public concern for nuclear safety and environment. The purpose of this Statement is to improve the consistency, adequacy and rationality of nuclear regulatory activities by notifying the public and concerned people in and out of the nuclear field of the Government's basic policies regarding nuclear safety.

As declared in the report titled, "Directions of Long-term Nuclear Energy Policy toward the Year 2030," which was approved at the 234th AEC in July 1994, Korean nuclear policy is aimed at establishing the safe use of nuclear energy for peaceful purposes and improving public welfare. Therefore, the assurance of nuclear safety should be given first priority in the development of nuclear power, and organizations and individuals engaged in nuclear power activities should adhere to safety principles as top priority.
The Korea public's distrust of nuclear safety has grown significantly these days due to the Chernobyl nuclear accident. Sometimes we are confronted with a vocal and often powerful anti-nuclear movement, particularly in the region where nuclear facilities will be built. Therefore, people in the nuclear field should have a more pro-active attitude in assuring nuclear safety so that the much-needed public trust and confidence can be obtained, and they should devote more effort to communicate with the public to resolve outstanding issues.

These days, nuclear safety is not a matter for one country but a world-wide concern. The Nuclear Safety Convention signed by IAEA member states during the 38th IAEA General Conference is one example of world-wide efforts to enhance nuclear safety. Its objectives are to establish national measures on nuclear safety and to ensure that each contracting party fulfills its obligations under the said Convention. As a result, each contracting country has an international responsibility for nuclear safety.

The Korean Government will continue to pursue its goal of achieving a high level of nuclear safety through the enhancement of safety technologies and the internationalization and rationalization of the regulatory system, recognizing that the overriding priority should be given to the assurance of nuclear safety before the development of the nuclear industry.

2. Safety Culture

The government reaffirms that nuclear safety takes a top priority in the development of nuclear energy and that it should be of foremost concern for organizations and individuals engaged in nuclear activities. The government also develops safety culture which was presented by the IAEA, recognizing that nuclear safety issues are more closely related to human factors rather than to technical ones, as demonstrated by two nuclear accidents, TMI and Chernobyl.

The safety of nuclear facilities can be secured through dedication to common goals for nuclear safety by organizations and individuals at all levels by giving a high priority to safety through sound thought, full knowledge and a proper sense of safety responsibility. The government recognizes that nuclear safety is achieved not only by safety systems and strict regulations throughout the whole stages of design, construction, operation and maintenance of nuclear power plants, but also by the spread of safety culture. In meeting this commitment, the government strives for strict regulations through the development of clear safety goals and regulatory policies. It will actively encourage safety-related research and technical development to achieve technical expertise of regulatory activities and will ensure regulatory independence and fairness by minimizing any undue pressure and interference.

Nuclear utilities establish management policies, giving a high priority to nuclear safety, and foster a working climate in which attention to safety is a matter of everyday concern. Managers encourage, praise and provide tangible rewards to employees for commendable attitudes and good practices concerning safety matters. On the contrary, when errors are committed, individuals are encouraged to report them without any concealment and to correct them to avert future problems. For repeated deficiencies in or negligent attitudes toward nuclear safety, managers take firm measures in such a way to prevent the same errors from occurring again. In this way, safety culture will be achieved through sound safety policies and full understanding of safety culture by the senior management and through proper practices and implementation by individuals engaged in the nuclear industry.

3. Regulatory Principles

The ultimate responsibility for safety of nuclear facilities rests with the licensee. This is in no way diluted by the separate activities and responsibilities of designers, suppliers, constructors and regulators.
The government has in nature an overall responsibility for ensuring the protection of public health and the environment from radiation hazards which may occur in the development of nuclear energy. It inspects and ensures the appropriateness of the licensee's safety practices through nuclear regulations and establishes a high level of safety assurance system in order to achieve safety goals on a government level. To effectively regulate, the government sets forth the following five principles to encourage high-safety performance.

3.1 Independence

The government establishes the legal framework for the independent regulatory organization responsible for nuclear regulatory activities. It takes proper measures to ensure the independence of the regulatory organization, which is functionally separated by the other organizations and systems involved in the development of nuclear energy. It also ensures that the regulatory organization acts on its own objective, technical judgment without any political interference and influence from external sources.

