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8th National Report for the Convention on Nuclear Safety

Nuclear Safety and Security Commission
the Republic of Korea

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Abbreviations

AMP	Aging Management Program
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. Brief Account on the National Report
2. National Nuclear Energy Policy

I

Introduction

1 Brief Account on the National Report

The Republic of Korea has prepared this report for submission in accordance with Article 5 of the Convention on Nuclear Safety as a full Contracting Party to the Convention. This report describes the actions taken by the Korean government to implement the obligations stipulated in Article 6 to Article 19 of the Convention.

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 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, 2018 but latest developments are incorporated for some major issues. The report is structured according to the Guidelines Regarding National Reports under the Convention on Nuclear Safety[1)] and the implementation status of obligations is described in the same order as the articles of the Convention.

For the purpose of preparing the 8th national report, the Nuclear Safety and Security Commission (NSSC) has run the Working Group for the Convention on Nuclear Safety led by Director General of Planning and Coordination Office, and, as a member of this group, the Korea Institute of Nuclear Safety (KINS) performed major works related to the preparation of this report. In addition, Korea Hydro & Nuclear Power Co., Ltd. (KHNP), KEPCO Engineering & Construction Company Inc.(KEPCO E&C), Doosan Heavy Industries & Construction (DHIC), Korea Atomic Energy Research Institute (KAERI) and Korea Foundation of Nuclear Safety (KoFONS) participated in the activities of the Working Group.

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

I. Introduction

II. Summary

III. Self-Assessment : Article-by-Article Review

Annex

1) Guidelines regarding National Reports under the Convention on Nuclear Safety, INFCIRC/572/Rev.6, 19 January 2018.

· 2 · National Nuclear Energy Policy

2.1 Nuclear Energy Policy

In October 2017, the government deliberated, decided and announced a Roadmap for Energy Transition with a basic direction of nuclear power phase-out and the expansion of renewable energy at the Cabinet meeting. The gist of the nuclear power phase-out policy is not to extend design life for old nuclear power plants and not to construct new nuclear power plants. These policies were incorporated in the 8th Basic Plan on Power Demand & Supply (2017-2031) announced in December 2017, and the construction of 6 nuclear power units including Shin-Hanul Units 3&4 was canceled. This policy direction is also incorporated in the 3rd Basic Plan for Energy announced in June 2019.

2.2 Nuclear Safety Regulation Policy

After the Fukushima Accident, the Nuclear Safety Act (NSA) was separated from the Atomic Energy Act, which had covered both promotion and regulation of the nuclear industry, in 2011 to reinforce the independence of nuclear regulation. The government established the NSSC in October 2011 for a comprehensive nuclear safety management at the national level. Accordingly, the NSSC has established and implemented the Comprehensive Plan for Nuclear Safety regarding safety management of the use of nuclear power every 5 years in accordance with Article 3 (Establishment of the Comprehensive Plan for Nuclear Safety) of the NSA.

The plan is the highest level of national plan that presents the mid- to long-term policy direction of nuclear regulation, covering the current state and prospect of nuclear safety management, policy objectives and basic direction of nuclear safety management, area-specific tasks and their implementation, investment plan, and procurement. In addition, a detailed implementation plan for each area is established every year under the Comprehensive Plan for Nuclear Safety. (See Article 10 for more details.)

II

Summary

1. Major Safety Issues
2. Implementation of International Peer Review (Common Issue 2)
3. Follow-up Measures from the 7th Review Meeting
4. Implementation Status of Common Issues Identified from the 7th Review Meeting
5. Implementation of the Vienna Declaration

II
Summary

Major safety issues including regulatory policies raised after the previous national report, follow-up actions based on the results of the 7th Review Meeting and implementation status of international independent reviews are described in Section 1 to 4 in this chapter according to INFCIRC 572.3.(B). As requested in the chairman's letter related to the 8th CNS Review Meeting (December 13, 2018), the implementation of the Vienna Declaration on Nuclear Safety is described in Section 5 of this chapter.

· 1 · Major Safety Issues

1.1 Establishment of a Comprehensive Plan to Strengthen Nuclear Safety Standards

The public concern over nuclear safety increased after the Gyeongju Earthquake in September 2016 and the Pohang Earthquake in November 2017. Accordingly, the NSSC has developed a draft comprehensive plan for strengthening safety standards reasonably based on the comprehensive review on nuclear safety standards and completed the final version of the comprehensive plan after collecting opinion from all walks of life through public hearings and Nuclear Safety Regulation Information Meeting. The comprehensive plan was finally approved by the NSSC (March 8, 2019). The major contents of the plan include the improvement of PSR regulation and the validation of seismic design of nuclear power plants (NPPs). (Refer to Article 10.)

1.2 Permanent Shutdown of the Wolsong Unit 1

On June 15, 2018, Korea Hydro & Nuclear Power Co., Ltd. (hereinafter referred to as the KHNP), a licensee for nuclear power generation in Korea, decided permanent shutdown and decommissioning of Wolsong Unit 1, the first CANDU reactor (PHWR) in Korea, which began its commercial operation in 1983. Korea Institute of Nuclear Safety (KINS) established the Regulatory Review Guideline on Permanent Shutdown for PHWRs (February 27, 2019) based on existing Regulatory Review Guideline on Permanent Shutdown for PWRs to conduct a review on permanent shutdown of Wolsong Unit 1 which has different design and system operation characteristics from those of PWRs. On February 28, 2019, the KHNP submitted the application for the amendment of operation license relevant to the permanent shutdown of Wolsong Unit 1 to the NSSC and the regulatory review on the amendment of operation license is underway as of June 2019. (Refer to Article 6.)

1.3 Containment Liner Plate (CLP) Inspection for All NPPs

In June 2016, the corrosion on the backside of CLP, which could threaten the integrity of the CLP, was found in Hanbit Unit 2. In order to check whether this degradation is underway in other NPPs, CLP inspection has been conducted in all NPPs one after another. As of December 2018, similar defects were found in 13 units. The CLP inspection found not only the corrosion on the backside of CLP but also cavities in concrete structure of containment building which is in contact with the backside of the CLP. It is confirmed that the cavities were created during the construction of the NPP. Accordingly, the inspection on the containment structure in all NPPs is underway to check whether there is issue of cavities in concrete structure along with CLP inspection. As of December 2018, similar problem was identified in 12 units. Repair works are underway to correct problems in NPPs with defects of CLP corrosion or cavities in the concrete structure. (Refer to Article 6.)

1.4 Construction and Operation Status of APR1400 Units

The Advanced Power Reactor (APR1400) with a capacity of 1,400 MWe, have 40% higher electrical output than Korean standard type reactors (OPR1000) and a design life of 60 years. APR1400 units are reinforced with safety equipment to prevent core damage in the event of accidents. As of the end of 2018, Shin-Kori Unit 3 is in its second operation cycle and the regulatory reviews on the operating license for Shin-Kori Unit 4 and Shin-Hanul Units 1&2 are underway. The application of operating license for Shin-Kori Units 5&6 is planned in 2020. The reactors exported to the UAE are also APR1400 units. Seismic safety assessment related to the Gyeongju Earthquake in 2016 and safety issues identified in pre-operational tests were shared in all APR1400 Units to find out solutions. (Refer to Article 6.)

1.5 Development of Accident Management Program

Korea has implemented the regulation on severe accidents through the Severe Accident Policy Statement (refer to Annex B) since 2001.

The NSA was amended in 2016 to stipulate the requirements for the Accident Management Program in order to strengthen the regulation on the severe accident. The amended NSA requires the submission of the Accident Management Program as an attachment to the application of operating license (OL), which contains details on the management of various accidents such as design basis accidents, multiple failure accidents, beyond-design-basis external events and severe accidents. An operator is required to submit the Accident Management Programs for all 28 units by June 2019 with 3-year grace period for operating units. The subordinate statues under the NSA were also revised in 2016 to implement the regulation and KINS published the regulatory standards, regulatory guidelines and safety review guidelines which will be applied to the regulatory review on the Accident Management Program. The KHNP, an operator of NPPs, has developed the Accident Management Program that describe accident management strategies and implementation structure, assessment of accident management capabilities, and accident management education and training plans according to regulatory requirements for the Accident Management Program.

It is expected that the accident management for domestic NPPs will be upgraded by ensuring the establishment of a comprehensive and planned accident management program through review and approval by the NSSC. (Refer to the implementation status of Vienna Declaration and Article 6.)

· 2 · Implementation of International Peer Review (Common Issue 2)

2.1 IAEA SEED Mission

The KHNP and the Ministry of Trade, Industry and Energy of Korea applied for the Site & External Events Design (SEED) Mission to the IAEA in January 2017 in an aim to review and assess the capability to cope with natural disasters such as earthquakes on operating NPPs in Korea based on international standards after Gyeongju Earthquake in September 2016. In August 2017, IAEA SEED review was conducted in Korea. The SEED review team, composed of 2 IAEA experts and 3 international experts, assessed the safety, seismic performance, seismic monitoring and emergency preparedness of the Wolsong Nuclear Power Plant Site through document review and field visits for 5 days.

The review identified 7 good practices, 10 recommendations, and 3 suggestions. Good practices include the actions, jointly with the regulatory body, immediately taken to check the safety in 6 areas including equipment integrity after Gyeongju Earthquake and the establishment of the Comprehensive Plan for Earthquake (Measures to improve Safety of nuclear installations in preparation for large earthquake, December 2016) at the government level. In addition, recommendations and suggestions identified in the areas of safety, seismic performance and earthquake monitoring for in the Wolsong Nuclear Power Plant Site have been being incorporated into existing Comprehensive Plan for Earthquake. The review and evaluation for the Plan will be completed by 2022 in line with government-wide survey on the ground faults. The safety standards relevant to IAEA SEED Mission include Safety Reports Series NO. 66, GSR Part1 (Rev.1), GSR Part2, GSR Part4 (Rev.1), SSR-2/1 (Rev.1), SSR-2/2 (Rev.1), NS-G-1.6, NS-G-2.13, NS-G-3.1, SSG-9, SSG-18, and NS-R-3 (Rev.1).

2.2 Independent Review on Stress Tests

The NSSC requested an independent review by international experts to the IAEA (July 18, 2018) to check the effectiveness of stress test and regulatory review, which are underway for operating NPPs in Korea after the Fukushima Accident in Japan, from an independent perspective. The IAEA accepted the NSSC's request and organized a team of IAEA experts in the areas of external events, integrity of SSCs, safety functions, severe accidents and emergency preparedness. The team conducted a document review (August 2018) on the Hanul Unit 3 stress test report and field visits (September 3-11, 2018). The IAEA expert group submitted the final report to the NSSC in December 2018. The results of the IAEA's independent review showed that stress tests were conducted in Korea without any violation of IAEA safety standards/guidelines and the current method was evaluated to be a good method to check the capabilities of the NPPs to cope with extreme natural disasters and accidents. Four good practices were identified. The IAEA review team, however, presented 16 advices to respond to extreme natural disasters and accidents in a more stable manner even though the advices are not related to IAEA safety standards/guidelines. These advices will be incorporated into regulatory review for stress tests on following units and Accident Management Program so that the safety of domestic NPPs will be increased. (Annex I. refers to good practices and advices identified in the IAEA review and utilization of the review results). The IAEA's independent report and KINS's regulatory review report are disclosed at the website for stress test information (http://nsic.nssc.go.kr/stresstest). The reports for Hanul Unit 3 that includes KINS's regulatory review report for the stress test conducted at Hanul Unit 3, IAEA's independent review report and KHNP's analysis report (public) will be made available in English for member countries' reference.

2.3 Plan to Receive OSART Review

The KHNP decided to receive IAEA OSART (Operational SAfety Review Team) Mission to assess the safety of domestic NPPs against the IAEA Safety Standards which have been strengthened after the Fukushima Accident. IAEA OSART review, which was conducted for the first time in Kori Unit 1 in 1983, has been conducted for NPPs one by one by reactor type.

The most recent OSART review in Korea was conducted in Hanbit Units 5&6, which are OPR 1000 units in 2007. Shin-Kori Units 3&4, APR1400 units, were selected as the units to receive the 7th OSART Mission in Korea. The KHNP applied for OSART Mission to IAEA in August 2018 with a target to receive the review in the second half of 2020. IAEA OSART review will be conducted in 11 areas from safety leadership to human- technology-organization interactions based on IAEA Safety Standards. The NSSC will support the comprehensive review on the operational safety of APR1400 through OSART and oversight the implementation of safety improvement items to be proposed based on the results of OSART review.

· 3 · Follow-up Measures from the 7th Review Meeting

The 7th Review Meeting identified five good practices and found three challenges and one suggestion from the Republic of Korea. The current implementation status of each challenge and suggestion is as follows:

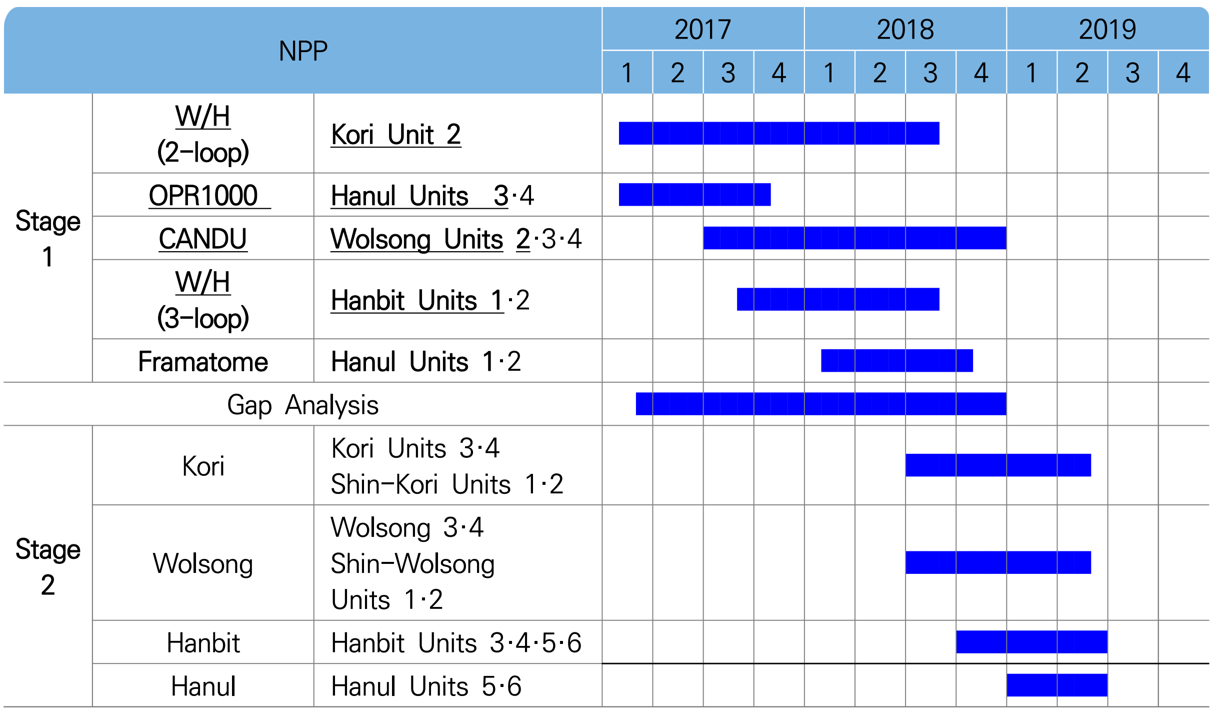
Challenges and suggestions

- (Challenge 1) Completion of (reinforced) stress tests for all NPPs
- (Challenge 2) Permanent shutdown of Kori Unit 1 (safety review and development of review guidelines, etc.) and review on decommissioning plan
- (Challenge 3) Verification of the seismic safety of Nuclear Power Plant Sites related to the Gyeongju Earthquake
- (Suggestion) Consideration of receiving IAEA OSART review

3.1 (Challenge 1) Completion of (Strengthened) Stress Tests for all NPPs

After the Fukushima Accident in Japan, the NSSC demanded that the licensee conduct stress tests for all NPPs in Korea to identify the safety level related to beyond-design-basis external events such as natural disasters in Korea and make reasonable safety improvements. To perform a stress test for all NPPs, KHNP adopted an approach to select a representative NPP by type for stage 1 assessment and utilize the assessment results to conduct gap analysis on other NPPs to complete the full assessment. Assessment on 5 representative NPPs (Westinghouse 2-loop, ORP1000, CANDU, Westinghouse 3-loop, Framatome) was initiated in 2017 and completed in December 2018 (the first stage assessment). The methodologies to perform gap analysis between a representative NPP and NPPs with same design were developed as well. Stage 2 assessment on NPPs with similar design, which has been underway based on gap analysis since 2018, will be completed by June 2019 and the results will be submitted to the NSSC. In particular, the reassessment results of seismic hazards considering the Gyeongju Earthquake (5.8-local magnitude) that occurred in September 2016 will be incorporated into the stress test. The progress of stress tests is presented in Figure 3-1. The regulatory body will verify the results of stress tests submitted by the licensee to make sure that safety to prepare for external events is improved reasonably for all NPPs. (Refer to Article 6.)

| Figure 3-1 | Current Status of Stress Test for All NPPs



3.2 (Challenge 2) Permanent Shutdown of Kori Unit 1 (Safety Review and Development of Review Guidelines, etc.) and Review on Decommissioning Plan

As the permanent shutdown of a power reactor starts, KINS, which was commissioned to conduct a technical review from the NSSC, established the Review Guideline on Permanent Shutdown for PWRs for the safety review on permanent shutdown of Kori Unit 1 on June 23, 2016.

As KHNP's application for an amendment of operation license for permanent shutdown of Kori Unit 1 was approved by the NSSC on June 9, 2017, Kori Unit 1 was permanently shutdown as of June 19, 2017 and currently, the preparation for decommissioning is underway. According to the NSA, which requires the submission of a decommissioning plan within 5 years after permanent shutdown, the KHNP should submit the final decommissioning plan for Kori Unit 1 by June 2022. KINS is currently developing the review guideline for a final decommissioning plan and planning to complete the development by 2020. (Refer to Article 6.)

3.3 (Challenge 3) Verification of Seismic Safety of Nuclear Power Plant Sites Related to the Gyeongju Earthquake

In September 2016, unusual large earthquake of 5.8 local magnitude occurred in Gyeongju, which is located near the Wolsong NPP Site. The NSSC conducted the safety inspection on all operating NPPs immediately after the earthquake and established the Comprehensive Plan for Improvement (December 22, 2016) to improve shortcomings found in the response to earthquake. Various findings related to safety and improvement in preparation for earthquakes were presented including the improvement of the earthquake response system, detailed evaluation and reinforcement of the seismic performance of NPPs, ground fault survey related to the Gyeongju Earthquake, reassessment of the effectiveness of design basis and the improvement of emergency response equipment to prepare for large earthquakes.

The seismic instrumentation and the alarming system were optimized to improve earthquake response systems, and operating procedures revised to make prompt reporting and actions possible. With the aim of assessing and reinforcing the seismic performance of NPPs, the seismic performance of safety shutdown systems of all NPPs, which are supposed to be actuated to achieve safe shutdown of a reactor after an earthquake, was assessed utilizing the probabilistic safety assessment (PSA) results. Seismic reinforcement was made, as necessary, to secure the safe shutdown capability to withstand at least 0.3g peak ground acceleration. The survey on the faults that caused the Gyeongju Earthquake and review on the effectiveness of design basis based on the survey results requires a significant amount of researchers and time, and a relevant research tasks project, which is supposed to be completed by 2021, is underway. The replacement of the existing Emergency Operation Facility (EOF) with a new emergency response building with seismic isolation feature is underway in an effort to improve emergency response facilities to prepare for large earthquakes. The replacement is to be completed by 2022. (Refer to Article 17 for more details.)

3.4 (Suggestion) Consideration of Receiving IAEA OSART Peer Review

The KHNP applied for IAEA OSART peer review for Shin-Kori Units 3&4, APR 1400 units, in 2018. (Refer to Section 2.3 of the Summary Chapter for OSART review plan.)

4 Implementation Status of Common Issues Identified from the 7th Review Meeting

The 7th Review Meeting identified a total of 10 common issues and the current implementation status of each issue is as follows:

4.1 Safety Culture

The NSSC declared in the 2nd Comprehensive Plan for Nuclear Safety (2017-2021) the improvement of the operation system including the adoption of integrated management models in line with IAEA GSR Part 2 "Leadership and Management for Safety" in order to make a safety culture take root. The NSSC selected in the comprehensive plan for strengthening nuclear standards (March 2019) "Strengthening Safety Culture of Licensees and the Regulatory Body" as an implementation task to win public trust. Specifically, it plans to revise rules for regulatory activities throughout the life cycle including the establishment of safety culture management system standards such as roles and responsibilities of operation organizations of NPPs and the establishment of a safety culture inspection system. Details are described in Article 10.

4.2 International Peer Review

Korea has actively utilized IAEA review services as it received IAEA SEED review in August 2017 and IAEA's independent review on stress test in September 2018. In addition, Korea accepted the proposal for receiving OSART review, which is one of the suggestions presented during the 7th CNS Review Meeting and applied for OSART review to IAEA in August 2018. The OSART review is planned to be conducted in the second half of 2020. The details are described in Section 2 of the Summary Chapter.

4.3 Legal Framework and Independence of the Regulatory Body

The Republic of Korea established the NSSC, an independent regulatory body, in 2011 to secure the independence of nuclear safety regulation after the Fukushima Accident.

Accordingly, the regulatory body was separated from government ministries responsible for nuclear energy promotion and the nuclear industry under the government organizational structure and the independence of the regulatory body is clearly stipulated in the Act on the Establishment of the Nuclear Safety and Security Commission. Details are provided in Article 8.

4.4 Financial and Human Resources

Korea established the Nuclear Safety Regulation Account(Atomic Energy Fund) in January 1, 2016 to include the financial resources for safety regulation, which was secured from charges and fees paid by nuclear power licensees, making it possible to secure financial resources for safety regulation stably and execute the budget in a transparent manner.

The budget of the NSSC is KRW 203.6 billion as of 2019, which is used for safety regulation, radiological emergency response and relevant R&D for nuclear installations. As of June 2019, the regular number of officers is 156 and 152 people are working at the NSSC Secretariat. Among them 118 officers work in headquarters and 34 officers work in regional offices. As of December 2018, the current number of employees of KINS is 558 and 551 respectively, and among them 526 employees work in headquarters and 25 employees people work as a resident inspector in 4 Nuclear Power Plant Sites. Its budget is KRW 115,900 million. Refer to Article 8 and Article 11 for more details.

4.5 Knowledge Management

The NSSC establishes an inspector training plan every year for its public officials to enhance their expertise. The training is dedicated to the subjects designed to better understand the national policy agenda and current issues as well as to enhance their expertise.

KINS runs intensive training programs and qualification system for regulatory inspectors to improve the job expertise and skill of regulatory inspectors. Licensing documents, regulatory experience, history and regulatory technologies are stored and shared through the intranet. And regulatory experience and knowledge are transferred by balancing the number of senior inspectors and junior inspectors to be dispatched to regional offices in Nuclear Power Plant Sites. Refer to Article 11 for more details.

4.6 Supply Chain

In order to maintain its supply chain, the KHNP has promoted various quality system establishment projects including the registration of qualified suppliers, acquisition and renewal of KEPIC(Korea Electric Power Industry Code) certification and support for the acquisition and renewal of overseas certification such as ASME(American Society of Mechanical Engineers). The plan for preemptive equipment replacement that is worth KRW 1.9 trillion was established and implemented between 2012 and 2022 for 14 NPPs, which have been in operation for more than 20 years, Design requirements, regulatory requirements and project owner's requirements are incorporated in purchasing documents properly to maintain equipment reliability and secure quality by responding to counterfeit, fraudulent and suspect items (CFSIs). Refer to Article 13 for more details.

4.7 Aging Management

The NSA requires the PSR(Periodic Safety Review), which is conducted every 10 years, to include matters with regard to aging of SSCs of reactor facilities and the details on the legislation including major activities to improve the efficiency in the implementation of aging management program are described in Article 14.

4.8 Emergency Preparedness

Korea conducted safety review led by the regulatory body to establish ways for improvement of emergency preparedness and emergency medical care system in Korea after the Fukushima Accident in Japan. The measures for improvement such as revision of radiation emergency plan including emergency declaration for multi units and addition of equipment for emergency medical care centers were implemented. See Article 16 for more details.

4.9 Discussion and Communication with Stakeholders

The NSSC collected opinions from all walks of life by holding public hearings and Nuclear Safety Regulation Information Meeting in the process of establishing the Comprehensive Plan for Strengthening Nuclear Safety Standards. It runs Nuclear Safety Information Center to disclose information on results of CP and OL review for nuclear installations and inspection results related to nuclear safety management. Seven Nuclear Safety Public Councils established near NPP sites are in operation to promote communication and understanding among local residents, local governments and the regulatory body. In addition, the attendance in the NSSC meeting is allowed according to the regulation of the NSSC to improve the transparency of the review conducted by the NSSC. The stenographic records of the meeting is disclosed according to the regulation on the conduct of the meeting. See Article 8 and Article 10 for more details.

4.10 Interface between Safety and Security

With high concerns over the security of nuclear installations around the world after the 9/11 terrorist attacks in 2001, the IAEA published the safety standards for the interface between safety and security in specific safety requirements [SSR-2/1 (design), SSR-2/2 (operation)] related to design and operation of nuclear installations. Accordingly, the NSSC has been being regularly held cooperation and collaboration meetings between KINS and KINAC, to which the NSSC committed the regulatory activities of safety and physical protection in nuclear installations on a quarterly basis since 2017. This cooperative meeting aims to strengthen collaboration between two organizations for the interface activities between safety and security. It is to preemptively respond to potential vulnerability in the interface working areas between safety and security and to ensure mutually complementary regulatory activities. The prime examples include “development of security measures for digital-based safety class I&C systems and safety review and regulatory inspection guidelines on their operating environment” and “safety review and regulatory inspection for cyber security of safety and non-safety I&C systems, security equipment and equipment for emergency response under ”Act on Physical Protection and Radiological Emergency Response of Nuclear Facilities”. See Article 18 for more details.

· 5 · Implementation of the Vienna Declaration

This section describes the implementation of the Vienna Declaration as requested by Chairman's Letter of the 8th CNS Review Meeting (December 13, 2018). The public concern over severe accidents of NPPs increased significantly and demand for strengthening safety to prepare for severe accidents in domestic NPPs emerged after the Fukushima Accident in March 2011. As a result, the National Assembly revised and promulgated the NSA in June 2015 to strengthen safety related to severe accidents. The revised NSA and subordinate statues require to secure integrated and systemic response capabilities against various accidents such as design-basis accidents, multiple failure accidents which are more severe than design-basis accidents, beyond-design-basis external natural disasters, man-made attacks and severe accidents, verify the capabilities to prevent and mitigate accidents and incorporate the results of the verification into the Accident Management Program. This is in line with the safety principle of defense in-depth required by IAEA.

The revised NSA requires the submission of the Accident Management Program as part of application for OL for new NPPs. As of June, 2016, when the revised Act took effect, 3-year grace period was applied to existing NPPs in operation and NPPs whose application for OL was under review. Accordingly, Accident Management Programs for 28 units were submitted by June 2019. Korea will fully implement the Vienna Declaration by reviewing the Accident Management Programs to be submitted.

5.1 Principle 1 (Design, Siting and Construction of New NPPs)

(Principle 1) New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclide causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

Under the revised NSA (June 2016), Accident Management Program to be submitted as part of licensing documents for new NPPs should present the design of SSCs(Structure, System and Components) for the prevention and mitigation of severe accidents and results of the performance evaluation according to the principle of defense in-depth required by IAEA INSAG-10. The severe accident prevention capabilities should be assessed to make sure that severe damage of nuclear fuel can be prevented even when multiple failure accidents, beyond-design-basis natural disasters or man-made attacks occur, by securing means to respond to such accidents. In addition, the severe accident mitigation capabilities should be assessed to make sure that early or large radioactive material releases caused by an accident can be prevented even when severe accidents occur by securing means to protect the radioactive material isolation function of a containment building from various threats such as hydrogen explosion. In addition, the results of the accident impact analysis should be presented to make sure that radiation exposure that could occur among residents living near NPPs can be kept within exposure limit in the process of severe accident prevention and mitigation.

Korea assures that the objective of safety principle 1 of Vienna Declaration can be achieved by checking whether the severe accident prevention and mitigation capabilities are sufficient in new units. Article 18 describes the licensing process for the design and construction of new units, design principle, and examples of prevention and mitigation equipment incorporated into design in more details.

5.2 Principle 2 (Implementation of Safety Assessment and Improvement of Safety)

(Principle 2) Comprehensive and systematic safety assessments are to be carried out

periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

Under the revised NSA (June 2016), existing operation units or units under OL review prepared and submitted the Accident Management Program to the regulatory body by June 2019. To meet the requirement of "avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions" in safety principle 1 of Vienna Declaration, Accident Management Program is required to show the capability to prevent and mitigate severe accidents. The objective of the severe accident prevention capabilities is to prevent the events from being progressed into a severe accident condition even though multiple failure accidents and beyond-design-basis external events occur by securing means to respond to such events. The objective of the severe accident mitigation capabilities is to prevent the large release of radioactive materials by maintaining containment integrity even in the event of severe accident.

The KHNP has developed Accident Management Programs incorporating the lessons learned from Fukushima Accident in Japan and comprehensive assessment and safety improvements that have been implemented so far. For example, Multi-barrier Accident Coping Strategy (MACST) which is to respond to beyond-design-basis natural disaster utilizing mobile equipment such as mobile generator that was adopted as part of post-Fukushima measures, was developed. Accident Management Programs for existing NPPs were submitted in June 2019 and the regulatory body will check the effectiveness of accident management strategies and implementation structure for the prevention and mitigation of a severe accident. Once the Accident Management Program is established and implemented, NPPs under construction carry out Pre-Operational Inspections while operating NPPs carry out regulatory periodic inspections, which includes accident management strategies, implementation structure, training and severe accident prevention and mitigation equipment. In addition Periodic Safety Review will be conducted every 10 years to have a comprehensive evaluation on the overall stability of the NPP, including the Accident Management Program. Comprehensive assessment on the safety of units including Accident Management Programs will be conducted to take this opportunity to promote reasonable safety enhancement. Such efforts assures the proper implementation of safety principle 2, which requires the achievement of reasonable practicable or achievable safety improvements of safety objective in safety principle 1 of Vienna Declaration. The specific details about the design of units to prepare for accidents are described in Article 18.

5.3 Principle 3 (Incorporation of IAEA Safety Standards and Good Practices)

(Principle 3) National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meeting of the CNS.

In the process of developing specific regulatory requirements for Accident Management Programs to implement the revised NSA, IAEA Safety Standards for the prevention and mitigation of a severe accident and safety standards of other countries including Europe and the US were taken into consideration. Basically, the concept of defense in-depth, which is the key element of Vienna Declaration, discussed in the 7th Review Meeting, was incorporated into the legalization process of the Accident Management Program. The principle of defense in-depth was clearly defined as a regulatory requirement by differentiating prevention and mitigation stage of severe accidents clearly and setting specific goals for each stage, making it possible to establish strategies and means in an independent and systematic manner. Standards related to design extension condition defined in IAEA SSR-2/1, a safety requirement regarding NPP design, was referred to establish the acceptance criteria of the severe accident mitigation stage. The basic concept of defence in-depth principle defined in Western European Nuclear Regulators Association (WENRA) was adopted as regulatory requirement to define the principle of defense in-depth in more details. FLEX (Diverse and Flexible Mitigation Capability) Guideline of the US, concept of hardened safety core in France, and new safety standards of Japan established after Fukushima Accident were referred to in an aim to establish basic concept of accident management strategies for beyond-design-basis natural disaster.

The method of conducting a stress test for existing NPPs referred to stress test methodologies of Europe which were used after Fukushima Accident. It was confirmed that stress test in Korea was conducted in line with relevant IAEA Safety Standards through the independent IAEA review on the stress test (August to September 2018). These efforts are in line with the purpose of principle 3 of Vienna Declaration which requires the development of reasonable and effective regulatory requirements by considering relevant IAEA Safety Standards and other good practices.

III

Self-Assessment : Article-by-Article Review

Article 6. Existing Nuclear Installations
Article 7. Legislative and Regulatory Framework
Article 8. Regulatory Body
Article 9. Responsibility of a 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 Review

This chapter describes a series of actions on civil nuclear power plants, storage, handling, treatment facilities for radioactive materials on the same site and facilities directly related to the operation of the nuclear power plants, by the government of the Republic of Korea in order to implement the obligations of Contracting Party imposed by Article 6-Article 19 (INFCIRC 449) of the CNS, Recent Activities and Improvements made to increase the safety of installations after the 7^{th} Review Meeting.

· 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.

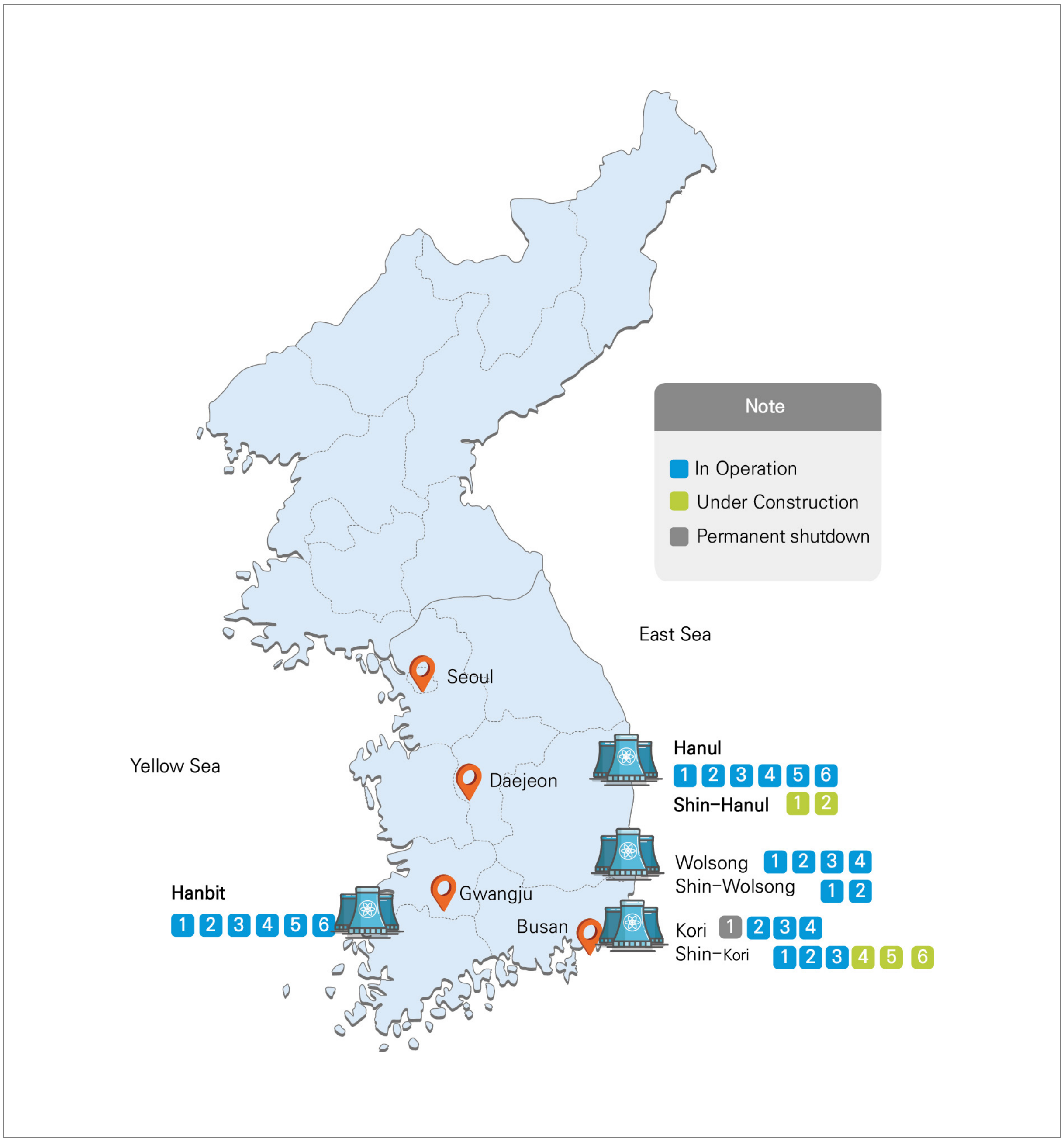
6.1 Implementation Details

6.1.1 Status of Nuclear Installations

The status of construction and operation of nuclear installations in the Republic of Korea is shown in Appendix A. As of December 2018, there are 24 units of nuclear power plant in operation and five units under construction. One unit is permanently suspended upon obtaining permission of the operational change for permanent suspension of the Kori Unit 1 in June 2017 (Figure 6-1). Those 24 operating units consist of 20 Pressurized Water Reactors (PWRs) and four Pressurized Heavy Water Reactors (PHWRs), while five units under construction are PWRs.

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

| Figure 6-1 | Current State of Nuclear Power Plants (As of end of 2018)
(* Wolsong Unit 1 is in shutdown condition for permanent shutdown.)



6.1.2 Safety Assessment of Nuclear Installations

The NSA stipulates that an applicant for CP and 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 NSSC, the regulatory body.

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 timing for Pre-Operational Inspection with respect to the construction and performance of the nuclear reactor facilities 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 step-by-step safety review and regulatory inspection and the general licensing procedures for nuclear installations are described in Article 7, while the details of the comprehensive safety assessment for the construction and operation of nuclear installations are described in Article 14.

(1) Safety Assessment and Inspection for Pre-operational Nuclear Installations

- Operation and Construction of APR1400 (Current Status of OL for Shin-Kori Units 3&4, Construction of Shin-Hanul Units 1&2 and Shin-Kori Units 5&6)

Shin-Kori Unit 3, which obtained OL in October 2015, completed pre-operational test for a year and started its commercial operation in December, 2016. It has been normally operated without reactor scrams, keeping power at 100% for about 13 months from the start of commercial operation to the first planned maintenance for refueling in January 2018. Shin-Kori Unit 4, which is under construction, obtained OL in February 2019 and pre-operational test is underway for commercial operation. Docket Review on the appropriateness of documents was completed for Shin-Hanul Units 1&2, for which OL was applied for in December 2014, review on OL has been underway since August 2015. The application for CP for Shin-Kori Units 5&6 was made in 2012 and CP was granted by the

NSSC in June 2016. However, the Public Engagement Committee was launched to reach a social consensus on the continued construction of Shin-Kori Units 5&6 based on energy transition policy of the new government in July 2017. The construction of Shin Kori Units 5&6, which was suspended temporarily, resumed as recommended by the Public Engagement Committee which conducted activities to reach a social consensus for 3 months. As of June 2019, pre-operational tests are being conducted in Shin-Kori Unit 4, Shin-Hanul Units 1&2 and Shin-Kori Units 5&6. Shin-Kori Units 5&6 prepare for the application for OL.

Post Fukushima measures were incorporated into APR1400 reactors which have been recently constructed and operated. The actions on common issues such as seismic safety assessment related to Gyeongju Earthquake, pressurizer safety relief valve and corrosion on the backside of CLP were taken in the same way.

(2) Safety Assessment and Inspection for Operational Nuclear Installations

In order to ensure the safety of operating nuclear installations, the KHNP, an operator of nuclear installations, improves the safety of the nuclear installations based on a comprehensive safety inspection which is conducted every within 20 months and assessment of safety-related operating experience and events in accordance with the NSA. The regulatory body checks whether the inspection results are satisfactory through safety review.

The regulatory body 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. In addition, it conducts a periodic assessment for main safety parameters, for example, unplanned reactor scram and actuation of safety-related equipment.

The KHNP performs the Periodic Safety Review (PSR) for all nuclear power plants every 10 years after the date of operating license issuance and submits the reports to the NSSC. The NSSC reviews the results of the utility's safety assessment and its plans for enhancing nuclear safety. More details on PSR are described in Article 14.

(3) Permanent Shutdown of NPPs (Kori Unit 1, Wolsong Unit 1) and Decommissioning Plan

Safety regulation framework on decommissioning was established with the revision of the NSA to prepare for the decommissioning of nuclear installations in 2015. Under the current framework, nuclear installations are required to submit a preliminary decommissioning plan to the NSSC upon application for CP and OL, update the plan periodically and get approval from the NSSC. Permanent shutdown of a power reactor is one of the operation stages and requires the application for an amendment of operation license and approval from the NSSC. It is stipulated that a final decommissioning plan for nuclear installations should be submitted within 5 years after the permanent shutdown. Specific laws, regulations and requirements for a decommissioning plan are described in details in Article 15.

Accordingly the regulatory body established the Review Guideline for Preliminary Decommissioning Plan in Construction and Operation Stages of Nuclear Installations and preliminary decommissioning plans for all NPPs, research reactors and fuel cycle facilities in Korea were submitted in 2017 and 2018 and are under review process.

KINS established the Review Guideline for Permanent Shutdown (June 23, 2016) to conduct safety review on amendment of operation license related to permanent shutdown of the Kori Unit 1 and prepared the Review Guideline for Permanent Shutdown for PHWRs on February 27, 2019 to conduct safety review on amendment of operation license for permanent shutdown of Wolsong Unit 1.

As the application for an amendment of operation license for the permanent shutdown of Kori Unit 1 submitted in June 24, 2016 by the KHNP, was finally approved in June 9, 2017, Kori Unit 1 shut down the reactor as of June 19, 2017 and entered into permanent shutdown stage. Preparation for decommissioning is underway and the regulatory body continues to perform safety regulation including safety review and regulatory periodic inspection during the permanent shutdown period. In addition, the KHNP decided permanent shutdown of Wolsong Unit 1 in June 15, 2018 and submitted the application for the amendment of operation license related to permanent shutdown to the NSSC on February 28, 2019. The review on the application for amendment of operation license for Wolsong Unit 1 is underway by KINS.

6.2 Recent Activities and Improvements

6.2.1 Inspection of CLPs and Actions for All NPPs

The CLP inspection in all NPPs started after the corrosion of the back side of the CLP was found during the 22^{nd} regulatory periodic inspection in Hanbit Unit 2 in 2016 for the purpose of confirming the integrity of CLP in all NPPs in operation and the inspection continues until now.

Also, the regulatory body ordered the licensee to perform the special inspection of structures of all operating PWR units to confirm the integrity of concrete structures (Sept. 27, 2017). Starting from Hanbit Unit 6 in Sept. 2017, the inspection of concrete structures excluding the backside of CLP was completed for 19 out of 25 operating units by late Dec. 2018. and is proceeding for six units. As a result, defects such as concrete pores, foreign materials, defective finishing and exposed rebar were found at 12 units. As of late Dec. 2018, the inspection of concrete pores in the CLP backside is progressing for a unit representing each reactor type. The KHNP is planned to inspect the suspected areas of the backside of CLP thoroughly based on the results of cause analysis of concrete corrosion especially on the backside of CLP.

6.2.2 Strengthened Stress Test for All NPPs

According to the administrative order of the NSSC, the KHNP conducted a stress test for Wolsong Unit 1 and Kori Unit 1, long-term operating units for which application for continued operation will be made, to assess the capabilities of the units to respond to beyond-design-basis extreme natural events and identify areas for improvement and KINS completed the technical verification of KHNP's internal assessment results in December 2015. The NSSC confirmed the verification results of KINS and related improvement items for Wolsong Unit 1 and Kori Unit 1 in February in 2015 and January in 2016 respectively, and gave an administrative order to the KHNP to implement the safety improvements. The NSSC decided the plan to expand the stress test to 22 NPPs in operation in Korea in September 2015, and the Guideline on Conducting Reinforced Stress Test (revision 1), which was reinforced based on detailed implementation plans and regulatory experience, was finally decided.

The NSSC presented phase-specific assessment plan considering design, site and response mechanism to conduct a stress test for all 22 NPPs in operation by the end of 2020. Under the plan, the KHNP will perform the stage 1 assessment for selected representative unit for each reactor type and gap analysis between the representative unit and other units with similar design. In the second stage assessment, the KHNP will complete the assessment at the site level for NPPs with similar design focusing on gap identified. As of end of December 2018, the KHNP submitted the results of stage 1 stress test and gap analysis for Hanul Units 3&4 (Korean standard type), Kori Unit 2 (W/H 2-loop), Hanbit Units 1&2 (W/H 3-loop), Hanul Units 1&2 (Framatome) and Wolsong Unit 2 (CANDU) to the regulatory body and KINS verified the results of Hanul Units 3&4 and currently verifying the stage 1 assessment results and gap analysis results. The KHNP plans to complete stress test for NPPs subject to stage 2 test and submit the second phase report incorporating the technical verification results by KINS on gap analysis by end of 2019. The NSSC and KINS will complete technical verification for 22 NPPs subject to assessment by 2020 according to original plan and check whether the KHNP implements mid-to long-term follow-up implementation plan properly based on the safety improvements identified in the verification process.

KINS established the strategy to improve reliability of technical verification with three pillars of regulatory independence, technical objectivity and transparency of the process along with technical verification of the stress test. In addition, it develops and applies guideline to verify stress test results, obtains technical advice from experts in the private sector, receives IAEA Peer Reviews, participates and gives feedback in regular meeting of the nuclear safety councils established in each NPP site and runs a website. As part of these activities the NSSC requested the independent review of IAEA on Korea's regulatory activities for stress test and stress test report for Hanul Unit 3 (Korean standard type, OPR-1000) prepared by the KHNP. In July 18, IAEA accepted the request from the NSSC to organize IAEA review team composed of experts in the areas of external events, integrity of SSCs, safety functions, severe accidents and emergency preparedness to conduct document review (August, 2018) and field visit (September 3-11, 2018). The final report of the independent review was submitted to December 2018. (Refer to Summary Chapter for IAEA's independent review.)

6.2.3 IAEA SEED Peer Review

The KHNP and the Ministry of Trade, Industry and Energy applied for the Site & External Events Design (SEED) review to IAEA in January 2017 review and assess the capability to cope with natural disasters such as earthquake of operating NPPs in Korea based on international standards in relation to Gyeongju Earthquake in September 2016. In August 2017, IAEA SEED review was conducted in Korea. The SEED mission team, composed of 2 IAEA experts and 3 international experts, assessed the safety, seismic performance, seismic monitoring and emergency preparedness of Wolsong Nuclear Power Plant Site through document review and field visit for 5 days. (Refer to Summary Chapter.)

6.2.4 Plan to Receive OSART Peer Review

The KHNP decided to receive IAEA OSART (Operational SAfety Review Team) Peer Review to assess the safety of domestic NPPs against the IAEA Safety Standards which was strengthened after Fukushima Accident. The KHNP selected Shin-Kori Units 3&4, APR1400 units, for IAEA OSART review applied for the service to the IAEA in August 2018. The OSART review will be conducted in the second half of 2020. (Refer to Summary Chapter.)

6.2.5 Strengthened Response to Seismic Safety (Seismic Performance)

The NSSC conducted safety inspection for all NPPs immediately after the 5.8-local magnitude Gyeongju Earthquake in September 2016 and identified safety improvements based on inspection results and problems raised in the response process to finalize the Measures to Improve Safety of Nuclear Installations in Preparation for Large Earthquake at the 63rd NSSC meeting in December 2016. (Refer to Annex L-1 Implementation Status of items under Measures to Improve Safety of Nuclear Installations in Preparation for Large Earthquake.) (Refer to Article 14 for more details).

6.2.6 Post-Fukushima Measures

Short-term and long-term improvements related to earthquake, tsunami and severe accidents were identified after Fukushima Accident in 2011 to secure safety against beyond-design-basis natural disasters as is the case of Fukushima Accident in Japan. The NSSC identified 53 areas for improvement (49 identified by the KHNP and 4 identified by the Korea Institute of Radiological & Medical Sciences) and most of the improvement items have been completed in all NPPs (refer to Annex L-2 Implementation Status of Improvement Items Identified in Safety Inspection (53 items). (Refer to Article 14 for more details).

6.2.7 Progress of the Accident Management Program (Implementation of the Vienna Declaration)

According to the revised NSA, which took effect in June, 2016, Accident Management Programs for 28 NPPs were submitted in June 2019, among them 25 units are in operation or about to be shutdown permanently. The NSSC revised subordinate statues of the NSA in 2016 to implement regulations and KINS developed regulatory standards, regulatory guidelines and guideline for safety review on Accident Management Programs. The KHNP prepared Accident Management Program for each plant and prepare for the installation of equipment to be used for accident management. The regulatory body will assess the adequacy of the Accident Management Programs and inspection on the accident management strategy, implementation structure, training, severe accident prevention and mitigation equipment will be conducted through regulatory periodic inspection. The Accident Management Program will be reviewed in the PSR, which is conducted every 10 years, to assess the overall safety level of NPPs.

· 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 operation of a nuclear installation without a license;
   (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licenses;
   (iv) the enforcement of applicable regulations and of the terms of licenses, including suspension, modification or revocation.

7.1 Implementation Details

7.1.1 Nuclear Legislative Framework

The laws relevant to nuclear safety includes the NSA, the Act on Physical Protection and Radiological Emergency and the Nuclear Liability Act. The NSA deals with safety regulation and radiation protection for nuclear installations and the Act on Physical Protection and Radiological Emergency stipulates matters related to physical protection. The list of laws related to safety regulation of nuclear installations is presented in Annex C.

(1) Related Acts

- Nuclear Safety Act

The NSA is the main law governing the safety regulation of nuclear installations, providing for major matters related to safety management in the research, development, production and use of nuclear energy.

The legal framework for Nuclear Safety, as shown in Figure 7-1, consists of five 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.

| Figure 7-1 | Nuclear Legislative Framework

Act	• Nuclear Safety Act, Act on Physical Protection and Radiological Emergency, and Nuclear Liability Act, etc.	Acts (NSSC)
Enforcement Decree (presidential Decree)	• Particulars entrusted by the Act • Enforcement Decree of the Nuclear Safety Act and Enforcement Decrees of Other Related Acts	
Enforcement Regulations (Ordiance of the Prime Minister)	• Particulars entrusted by the and/or Decree and necessary for their enforcement (including detailed procedures and format of documents) • Enforcement Regulations of the Nuclear Safety Act and Enforcement Regulations of Oter Related Acts	
Technical Standards (Administrative Regulation)	• Brief technical standards as delegated by the Act and/ or Decree • Regulations on Technical Standards for Nuclear Reactor Facilities, etc,. Regulation on Technical Standards for Radiological Safety Management, etc.	
NSSC Notice (Administrative Regulation)	Details on technical standards, procedures of formats as delegated by the Act, Decree and/ or Regulation Notice on technical standards for the location of nuclear installations	
Regulatory Standards	• Further particulars or interpretation of technical standards	Guidelines (KINS)
Regulatory Guidelines	• Acceptable methods, conditions, specifications, etc.	
Guidelines for Safety Review and Inspection	• Standard Review Plan, Inspection Manuals, etc.	
Industrial Code and Standards	• KEPIC, ASME, IEEE, ASTM, etc.	

As shown in Annex D, the NSA stipulates matters such as the basis and general matters related to nuclear safety regulation and matters related to the NSSC, Comprehensive Plan for Nuclear Safety and CP and OL of nuclear installations. Presidential Decree (the Enforcement Decree of the NSA) provides for matters commissioned by the NSA, procedures to implement the NSA and administrative matters. The Enforcement Regulations of the NSA stipulate the matters delegated from the Enforcement Decree of the NSA. The Regulation on Technical Standards provides for details about the matters delegated by the NSA and its Enforcement Decree and technical standards to implement them. The NSSC Notice describes the matters delegated from the NSA, its Enforcement Decree, Enforcement Regulations and Technical Standards and specific regulatory requirements and standards required for the implementation of the laws. The list of technical standards and NSSC Notices applicable to nuclear installations is shown in Annex E. In addition, industrial standards applicable to the nuclear industry were endorsed by the regulatory body and applied to the design and operation of nuclear installations.