The regulatory organization should maintain an extensive program of research and sufficient staff resources to review and audit the licensee's submittals so that it can independently verify the validity of the licensee's assertions which are critical to regulatory decisions. The regulators do their work seeking to achieve the highest standards of ethical performance and professionalism. Regulators' decisions and judgments must be based on objective, unbiased assessments, considering possible conflicting interests of those involved, and their work must be documented. Based on the safety culture, the regulatory organization should support and guide the licensee in solving its problems, but only to the extent that the regulatory organization's independence is not impeded.

3.2 Openness

The purpose of nuclear regulations is to protect public safety and to ensure that all activities are legal and public. The government maintains an open channel with the public for regulatory information so that the public can understand and rely on the regulatory process. The government is also devoted to establishing a sound social stand on nuclear safety by making an effort to inform the public properly and openly of nuclear activities including safety matters.

The government also develops nuclear policies based on public consensus, paying attention to the public's right to know the regulatory process. To accomplish this, the government extends an opportunity to the public to participate in the regulatory processes and publicizes related information under the principle titled, "Openness and Democratization of Nuclear Administration."

However, the restricted information from industries or concerned individuals is protected and kept in confidence, and treated according to the provisions concerned. The government objectively informs the public of its activities so that it may collect public opinions more soundly and properly, and it strives to get public consensus through constant communication and interaction with the regulators, licensees and the public.

3.3 Clarity

Nuclear regulations should be enforced through clear regulatory policies which are based on safety goals on a national level. There should be a coherent nexus between regulations and agency goals and objectives. Agency position should be documented to be readily understood and easily applied.

The government endeavors to ensure that the licensee is fully informed about the regulators' policies so that the licensee can prepare for new policies in advance in order to achieve nuclear safety effectively upon implementation. In a case where a new or revised regulation is expected, the government informs the licensee of the regulatory policies and provides guidance in advance and establishes regulatory practices to minimize the licensee's trials and errors caused by the revision of regulatory requirements.

The licensee should thoroughly observe the Atomic Energy Act, technical standards and regulatory guidance, and if there is a need to revise them or there is any unreasonable act or technical standard, the licensee should communicate its view with the regulatory organization in order to initiate any revisions.

3.4 Efficiency

The regulatory organization has the responsibility to provide the licensee and the public with the best possible management and administration of regulatory activities. To accomplish this, it must make constant efforts to evaluate and upgrade its regulatory capabilities.

The regulatory organization should possess sufficient staff members capable in performing regulatory activities which are closely connected with many technical areas, and the regulatory activities must be performed efficiently to contribute to the achievement of the goal of "Nuclear risk reduction."

Regulatory decisions must be made with the best use of all the resources invested in the regulatory process to minimize undue impediments.
Before regulatory decisions related to the improvement in nuclear safety are made, the nuclear risk reduction scale and economic benefits which can be gained from the improvement should be reviewed first.

To efficiently perform regulatory activities with limited capabilities and time, appropriate prioritization of regulatory activities must be made based on risks, costs, and other factors. Regulatory alternatives which minimize cost are adopted unless they increase the degree of risk, and in all cases resources should be used effectively for the improvement of nuclear safety.

3.5 Reliability

The regulatory organization endeavors to eliminate public distrust and fear of nuclear activities and obtain the public's trust and support through fair regulations based on technical and professional judgments. Regulatory decisions must be made promptly and fairly, and reliably based on the best available knowledge from research and operational experiences.

The government obtains up-to-date technical information on nuclear safety and applies this information to regulatory activities. When regulatory requirements need to be either newly established or changed, the most suitable option is adopted after the effectiveness of its implementation and technological difficulties resulting from any changes are sufficiently reviewed.

The government does its best to run its regulatory system efficiently and systematically, and to thoroughly enforce the regulations in order to secure the public's trust on nuclear safety systems.

4. Directions of Nuclear Safety Policy

- To quickly realize the establishment of safety culture and safety assurance system, each organization prepares its Implementation Program of Safety Culture and a regulatory body provides a systematic basis to evaluate the results of its implementation.

- Nuclear power plants in operation or under construction are supplemented with regulatory requirements consistently and systematically to achieve an international level of nuclear safety, taking into account the possibility of severe accidents.

- For the newly constructed nuclear power plants, factors which may increase the total risk caused by the construction of an additional nuclear power plant at the same site of existing ones are to be mitigated by improving the safety level at each grade as compared with that of the existing nuclear power plant. For the nuclear power plants in operation, maintenance, repair, inspection, and monitoring of the components are to be strengthened. Periodic Safety Reevaluation is established and implemented to reassess and supplement safety deficiencies which may be caused by the aging of the facilities and application of old technical standards.