KINS has developed and utilized regulatory guidelines for specific details required to apply technical standards and requirements described in laws for the purpose of performing safety regulation works including review on licensing and inspection of nuclear installations. The regulatory standards and guidelines interpret the specific matters of technical standards and provide detailed description on allowable method, condition and specifications to meet the technical standards.

- Act on Physical Protection and Radiological Emergency

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. The Act has its Enforcement Decree that stipulates particulars necessary for the implementation of the Act. The details on strengthening emergency preparedness are described in Article 16.

- Nuclear Liability-related Act

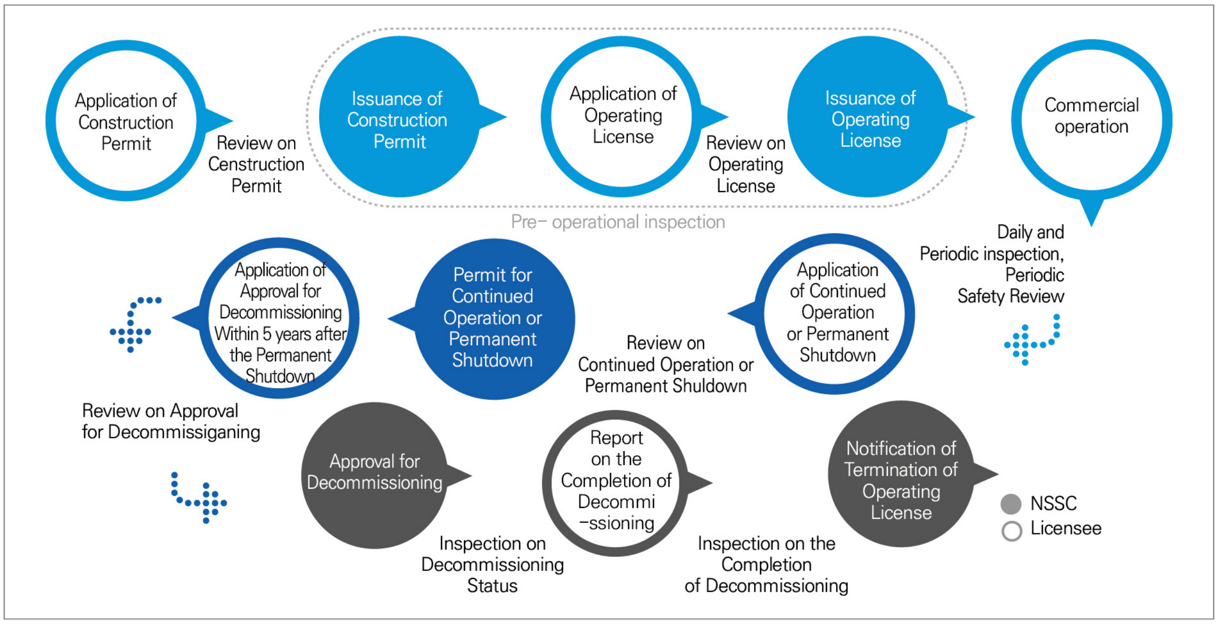
With regard to the utility's civil liability for any nuclear accident, the Nuclear Liability Act and the Act on Indemnification Agreement for Nuclear Liability were established in 1969 and in 1975, respectively to provide for general principles concerning the civil liability for nuclear damage. Each 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 stipulated in the NSSC Notice.

7.1.2 Regulatory System

(1) Licensing Process

The licensing processes for nuclear installations consist of two steps: the Construction Permit (CP) and the Operating License (OL), pursuant to the Article 10 and 20 of the NSA respectively. When necessary, a licensee may apply for Standard Design Approval and the Early Site Approval in accordance with Article 12 and Article 10.3 of the NSA respectively (Figure 7-2).

| Figure 7-2 | Licensing Process for the Whole Life Cycle of Nuclear Installations



- Standard Design Approval (SDA)

As the design of NPPs with enhanced level of safety has been standardized, a new licensing system under which those who would repetitively construct power reactors and relevant facilities with the same design can obtain license for the design itself, is introduced to improve regulatory efficiency. The standard design approval (SDA) 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

It is to start a limited construction work on a proposed site before the CP is issued and 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)

An applicant for CP for a nuclear installation shall submit an application accompanied by a radiological environmental report, a Preliminary Safety Analysis Report (PSAR), a construction quality assurance plan, and a decommission plan to the NSSC. The NSSC issues 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 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. The safety review is conducted to check the safety and implementation of regulatory requirements including the principle and concept of the design of nuclear installations and assess the radiological impact to the environment and ways to minimize those impact.

- 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 program, a quality assurance program for operation, a radiological environmental report, a decommissioning plan, and a plan to release liquid and gaseous radiological materials. The NSSC will issue OL after deliberation of the application documents 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 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 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.

- Periodic Safety Review (PSR)

Power reactor operator is required to conduct comprehensive safety review every 10 years after obtaining OL for the nuclear installations and submit the assessment report to the NSSC.

There were 11 safety factors originally including the physical condition at the timing of assessment of nuclear installations but 3 safety factors (plant design, probabilistic safety assessment and hazard analysis) were added in November 2014 with the revision of applicable laws in compliance with IAEA Safety Standards.

Individual assessment for 14 safety factors and interconnected items are conducted and comprehensive safety level is determined based on the assessment of each item and results of safety measures taken based on the assessment result. The assessment criteria shall consider the applicable technical standards to the nuclear installation at the timing of safety review and safety improvement items for each unit identified by the licensee or the regulator shall be implemented and implementation results shall be checked by the regulatory body regularly.

- Continued Operation

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 Article 14 for PSR.) 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, a licensee intends to decommission a nuclear installation, the licensee shall submit decommissioning plan within 5 years after the permanent shutdown 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 radiation dose exceeds the limit.

- Termination of OL

When a licensee wants to complete decommissioning of a nuclear installation, the licensee of the nuclear installation shall report the decommissioning completion report to the NSSC. The NSSC should inspect the decommissioned nuclear installation and notifies the termination of the OL to the licensee of the facility after the inspection is completed.

(2) Regulatory Inspection

Articles 16 (Inspection) and 22 (Inspection) of the NSA stipulate that the authorized parties receive inspection of the NSSC, the regulatory body, 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 samples for a test. These regulatory inspections of the regulatory body are carried out independently from the self-inspections by the KHNP, 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 installations 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 described below.

- 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 review 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 under construction.

- Inspection on Suppliers, Etc.

Inspection on suppliers, etc. 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 if necessary.

- Regulatory Periodic Inspection

The regulatory periodic inspection for nuclear installations in operation is conducted to verify whether the nuclear installation is being properly operated in conformity with the conditions of the OL; 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 review, field inspection, and interview during the period of refueling outage for PWRs and during periodic maintenance period for PHWRs.

- Reporting, Checking and Inspection of Decommissioning Process

Nuclear installation licensee should report the information on the current state of decommissioning and decontamination, radiation safety and radioactive waste management on a regular basis (every 6 months) during the decommissioning period to the regulatory body according to the NSA. The regulatory body should check whether the decommissioning activities by the licensee are conducted properly according to approved decommissioning plan and the NSA by conducting check and inspection of decommissioning condition (decommissioning inspection) as soon as the report on decommissioning status is received.

- Inspection on Completion of Decommissioning and Restoration of the Site

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

- Daily Inspection

The NSSC installs a regional office at theNuclear Power Plant Sites to check the nuclear installations under construction or in operation on a daily basis. It includes an observation of surveillance and monitoring, 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.

(3) Enforcement

When the safety review results of the license application meet the relevant requirements, the NSSC will issue a license. 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:

- 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 KHNP 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) are subject to imprisonment for not more than 3 years or fine not more than KRW 30 million according to Article 10.1, 20.1 and 116.1 of the NSA.

7.1.3 International Conventions

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 has fulfilled its obligations faithfully. The conventions that the ROK joined are shown in Table 7-1.

| Table 7-1 | List of International Conventions on Nuclear Safety that the ROK Joined

Conventions	Joined Date	Effective Date
Convention on Nuclear Safety	September 20, 1994	October 24, 1996
Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management	September 16, 2002	December 15, 2002
Convention on Early Notification of a Nuclear Accident	June 8, 1990	July 9, 1990
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	June 8, 1990	July 9, 1990
Convention on the Physical Protection of Nuclear Material	April 7, 1982	February 8, 1987
Treaty on the Non-Proliferation of Nuclear Weapons	July 1, 1968	April 23, 1975

7.2 Recent Activities and Improvements

7.2.1 Enactment and Revision of Laws

Laws related to nuclear safety have been revised to incorporate changes in regulatory policies, adoption of new institutions and technologies, response to international norms, changes in internal and external changes and operating experiences and enactment and revision of the laws are made based on opinion from relevant organizations and experts.

The NSA was revised in December 19, 2017 to be in line with the principle of legal reservation by stipulating those subject to exemption from design approval and inspection on radiation equipment and those subject to exemption from safety actions directly in the NSA.

The Enforcement Decree of the NSA was revised to define the information subject to disclosure and disclosure method with the revision of the NSA (Law No. 13389, promulgated in June 22, implemented in June 23, 2016) that requires the disclosure of information on CP and OL of nuclear installations to the public to win public trust over nuclear safety and promote public health.

NSA was revised (Law No. 13389, promulgated in June 22, 2015 and implemented in June 23, 2016) to clearly define roles and responsibilities and regulatory requirements for accident management including severe accident management after Fukushima Accident in 2011. Therefore licensees should submit Accident Management Program when they apply for OL.

Accordingly, the Enforcement Regulations of the NSA and Regulations on the Technical Standards for nuclear installations under NSA were revised in June 30, 2016 to stipulate specific regulatory requirements for the Accident Management Program such as the scope of accidents to be managed, equipment, and education and training for accident management of NPPs.

As the NSA was revised (Law No. 13545, promulgated in June 22, 2015 and implemented in

June 23, 2016) to require the addition of the plan for liquid and gaseous radioactive waste release to the application documents for OL of power reactors and relevant facilities to prevent the damage to the public from the release of liquid and gaseous radioactive waste, the revision of the Enforcement Regulations of the NSA was revised to determine the matters delegated from the NSA and matters for its implementation including the information to be included in the release plan.

As the revised NSA (Law No. 13616, promulgated in December 22, 2015 and implemented in December 23, 2016) took effect to require the addition of the requirements for making the post-closure management plan for radioactive waste disposal facilities be in line with management criteria to ensure stability of waste disposal facilities for the period designated by the Presidential Decree, within the limit of 300 years, to the CP and OL criteria for radioactive waste management facilities, the Enforcement Decree of the NSA was revised to provide for matters delegated by the law and matters necessary for the implementation including the designation of management period depending on the radioactive waste disposal method.

Major revision of laws related to nuclear safety between 2016 and 2018 is included in Annex F.

7.2.2 Improvement of PSR Framework

PSR has been utilized to make continuous improvement of safety in NPPs in operation in Korea.

The KHNP should conduct PSR that covers 14 items defined in Article 37.1 of the NSA that incorporate IAEA regulations, include the safety improvement plan to respond to the latest technology in the PSR report and present alternatives or demonstrate that the impact on safety is not significant even though the latest technology is adopted in case where the latest technical standards are not applied. As the domestic laws related to safety, however, require the submission of contents and results of PSR, the issue regarding unclear roles of the regulatory body for the review on PSR has been raised.

Accordingly, the NSSC is in the process of adopting the system to review and approve the appropriateness of the results of PSR, which is conducted every 10 years, and safety improvement implementation plan to strengthen the role of the regulatory body in the PSR and progressively improve the safety of operating NPPs.

· 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 fulfill 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.

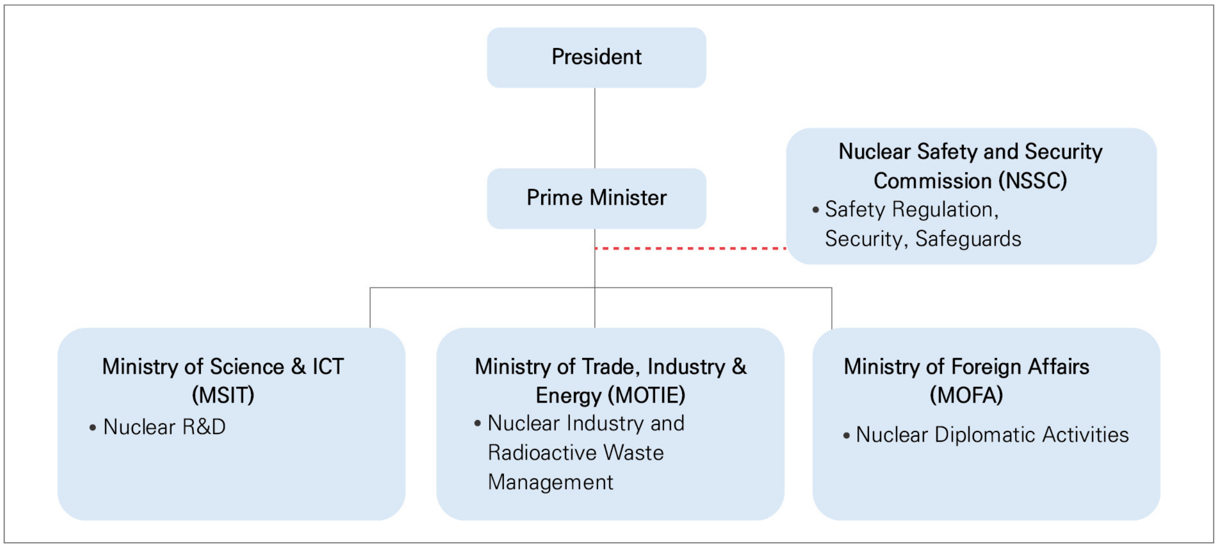
8.1 Implementation Details

8.1.1 Government Organizational Structure for Nuclear Energy

In the past, the Ministry of Education, Science and Technology (currently, the Ministry of Science and ICT) was responsible for the promotion and regulation of nuclear energy and the Ministry of Knowledge Economy (currently, the Ministry of Industry, Trade and Energy) was responsible for the nuclear development and industry. After the Fukushima 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 responsible for nuclear safety, security, and non-proliferation. When the Act on Government Organization was revised in March 2013, the NSSC was placed under the Prime Minister's Office from President.

The current government organizations on nuclear energy is shown in Figure 8-1.

| Figure 8-1 | Government Organizations on Nuclear Energy



The NSSC has the authority of and responsibilities for safety regulation of nuclear installations including licensing of nuclear installations under the NSA. On the other hand, in accordance with the Nuclear Promotion Act, the Ministry of Science and ICT 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 MSIT and the MOTIE are charged with focusing on promoting nuclear power generation and in these aspects of their functions, they are legally separated.

KINS and KINAC, the technical support organizations of the NSSC, provide technical support related to safety regulation of nuclear installations, nuclear security and safeguards according to Article 5 (Nuclear Safety-Specialized Institution) and Article 6 (Establishment of the Korea Institute of Nuclear Nonproliferation and Control) of the NSA and Act on the establishment of KINS. In addition, KoFONS is in charge of preventive safety management and support related to nuclear power and radiation.

- Independence of the Regulatory Body (Common Issue 3)

The Republic of Korea separated the government ministries in charge of nuclear energy promotion and industry from the regulatory body under the government organizational structure to ensure the independence of the nuclear safety regulation and the Act on the Establishment and Operation of the NSSC (hereinafter referred to as the NSSC Act) clearly defines the regulatory independence.

Article 2 (Principles of Operation) of the NSSC 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 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.

8.1.2 Regulatory Organizations

(1) Nuclear Safety and Security Commission (NSSC)

The NSSC was established in October 26, 2011 based on the NSSC Act which was enacted in July 2011. The purpose and operating principles of the NSSC are defined as follows.

- The purpose of installation is to protect the public from radiological disaster caused by production and the use of nuclear power and contribute to the public safety and environmental preservation.
- Operating principles are to maintain independence and fairness and come up with measures and implement such measures required for safety management of the research, development, production, and use of nuclear energy.

〈Composition of the NSSC〉

The NSSC is composed nine members including the Chairman in accordance with the NSSC Act and Presidential Decree of Organization of the Nuclear Safety and Security Commission and its Affiliated Bodies. 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. The 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 term of office of the commission members shall be three years, and they may be reappointed once.

The NSSC is responsible for the deliberation and decision making regarding the matters as follows:

- coordination and adjustment of matters regarding safety management of nuclear power;
- establishment of the Comprehensive Plan for Nuclear Safety pursuant to Article 3 of the NSA;
- 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 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.

〈Special Committee〉

The NSSC operates a special committee as prescribed in the NSSC Act, its Enforcement Decree 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.

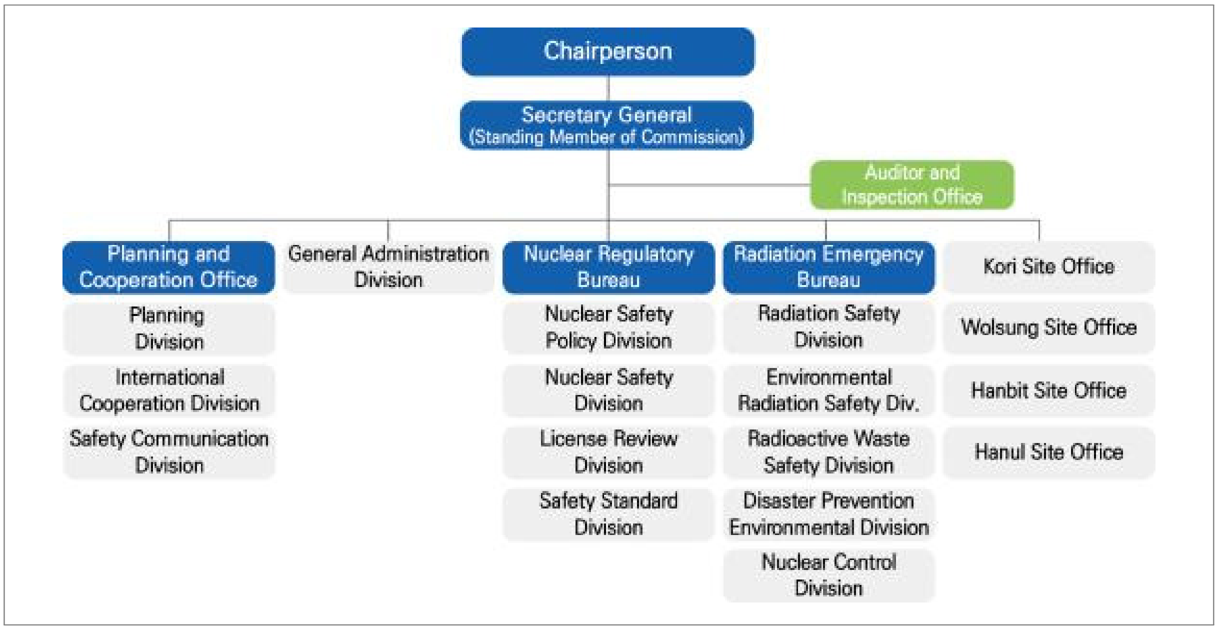
The Special Committee consists of 15 experts from various fields and has five specialized departments (reactor system, radiation protection, site and structure, policy and system, and radiation disaster prevention, and environment) to ensure efficient deliberation on technical matters. In case of a nuclear or radiation accident, the Committee may form and run a Special Investigation Committee. The Special Committee conducts a pre-review for the NSSC's major licensing decision such as CP, OL, change permit, continued operation permit, PSR results.

〈NSSC Secretariat〉 (Common Issue 4)

The NSSC has the Secretariat to deal with the general affairs, with the standing member of the Commission working as the Secretary General. The NSSC Secretariat is responsible for overall administrations related to safety regulation of the nuclear, relevant installations, nuclear fuel cycle facilities, radioactive waste management facilities, nuclear materials, the use of isotope and radiation generation devices under the NSSC Act.

The Secretariat consists of Chairman, Secretary General, one office, two bureaus, four coordinators and 10 divisions. There are four site offices (Kori, Wolsong, Hanbit, and Hanul) as shown in Figure 8-2.

| Figure 8-2 | Organization Chart for NSSC Secretariat



As of June 2019, the fixed number and current number of the officers at the NSSC Secretariat are 156 and 152 respectively and among them 118 employees work in headquarters and 34 employees work in site offices. The budget of the NSSC was KRW 203.6 billion in 2019, which is used for safety regulation of nuclear installations, radiological protection and related research and development activities.

(2) Technical Support Organizations

The NSSC has 3 technical support organizations under it as follows.

- Korea Institute of Nuclear Safety (KINS)

KINS was established as an independent technical support organization in February 1990 under the Korea Institute of Nuclear Safety Act. It has conducted the technical regulatory activities for nuclear safety including tests on nuclear installations, nuclear fuel cycle facilities, radiation source and transportation, radioactive waste management facilities and radiation around living environment 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).

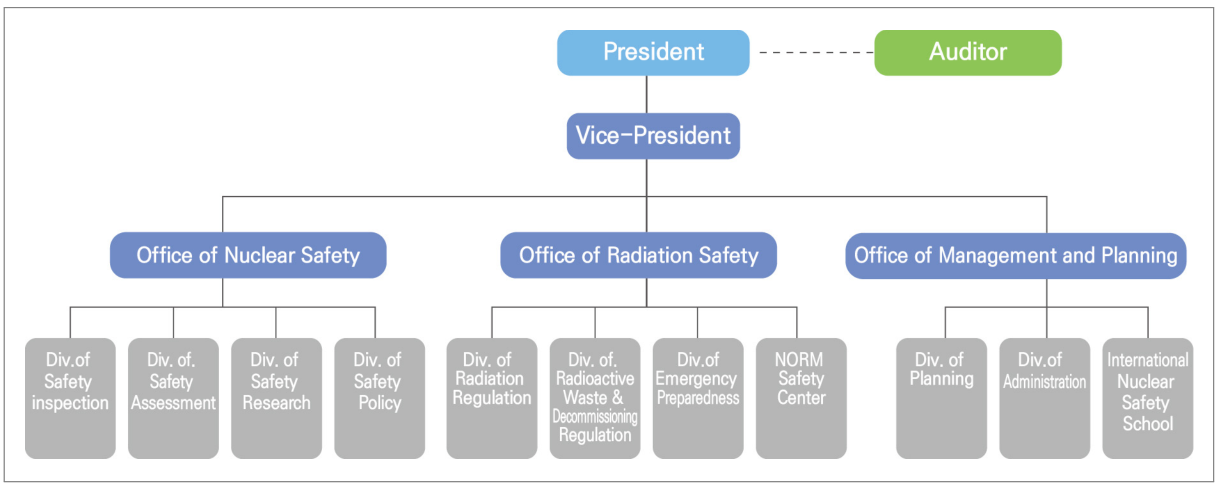
- Safety review for licensing and approval of nuclear reactor facilities and inspection of safety regulations for operation of nuclear reactor facilities
- Safety review for licensing for fuel cycle facility business and regulatory periodic

inspection of the functions of fuel cycle facilities

- Safety review for licensing of radiation sources
- Safety review for design certificate of radiation devices and packages
- Safety review and regulatory periodic inspection of the design, construction and operation of radioactive waste management facilities
- Registration to handle materials that contain natural radioactive nuclides, report on export and import, and submission and review on current circulation status

As of April 2019, KINS is composed of Executive Vice President, three offices and 11 divisions (including one center and one school) as shown in Figure 8-3.

| Figure 8-3 | Organization Chart for KINS

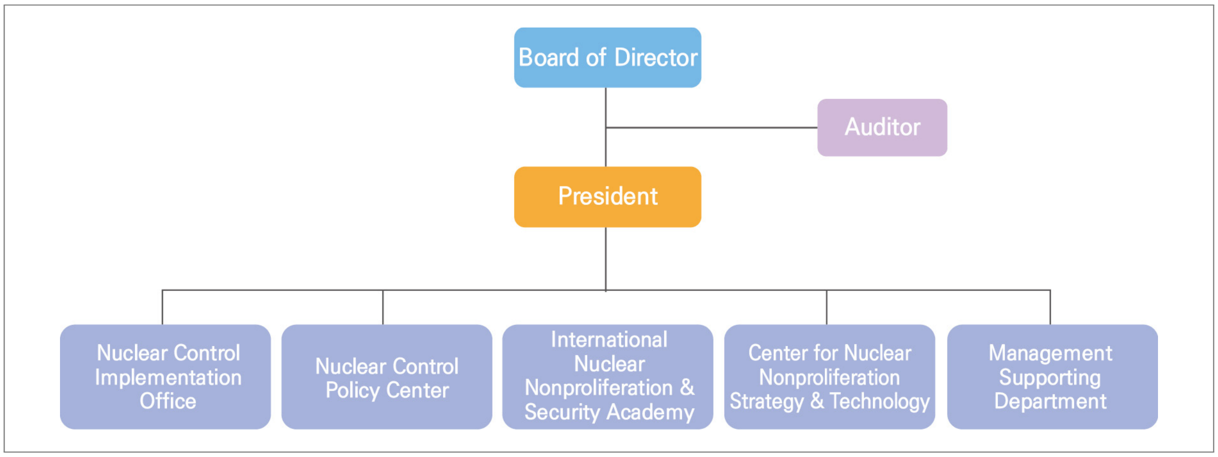


As of December 2018, the fixed number and current number of employees are 558 and 551 respectively. 526 employees work in the headquarters and 25 employees work for resident inspection team in four Nuclear Power Plant Site. The budget is KRW 1,159,000.

- 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 Article 6 (Establishment of the Korea Institute of Nuclear Nonproliferation and Control) and Article 7 (Business of KINAC) of the NSA. As of April 2018, KINAC is composed of one office, three centers, and one department as illustrated in Figure 8-4 and the total number of employees is 103.

| Figure 8-4 | Organization Chart for KINAC

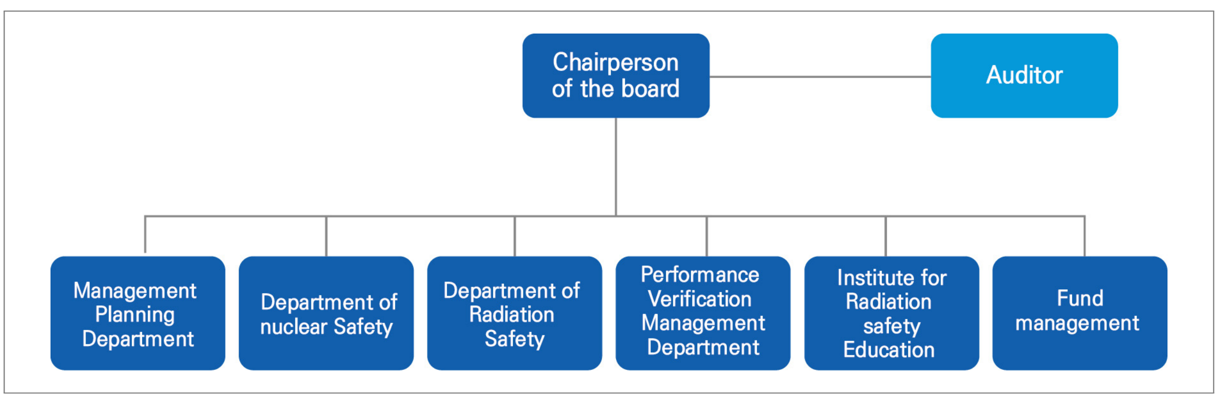


- Korea Foundation of Nuclear Safety (KoFONS)

Korea Foundation of Nuclear Safety was established in November 2012 to support administrative and policy work of the NSSC including planning and supervising nuclear safety R&D, management on equipment qualification organizations for reactor components, dose management for radiation workers, safety training and the management of nuclear safety regulation funds.

KoFONS was established under the clear legal basis prescribed in the NSA. As of March 2019, the fixed number and current number of employees are 65 and 57 respectively. The organizational structure is shown in Figure 8-5.

| Figure 8-5 | Organization of Korea Foundation of Nuclear Safety (KoFONS)



8.2 Recent Activities and Improvements

8.2.1 Communication Activities of the Regulatory Body (Common Issue 9)

The NSSC specified the subject and method of information disclosure under the Article 103.2 (Obligation of Information Disclosure) of the NSA by revising the NSA in June 23, 2016 in an aim to disclose information on nuclear safety management to the public in an preemptive and proactive manner. Accordingly, the scope of information disclosure including CP and OL review results and results of inspection related to nuclear safety management are stipulated by law. Under the Act, Nuclear Safety Information Center was established and the website (http://nsic.nssc.go.kr) was established and run to make anyone can access the information related to nuclear safety. In addition, the attendance in the NSSC meeting is allowed according to the regulation of the NSSC to improve the transparency of the review conducted by the NSSC. The stenographic records of the meeting is disclosed according to the regulation on the conduct of the meeting.

The NSSC has 7 Nuclear Safety Councils related to Nuclear Power Plant Sites to improve communication and understanding among local residents, local governments and the regulatory body. The plan to promote the activities of the council was established as well. The quarterly meeting of Nuclear Safety Council has been held and technical meeting with invitation of experts was held for council members. In addition, many activities have been conducted to vitalize the council which serves as a communication channel with local residents. The NSSC has formed and run the information disclosure center monitoring group composed of local residents, officials from local government and civil activists to operate the Nuclear Safety Information Center more actively and vitalize the use of the portal site. These activities are to conduct monitoring on information disclosure and collect and incorporate various opinion. In particular, there are 7 Public Information Councils related to areas where NPPs are in operation to share major issues for the purpose of improving mutual understanding on nuclear safety information disclosure with the local government.

· Article 9 · Responsibility of a License Holder

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

9.1 Implementation Details

9.1.1 Legal Basis

According to the Article 2.2 of the NSA, safety management related to the research, development, production and use of nuclear energy should be conducted in accordance with international norms including the CNS, contribute to protection of the public safety and environment from radiation hazards and establish safety standards incorporating the advancement of science and technology. The legal basis for OL is the Article 20 (Operating License) and for OL permit criteria is the Article 21 (Licensing Criteria) of the NSA.

The ultimate responsibilities of the safety of nuclear installations include indemnification if a loss occurs. Article 3 of the Nuclear Liability Act stipulates the liability for the loss, in the event of nuclear damage caused by the operation of a reactor shall be borne by the licensee. Unlike general illegal activities (Article 750 of the Civil Law), the licensee shall assume absolute liability even without willful negligence.

9.1.2 Responsibility of a License Holder

CP and OL holders assume the responsibility to construct and operate a nuclear installation as approved at the time of CP or OL was issued. In addition, the permit holders also assume the responsibility to comply with the conditions imposed on the CP or OL by the regulatory body.

The Korean government declared the safety first principle for the use of nuclear power through the Nuclear Safety Policy Statement, which states that 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.

OL holders should take actions to prevent the expansion of an accident by taking actions according to Severe Accident Management Guidelines (SAMGs) as a mitigating measure in case of emergency such as core damage and are responsible for organizing emergency organizations according to radiation emergency plan.

In relation to the management of Accident Management Program, those who want to run power reactors and relevant facilities are required to submit the Accident Management Program upon application for OL by law and operating NPPs with OL are required to submit the Accident Management Program by June 2019.

9.1.3 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 7.4, 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.

9.2 Recent Activities and Improvements

9.2.1 Enhancement of Communication with the Public

The KHNP has produced and released various advertisements on new and renewable energy such as fuel cell and photovoltaic energy to establish the image of a company that emphasizes safety and comprehensive energy company. The KHNP is also making an effort to strengthen public communication by holding cultural event (KHNP Art Festival) for a shared growth with the local community.

In addition, the program for visit to information center in Head Office and nuclear power plants has been expanded. Customized PR activities have been implemented proactively such as the establishment of the communication channel for organizations related to NPPs, maintaining the ecosystem of the nuclear industry and enhancement of the communication with stakeholders. In particular, the KHNP has run the NPP Information Center to disclose relevant information for the purpose of improving transparency and reliability of the information. By making citizens observe the construction process of Shin-Kori Units 5&6, the KHNP contributed to the construction of NPPs in a safe and transparent manner together with the public.

KHNP runs its website to enhance transparency of information disclosure for each stakeholder. It helps users more easily access to the web and maximize the effect of information disclosure by utilizing diagrams and charts instead of text based lists. It also promotes open communication through Social Networking Sites (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 customized information.

The transparency of the information disclosure has been increased through KHNP website and the users have greater accessibility to the web site. The effect of information disclosure has been maximized by using diagrams and pictures, which are easy to understand moving away from ten approach of listing text. 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. It was possible to achieve outstanding outcome such as conclusion of settlement regarding distorted media coverage by the Press Arbitration Commission. 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.

In addition, the KHNP shares various information on NPP operation through channels including regular meetings with private environmental monitoring group in each Nuclear Power Plant Site, ad-hoc meetings, presentation for the residents, observation in the outage and presentation on various issues. For some issues, the KHNP organizes the third party verification committee to improve the understanding on the nuclear safety by disclosing the problem solving process and results to residents living near NPPs.

· 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.

10.1 Implementation Details

The government issued Nuclear Safety Policy Statement in 1994 to emphasize a fundamental principle of "safety first" in the use of nuclear energy, and presented the five principles of nuclear safety regulation: independence, openness, clarity, efficiency, and reliability.

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 according to the NSA. A detailed implementation plan is established every year and implementation status is checked. The Comprehensive Plan for Nuclear Safety is at the pinnacle of national nuclear safety plan and presents mid and long-term policy direction for nuclear safety. The First Comprehensive Plan for Nuclear Safety (2012-2016), which established 3 policy objectives, 7 implementation strategies and 16 focused implementation tasks to respond to internal and external policy environment incorporating lessons learned from Fukushima Accident in Japan, was formulated in October 2012, and was implemented from 2012 to 2016. The Second Comprehensive Plan for Nuclear Safety (2017-2021) was formulated in December 2016 based on the analysis on the outcome of the first comprehensive plan and future policy environment and has been implemented based on a detailed plan which is established every year.

The Second Comprehensive Plan for Nuclear Safety (2017-2021) adopted "to achieve nuclear safety which the public empathize with, and make the society safe from radiation risk" as a vision and "to prevent accident through strict safety management", "to establish a transparent and trusted regulatory system", and "to innovate regulatory infrastructure and secure capabilities to prepare for the future" as policy directions. To achieve the directions, seven implementation strategies were set as follows:

- [Strategy 1] Strengthen safety management from normal operation to severe accidents for NPPs
- [Strategy 2] Improve transparency through information disclosure and communication

- [Strategy 3] Establish safety management system related to back-end nuclear fuel cycle
- [Strategy 4] Improve the effectiveness of preparation for disasters such as earthquake and radiological emergency response system
- [Strategy 5] Advance nuclear security regulations and strengthen implementation framework for nuclear non-proliferation
- [Strategy 6] Manage safety preemptively in response to changes in the radiation use environment
- [Strategy 7] Expand regulatory infrastructure such as research and development, human resources development and international cooperation

Both the regulatory body and the KHNP put the nuclear safety as a top priority in executing their jobs as the strengthening the nuclear safety management was presented as Strategy 1 of the Comprehensive Plan for Nuclear Safety.

Even though the NSSC has been making efforts to strengthen safety standards such as the establishment of post-Fukushima measures and the legislation to submit the Accident Management Program since its establishment in 2011 as an independent regulatory body, the public continued to concern about nuclear safety. In addition, local magnitude 5.8 and local magnitude 5.4 earthquakes occurred in areas near the Wolsong site for two consecutive years in September 2016 and November 2017 respectively and it is found that the radon contained in a bed mattress emits radiation above a dose limit. The public concern over radiation exposure is raised not only related to NPP but also related to household goods due to a series of these events.

In the meantime, the Korean government formed a task force team to improve and strengthen the current nuclear safety standards to allay the public concern and respond to changing industry environment. The task force team held public hearings for four times, presentation for local residents and collection of opinion through online channels to summarize safety issues in Korea, collect opinion enough from all walks of life and establish measures to strengthen standards in an objective and clear way. Based on these activities the task force team established the Comprehensive Plan for Strengthen Nuclear Safety Sstandards in March 2019 as follows:

- Strengthen PSR: improve PSR system, etc.
- Strengthen seismic safety of NPPs: verify the adequacy of seismic design of NPPs
- To strengthen PSR: to improve PSR system, etc.
- To strengthen seismic safety of NPPs: verify the adequacy of seismic design of NPPs

- To strengthen regulation on PSA for multi-units: to implement quantitative assessment on the nuclear safety of multi-units
- To adopt two step licensing process for fuel cycle facilities: to change to construction permit and operating license system
- To strengthen the safety management of radiation in the natural environment: to prevent the use of radioactive material in household goods
- To establish radiological emergency response system throughout whole cycle of emergency: to establish emergency response system from the early stage of emergency
- To assess the impact of radiation on health: to survey on the relationship between radiation exposure and outbreak of diseases of population living around nuclear power plants
- To secure transparency of safety regulation and enhance communication: to establish a law on safety information disclosure and communication
- To enhance safety culture of a licensee and the regulatory body: to add a requirement for operating license (OL) review
- To develop domestic technical safety standards: to develop technical basis for adopting foreign standards

PSR has been conducted by an operator every 10 years on a voluntary basis since it was introduced in 2001 for improving safety. In the future, it will be institutionalized that the regulatory body checks the adequacy of safety enhancement plan. The NPPs in operation are designed to withstand 0.2g or 0.3g peak ground acceleration and the NPPs under construction will withstand 0.3g peak ground acceleration. With increasing public concern over seismic safety of the nuclear power plant due to recent earthquakes, the research on the characteristics of seismic source in areas where earthquake occurred will be conducted and seismic design criteria will be reviewed based on the research results.

In Korea where multiple units are operated in the same site, the need for assessment of the impact of multi-unit accident has been increased. Accordingly, it is planned to implement quantitative assessment by 2021 for two main areas: 1) multi-unit accident risk that considers the possibility where radioactive materials can be released from multiple units in case of external events; and 2) site risk that considers the possibility of accidents related to radioactive material release based on each site.

Korea operates power plants with different design including Westinghouse, Framatome and CANDU and continues to improve technical standards to increase the reliability of nuclear safety regulation. In addition, Korea has established and implemented regular analysis system for overseas safety standards to establish the safety standards that meet international standards. In addition, the requirements for an OL will be revised including the roles and responsibilities of the management regarding safety culture in the OL document in order to strengthen the management and supervision of safety culture by the licensee.

The Comprehensive Plan for Strengthening Nuclear Safety Standards is part of proactive regulatory activities to establish a transparent and reliable regulatory system which the public can accept and trust to achieve the level of nuclear safety which the public feels relieved and to make the society safe from radiation risk.

10.2 Recent Activities and Improvements

(1) Safety Culture of a Licensee (Common Issue 1)

In order to enhance safety culture of a licensee, the KHNP created a division dedicated to safety culture and has established and implemented measures to improve nuclear safety culture every year to help safety culture to take firm root and spread further. The safety culture assessment, which was conducted every two years for plant employees, expanded to headquarters and supporting organizations of the Nuclear Power Plant Site in 2016 and the assessment frequency was reduced to once a year in 2017 to establish the virtuous cycle of safety culture assessment, identification of areas for improvement and establishment and implementation of improvement measures to enhance safety culture. In addition, safety culture training courses by CANDU Owners Group (COG) have been provided since 2017 and various online and classroom training programs are prepared to provide position-specific training, creating a continuous learning environment.

The KHNP adopted nuclear oversight (NOS), which is an operating process in advanced NPPs in other countries in 2016, as a pilot program. NOS performs the role of independent inspection and reporting of major issues that are raised in NPPs. NOS is under the Head Office of the KHNP and the program was adopted in earnest in November 2017 for an independent oversight. NOS encourages improvement by observing major tests and jobs performed by plant employees including contractors, checking the compliance with safety related regulations and procedures, identifying areas for improvement and providing feedback to the plant.

* NOS (Nuclear Oversight): independent oversight (an organization that provides independent observation and assessment on human behaviors and weaknesses in every area of nuclear power generation.)

(2) Safety Culture of the Regulatory Body (Common Issue 1)

Korea presents "Enhancing Safety Culture of the Licensee and the Regulatory Body" as one of the 11 implementation tasks of the Somprehensive Plan for Strengthen Nuclear Safety Standards and the regulatory body is making an effort to enhance safety culture based on its safety objectives and core values.

The regulatory body developed the safety culture principles (draft) in May 2016 as a pilot project to enhance the safety culture of the regulatory body. It established 5 principles of safety leadership, ethics and independence, communication and cooperation, attitude toward work and decision-making and continuous improvement and 41 traits. In addition, the procedure on safety culture management that defines the general procedures for safety culture management to make safety culture principles take root in an organization was established in November 2016. According to the procedure for safety culture management, survey on the understanding of safety culture principles was conducted among employees of regulatory body in 2017 and pilot assessment on overall matters related to safety culture was conducted through interview in 2018.

(3) Regulatory Oversight on Safety Culture

The NSSC declared the improvement of management system including the adoption of integrated management model in line with IAEA GSR Part 2 'Leadership and Management for Safety' in the 2nd Comprehensive Plan for Nuclear Safety (2017-2021) in an aim to make safety culture take root. And the NSSC selected 'Strengthening Safety Culture of a Licensee and the Regulatory Body' as an implementation task to gain public trust in Comprehensive Plan for Strengthening Nuclear Safety Standards (March 2019). Specifically, the NSSC plans to improve rules for regulatory activities including the establishment of the criteria for managing safety culture with the roles and responsibilities of NPP operation organization and system to check safety culture.

· 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 and for each nuclear installation, throughout its life.

11.1 Contents of Implementation

11.1.1 Regulatory requirements on Financial and Human Resources

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 Regulation on Preparation of Technical Ability Description concerning Installation and Operation of Nuclear Reactor Facilities (NSSC Notice 2017-3) 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.

11.1.2 Organization of the Operator

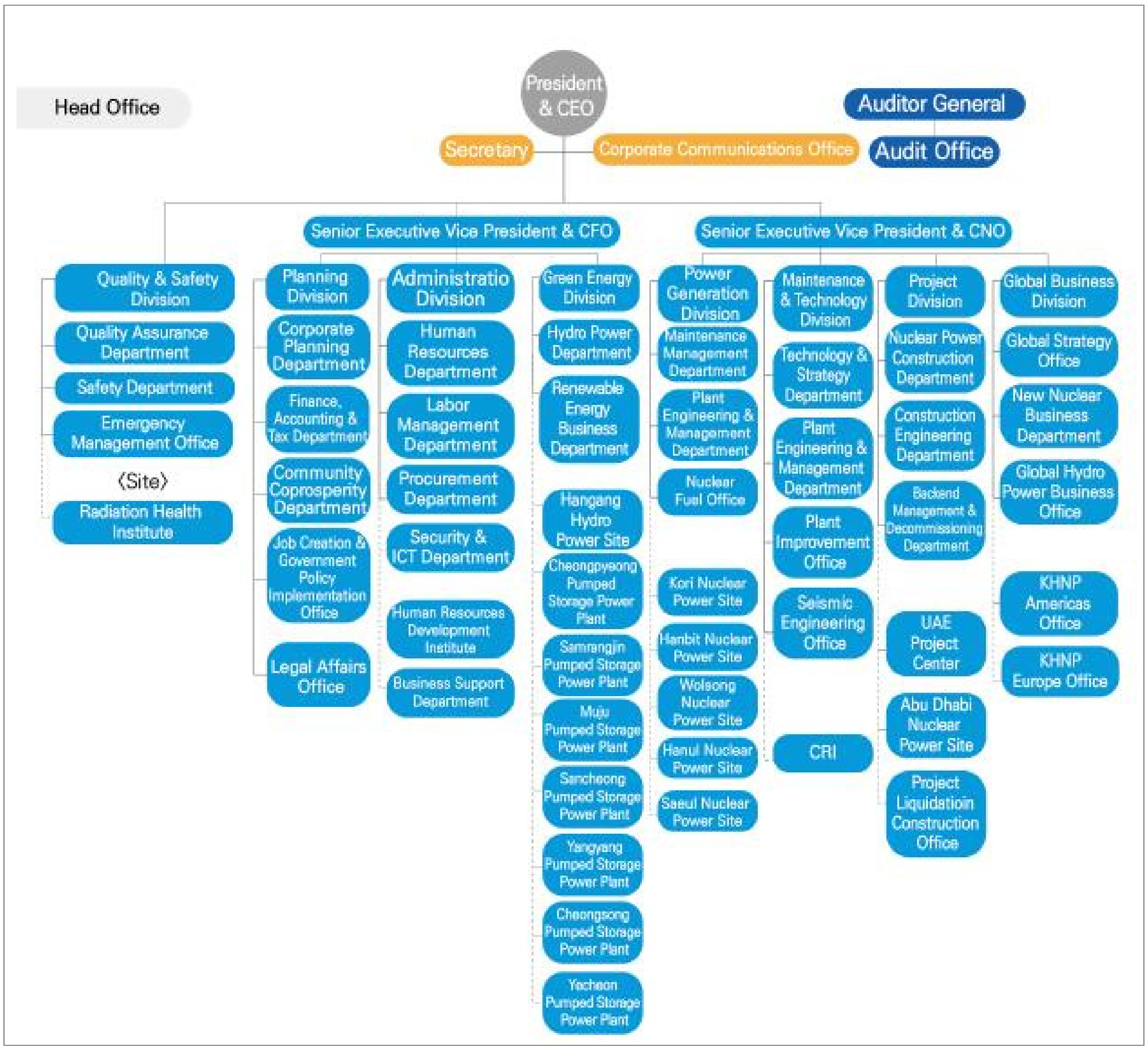
(1) Status of Organization and Workforce

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 Plant Sites, one hydro power site, six pumped storage power plants, and eight special institutes. With assets worth about KRW 55.4 trillion, the operator hires approximately 11,700 persons and among them, approximately 8,800 persons are involved in construction and operation of nuclear power plants (Figure 11-1).

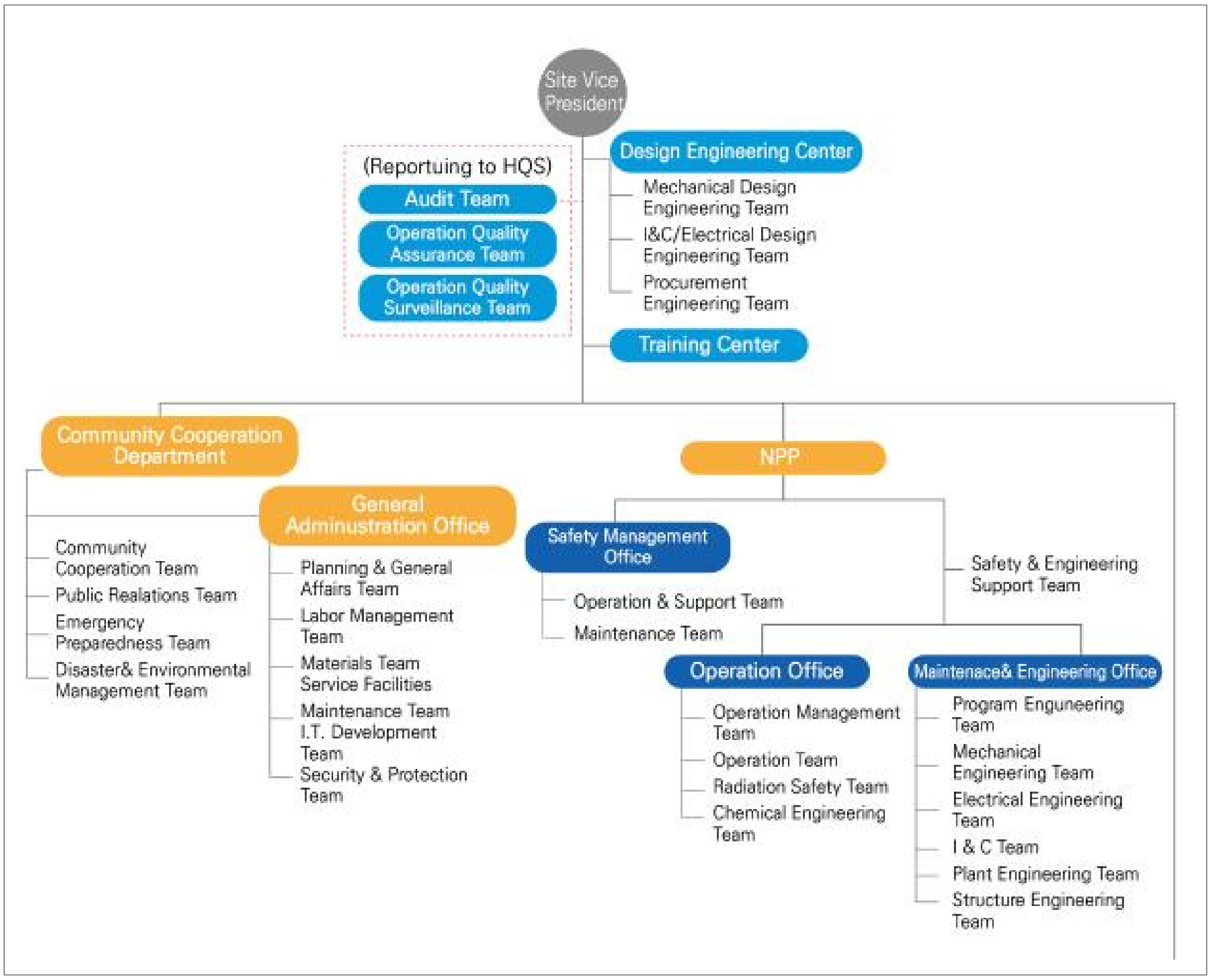
As shown in Figure 11-2, each Nuclear Power Plant Site of the KHNP consists of Quality Assurance Team, Quality Engineering Team, Training Center, General Administration Department, and Director Generals of Nuclear Power Plants. There are Safety Engineering and

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, I&C Team, Plant Engineering Team, and Structural Engineering Team.

| Figure 11-1 | KHNP Organization Chart



| Figure 11-2 | NPP Installation Operation Organization Chart



(2) Maintaining and Securing Human Resource for NPP Operation

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 3,364 (including double licenses) as shown in Table 11-1. 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 11-1 | License Holders Employed in Reactor Facilities

(As of December 31, 2018.)

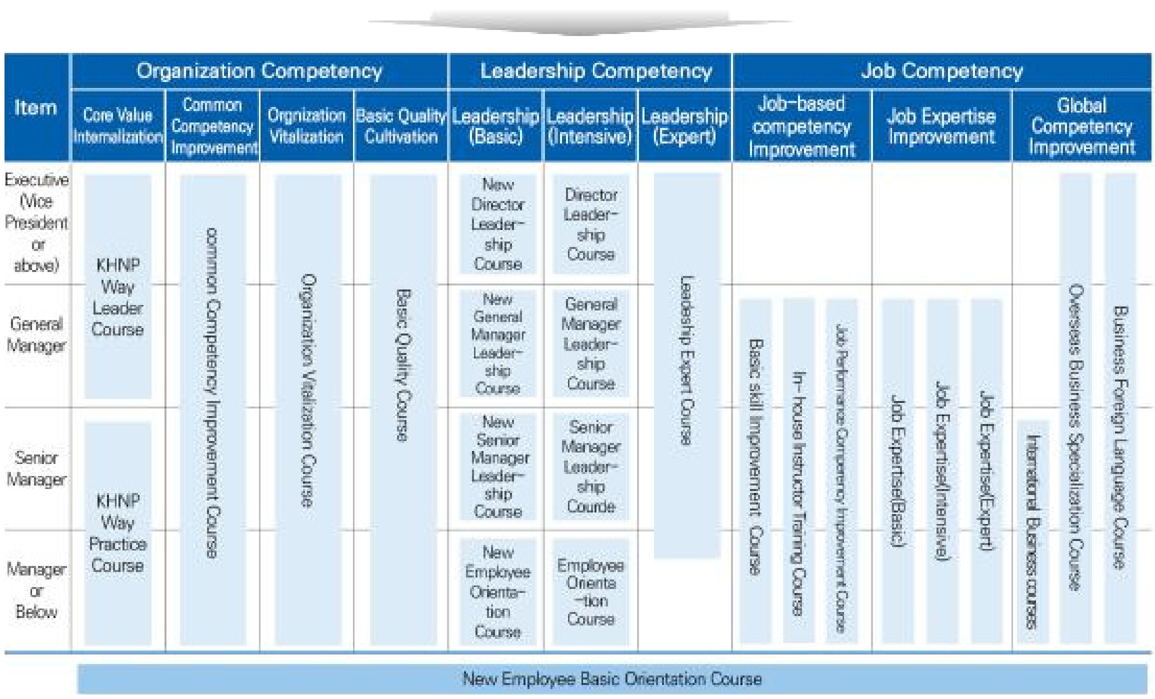
Category / Field	Type of License	Number of Holders
Reactor	Senior Reactor Operator	1,354 (1,047)
	Reactor Operator	1,415 (1,587)
	Subtotal	2,769 (2,634)
Nuclear Fuel Materials	Senior Nuclear Fuel Material Supervisor	72 (65)
	Nuclear Fuel Material Supervisor	21 (18)
	Subtotal	93 (83)
Radioisotope	Senior Radiation Safety Supervisor	6,951 (581)
	Radioisotope Supervisor	896 (1)
	Radioisotope Supervisor in Medical Use	920 (65)
	Subtotal	8,767 (647)
Total		11,629 (3,364)

* 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 11-2.

| Table 11-2 | 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



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.