- In accordance with the regulatory requirement changes in and out of the country, the existing atomic energy law system is to be revised and supplemented, and related technical standards and regulatory guidance are to be maintained in order to efficiently perform regulatory activities.

- In consideration of the technical expertise required for nuclear regulatory activities, safety research should be continuously strengthened to meet the growing demand of regulatory requirements due to technical advancements in the nuclear field.

- Solutions for unresolved safety issues including generic safety issues of the nuclear power plants are promptly found and reflected in the policy. Operating record and accident and failure data are analyzed to determine the factors which affect the safety of the nuclear power plants, and efficient safety supplement measures are also established.

- The regulatory organization reviews the introduction of Optimum Assessment & Probabilistic Assessment for safety analyses, and encourages the licensee to introduce new technologies when and if they are considered to be reasonable safety assurance measures, as proven by their application.

- An Overall Safety Assessment is performed using probabilistic safety assessment and Nuclear Regulation based on Risk is done through sound safety regulations in consideration of cost-benefit factors.

- Quantitative safety goals and regulatory guidelines for the examination, prevention and mitigation of severe accidents are established and improved to be gradually applied to advanced nuclear power plants as well as to existing ones. In addition, design and operational safety of nuclear power plants are achieved through the measures in order to minimize human errors.

- Radiation protection is achieved by the concept, "Radiation exposure should be kept as low as reasonably achievable," taking into account economic and social circumstances, and for the individual exposure dose, introduction of radiation protection standards based on the new ICRP 60 recommendations is being favorably reviewed.

- In response to the growing public concern about nuclear safety, nuclear safety-related information and regulatory activities are open to the public through the publication of the White Paper on Nuclear Safety and through the periodic release of information about accidents and failures at nuclear power plants.

5. Conclusion

The nuclear community strives for the public's proper understanding of nuclear energy and the establishment of safety culture by hearing and addressing the public's concerns with understanding and by using the collected wisdom of those involved to solve any problem together.

Nuclear safety can not be achieved in a day, but rather it is secured through the licensee's constant efforts to improve nuclear safety and through the regulator's thorough enforcement activities. The basic concept of nuclear regulations is to protect the public from radiation hazards and to pursue a "better safety performance" as allowed by the circumstances. To this end, the government is devoted to developing a higher level of nuclear safety technology and regulatory system, and to achieving an international level of nuclear safety through participation in the "Nuclear Safety Convention."

In conclusion, the government reaffirms that the assurance of nuclear safety is the highest duty of the regulatory organization and ensures that such an important role is performed faithfully to secure nuclear safety on behalf of the public.

September 10, 1994

Annex D. Policy on Severe Accident of Nuclear Power Plants

1. Background

Nuclear power plants are subject to stringent technical codes and standards in all phases of their design, construction, and operation. The probability of severe accident which could result in large off-site release of radioactive materials is very low. If it occurs, however, its social and economic effects could be very serious.

Thus, the license holders are required to take measures to minimize its possibility and, if it should occur, to take proper measures to minimize the risk of radiation exposure to the public. Hence the quantitative safety goals are to be established and implemented against severe accident.

2. Definitions of the Terms

1) The term "severe accident" means the beyond design basis accident leading to core damage.

2) The term "severe accident management" means those actions taken by the plant staff during the severe accident to terminate the progress of core damage, to maintain containment performance, to minimize on-site and off-site release of radioactive materials, and to recover the plant into stable state.

3) The term "PSA update" means activities which revise probabilistic safety assessment model reflecting the latest plant status including changes of facilities and operational procedures, and perform the probabilistic safety assessment again.

4) The term "risk monitor" means a plant specific real-time analysis tool used to determine the instantaneous risk based on the actual status of the systems and components related to the activities such as preventive maintenance or periodic inspection of plant systems and components.

5) The term "PSA" means a comprehensive assessment that identifies the accident scenarios and quantifies the occurrence frequency and consequence of the accident and its effects on the public through probabilistic approach.

- Level 1 PSA identifies the sequence of events that can lead to core damage and estimates the core damage frequency.
- Level 2 PSA identifies the scenarios that can lead to radioactive release from the containment and estimates their magnitude and frequency.
- Level 3 PSA estimates the consequence of off-site release of radioactive materials in order to determine the risks to the public.