11.1.3 Financial Resources of the Operator

The KHNP is the only NPP operator in the Republic of Korea, and it is designated as a public institution by the Act on the Management of Public Institutions. Under the Act, it is controlled by the government on such matters as management objectives, budget, business management plan, mid and long-term financial management plan, and use of reserve fund. The KHNP is required to disclose 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 the pursuit of profit. The KHNP has invested in the replacement and reinforcement of equipment 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 the decommissioning of the NPPs every year. It also manages a reserve fund in cash which can cover one unit of nuclear power plant stably to prepare for unexpected situation.

〈Research & Development〉

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 promoting safe operation of nuclear installations and preparing for the 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 5th Comprehensive Promotion Plan for Nuclear Energy (2017-2021), the total budget to be invested into the research and development programs during the period from 2017 to 2021 amounts to approximately KRW 1.0604 trillion. It is also planned to secure core technologies to improve nuclear safety and resolve issues.

Nu-Tech 2030, a nuclear technology roadmap, will be announced in March 2019 to establish the mid-to long-term R&D direction of the nuclear industry for the purpose of maintaining competitiveness of nuclear core technologies. Nu-Tech 2030 contains four areas for discussion: safety, decommissioning, radioactive waste, export and international cooperation (future nuclear technology). (To be added if follow-up announcement is made).

〈Facility Investment〉

The KHNP is replacing and/or reinforcing its equipment under the Mid- to Long-term Plant Investment Plan to ensure the safe operation of nuclear power plants for the next 20 years.

As post-Fukushima measures, the KHNP selected 59 items for improvement and completed 51 items including building up the coastal barrier for Kori site and installing injection line for emergency cooling water in spent fuel pool by 2018. The KHNP is set to complete eight additional items such as installing containment filtered venting system (CFVS) by 2021.

〈Resources for Radioactive Waste Management and Decommissioning Program〉

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 Ministry 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 and the Ministry of Industry, Trade and Energy respectively. The KHNP has accumulated a separate reserve fund for nuclear decommissioning every year.

11.1.4 Regulatory Workforce

The NSSC has continuously expanded the organization of the 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, safety management of radiation around living environment and response to earthquake and Radioactive Waste Safety Department was newly established. Accordingly, the number of employees increased by 74 from 82 in 2011 when the NSSC was launched to 156 as of June 2019.

KINS established and ran human resource supply and demand plan every three years. The plan is to secure the sufficient number of regulatory personnel every year corresponding to ever increasing regulatory demands. According to a mid- and long-term human resources management plan from 2019 to 2021 established in December 2018, KINS plans to increase the number of its staff to 627 by 2021. As of March 2019, KINS has 549 employees and human resources are allocated to each department considering the nature and scale of regulation target facilities and the necessary regulatory activities. KINS enhances efficiency of job performance through standardization of work processes and utilization of IT infrastructure. Since 2016, KINS has run retirement age extension program for competent staff and at the same time, maintained the policy to hire competent staff as temporary commissioned experts after retirement.

KINS operates an open hiring system to recruit those with relevant experience and those with doctorates, masters and/or bachelor degrees in areas necessary for regulatory activities in a fair and transparent manner. 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.

11.1.5 Financial Resources

The NSSC established the Nuclear Safety Regulation Account (the Atomic Energy Fund) in

January 1, 2016 by incorporating the charges and fees borne by the nuclear operators, etc. into the national finance to secure financial resources to respond to immediate nuclear issues, conduct R&D activities, and actively respond to rapidly increasing regulatory demand from new NPPs stably and to secure transparency of budget execution.

The purpose of the Nuclear Safety Regulation Account (the Atomic Energy Fund) is to make sure that the safety regulation activities related to the use of nuclear energy under the Article 1 of the NSA can be performed in a stable and sustainable manner. Every year, mid-term business plan and fund management plan are established to lay the financial foundation for the consistent and systematic implementation of nuclear safety regulation policies.

The major source of the Nuclear Safety Regulation Account (the Atomic Energy Fund) is the fees collected from organizations concerned in nuclear activities including NPPs and organizations using radiation according to the polluter pays principle. Stable income source was secured to have a financial structure where nuclear safety regulation activities can be performed smoothly without external financial support. In addition, the account is managed in a way to set margin and manage assets efficiently to make sure that the fund can be used for immediate response to and support for unexpected regulatory demand.

| Table 11-3 | Allocation of Budget the Nuclear Safety Regulation Account (the Atomic Energy Fund) for 2018

(Unit: 100 million won)

Laying the foundation for nuclear safety	Laying the foundation for radiation safety	Nuclear safety regulation	Radiation safety regulation	Total
21,395	2,171	45,202	23,863	92,631

The Nuclear Safety Regulation Account (the Atomic Energy Fund) supports the cost of activities for nuclear safety regulation and a plan for precise settlement of the cost is established every year to improve the fitness for purpose and transparency in execution of budget in accordance with the Guideline on the Management of Business under the Nuclear Safety Regulation Account (the Atomic Energy Fund). Through the precise settlement, it is checked whether the budget is executed normally according to applicable laws and procedures by project execution entities (NSSC, KINS, KINAC, Korea Institute of Radiological & Medical Sciences, and KoFONS). Actions are taken to recover unreasonable budget execution.

11.2 Recent Activities and Improvements

11.2.1 Operation of Education and Systems to Maintain and Strengthen Expertise of Regulatory Workforce (Common Issue 5)

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 competency.

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. 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 competency. 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 competency. 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 Nuclear Power Plant Site for more than two years. KINS implements staff rotation system between regulation department and research department and strives to enhance regulatory competency and to create synergy effect between departments with different nature.

The KINS also conducts competency diagnosis on employees working for the KINS for less than 7 years, to develop their expertise early. The self-driven individual development plan (ADP) is established and incorporated into a training plan and the ADP is linked to personal assessment and issuance of inspector certificate.

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.

· 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.

12.1 Contents of Implementations

12.1.1 Regulatory Requirements on Human 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 managed by being divided into 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 the 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,' in accordance with the construction and OL standards in NSA.

Therefore, 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 addition, regarding to the technical capabilities for operation, in 2001, new provisions on "Technical Capabilities for Operation" were added to the nuclear related laws to institutionalize a system which nuclear operators manage technical capabilities for operation of NPP in operation. Technical capabilities for operation refer 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 related provisions of the law such as 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.'

Based on such provisions, the Central Research Institute of KHNP manages operating experience feedback system, performs trend analysis periodically, and reflects the results to improve human performance. 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 NPPs in operation

12.1.2 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, 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, 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, the stage of verification and validation and design implementation and human performance monitoring 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.

12.1.3 Measures to Minimize Human Error in Nuclear Installations

Following the Kori Unit 1 SBO cover-up event 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. 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.

KHNP established "Guideline on Operation Change Management" in 2016 in order for successful implementation of major changes including policies on operation or introduction of new system. The Guidance is managed in a consistent manner to improve its effectiveness in the integrated model management department.

In addition, the KHNP evaluated the effectiveness of its entire human error prevention system following the human error-related event (Reactor shutdown caused by high level of steam generator) at Hanul Unit 5 in 2013. As a follow-up measure, it has made overall adjustment to how the system works by consolidating tasks related to human error in each NPP into a single department to be responsible for the operating experience feedback and K-HPES. Improved human behavior management system is also managed in the newly coordinated organization. In addition, a working group for practical exchange on human error is in operation for continued update on items for improvement.

12.1.4 The System of Operating Experiences Feedback Related to 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 KHNP has complied not just domestic operating experience, but also foreign operating experience 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 experience and take follow-up measures. For more systematic management of follow-up measures 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 measures are implemented in a fast and correct manner. If Operating Experience (OE) reports are to be written for specific event, its follow-up measures are automatically registered and managed in MAP, and managers check the implementation status for each event, period, and unit in real-time.

In addition to the retrospective approach to human and organizational factors related events, KHNP is also engaged in identifying and addressing the improvement in the overall operations of a plant in a prospective way through the self assessment on effectiveness of operation and contribution of safety and performance level of NPP for each organization, and the manager observation on important test and maintenance. Improvements identified from this process have been collected and corresponding follow-up measures have been managed through the CAP system. In addition, “Operation Behavior Standard Guideline” was established in 2018. It suggests the provisions of operator action and fundamental regulations which operator should conform in order to prevent human error. Especially the process of manager observation is strengthened by deriving unreasonable work practice and improving prevention of human error. Since 2017, KHNP head office has valuated its effectiveness and visualized the results to induce improvements in performing manager observation. In addition, the manager and trend analysis of observation result has been computerized by developing the Nuclear Plant Manager Observation System (NPMOS) in 2018. Through this system, administrator could manage the performance results, monitor the implementation status of improvements based on the results which supervisor inputs into the system, and utilize the data for validation evaluation and trend analysis.

12.1.5 Regulatory Issues on Human and Organizational Factors and Implementation 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. The regulatory body reviewed the applicant implemented HFE program systematically in the construction phase of the Units, and confirmed the issues related to human factors identified by the evaluation were resolved by establishing detailed plan and implementation.

Through stress test which is conducted to respond to beyond design basis accidents and severe accidents such as Fukushima accident, KHNP evaluated the suitability and validity of accident coping strategy and organization, procedure, human-system interface, environment. According to the evaluation, KINS has addressed the improvements in terms of technical capability of operation, and expected to confirm all of issues are resolved and improve the coping capability on beyond design basis accidents and severe accidents.

The regulatory body requires the KHNP to establish the detailed operation plan for human performance monitoring (HPM) in the process of review on OL for Shin-Hanul Units 1&2 to make sure that HPM is implemented in a systematic manner during the operation stage of the plant after OL is approved. Accordingly, the regulatory body will confirm whether the human performance evaluation and cause analysis are conducted and corrective actions are taken properly to make sure that operators' performance evaluated during the construction stage of the plant is maintained and design modifications made in the operation stage do not have a negative impact on human performance.

In 2018, the regulatory body established regulatory requirements for the analysis and assessment on human factors related to reliable manual actions by operators, which replace automatic function in the event of anticipated transients or postulated accidents that incorporate common cause failure of software of safety-class digital I&C (Instrumentation and Control) system. The regulatory requirements will be applied in the CP licensing process for new NPPs.

The regulatory body established the regulatory foundation and requirements for the application of human factor into design process consideration of beyond-design-basis accident and severe accident condition based on lessons learned from the Fukushima accident, experience of conducting stress test and research projects, and the requirements will be applied in the CP licensing process for new NPPs.

12.2 Recent Activities and Improvements

12.2.1 Ways to Minimize Human Errors in Nuclear Installations

The KHNP developed a Korean version of HPES (K-HPES) based on the Human Performance Enhancement System (HPES) of the Institute of Nuclear Power Operations (INPO) and the system was operated in each NPP from 1993 to 2017 to conduct the systematic cause analysis on events related to human errors. However, it was found that these activities under K-HPES are overlapped with functions of other programs such as the Corrective Action Program (CAP) and experience. Therefore, it was necessary to change the K-HPES system for the improvement of efficiency and utilization. In particular, the result of cause analysis on human error events through previous K-HPES system was lack of reliability because the analysis was conducted mostly by those who caused the events. And the identification of improvements had limitations as the code classification system for causal factors was not enough for conducting trend analysis. Accordingly, the KHNP established the Human Performance (HU) system that integrates the K-HPES system with CAP in an effort to improve the ways of conducting cause analysis on human error events and establish and manage corrective action plans through the newly developed system. Through the HU system, the KHNP has conductsed cause analysis, corrective action, trend analysis, and the propagation of operating experience on important events caused by human errors among the notices issued through CAP. Especially, KHNP has conducted the cause analysis of the error trigger factors, error prevention barrier, error contribution factors, individuals/organization factors, etc. in detail through the development of human error analysis sheet, and recurrence of the same events is prevented by establishing and implementing the corrective action plan based on cause analysis results. In addition, continuous efforts are made to improve human performance of NPP personnel through various programs such as CAP, human performance tools and manager observation.

As the human error events related to unplanned reactor shutdown increased, the team composed of experts from the regulatory body, industry and academia was established to reduce human errors in 2007 and the team established the measures to resolve human error issues in nuclear installations.

The actions that require immediate attention such as improvement of the management of operators' physical condition, qualification management for maintenance contractors, and improvement of simulator configuration and operation were taken as a short-term measure by the KHNP from 2007 to 2008. In addition, the KHNP led the establishment of the comprehensive plan to reduce human errors for matters that need to be addressed in the mid- and long-term and the measures were taken through a joint research by experts from the industry, academia and research field from 2009 to 2012. In the meantime, the regulatory body demanded the effectiveness valuation on overall human error prevention system in 2013. Accordingly, the KHNP established the task force team composed of internal and external experts to conduct inspection on organizations and programs related to human error prevention and human error prevention tools in NPP in 2014. Furthermore, follow-up measures such as the operation of working group on human performance improvement, unifying a departments dedicated to works related to human error, and the training program to poster experts of human factors and human errors have been taken since 2015. Training on human error prevention, which was provided, for each plant, had limitations in terms of the training subject and the number of participants, making it difficult to keep the effects of training continuously. Accordingly, e-learning program on human error prevention tools was developed and has been implemented since 2017 using the intranet which can be utilized regardless of time and space. In the mid and long-term, step-by-step strategies will be established and implemented for the comprehensive operation of human performance programs, incorporating matters related to human performance improvement such as training requirements for human error prevention tools and application method for NPP personnel, method of dealing with human error events and reflecting lessons learned, and management of human performance indicators after 2018.

· 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.

13.1 Contents of Implementations

13.1.1 Relevant Regulatory Requirements

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 fulfillment state and effectiveness of the QAP implemented by the licensee and its main contractors in accordance with the NSA.

13.1.2 Operators Quality Management

(1) 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) control of 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 in accordance with the NSSC Notice Detailed Requirements for Quality Assurance of Nuclear Reactor Facilities (reactor.26). For NPPs under operation, ANSI/ANS 3.2 technical standards are additionally applied.

(2) 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.

(3) 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 Quality 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 Quality 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.

13.1.3 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.

(1) 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.

(2) Quality Assurance 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.

(3) Inspection on Vendor. etc

In November, 2014, the inspection system on vendor and performance verification institute was first introduced for safety related equipment(SSC and component parts) that is installed and replaced in NPPs under construction and operation. It is implemented by KINS entrusted by NSSC. KINS verifies if the quality activities of vendors that manufacture safety related equipment and the performance verification institute that performs verification satisfies the approval criteria in accordance with the NSSC Notice, Regulation regarding Inspection on Suppliers of Safety Related Equipment for Nuclear Facilities (Reactor.39). When those manufacturers whose quality assurance system is found to be weak or which relates with safety issues of NPPs is subject to unannounced inspection. Regarding to the issues drawn from the vendor inspection, suggestions or recommendations are issues in accordance with the relevant Notice so that the responsible institute is able to perform corrective or improvement actions. Among others, in order to identify and correct the issues drawn from defects in the quality assurance system of the licensee, vendor inspection is performed in interfaced with quality assurance inspection on licensee.

In addition, in order to prevent any issues found in vendors from being repeated or expanded, the training on regulation status on vendors is conducted three times a year targeting various domestic suppliers and performance verification agencies

13.2 Recent Activities and Improvements

13.2.1 Measures to Maintain the Supply Chain for Parts (Common Issue 6)

Ministry of Trade, Industry, and Energy periodically checks up the current nuclear industry status and also prepared support policies not only to strengthen the safety of NPPs but also to establish the maintenance project road map and expand the scope of support.

Accordingly, KHNP is making an effort to maintain the supply chain that can prevent the contracters of nuclear industry from exiting the industry due to the national energy transition policy and to maintain stable supply chain. Part of the effort can be registration of qualified supplier and supporting the acquiring/renewing of the KEPIC/ASME/overseas certification since 2017. Since April, 2019, by removing existing financial support ceiling, it starts to fully cover the entire cost of acquisition of quality certificate. In addition, by expanding the financial support such as increasing the proportion of advanced payment(51.4% in 2018 to 56.4% in 2019) and raising energy innovation growth fund(more than 50billion won) and the procurement schedule for back-up parts on main equipment(MMIS, RCP, etc.) that need to be applied to Shin-Kori Unit 5&6 is shortened by two years (from April, 2023 to April, 2021). Likewise the endeavor for maintaining the supply chain for NPP parts is continued

Additionally, for 14 units that have been operated for more than 20 years, it is implemented pro-active equipment replacement plan by investing 1.9trillion won from 2012 to 2022. This is not only to contribute to the enhanced safety and safety operation though improved reliability on NPP equipment but also to maintaining the supply chain.

In order to maintain the reliability of existing NPP materials by properly reflecting the design/regulatory/management requirement by the requesting personnel into the procurement documents, thereby ensuring quality. The procurement documents describe the scope of supplied material and service, technical standards, establishment and implementation of QA plan, vendors authority to confirm, and CFSI verification requirements. Once the procurement document is confirmed, its level of completion is reviewed. Materials and service need to be provided by qualified supplier with proper capabilities. They are qualified based on their technical ability, QA ability, and contract implementation ability and periodically checked within the qualification effective date. Supplier takes primary responsibility to perform quality related tasks and KHNP should authorize the shipment.

Especially, in order to prevent falsification of quality document, the test results requested by the supplier to an external test institute should be submitted to KHNP not by supplier but by the external test institute itself and checked in manufacturing and taking-in stage in addition to the existing parts quality compliance test. Especially, in February, 2014, QR code based anti-falsification system was adopted to establish a swift and accurate falsification checking system and it exchange information with nuclear industry in terms of prevention of quality document verification system.

· 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.

14.1 Contents of Implementation

14.1.1 Assessment of Safety

(1) Assessment of Safety of New NPPs

Pursuant to the NSA, the licensing procedure for nuclear installations, as described in Section 7.2 of this report, consists of two stages: construction permit (CP) and operating license (OL). If the operator intends to construct multiple reactors of the same design, s/he can apply 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 should 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 be accompanied by construction or operation of nuclear installations. The results of those assessments should be documented as follows: Standard Safety Analysis Report for a SDA; PSAR and Radiological Environment Impact Assessment Report for a CP; and FSAR and Radiological Environment Impact Assessment Report for an OL. These reports should be submitted to the NSSC.

A SAR should include the results of the safety assessment of nuclear installations, such as design features, structural integrity & performance evaluation by function of structures, systems and components, human factors engineering, coping capability of design basis accidents, radiation protection, and site characteristics. The contents of a SAR are prescribed in Article 4 of the Enforcement Regulation of the NSA and applied to all types of reactors, as shown in Table 14-1. Severe accidents and a PSA are addressed in an accident management program.

| Table 14-1 | Contents of SAR of Reactor Facilities

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 Factors Engineering

As for new NPPs, as per the NSA revised on January 20, 2015, the operator should submit a decommissioning plan in advance when applying for a CP and an OL, after which, the plan should be periodically (every 10 years) 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 a final version of the decommissioning plan is prepared. In such case, a hearing should be held when requested by residents within the scope designated by Presidential Decree or by the head of a local government having the area under its jurisdiction. (Refer to Section 6.2.2 Permanently Shutdown NPPs and Decommissioning Plan)

In order to manage a severe accident which exceeds design basis and causes significant damage to a reactor core, an accident management program which includes a severe accident management program should be submitted to the NSSC, when applying for an OL, as per the

NSA revised on June 22, 2015. The accident management program should contain relevant actions taken to prevent an escalation of the accident, mitigate the consequence of the accident, and recover to a safe state in case of an accident in reactor facilities. (Refer to Section 6.2.2 Status of accident management program)

A radiation environmental impact assessment report should include an assessment of radiological effects on the public and the environment and, as prescribed in the Enforcement Regulation of the NSA, contain the below items, and is prepared in accordance with the NSSC Notice No. 2017-16 (Regulations on Preparation of Evaluation Statement of Environmental Impact by Radiation at Nuclear Facilities).

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

(2) Assessment of Safety of Operating NPPs

- Periodic Safety Review

In order to manage and improve the safety of operating NPPs continuously, Korea has legislated and implemented a PSR system for nuclear power reactors and related facilities since 2001. As per Article 23 (Periodic Safety Review) of the NSA, the reactor operator should comprehensively assess the safety of reactor facilities every 10 years after the operating license thereof is issued, and report the assessment results to the NSSC.

The assessment scope was originally based on 11 safety factors including physical condition of reactor facilities; however, three more factors - plant design, probabilistic safety analysis, and hazard analysis - were included (Table 14-2) when the Enforcement Decree and the Enforcement Regulation of the NSA were revised accordingly to be consistent with the revised IAEA Safety Standard SSG-25 Periodic Safety Review for Nuclear Power Plants in 2013. In addition, the PSR review guideline was revised to include the above three factors, and the format of the review report was enhanced.

The review is designed not only to evaluate 14 factors individually, but also to analyze cross-cutting items, after which, the evaluation results and the safety actions based on the evaluation are considered to draw up comprehensive review results. Technical standards of the respective NPP effective at the time of review should be utilized as the review standards.

| Table 14-2 | Safety Factors of PSR

1. Plant design
2. Actual condition of SSCs important to safety
3. Deterministic safety analysis
4. Probabilistic safety analysis
5. Hazard analysis
6. Equipment qualification
7. Aging
8. Safety performance
9. Use of experience from other plants and research findings
10. Procedures for operation, maintenance, etc.
11. Organization, the management system and safety culture
12. Human factors
13. Emergency planning
14. Radiological impact on the environment

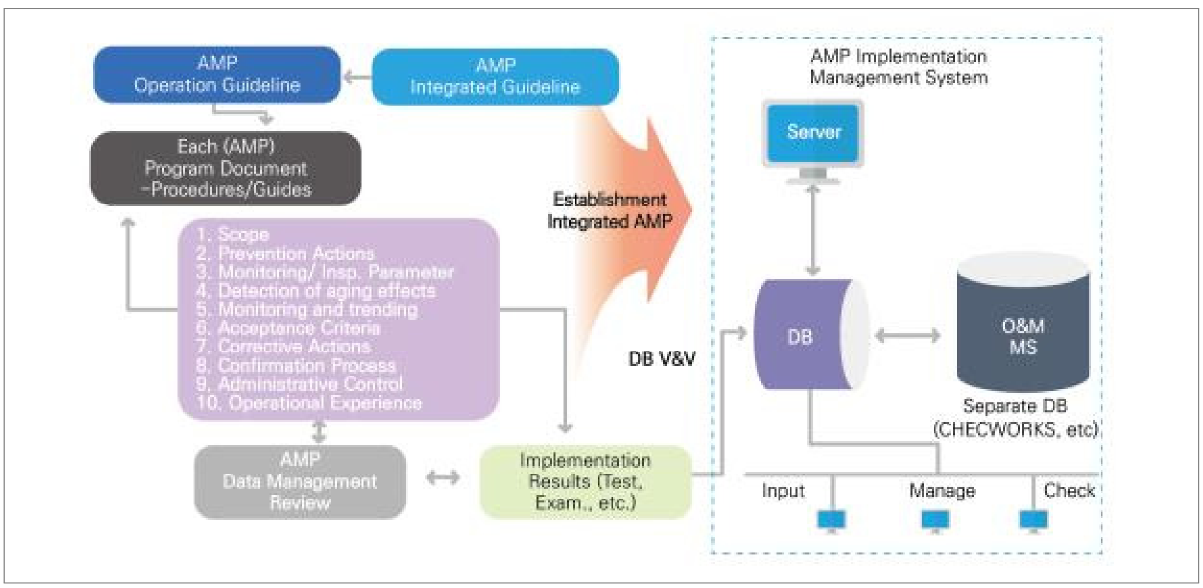
- Aging Management Program (Common Issue)

It is stipulated in the NSA and its subsequent regulations that a PSR include matters with regard to aging of SSCs of reactor facilities, which is to confirm whether 1) to control effectively aging of SSCs to maintain required safety margins and 2) to establish an adequate aging management program for the safe operation in the future. The scope of an adequate aging (including a management program) assessment includes classification and selection, evaluation of aging degradation, functions· safety margins, prediction of the timing of under-performance and future physical condition and aging mitigation measures· management program.

The PSR for a NPP in operation beyond design life (hereafter 'Continued Operation') additionally shall include life assessment for continued operation and use of operational experiences and research findings, and details are presented in the NSSC Notice No. 2017-29 (Guidelines on Application of Technical Standards for Assessment of Continued Operation of Nuclear Reactor Facilities beyond Design Life). The time limited aging analyses (TLAA) for life assessment is to demonstrate 1) TLAA remain valid for the period of continued operation or 2) TLAA have been projected to the end of the extended period of operation, or 3) The effects of aging on the intended functions will be adequately managed for the period of continued operation. When reviewing the PSR of each plant, the regulatory body confirms whether the aging of SSCs is adequately evaluated.

In particular, the regulatory body requested the KHNP to develop and implement an "Integrated Management Plan for Aging Management Program for Operating NPPs" as part of the plan for safety improvement identified as a result of Special Safety Inspection after the Fukushima Daiichi accident. Currently, the integrated aging management program has been established for each operating plant in which prevention actions, and detection, monitoring and trending of aging effects are performed for equipment within the scope in accordance with about 40 procedures. In addition, "Computerized AMP Implementation Management System" has been developed and in operation since February 2019 to improve the efficiency of aging management, as shown in Figure 14-1. When conducting a periodic inspection, the regulatory body reviews the adequacy of implementation of the aging management program of each plant.

| Figure 14-1 | Overview of AMP Implementation Management System



Meanwhile, the Korean nuclear industry has participated in the IAEA IGALL (International Generic Ageing Lessons Learned) working group since 2014, and reviewed action items to be incorporated into the current aging management program with an intention to implement and improve the program more effectively. The nuclear industry will also participate in the Phase 5 of IAEA IGALL Program starting in 2020. The regulatory body has joined in WGCS (working group on codes and standards) under OECD/NEA CNRA and WGIAGE (working group on integrity and ageing of components and structures) under CSNI to identify overseas operating experiences and review their applicability to Korean NPPs.

14.1.2 Verification of Safety

(1) Verification of Safety of New NPPs

As described in Section 7.2.2 of this report, a Pre-Operational Inspection of reactor facilities under construction is conducted to verify whether the reactor facilities are properly constructed in conformity with conditions of the CP therefor and whether the constructed reactor facilities may be operated safely throughout the lifetime. As per Article 16 (Inspection) of the NSA and Article 27 (Pre-Operational Inspection) of the Enforcement Decree of the NSA, the installer of reactor facilities is required to undergo a Pre-Operational Inspection at the defined time in Article 29 (Time, etc. of Pre-Operational Inspection) of the Enforcement Decree of the NSA to verify that the construction and performance of reactor facilities satisfy the technical standards defined in the CP and the OL therefor, and will operate the facilities only when the Pre-Operational Inspection is passed. The Pre-Operational Inspection is divided into facility inspection and performance inspection, and conducted by means of a document inspection and a field inspection.

- Pre-Operational Inspection and Test for New NPPs

As per the NSA and its Enforcement Decree, a Pre-Operational Inspection should be conducted for a nuclear power plant under construction to verify that the construction and performance of reactor facilities satisfy related technical standards.

In order to verify that systems and components including reactor coolant system operate as designed and satisfy safety requirements, a Pre-Operational Inspection of NPPs was conducted phase-by-phase: 1st phase inspection of foundation excavation and reinforcement and construction test of a reactor building ; 2nd phase inspection of installation of major systems and components ; 3rd phase inspection for performance verification of components in a cold state ; and 4th phase inspection for comprehensive performance verification of systems and components in actual operating conditions. The 5th phase inspection of fuel loading and startup test will be conducted after the OL therefor is issued.

(2) Verification of Safety of Operating NPPs

The operator of reactor facilities should undergo a periodic inspection from the NSSC to assure that the performance of reactor facilities is maintained in conformity with the technical standards as prescribed in the relevant regulations, and other performances including resistance to pressure and radiation are maintained in the same state as they were when passing the Pre-Operational Inspection, pursuant to Article 22 (Inspection) of the NSA, Article 35 (Periodic Inspection) of the Enforcement Decree of the NSA, and Article 19 (Periodic Inspection) of the Enforcement Regulation of the NSA. The operator should also receive a periodic inspection every within 20 months from commencement of its initial commercial operation or its inspection in accordance with Item 2 of Article 19 (Periodic Inspection) of the Enforcement Regulation of the NSA. The periodic inspection is conducted by means of a field inspection and a document inspection during the refueling period for PWRs and the planned outage for PHWRs.

- Preventive Maintenance of Operating NPPs

The KHNP carries out a preventive maintenance program in accordance with the provisions defined in the Technical Specifications of each NPP in order to keep the operating conditions and performance of NPPs within the design limits thereof and to prevent failures. With an equipment reliability process in place, the operator operates the preventive maintenance program systematically and preemptively by selecting preventive maintenance targets based on the functional importance of equipment, standardizing preventive maintenance tasks based on PM templates, performing predictive maintenance activities based on condition monitoring, and introducing online status monitoring and early alarm, with aim to enhance equipment reliability and plant safety.

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

Pursuant to the NSA and its Enforcement Decree and the NSSC Notices, the KHNP should submit to the NSSC a long-term ISI Plan for each plant every 10 years, and perform in-service inspections according to the plan thereof.

The NSSC Notice No. 2016-11 (Regulations 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 PWRs, 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 PHWRs.

The NSSC Notice No. 2016-14 (Regulations 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 PWRs and PHWRs during ISTs. Therefore, pumps should 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 ASME OM Code Sec. IST. As for valves, KEPIC MOC section or Subsection ISTC of ASME OM Codes Sec. IST should be applied to carry out the leakage test, the actuation test, and the position indicating test and the fail-safe test, and also analyze any change in reference values of the parameters.

14.2 Recent Activities and Improvements

14.2.1 Assessment of Safety

(1) Improvement of Safety of New NPPs

As a result of reviewing an application for construction permit for Shin-Kori Units 5&6 (June 2016), compared to other units, measures for safety improvement are added as follows: as part of post-Fukushima measures and in order to be prepared against SBO(Station Blackout) at multi-units, a seismic category I, AAC(alternative alternate current) diesel generator is installed for each unit so as to cope with SBO simultaneously occurring at the both units; the capacity of batteries, the only electric power source of the plant in SBO conditions is increased from 8 to 24 hours; the emergency reactor depressurization system (ERDS) is installed for rapid depressurization of the reactor coolant system in case of a high pressure severe accident; and the walls of the reactor containment building and the auxiliary building are reinforced to be prepared against intentional crash of a commercial aircraft.

In the operating licensing process for Shin-Kori Unit 4 after issuance of the OL of Shin-Kori Unit 3 (October 2015), earthquakes occurred in Gyeongju (a local magnitude of 5.8, Sept. 12, 2016) and Pohang (a local magnitude of 5.4, Nov. 15, 2017), and the KHNP was promptly requested to re-assess their seismic safety. Accordingly, the operator created a seismotectonic model based on available information, and assessed and reported to the regulatory body the maximum possible earthquake of the faults which caused the earthquakes and the maximum ground motion of the site. As a result of reviewing them, it was confirmed that the peak ground accelerations (0.06g, 0.026g) of the faults of the Gyeongju and Pohang earthquakes were enveloped by the safe shutdown earthquake of Shin-Kori Unit 4 (0.3g).

A review of technical adequacy was performed for the CFSI investigation and the follow-up actions which were initiated by the counterfeit event of qualification verification documents (QVDs) in 2013. The counterfeit investigation was completed of 93,000 QVDs associated with the safety class items of Shin-Kori Unit 4. As a result, 20 non-conformed QVDs were revealed and it was confirmed that follow-up actions for the components with non-conformed QVDs were properly taken (e.g. sample test and re-issuance of QVDs).

In-Vessel Retention-External Reactor Vessel Cooling (IVR-ERVC) is one of severe accident management strategies of Shin-Hanul Units 1&2. At a walkdown as the validation process of Severe Accident Management Guide (SAMG), a duct of HVAC connected to the reactor cavity at lower elevation than the target water level for IVR-ERVC strategy was identified. Because the design of the duct did not consider the severe accident environment, it cannot be sure that IVR-ERVC strategy can be achievable. Finally the duct was reinforced with steel pipe and supports so as to maintain the structural integrity under the IVR-ERVC strategy. In addition, an error in the common mode failure analysis of the reactor protection system was found, which led to an improvement in the design of the diversity protection system.

(2) Improvement of Safety of Operating NPPs

- Periodic Safety Review

The NSSC strives to introduce a system in which the results of all PSRs conducted every 10 years should be reviewed and approved with an intention to strengthen the role of the regulatory body with regard to PSR and to further raise the safety of operating NPPs. To that end, the NSSC will legislate to specify criteria for approval clearly and impose an administrative order if a NPP fails to meet the criteria. (Refer to Section 7.2.2 of this report.)

- Change Permit of Operation

After revision of the Enforcement Regulation of the NSA (Nov. 24, 2014), any change, replacement or addition to equipment or facility defined in the licensing documents of a nuclear power plant should be subject to a change permit or a report of change depending on whether it is safety-related. Moreover, as per the improvement plan for the procedure for a change permit for a nuclear power reactor, etc. which was reported in the 83rd NSSC (June 14, 2018), a change permit for a nuclear power reactor, etc. which was to be approved by the Chairperson of the NSSC should be now subject to deliberation by the NSSC.

- Implementation of Post-Fukushima Measures

After the Fukushima Daiichi Accident on March 11, 2011, the Korean government formed a safety inspection team consisting of experts from relevant fields and KINS, and carried out a safety inspection for domestic reactor facilities 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; response to severe accident; emergency preparedness;

NPPs in long-term operation 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 - 46 for the KHNP, one for Korea Institute of Radiological and Medical Sciences (KIRAMS), and three for Korea Atomic Energy Research Institute (KAERI) - and requested them to develop and implement action plans. Together with 10 additional items that the KHNP identified from its self-assessment in February 2012 and three more items identified in the 1st half of 2016, a total of 63 action items for safety improvement were finalized (Refer to Annex J-2), and their implementation status has been reviewed every year. For each NPP unit, the regulatory body has received reports of minor changes or approved permit changes of operation and also carried out technical reviews of the safety of the action plans for improvement. Periodic inspections and other field activities are also being used as a way to confirm the adequacy of the corrective actions for each NPP unit. In addition, the result of each item's corrective action is confirmed when their implementation and review are completed. Currently, most of the items have been completed and the remaining eight long-term items including four additional items produced in the first half of 2016, such as the installation of containment vent or depressurization facilities, are being implemented with a target of completion by 2021.

- Post-earthquake Measures

Immediately after an earthquake with a local magnitude of 5.8 occurred nearby Gyeongju in Sept. 2016, a safety review of all NPPs was conducted. The review results and problems raised in the process of responding to the earthquake were developed into action items for safety improvement and finalized into『Safety Improvement Plan for Nuclear Facilities against Large Earthquake』in the 63rd NSSC (Dec. 2016). With regard to that, the NSSC requested concerned parties to submit detailed action plans and based on which, to implement 23 action items in six areas thoroughly including improvement of seismic response system, seismic reinforcement of operating NPPs and detailed assessment of seismic capacity, and to report their implementation status on a quarterly basis. As of late December 2018, 12 action items were completed and the remaining 10 items including building of seismically isolated emergency control center for each site are underway with a target of completion by 2021.

14.2.2 Verification of Safety

(1) Improvement Made During Pre-Operational Inspection of New NPPs

A cold hydraulic test of Shin-Kori Unit 4 RCS and SG secondary system was implemented following a foreign object search and retrieval (FOSAR) on the SG secondary side and an eddy current test (ECT) of SG tubes. As a result, foreign materials (processed metal chips) and abnormal signals were detected inside the SG, which prompted the KHNP to conduct an inspection. With regard to that, KINS requested the operator to remove the foreign materials in the SG secondary side and to conduct additional inspection of the wider areas of the SG. Thanks to such efforts, it was confirmed that foreign materials no longer existed in the SG secondary side. The KHNP was also requested to conduct follow-up actions which included investigation of causes for foreign material entry in the SG secondary side and establishment of recurrent prevention measures.

Findings identified during the startup inspection as well as during the 1st cycle of commercial operation of Shin-Kori Unit 3 whose operating license was issued in Oct. 2015 were examined to ensure that they were properly incorporated into Shin-Kori Unit 4. As a result, it was confirmed that a design change to prevent the displacement of the retaining ring of the low pressure turbine which occurred during the commissioning period of Shin-Kori Unit 3 was already incorporated and the locally manufactured venturi for main feedwater flow measurement which caused a power indication difference between the primary and the secondary sides was replaced with a proven foreign venturi. In addition, a cause analysis of the reactor scram due to a communication error in the control element control system was conducted so that a new alarm was created and related procedures were properly revised.

With respect to the Pre-Operational Inspection of Shin-Hanul Units 1&2, action items for safety improvement were added as follows: during the performance test of turbine driven auxiliary feedwater pump, a damage to the turbine blade was found, which led to addition of a foreign material inspection as a hold point to the factory assembly of the turbine driven auxiliary feedwater pump. In addition. a request to revise a related test procedure was made to inspect any abnormality, using turbine vibration data. One step further, this experience was distributed for other NPPs in Korea to take recurrence prevention measures properly.

With enhanced safety made based on findings and recommendations from the Pre-Operational Inspections Shin-Kori Units 5&6, the civil construction of Shin-Hanul Units 5&6 is currently underway and nothing special has been identified.

(2) Verification of Safety of Operating NPPs

- Safety Performance Indicators

The Safety Performance Indicators (SPIs) system was developed and applied by the regulatory body in 1995 to monitor and assess the operating status of a NPP and its radiological influence. By analyzing the indicators, it is possible to show the safety of a NPP based on quantified performance measures, to conduct effective safety regulations through trend analysis of the indicators, and to improve public confidence in nuclear safety by providing operational information. The Korean SPI system has been constantly improved through research findings and in accordance with guidelines on SPIs developed by the IAEA and the US Nuclear Regulatory Commission (USNRC), and starting from 2002, the quarterly analytical results of SPIs are posted on the web site (http://opis.kins.re.kr).

The SPI system is composed of two safety areas, five categories and 14 indicators as shown in Table 14-4.

| Table 14-4 | Structure of Safety Performance Indicator (SPI) System

Area	Category	Safety Performance Indicator
Reactor Safety	Operational Safety	• Unplanned Reactor Scram • Unplanned Power Reduction • Scrams with Complications
	Safety System	• SI System Unavailability • EDG System Unavailability • AFW System Unavailability • RHR System Unavailability • CW System Unavailability • Safety-related Equipment Failure
	Multiple Barrier	• Fuel Reliability • RCS Integrity • Containment Reliability • Emergency Preparedness
Radiation Safety	On-site Rad. Safety	• On-site Radiation Dose
	Off-site Rad. Safety	• Off-site Radiation Level

An analysis of the SPIs is performed every quarter and the performance is classified into four grades: excellent, good, normal, and warning which is indicated by four colors from green, blue, yellow, and orange. Quantitative thresholds for performance grades are set considering operating margin, limits defined in Technical Specifications, and severity levels when the limits are exceeded.

- Monitoring and Assessment of Safety-related Indicators

In order to confirm the safety of NPPs in a real time, the KHNP conducts a continued monitoring and assessment for the safety-related indicators as follows:

Since 2008, all operating NPPs in Korea have established and operated computerized systems for real-time risk assessment and management which are Risk Monitoring System (RIMS) during normal operation and Outage Risk Indicator of Nuclear Power Plants (ORION) during outage.

Based on the results of PSA of each plant, RIMS is designed to quantify, assess, monitor and manage the level of risk changed depending on operating conditions such as tests, inspections or maintenances of systems and components during normal operation. Thanks to incorporation of operating experiences and continuous system improvement, an integrated monitoring system of all NPPs has been established since 2011. On the other hand, ORION is designed to assess, monitor, and manage quantitatively the level of maintaining in-depth defense resulting from changed operating conditions such as temperature, pressure and water level of RCS during outage, and as of 2019, applies to all operating NPPs. As such, NPPs in Korea have established a comprehensive safety management system to assess and manage in a real time not only design safety but also operational safety against all possible events during operation.

· 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 to the members of 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.

15.1 Contents of Implementation

15.1.1 Relevant Regulatory Requirements

Republic of Korea takes appropriate measures to keep the radiation exposure of population near the NPP sites as low as reasonably achievable and to prevent radiation exposure, radioactive material discharge from exceeding national radiation dose limits as well as radiation worker training.

「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);
- Measurement and management on the radiation exposure for any person who is employed in, or who has frequent access to nuclear installations;
- Provisions on safety measures relating to operations stipulating the necessary actions to be taken for protecting human bodies, materials, and the public from radiation hazards which may accompany the operation of nuclear installations,
- Prevention of damage and control of public exposure dose by managing the total amount of discharge of liquid and gaseous radioactive material in normal operation
- Training of radiation workers

(1) Dose management

Facilities, etc., and the Regulations on Technical Standards for Radiation Safety Management, etc. include the detailed procedures and methods for executing dose management for radiation workers and the population near the NPP in accordance with the NSA and its Enforcement Decree as follows:

- Measures taken for radiation protection on doses from exposure to radiation such as keeping the radiation dose limits related to radiation protection (The dose limits defined by this regulation are as shown in Table 15-1);
- Measures to minimize the radiation exposure of the workers engaged in radiation work, the persons who have frequent access to nuclear installations, during normal and abnormal operation state(in exclusive of accident)
- Safety measures against those who experience radiation hazards and relevant reporting
- Particulars on installation of radiation protection equipment for protection from radiation exposure within nuclear installations
- Consideration on appropriate methods to keep ALARA during operation of NPPs by evaluating the expected dose for radiation workers and residents nearby when designing the nuclear installations
- Detailed provisions necessary for implementing the radiological control measures such as criteria and access control of radiation controlled area;
- Detailed provisions on registration of dosimetry service providers
- Detailed provisions on the cases of damage and loss of personal dosimeters, and the cases of dosimeter readings exceeding the dose limits
- Detailed provisions on the evaluation and management of radiation exposure level such as legally approved types of dosimeters and personal dosimeter reading

| Table 15-1 | Radiation Dose Limits

(Unit: mSv)

<table>
<tr><th rowspan="2">Classification</th><th rowspan="2">Effective Dose Limits</th><th colspan="2">Equivalent Dose Limits</th></tr>
<tr><th>Lens of Eye</th><th>Hands, Feet and Skin</th></tr>
<tr><td>1. Radiation Worker</td><td>100 mSv for five years within the scope not exceeding 50 mSv per annum</td><td>150 mSv per annum</td><td>500 mSv per annum</td></tr>
<tr><td>2. Persons with frequent access, personnel engaging in Transport and persons under 18 with the purpose of education and training, etc. as recognized by the Commission</td><td>6 mSv per annum</td><td>15 mSv per annum</td><td>50 mSv per annum</td></tr>
<tr><td>3. Persons other than those in No1&2</td><td>1 mSv per annum</td><td>15 mSv per annum</td><td>50 mSv per annum</td></tr>
</table>

Note

1. Dose limits refers to the accumulative radiation dose from January 1 to December 31 (1year).
2. Despite the dose limits 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 dose of more than 1 mSv per annum, effective dose limits, despite being specified in the table above, shall be set to exceed 1 mSv per annum to the extent that an average of 5 years of dose from radiation exposure 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 1, 1998.

※ The effective dose of the personnel of frequent 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.

(2) Management of radioactive material discharge

In order to manage the radioactive material discharge from nuclear installations, it is requested to applicant for OL to submit the Plan to discharge liquid or gaseous radioactive materials in accordance with the NSSC Notice (Standard Format and Content of Discharge Plan for Liquid and Gaseous Radioactive Materials from Nuclear Reactor and Related Facilities). Technical requirement on the conditions for discharge should be in consistence with NSSC Notice (Standards on Radiation Protection, etc.).

(3) Training of Radiation Workers

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 three courses; one is for radiation workers and one is for persons with frequent access and the other is for radiation safety officer. Each course is further divided into common area and radiography testing 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 15-2 | Training of Radiation Workers

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 testing area	New training	12	
			Regular training	5	
	Persons with Frequent Access	Common areas	Regular training	3	
		Radiographic testing area	Regular training	5	
	Radiation Safety Officer	Common areas	Regular training	3	
		Radiographic testing 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	
		Radiographic testing area	New training	6	
			Regular training	5	

15.1.2 Implementation of Radiation Protection

(1) 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 is located in shielded cubicles separated from non-radioactive equipment and redundant components are isolated from one another
- Radioation shields are installed to fully attenuate the radiation from the radioactive pipes and equipment
- Labyrinths or hatches are installed to limit the direct and scattered radiation out of shielded cubicles
- Lockable doors and audio/visual alarms are provided for high radiation areas

- Remote viewing devices are provided in high radiation areas where routine visual surveillance inspections are required

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

- Sufficient work space is secured to provide easy access to the equipment and facilitate work during decommissioning
- Equipment for lifting heavy components and equipment hatch of appropriate size are secured in the reactor containment building during decommissioning
- Package units are skid mounted for easy removal during decommissioning
- Non-radioactive systems and equipment are installed separately from radioactive systems and equipment to avoid unnecessary exposure during decommissioning
- The leakage of radioactive fluid is minimized and once it leaks, the drainage is collected into equipment drain sumps and floor drain sumps and processed by radioactive waste management systems

〈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 15-1, 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.

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.

〈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 and Working 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 Figure15-1.

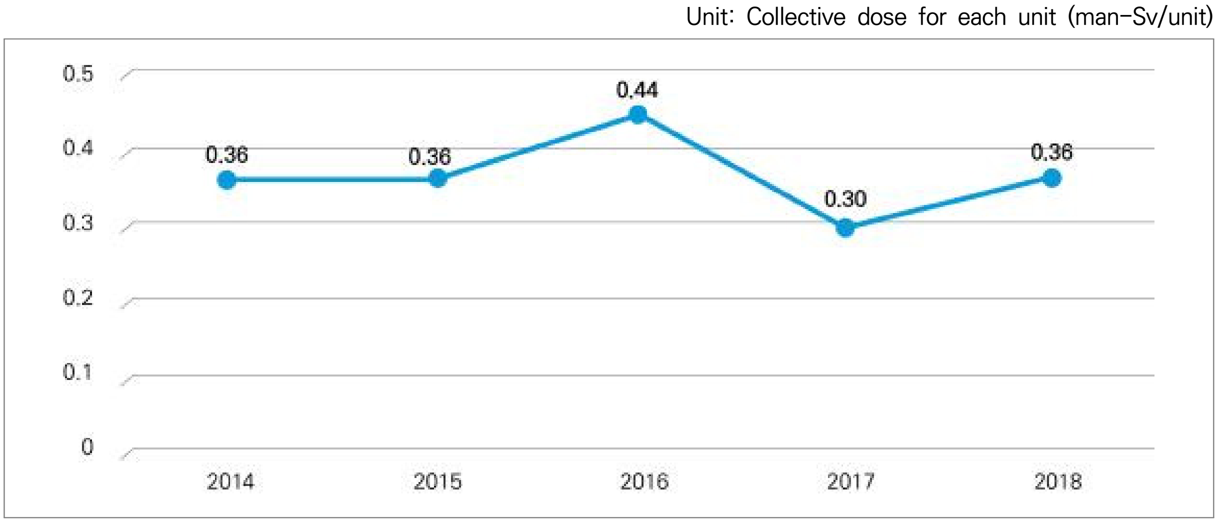
〈Read and Verification on TLDs〉

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.

| Figure 15-1 | Average Dose of Radiation Workers in Nuclear Installations

Unit: Collective dose for each unit (man-Sv/unit)



〈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.

(2) Discharge of Radioactive 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

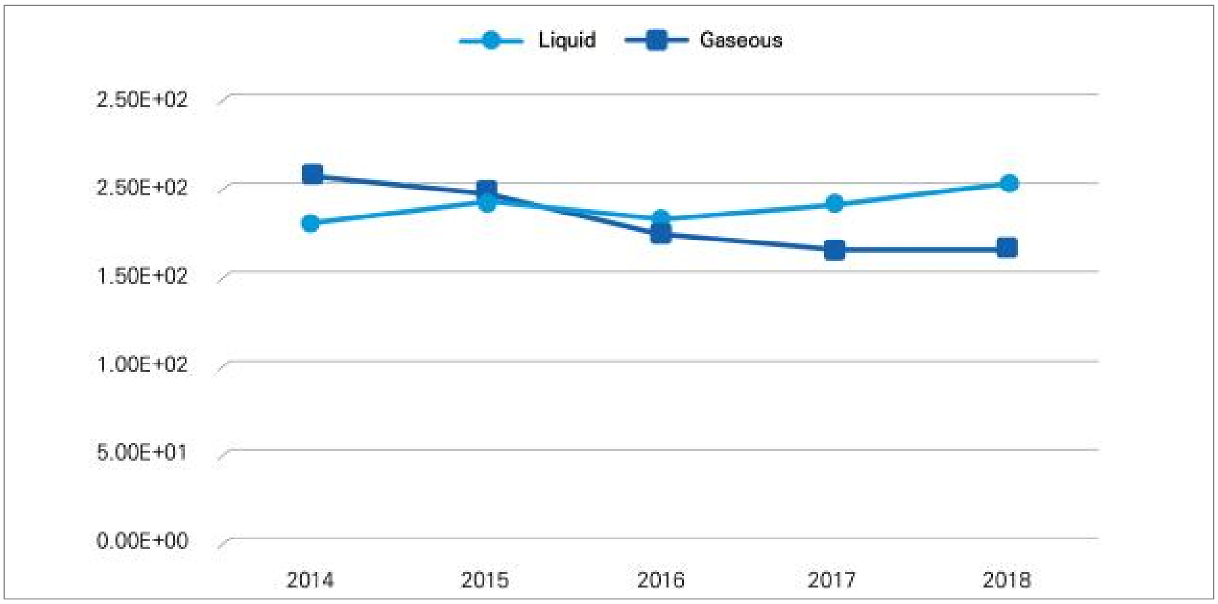
- thyroidal equivalent dose : 0.75 mSv/yr

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 Figure 15-2.

| Figure 15-2 | Trend of Annual Release of Liquid and Gaseous Effluents per Site and Off-site Dose

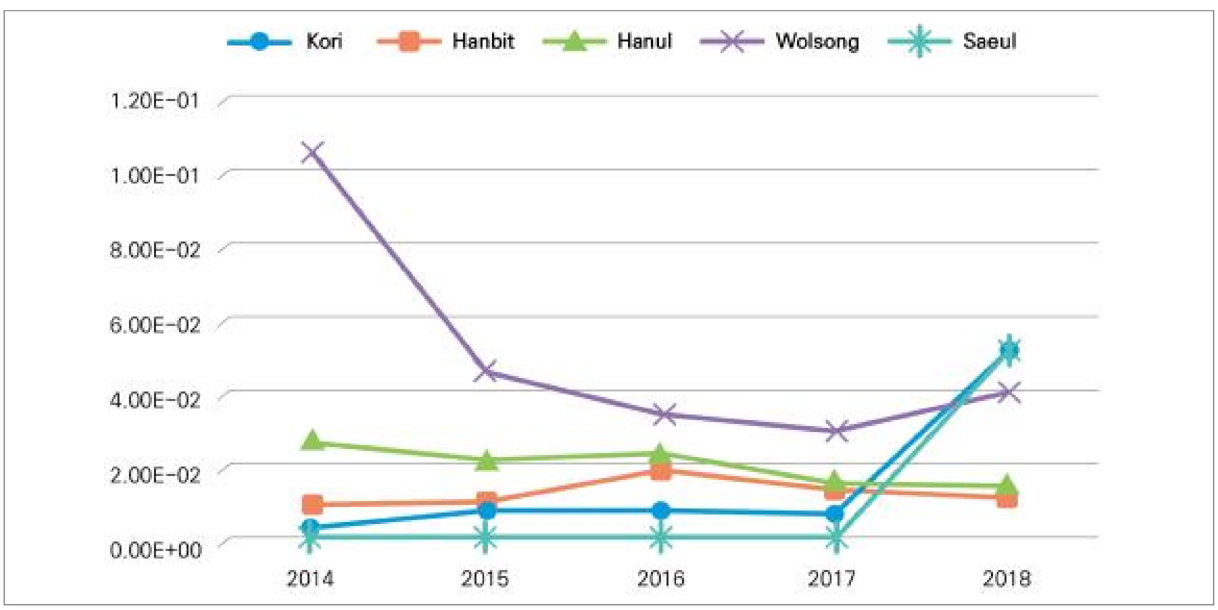
〈Liquid and Gaseous Effluents (Total)〉

Unit : TBq



〈Doses of the Population nearby NPP Site〉

Unit: mSv



* The Saeul site started its measurement from March, 2018 in a integrated measuring with Kori site.