3. Policy on Severe Accident

1) Safety Goal

The risk to an average individual in the vicinity of a nuclear power plant of prompt fatalities that might result from reactor accidents should not exceed 0.1% of the sum of prompt fatality risks resulting from all other accidents. The risk to the population in the area near a nuclear power plant of cancer fatalities that might result from nuclear power plant operation should not exceed 0.1% of the sum of cancer fatality risks resulting from all other causes. To achieve the above safety goals, the performance goals which are aimed at preventing the core damage and mitigating the fission product releases from the containment are to be established.

2) Probabilistic Safety Assessment

An owner of nuclear power reactor should assess the safety of the nuclear power plant through probabilistic approach to find measures which can reduce the risk as low as possible. The design and operational procedures of nuclear power plant should be reviewed and assessed to improve the capabilities for accident prevention and mitigation, especially for the accident scenarios which have relatively high probability of core damage. It should be also complemented by the cost-benefit consideration.

3) Severe Accident Prevention and Mitigation Capability

Nuclear power plant should have a capability to prevent core damage for minimizing severe accidents. Reactor containment should maintain its structural integrity and function as a barrier against fission product release to mitigate the consequence of accident, if core damage occurs.

4) Severe Accident Management Program

An owner of nuclear power reactor should establish and implement severe accident management programs. The programs should include accident management strategies, accident management organization, guidelines, training and education program, instrumentation, and analysis of essential information, etc.

Annex E. Recent Major Events (2013-2015)

1. Kori Unit 2 Turbine Manual Stop and Reactor Automatic Trip by Flood in the Circulation Pump Room due to Localized Downpour

At 13:00 on August 25, 2014, the Korea Meteorological Administration issued a heavy rain warning in Busan area, and from 13:05, the NPP operator began checking for leaks, etc. of flood control materials in the turbine building, intake building, etc. and in the auxiliary building, fuel building and intermediate building, etc. according to the 'Natural Disaster Preventive Checks and Actions.' At the same time, a shift technical adviser of operations team and a secondary side local operator were in the circulation water pump (CWP) room to supervise the replacement of a power supply to the circulation pump C alarm panel following its power failure yesterday (Aug 24). Around 14:10 to 20, the shift technical adviser and the secondary side local operator detected that rain leaking through the fan located up in the circulation pump room and the outlet pipe penetration of a rotating filter washer pump, and around 14:30 to 50, the secondary side local operator identified an inpour of rain (to the extent where it was impossible to distinguish the type of conduits) through the cable conduit located up on the wall of the circulation water pump A side.

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As the flood in CWP room continues with rain leaks due to downpour, the NPP operator installed four temporary drainage pumps (14:10 to 15:50) to drain water. Despite the effort, the leakage continued to flood the CWP room, stopping the two out of four CWPs in sequence (CWP 'D', 15:40, CWP 'C', 15:51), which lowered the condenser vacuum (0.044kg/cm^2 →0.065kg/cm^2) and led to power reduction operation. Soon afterwards, another CWP failed (CWP 'B', 15:53) setting off the "Condenser Vacuum Low" alarm (15:54, setpoint: 0.092kg/cm^2). The operator predicted that condenser vacuum could not be maintained for the normal operation of the turbine/generator and a turbine trip (setpoint:0.152kg/cm^2) will occur due to low condenser vacuum and the operator manually stopped the turbine (15:54). As the turbine tripped at the reactor power of 30% or higher, the RPS was activated to automatically trip the reactor following the automated logic signal interlock.

Following the reactor trip, plant systems and equipment worked as designed and safety features such as entering hot standby mode, maintaining safe shutdown, etc. were maintained. It was confirmed later that no harm was made to the safety related systems and no safety related events such as leakage of radioactive materials occurred due to the downpour. According to the investigation into the event, it was confirmed that a large amount of rainwater leaked into the CWP room through a penetration pipe within the cable conduit installed in Kori Unit 2 site due to the record rainfall (134mm/hr) in Kori NPP site, stopping three CWPs and reducing condenser vacuum. As it was impossible to maintain the condenser vacuum within the normal operating range, the operator manually tripped the turbine/generator and verified the automatic reactor trip following the automated logic signal interlock as well as the leakage in the bottom of condensate pump room in the turbine building due to the heavy rainfall.