〈An 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 radioactivities by type, atmospheric conditions, human body metabolism, as well as the daily usage data such as the amount of agricultural, livestock and maritime products intakes in the local community within the radius of 80km. The KHNP reports the assessment results to the NSSC in conformity with the NSSC Notice (Regulation on Survey of Environmental Radiation and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities).

The NSSC reviews the reports on survey of environmental radiation 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.

From 1991 to 2001, under the government's leadership, Seoul University Medical Research Institute performed epidemiological study on surroundings of NPP sites. As a part of comprehensive measure to strengthen the nuclear safety standards in 2018, NSSC is planning to conduct a assessment of health effect from radiation exposure for the population living nearby NPP sites.

15.1.3 Regulatory Control Activity

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. Development of technical standard is made by referencing the domestic and overseas research and relevant technical standards overseas.

15.2 Recent Activities and Improvements

15.2.1 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 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 dose of radiation workers and SMS alarm service to those workers whose does from radiation exposure are reaching to the dose limits. In addition, the operation of KISOE was transferred to KoFons from KINS on December 31, 2018 to have a more close interface in securing the safety management on radiation workers.

15.2.2 Submission and Review on the Discharge Plan

In December, 2015, Government was determined to manage the discharge of liquid and gaseous radioactive materials from nuclear reactor and relevant facilities and revised the NSA (legalization no. 13545) to have applicant for OL to submit discharge plan and be authorized from regulatory body and started its implementation in December, 2016. Accordingly, for new OL review, discharge paln is submitted and reviewed and the discharge plan for operating NPPs were also submitted and under review process.

The discharge plan should include total discharge amount by nucleid group for period and the licensee is required to operate the NPPs in a way not to exceed the target described in its discharge plan. The plan should describe 1. overview, 2 treatment and monitoring facilities for liquid and gaseous radioactive materials, 3. sampling and analysis for liquid and gaseous radioactive materials, 4. setting the discharge limit for liquid and gaseous radioactive materials, and 5. discharge limit calculation and discharge plan. Following the revision of the law, it is expected that the control on liquid and gaseous radioactive materials will be strengthened.

15.2.3 Submission and Approval of Decommissioning Plan

In January, 2015, the government announced the revised NSA that reflected the decommissioning safety regulation framework. This is to change the safety regulation framework in a way to consider the decommissioning of the nuclear installation from its design phase to establish the regulation on the phases such as permanent shutdown, transition, decommissioning, and end of OL. In the process, it set up the regulations on the responsibility of licensee and inspection of the regulatory body that need to be performed during the decommissioning phase

The revised NSA defines decommissioning as entire activities that take place, after permanent shutdown of an NPP, including dismantling of the facility and removal of radioactive contamination from the site in order to make the nuclear installation no longer subject to the application of the NSA. In accordance with the Enforcement of NSA and NSSC Notice 2018-10 (Standard Format and Content of Decommissioning Plan for Nuclear Facilities) the decommissioning plan needs to describe strategy, schedule, measures to protect itself from radiation hazards, decontamination methods, etc. in a detailed manner. The licensee is required to submit the initial decommissioning plan as an appendix of the application forms of CP and OL and get the approval from the NSSC through review and renew its approval every 10 years. In order to start the decommissioning, the licensee is required to apply a decommissioning approval from the regulatory body within five years from the day it acquires the approval for permanent operation, for which it should submit the final decommissioning plan in its decommissioning approval request.

NSSC Notice 2018-10 (Standard Format and Content of Decommissioning Plan for Nuclear Facilities) describes the general requirements, composition, and how to write the plan when drawing up the initial decommissioning plan during the construction and operation phase and when applying for decommissioning approval.

Main items for initial decommissioning plan are as follows:

- Overview of plan
- Project management
- Description of the Site and environment
- Decommissioning Strategy and methodology
- Design characteristics and measures for decommissioning facilitation
- Safety assessment
- Radiation protection
- Radioactive waste management
- Environmental Impact Assessment
- Fire protection

· 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.

16.1 Contents of Implementation

16.1.1 Relevant Regulatory Requirements

Radiological emergency preparedness is based on the Act on Physical Protection and Radiological Emergency (APPRE), which stipulates the system of managing radiological emergency, as well as Framework Act on Civil Defense and Framework Act on the Management of Disasters and Safety, 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 Preparedness Plan every five years, which is interlinked with Basic Plan for National Safety Management established based on the Framework Act on the Management of Disasters and Safety. Each year, the NSSC prepares a National Implementation Plan for Preventing Radioactive Disasters, which is an yearly implementation plan for Five year based National Radiological Emergency Preparedness Plan. Local governments with relevant jurisdiction establishes and implements Regional Radioactive Disaster Prevention Plan every year in accordance with National Radiation Disaster Prevention Plan and National Radiological Emergency Preparedness Plan. The nuclear licensee shall formulate a radiation emergency plan and obtain approval therefor from the NSSC before using the nuclear facilities.

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 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 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 2017-53 (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.

The NSSC revised the APPRE in June, 2018 in order to establish and operate a radiological impact assessment information system when a radiological disaster occurs. The revised APPRE stipulates that KINS is responsible for collection, analysis, and management of meteorological, socio-geographic, and nuclear power installation status information as well as environmental radiation monitoring and radiological analysis results.

In order to make sure the emergency response capability of the licensee, government, and local authorities in case of a radiological emergency, Radiological emergency preparedness training is carried out every year in accordance with the National Implementation Plan for Preventing Radioactive Disaster based on National Radiation Disaster Prevention Plan. This training, planned as described in the National Implementation Plan for Preventing Radioactive Disaster, aims to confirm the radiological disaster management process and to evaluate categorization and response to emergency, population protection measures, securing and availability of disaster prevention facility and equipment, and education and training.

- Classification of Emergency Situation

Radiological emergencies at a nuclear installation site are classified into facility emergency, site area emergency, and general emergency according to the severity of accident. Emergency can be declared based on the state of nuclear power installation, parameters, and on and off-site radiation level.

- Facility Emergency: Accidents that cause or can cause damage on sealing states of radiactive materials or on power supply function to maintain the safety of the nuclear power installation. It is expected that release of the radioactive materials and its radiation impact can be contained inside of the nuclear power installation.
- Site Area Emergency : When an accident that caused Facility Emergency is progressed to an extent that main safety functions are or can be damaged due to the degradation in the safety recovery function. It is expected that the release of the radioactive materials and its radiation impact can be contained inside of the nuclear power plant site.
- 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 site of a nuclear facility.

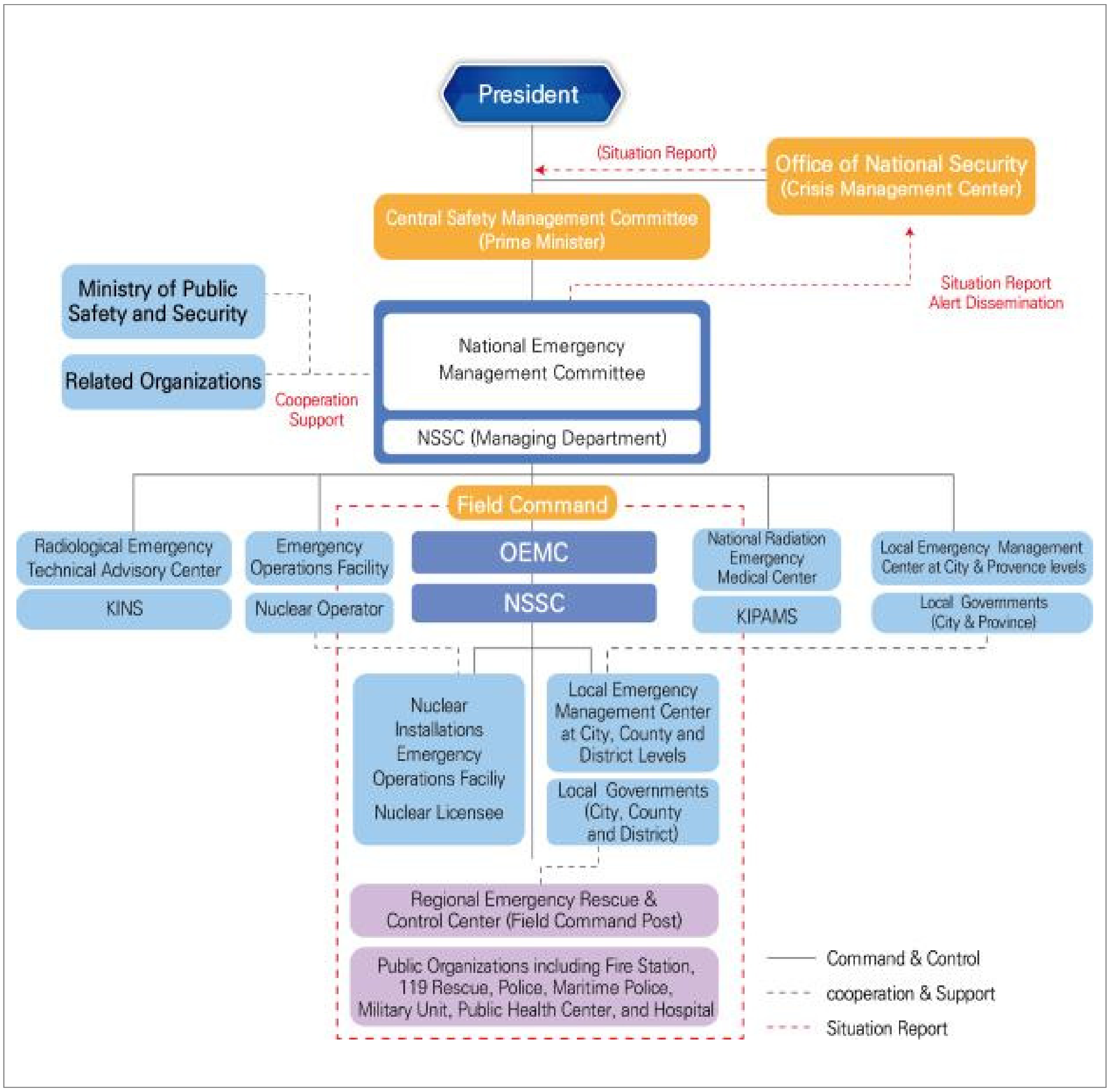
It is stipulated in the APPRE that, in case of radiological emergency subject to Facility Emergency/ Site Area Emergency/ General Emergency in nuclear installations, the operator shall report the emergency situation to the NSSC and local governments, in accordance with the procedure defined in the Radiological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

It is stipulated in the APPRE that, in case of radiological emergency subject to Facility Emergency/ Site Area 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.

16.1.2 National Radiological Emergency Response Scheme

The radiological emergency response scheme is composed of National Emergency Management Committee (NEMC) 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 Korea Institute of Nuclear Safety (KINS), Radiological Emergency Medical Service Center of Korea Institute of Radiological and Medical Sciences (KIRAMS), and Emergency Operations Facility (EOF) of the nuclear licensee as shown in Figure 16-1.

| Figure 16-1 | National Radiological Emergency Preparedness Scheme



The NSSC has the responsibility to control and coordinate the countermeasures against radiological disaster. When a radiological emergency occurs (site area emergency or above), the NSSC operates National Emergency Management Committee in which 19 central government departments 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 Off-site Emergency Management Center Advisory Committee (OEMCAC) 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.

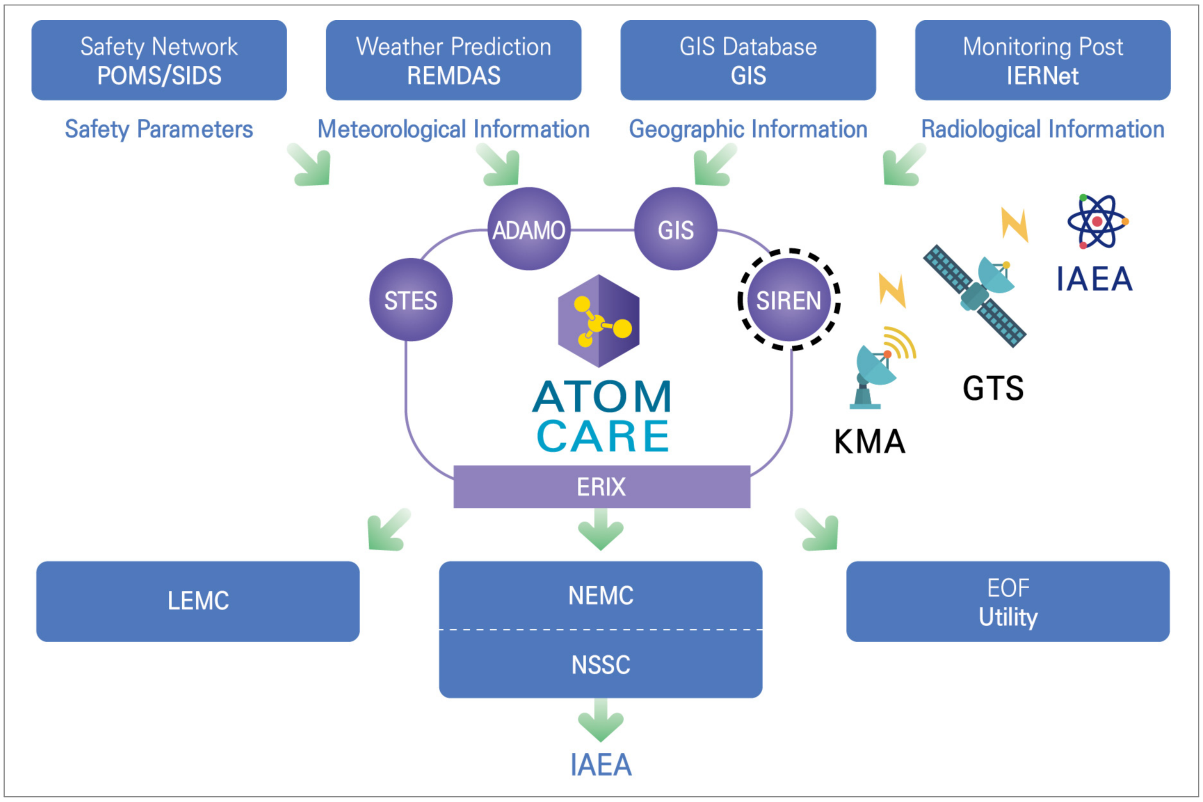
The LEMC, established by the local governments concerned, implements the OEMC's decision on protective measures for residents. It also takes charge of coordination and control of emergency relief activities utilizing local fire stations, police stations and military units.

When an accident occurs, the KHNP, the licensee of nuclear installation, is responsible for organizing an Emergency Operation Facility and for taking measures to mitigate the consequences of the accident, to restore installations, and to protect the on-site personnel.

KINS organizes Radiological Emergency Technical Advisory Center (RETAC), 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 171 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 under operation to provide various technical supports effectively for the public and environment protection in radiological emergencies. The AtomCARE enables the rapid analysis, assessment of radiological impact of emergencies and the comprehensive management of information to protect the public. Its configuration is represented in Figure 16-2.

✔ AtomCARE operated by KINS receives information about NPPs operation status, weather, social geography, environmental radiation monitoring and radiological analysis results in accordance with APPRE in its 3rd paragraph (newly added in December, 2017) of Article 32 as well as Article 17.2 (newly added in June, 2018) of the Enforcement Regulation of APPRE. First, in its information collection stage, it gathers information such as the 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). Social geography information is not a network; rather it is established in a form of database on population and medical relief station of the administrative district managed by the local government near the NPP sites. In the analysis stage during a radiological disaster, Source Term Evaluation System (STES) is used to evaluate the source term by calculating the core damage level, discharge path and discharge amount. Accident Dose Assessment Modeling system evaluates the possible impact of radiation exposure in case of an accident in an NPP located domestically(100m, 1km resolution) and overseas (25km resolution) by utilizing the source term information from STES and weather information of REMDAS. In case of an accident that takes place overseas, a multi-model ensemble prediction system is established in order to prepare for a worse case scenario. Geographic Information System (GIS) displays the weather information, evaluation result on anticipated exposure dose, and environmental radiation information together with the residents evacuation status by administrative district and radiological protection facilities. Such information is provided to relevant emergency response agencies to support decision making on resident protection in an effective manner.

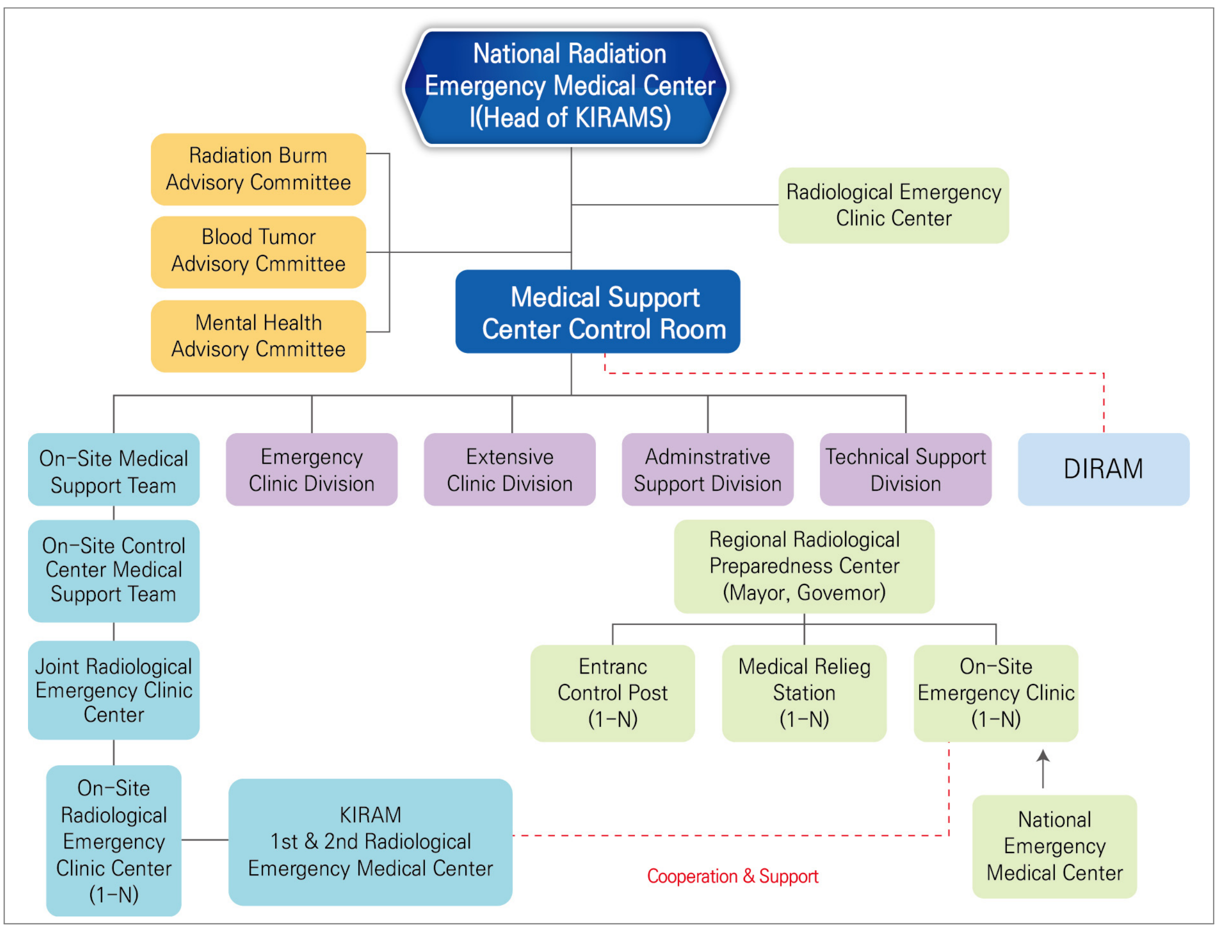
| Figure 16-2 | AtomCARE(Atomic Computerized Technical Advisory System for a Radiological Emergency) operation system



- POMS : Plant Operation Monitoring System
- SIDS : Safety Information Display System
- REMDAS : Radiological Emergency Management Data Acquisition System
- IERNet : Integrated Environmental Radiation Network
- STES : Source Term Evaluation System
- ADAMO : Accident Dose Assessment Modeling system
- GIS : Geographic Information System
- ERIX : Emergency Response Information eXchange system
- KMA : Korea Meteorological Administration
- LEMC : Local Emergency Management Center
- NEMC : National Emergency Management Committee
- NSSC : Nuclear Safety and Security Commission

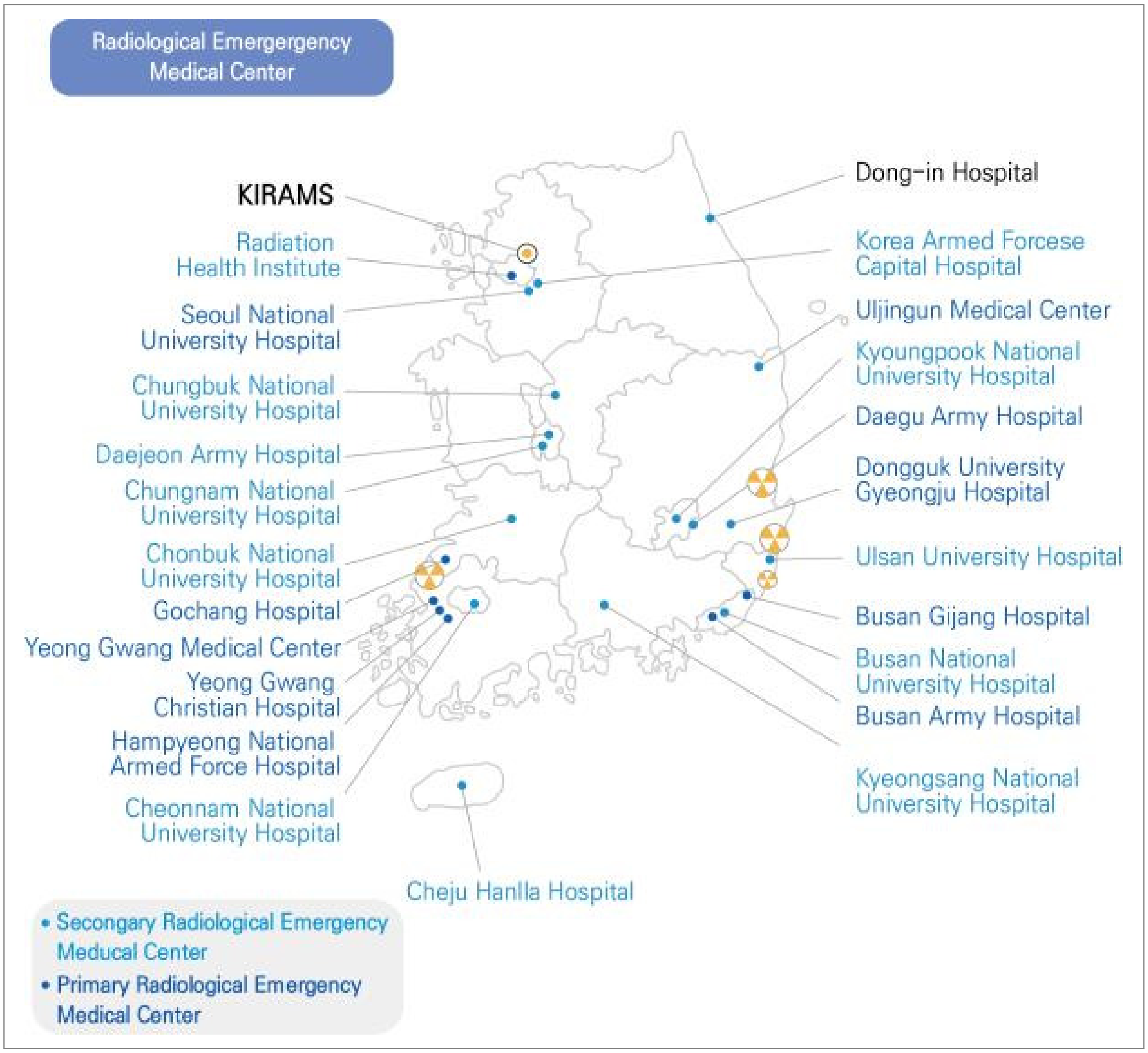
KIRAMS establishes National Radiation Emergency Medical Center in case of radiological disaster to take an overall management in radiation emergency medical activities including advice on medical relief, technical support and medical treatment on those who have radiation damage or are likely to have radiation damage as illustrated in Figure 16-3. 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 16-3 | Radiation Emergency Medical Response Framework



The government designated primary and secondary radiation emergency treatment center nationwide together with the KIRANS National Radiation Emergency Treatment Center.

| Figure 16-4 | List of Radiological Emergency Medical Centers



16.1.3 Implementation of Emergency Preparedness and Response Actions

(1) Public Protective Actions

In order to carry out public protective measures effectively, Emergency Planning Zone (EPZ) was expanded from 8-10 km to 20-30 km and further divided into Precautionary Action Zone (PAZ) and Urgent Protective action planning Zone (UPZ). As a result, the public in PAZ can be provided with prompt and effective protective measures in case of radiological emergencies and release from facilities. Local government designates public buildings in various regions as evacuation centers in advance, considering estimated population, time, and distance for evacuation of the public in EPZ. 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.