Short-term corrective measures to prevent the same event from happening again have been conducted, which include: CWP room cable conduit was sealed; the terminal block for CWP outlet pressure switch was relocated higher than before; a cutoff wall for turbine building side cable conduit was installed; damaged or leaking pipes inside the annulus were checked and repaired; the maintenance of flood prevention facility was completed; the sealing of penetration that links outside buildings was checked; the procedure on natural disaster preventive inspection was revised, etc. For the mid- and long-term, the measures including the duplication of main building power supply facility, the installation of the underground flood prevention concrete wall, the waterproofing of CWP control room entrance, the improvement of rainwater drainage flow path outside the upper dome of the shield building, the flood mitigation measures in case of downpour, the new installation of sump level monitors for main buildings and MCR alarms, the plant site waterproofing measures, etc. have been put in place.

2. Hanbit Unit 3 Automatic Reactor Trip During Power Reduction for the Maintenance of Leaking SG Tube

On October 16, 2014, a sign of leakage from SG tube was detected during the full power operation of Habit Unit 3. Operator reduced the reactor power for the maintenance, but during this process, a 'Departure From Nucleate Boiling Ratio (DNBR) Low' signal was generated at 02:09 on Oct 17, tripping the reactor automatically.

The investigation found that the reactor trip occurred following the activation of reactor protection signal. The reactor power was reduced for the maintenance of leaking SG tube and had been maintained at a low level (-15%) in coordination with power supply system, but there was a difference between the reactor power that bypasses reactor trip signal based on core protection calculator axial shape index and the actual reactor power displayed to the MCR operator, which triggered the reactor protection signal.

It was confirmed that SG tube leak was caused by the metal scraps resulted from processing carbon steel, which entered into the SG secondary side and worn down the tube through repetitive contacts. The review on the response to SG tube leak found that the N-16 leak monitor in main steam line failed to detect the leak and SG #2 blowdown RMS flow path had been blocked, misleading operators in identifying and isolating the leaky SG tube, thereby delaying the isolation of leaking SG. The cause of N-16 leak monitor failure was confirmed to be the mis-calibration of the instrument according to the revised calibration procedure that was not in line with manufacturer's recommendations, whereas the blockage of RMS flow path was due to the accumulation of sludge inside the path, which had slowed down the flow.

The dose of radioactive materials released into the environment through condenser air ejector, etc. was a total 1.88E+10 Bq with the concentration in the boundary of exclusion area amounting to 0.12% of release control standard as specified in the NSSC Notice. The resulting exposure dose of residents is 3.056E-06 mSv per year, about 1/320000 of annual dose limit of an adult, which gives little impact on human health. Moreover, the environmental radioactivity monitors in the Habit NPP site area were retrieved to examine any radioactive level changes and analyze samples before and after the event, but it turned out no specific changes were made, reconfirming that the environmental impact of the event was minimal.
As the short-term corrective measures, the NPP operator completed the following: 1) the revision of comprehensive operations procedure on axial shape index reactor trip signal; 2)

Updates/revision of leak monitor calibration procedure; 3) the manufacturer's inspection and maintenance of all (four) leak monitors; 4) the complete overhaul of blowdown flow path; 5) the quarterly cleanse of blowdown flow path and the improvement of inspection process including the weekly check of pressure gauge, etc.; 6) Updates/revision of an abnormal procedure for tube leak response; 7) the improvement in reporting process to ensure an immediate and direct reporting to Operations Team when indicated value shows an abnormal increase; 8) the clarification of sample testing procedures when releasing radioactive materials off-site through an exhaust flow path; 9) special management of area where metal scraps can be generated; and 10) the revision of a procedure to ensure the prevention of foreign substances from entering NPP. Along with these corrective measures, long-term plans including: 1) the review on the possibility of design change to place an axial shape index indicator; 2) the repurchase of verification sources for N-16 calibration; and 3) the improvement of a flowmeter in the blowdown sampling flow path have been developed and suggested.

To reflect the lessons learned from this Habit Unit 3, the NPP operator conducted the following inspections on all NPPs: 1) the flowmeter check in the blowdown flow path; 2) the correctness of N-16 leak monitor calibration procedure and the suitability of monitoring range - all plants confirmed the suitability of their leak monitors; and 3) the effectiveness of calibration sources for N-16 leak monitor - plans were laid out to repurchase some sources or re-assess the source effectiveness. Following the comprehensive review on above measures, it was confirmed that they have been valid actions to prevent similar events from happening again.

Annex F. List of Agreements and MOU

Table F-1 Lists of Agreements and MOU between the NSSC and relevant foreign authorities

Counterparts (Contracted Party)	Type	Effective Date
Arab Emirates, Federal Authority for Nuclear Regulation (FANR, Regulatory Body)	Agreement	2011.12.20
Canada, Canadian Nuclear Safety Commission (CNSC, Regulatory Body)	MOU	2012.4.16
Finland, Radiation and Nuclear Safety Authority (STUK, Regulatory Body)	Arrangement	2012.5.4
United States, Nuclear Regulatory Commission (NRC)	Arrangement	2012.9.18
France, Autorité de sûreté nucléaire (ASN)	Arrangement	2012.12.19
Sweden, Swedish Radiation Safety Authority (SSM)	MOU	2014.9.23
Germany, Federal Ministry for the Environment (BMUB)	Joint Declaration	2014.9.24.
Jordan, Energy and Minerals Regulatory Commission (EMRC)	MOU	2014.12.22.
Vietnam, Vietnam Agency for Radiation and Nuclear Safety (VARANS)	MOU	2015.9.15
China, National Nuclear Safety Administration (NNSA)	Special Agreement	2015.10.23

Table F-2 Lists of Agreements and MOU between the KINS and relevant foreign authorities

<table>
<tr><th colspan="2">Counterparts (Contracted Party)</th><th>Type</th><th>Effective Date</th></tr>
<tr><td colspan="2">United States, Nuclear Regulatory Commission (NRC)</td><td>MOC</td><td>2011.3.8</td></tr>
<tr><td colspan="2">France, Institute of Radiation Protection & Nuclear Safety (IRSN)</td><td>Cooperation Agreement</td><td>1990.9.24
Revised on
2012.12.17</td></tr>
<tr><td colspan="2">Germany, Gesellschaft für Anlagen und Reaktorsicherheit mbH (GRS)</td><td>Arrangement</td><td>1998.9.25
Revised on
2012.6.8</td></tr>
<tr><td colspan="2" rowspan="2">Rumania, National Commission for Nuclear Activities Control (CNCAN)</td><td>MOU</td><td>1996.9.21</td></tr>
<tr><td>Additional Arrangement</td><td>2006.12.1</td></tr>
<tr><td colspan="2">Finland, Radiation and Nuclear Safety Authority (STUK)</td><td>Arrangement</td><td>2006.9.8</td></tr>
<tr><td colspan="2">Indonesia, Nuclear Energy Regulatory Agency (BAPETEN)</td><td>Arrangement</td><td>2006.11.20</td></tr>
<tr><td colspan="2">Jordan, Energy and Minerals Regulatory Commission (EMRC)</td><td>MOU</td><td>2014.9.26</td></tr>
<tr><td colspan="2">Republic of South Africa, The National Nuclear Regulator (NNR)</td><td>MOU</td><td>2011.12.11</td></tr>
<tr><td rowspan="2">Japan</td><td>Japan Chemical Analysis Center (JCAC)</td><td>MOU</td><td>1989.3.3
Revised on
1991.7.9</td></tr>
<tr><td>National Institute of Radiological Sciences (NIRS)</td><td>MOU</td><td>2009.10.15</td></tr>
<tr><td rowspan="4">China</td><td>National Nuclear Safety Administration (NNSA)</td><td>Arrangement</td><td>1996.4.17
Revised on
2000.12.4</td></tr>
<tr><td>China Institute for Radiation Protection (CIRP)</td><td>Arrangement</td><td>1995.6.19</td></tr>
<tr><td>Nuclear and Radiation Safety Center (NSC)</td><td>MOU</td><td>2015.11.30</td></tr>
<tr><td>National Nuclear Emergency Response Technical Advisory Center (NNERTAC)</td><td>MOU</td><td>2015.11.30</td></tr>
<tr><td rowspan="2">Vietnam</td><td>Vietnam Agency for Radiation and Nuclear Safety (VARANS)</td><td>MOU</td><td>2007.1.29</td></tr>
<tr><td>University of Dalat</td><td>MOU</td><td>2007.1.31</td></tr>
<tr><td rowspan="2">Arab Emirates</td><td>Federal Authority for Nuclear Regulation (FANR)</td><td rowspan="2">MOU</td><td>2010.5.25</td></tr>
<tr><td>Khalifa University of Science, Technology and Research</td><td>2011.12.18</td></tr>
</table>

SEVENTH NATIONAL REPORT FOR THE CONVENTION ON NUCLEAR SAFETY

THE REPUBLIC OF KOREA