(2) Measures to 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.

(3) Securing Emergency Facilities, Equipment, and Procurement

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

(4) Training

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 24 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.

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 a years according to emergency preparedness training plan schedule;

- integrated emergency exercises, in which all on-site and off-site emergency organizations of licensee(commercial and research reactor) shall participate, are held at the nuclear installation site once every two 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 for each emergency organization; and
  - for newly constructed nuclear installations, an on-site emergency exercise is held to demonstrate the ability of emergency response before the rated thermal output reaches 5%. Provided, integrated emergency exercise is carried out for those nuclear power installations constructed in a new site.

16.1.4 Environmental Radiation Monitoring

The environmental radiation detectors are installed at about 12 to 24 stations within a 30 km radius of nuclear facility depended on topography, population density, and atmospheric dispersion factors, and continuously monitor the gamma dose rate at 1 meter height aove the ground. The dose rate of each detector and operational status are shown at main control room (MCR) and environmental laboratory by CDMA based wireless data communication. In addition, thermoluminescence dosimeters (TLD) are installed at 26 to 41 radiation monitoring posts located within a 30 km area of each NPP site to measure and assess quarterly based accumulated dose. For the assessment of the radiological impact to the environment from the operating nuclear facility, environmental samples are collected within 30 km radius of NPPs facility depended on the distance and directions from the nuclear facility with due consideration of meteorological data, geographical characteristics and atmospheric dispersion evaluation result of the area. The samples are airborne dust, land samples (soil, pine needles), water samples (seawater, underground water, precipitation), marine samples (sediment, benthos), and food samples (milk, fishes and shellfish, grain, meat, seaweed).

| Table 16-1 | Environmental Radiation Monitoring in the Vicinity of NPPs

Items				Frequency	
Sample	Media		Monitoring Item	Sampling	Analysis
Air	Air dose rate		Gamma ray dose rate (ERMS)	Continuous	Monthly
			Gamma ray dose rate (TLD)	Continuous	Quarterly
Land	Air	Dust	Gross β	Continuous	Weekly
		Particles, Gas	^{131}I		Weekly
		Dust	γ radionuclides		Monthly
		CO2	14C		Monthly
		Moisture	^{3}H		Semimonthly
	Drinking Water		^{3}H	Quarterly	Quarterly
			γ radionuclides		
	Ground water		^{3}H	Quarterly	Quarterly
			γ radionuclides		
	Surface Water		^{3}H	Monthly	Monthly
			γ radionuclides		
	Rainfall		Gross β	Monthly	Monthly
			^{3}H		
			γ radionuclides		
	River Sediments		γ radionuclides	Quarterly	Quarterly
	Soil		γ radionuclides	Semi-annual	Semi-annual
			^{90}Sr		
	Milk		γ radionuclides	Monthly	Monthly
			^{90}Sr	Monthly	Quarterly
			^{14}C		
			^{3}H		
	Farm Products		γ radionuclides	Monthly	Quarterly
			^{90}Sr		
			^{14}C		
			^{3}H		
	Surface Organism		γ radionuclides	The harvesting season	Once or twice a year
			^{90}Sr		
	Meat		γ radionuclides	Semi-annual	Semi-annual
			^{14}C		
			^{3}H		

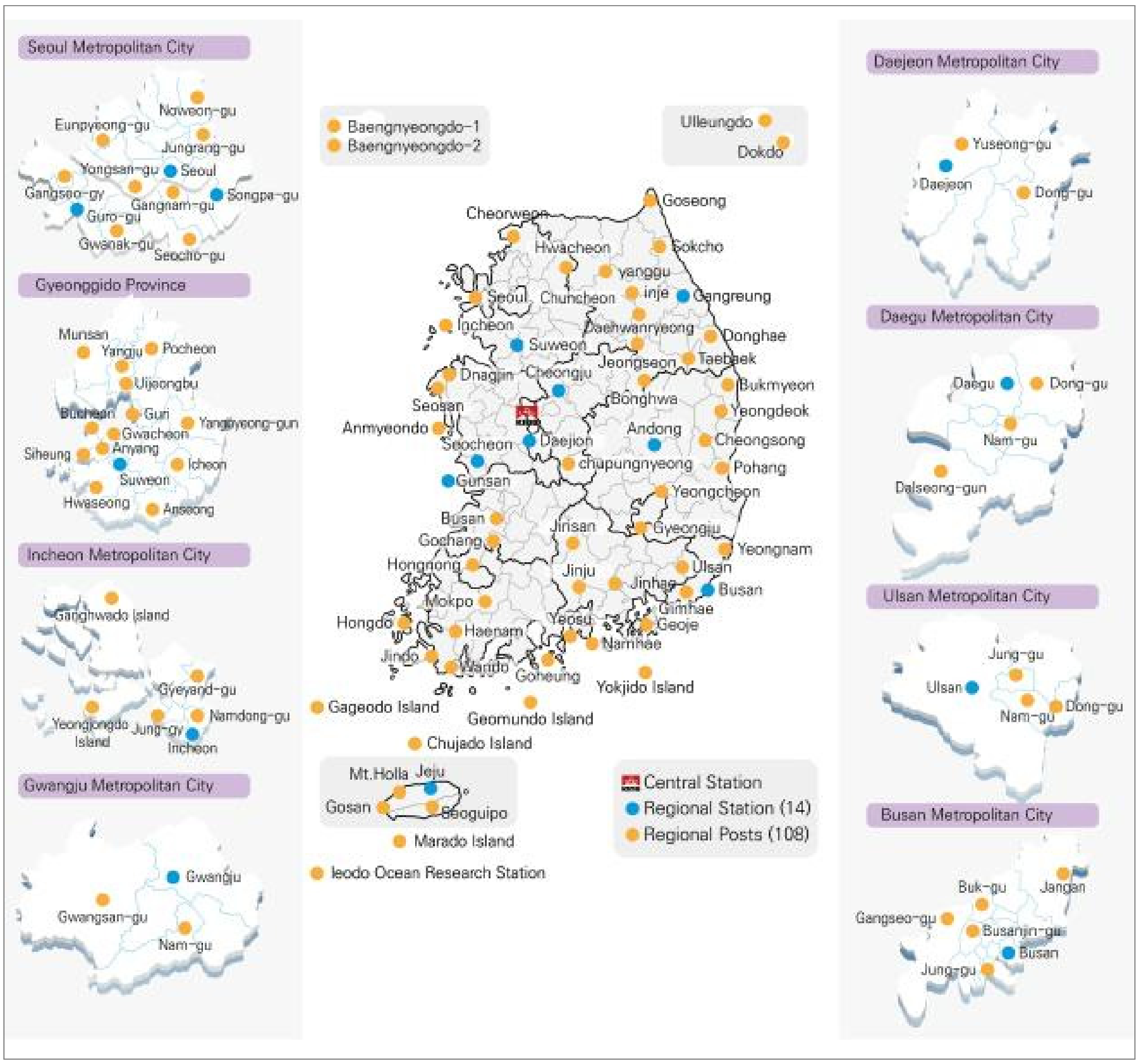
KINS performs a radiological environmental monitoring independently for quality management and confirmation of nuclear power plant operator's (KHNP) environmental monitoring results. The details of monitoring scheme including sample matrices, analyte, frequency are shown in the Table. 16-2.

| Table 16-2 | Environmental Radiation Monitoring in the Vicinity of NPPs by KINS

Sample			Item	Frequency
Radiation Monitoring	Gamma ray dose rate (ERMS)		Gamma ray dose rate (ERMS)	Continuos
	Gamma ray dose rate (TLD)		Gamma ray dose rate (TLD)	Quarterly
Radiation Analysis	Environment	Soil	γ radionuclides, ^{90}Sr, $^{239+240}$Pu, ^{240}Pu/^{239}Pu atomic percent, U radionuclides	Semi-annual Semi-annual Annual
		Marine sediments River sediments	γ radionuclides, ^{90}Sr, $^{239+240}$Pu, ^{240}Pu/^{239}Pu atomic percent, U radionuclides	Semi-annual Annual Annual
		Air	^{3}H, ^{14}C	Monthly
		Pine needles	^{3}H, ^{14}C	Monthly
	Water	Seawater	γ radionuclides, ^{3}H, ^{90}Sr, $^{239+240}$Pu, ^{240}Pu/^{239}Pu 원자비	Quarterly Semi-annual
		Ground water	γ radionuclides, ^{3}H ^{99}Tc, U radionuclides, ^{90}Sr, $^{239+240}$Pu, ^{240}Pu/^{239}Pu atomic percent	Semi-annual
		Surface water	γ radionuclides	Quarterly
		Rainfall	γ radionuclides ^{3}H	Monthly
	Food	Milk	γ radionuclides ^{90}Sr ^{3}H, ^{14}C	Quarterly Monthly Semi-annual Monthly
		Cabbage	γ radionuclides	Annual
		Rice	γ radionuclides	Annual
	Sea	Fish	γ radionuclides	Semi-annual
		Seaweeds	γ radionuclides	Semi-annual

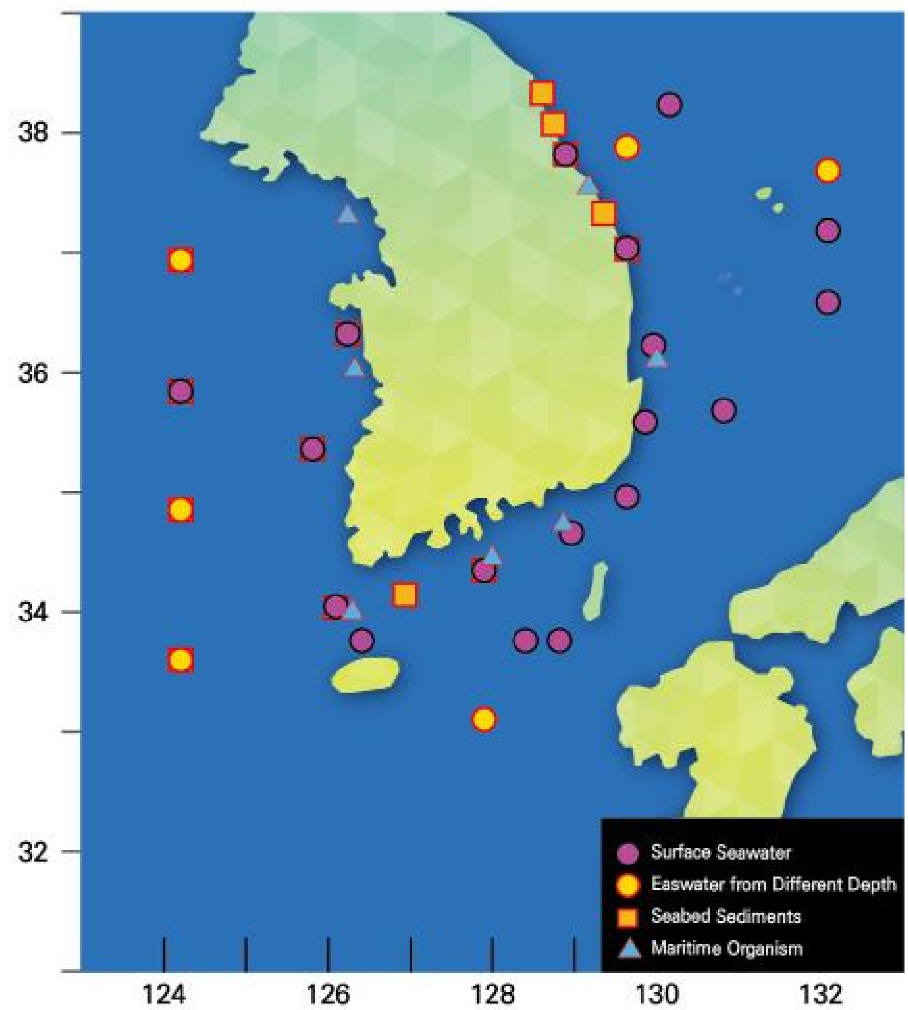
KINS is continuously monitoring nationwide environmental radioactivity and gamma dose rates and also it monitors routinely the radioactivity contamination of airborne dust, fallouts, precipitation, farm products, soil, tap water and milk for early detection and response to the radiation emergency. KINS has also been operating Intergrated Environmental Radiation Monitoring Network system (IERNet) since 1997. A total of 171 radiation monitoring posts are installed and interconnected to the central monitoring station at KINS by CDMA based wireless data communication (Figure 16-5). KINS provides annual training course to enhance the radioanalytical capability of regional radioactivity monitoring stations and organised its proficiency test and participate to the IAEA proficiency test for the quality management of environmental monitoring results.

| Figure 16-5 | National Environmental Radiation Monitoring Network



After Fukushima accident, KINS extended the marine radioactivty monitoring program in Korea. 137Cs, 3H, 90Sr, and 239+240Pu activity concentrations are analysed in surface seawater collected at 32 sample stations and marine organisms (fish, shellfish, seaweeds) and sediment to assess any radiological impact to marine environment (Figure 16-6).

| Figure 16-6 | Sampling Location for Marine Radioactivity Monitoring



16.1.5 International Cooperation on EPR

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." In additon, since 2017, Republic of Korea has participated in the ConvEx Training with NSSC, KINS, and KIRAMS in accordance with Convention on Early Notification of a Nuclear Accident of IAEA.

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. 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.

Meanwhile, Korea, China, and Japan signed the Memorandum of Cooperation (MOC) on Top Regulatory Meeting(TRM) in August, 2009 in order to enhance the regional nuclear safety capability in Northeast Asia, through which a trilateral framework for information exchange on nuclear accident has been established and ways for mutual cooperation have been continuously discussed. Korea has been the chair nation of the Working Group Emergency Preparedness & Response (WGEPR) for three years since 2016 and has taken a leading role in establishing a cooperation system for emergency response information exchange when an accident takes place in a neighboring nation. To this end, three nations discussed ways to share regulatory experience on radiological preparedness, real-time environmental radiation information, and emergency contact as well as reached agreements on a procedure to share emergency information and ways to conduct a joint emergency preparedness training. TRM joint radiological preparedness training has been annually conducted since its first training in November, 2014 at Kori NPP site of Korea (Ikata NPP of Japan in 2015, Daya Bay NPP of China in 2016, Hanul NPP of Korea in 2017, and Nuclear Regulation Authority/Shimane NPP of Japan in 2018). In its 11th TRM in 2018, Korea, Japan, and China discussed to set up TRM-MEIS-2018 to ensure more swift and accurate information exchange in case of an emergency

16.2 Recent Activities and Improvements

16.2.1 Post-Fukushima Response (Common Issue 8)

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.

NSSC, KINS, as well as KHNP, which is the operator of nuclear power plants, the research reactor, and KIRAMS which is the emergency medical institution and the nuclear cycle facility operator have implemented the detailed action plans established after Fukushima Daiichi Accident as the table below(Table 16-3).

| Table 16-3 | Actions for Improvement in main emergency response areas after Fukushima Daiichi Accident

Item	Main Content
Environment Monitoring	The number of regional radioactive monitoring station was expanded from 12 to 15, and Integrated Environmental Radiation Monitoring Networks (IER-Net) from 71 to 171 so as to strengthen the capability for early detection of radiation (radioactivity) abnormalcy following nuclear accidents at home and abroad.
Reforming EPZ	To comply with IAEA standards, 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, based on which the licensee already completed revising its radiation emergency plan.
Revising radiation emergency plan including the multi-unit emergency alert	Completed the reflection of radiation emergency composition plan on the emergency plan in preparation for multi-unit emergency alerts (December, 2011)
Securing additional equipment to prepare for a prolonged emergency	For emergency response to the prolonged emergency situation, radiation instruments and radiation protection items were secured 200% of what is was in the past
Increasing the equipment of emergency medical treatment institutions	To effectively respond to a sudden increase in patients due to a radiological disaster, medical institutes designated to provide radiological emergency medical service are provided with medical equipment, facilities, and products in a continuous manner.
Reinforcing radiation emergency drill	KHNP conduct a blind drill for radiation emergency at each NPP site once a year. A blind drill refers to a drill in which personnel participating in the exercise must not be advised in advance, of the exact date, time and scenario of the exercise. Training scenario for eatrhquake, and tsunami to apply in government-led national radiation preparedness joint training.
Devising a means for securing necessary information in case of a prolonged loss of electrical power	KHNP completed the additional deployment of mobile generator equipment in 2015 in order to ensure stable power supply to main computer in NPPs, thereby securing essential information in the emergency response facilities during the prolonged loss of power event. In addition, mobile environmental radiation monitoring equipment was introduced to monitor envionmental radiation, if necessary.

Item	Main Content
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.
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.
Amending the information disclosure procedure in the event of a radiological emergency	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	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 alarm 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., Emergency power and wireless communications for emergency alarm system are secured to respond to loss of power caused by natural hazards such as earthquake and tsunami.
Improving a cooperation system withrelevant 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. Kori site and Busan City, and regional agencies made a “regional cooperation c agreement for nuclear safety and radiation preparedness (August, 2015) while Hanbit site did the same with its regional government and agencies to lay a foundation for human/resource/technical support in case of radioactive release accident

Item	Main Content
Operating an assessment program for public protective actions	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.
Securing an on-site emergency response center in an isolated building	To secure the on-site emergence response center in isolated building to make a comprehensive response to a multi-unit accident which is planned to be completed in 2022

· Article 17 · Siting

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

1. for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
2. for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
3. for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (1) and (2) so as to ensure the continued safety acceptability of the nuclear installation;
4. 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.

17.1 Contents of Implementation

17.1.1 Related Regulations

(1) Site Selection Procedure

The installer and operator of reactor facilities should perform the site characteristics investigations, under the provisions of the NSA and subsequent regulations, including the site suitability analysis and detailed investigations for the proposed site.

Afterwards, the installer and operator of reactor facilities is able to apply for an early site approval prior to a construction permit, and under Article 10 (Construction Permit) of the NSA, should submit to the NSSC an application together with a radiation environmental impact assessment report, a preliminary safety analysis report, and other documents as prescribed by the Ordinance of the Prime Minister. After review based on the results of safety review by KINS, the Commission may issue an early site approval and then the operator is able to execute construction to such extent as defined by the NSSC prior to issuance of CP. The installer and operator of reactor facilities who wishes to obtain an approval for a construction site shall file an application for the approval to the Commission, together with a radiation environmental impact assessment report, a preliminary safety analysis report, a construction quality assurance manual, a decommissioning plan for the nuclear power reactor and related facilities, and other documents as prescribed by the Ordinance of the Prime Minister.

(2) Regulatory Requirements of the Site of Nuclear Reactor Facilities

It is stipulated in Article 11 (Standards for Permit) and Article 21 (Standards for License) of the NSA that the site of a nuclear power reactor and related facilities shall conform to technical standards defined by the NSSC in such way that it does not present any impediment to the protection of people, properties and the environment from the radiation hazards. The regulatory requirements regarding the site of the reactor and related facilities under the NSA are defined in Article 4 to 10 of the Regulations on Technical Standards of Reactor Facilities, etc.

Pursuant to the Regulations, detailed regulatory requirements for each field are specified in the NSSC Notices as follows:

- Technical Standards for Locations of Nuclear Reactor Facilities: NSSC Notice No. 2017-15
- Technical Standards for Investigation and Evaluation of Meteorological Conditions of Nuclear Reactor Facility Sites: NSSC Notice No. 2017-26
- Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites: NSSC Notice No. 2017-27
- Regulation on Consultations due to Installation of Industrial Facilities, etc. around the Nuclear Facilities: NSSC Notice No. 2017-30
- Standard Format and Content of Radiation Environmental Impact Assessment Report for Nuclear Power Utilization Facilities: NSSC Notice No. 2017-16
- Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities: NSSC Notice No. 2017-17

17.1.2 Site Characterization and Radiation Environmental Impact Assessment

(1) Site Characterization

〈Geography and Population〉

The installer and operator of reactor facilities should conduct a survey and assessment regarding geographical and geomorphological conditions and current & future estimates of population distribution of a proposed site and nearby areas, and public facilities in the low population zone. The installer and operator of reactor facilities should also perform an analysis and assessment regarding the adequacy of distance of the exclusion area boundary, the low population zone, and distance to the population center from a proposed site and the feasibility to take adequate measures to protect and evacuate local residents in an emergency. In accordance with the NSA, the installer and operator of reactor facilities should establish an exclusion area within a specified radius from each reactor.

〈Nearby Industrial, Transportation and Military Facilities〉

When selecting a site, the installer and operator of reactor facilities should survey the distribution of industrial, transportation and military facilities around the site and their distance to the reactor facilities, and assess the probability of potential hazards that can occur at those facilities and their safe distance from the reactor facilities so that they should not affect the safety of the reactor facilities. The NSSC Notice No 2017-30 stipulates that the heads of administrative agencies concerned shall, at the time of permission, authorization and approval, consult with the NSSC for the facilities, which are deemed to cause a serious impact to the safety of a nuclear reactor and related facilities under construction or in operation.

〈Meteorology, Hydrology and Oceanography〉

The installer and operator of reactor facilities should investigate and assess regional climate conditions (typhoon, heavy snow, heavy rain, and tornado), local meteorological characteristics, on-site meteorological characteristics, and characteristics of dispersion of gaseous effluents in case of radioactive release, which are needed for the siting and safety design of the reactor facilities, in conformity with the NSSC Notice NO. 2017-26 and No. 2017-27. The operator should also establish and implement a site meteorological observation plan for safe operation of the facilities.

The flood history and the maximum flooding of streams and rivers should be investigated and based on the investigation results, an assessment should be conducted regarding any potential effect from different types of flood or local heavy rainfalls, and the possibility of any potential hazard that might affect safety-related structures of the reactor facilities due to destruction of a dam upstream or downstream near the site. In addition, the minimum sea water level should be assessed to check the capacity of cooling water supply including securing the ultimate heat sink, and reflected in the design.

〈Geology, Earthquake and Geotechnical Engineering〉

The installer and operator of reactor facilities should conduct an investigation and analysis of the area within a radius of 320km from a proposed site with regard to topography, geology, geological structure, stratigraphy, geological history, geo-tectonics and seismicity in conformity with the Regulation on Technical Standards of Reactor Facilities, etc. As for the area within a radius of 8km from a proposed site, a detailed investigation should be conducted. Through such investigations, the maximum ground motion estimated to occur at the reactor site should be analyzed and assessed, and the result should be conservatively incorporated into the design of the reactor facilities to ensure that the reactor facilities or safety related facilities are safe from the capable fault.

The installer and operator of reactor facilities should investigate whether any geological hazard, for example settlement or collapse, exists in the proposed site. The operator should also assess 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 materials under static and dynamic load conditions. If needed, the operator should reinforce the foundation to maintain its stability. Through a pro-operational inspection to be conducted after issuance of CP, KINS re-confirms the stability of the foundation of a reactor and safety-related structures, and finally confirms whether the areas including soft foundation that needs reinforcement work satisfy design criteria through such reinforcement work.

(2) Radiation Environmental Impact Assessment

When applying for a CP and an OL, the KHNP should conduct a radiation environmental impact assessment on a proposed site in accordance with the NSSC Notice No. 2017-16. The key areas of the assessment include data on use of the land within a radius of 80km of reactor facilities; use of the sea; and data sets which demonstrate site characteristics including meteorological data, atmospheric dispersion factors, oceanic conditions and dispersion factors, and population distribution. The operator should conduct the survey on aforementioned data sets as well as current status of environmental radiation and radioactivity in surrounding areas and submit the results. Moreover, the impact of radiation from NPP operation should be evaluated firstly by assessing the estimated source term release and based on which, worker exposure dose rate from construction and operation of an NPP. Also, if there already exist operating reactor facilities at the site, an environmental impact assessment on multiple reactor facilities should be conducted to confirm if the standards for protection against radiation (NSSC Notice No. 2017-36) are satisfied.

As part of application for a CP and an OL, the KHNP is required to submit an environmental impact monitoring plan for both before and during operation of reactor facilities as prescribed in the NSSC Notice No. 2017-16. The plan should be prepared in accordance with NSSC Notice No. 2017-17. KINS confirms if the environmental impact monitoring plan submitted by the operator satisfies the regulations.

The radiation environmental impact assessment report submitted when an application for a early site approval and a construction permit is filed should include opinions collected from local residents living in the proposed site (if needed by holding a public hearing). Accordingly, the radiation environmental impact assessment report for Shin-Hanul Units 3&4 contains opinions of residents collected in the process of applying for the construction permit therefor. The operator prepared and submitted a draft of the assessment report to the NSSC and local governments concerned to collect opinions from concerned parties. After announcement in the major news papers, a public inspection of the assessment report was conducted in the local governments concerned. Then to gather opinions from local residents, a public hearing on the assessment report was conducted again through the same process. Opinions collected from concerned parties and local residents were reviewed and incorporated into the radiation environmental impact assessment report by the applicant for the construction permit.

17.2 Recent Activities and Improvements

17.2.1 Re-assessment of site safety of new NPPs

On Sept. 12, 2016, an earthquake with a local magnitude of 5.8 occurred in Gyeongju (hereafter Gyeongju earthquake). The earthquake was the largest earthquake since the Korea Meteorological Administration started to observe instrumental earthquake on the Korean peninsular in 1978. A foreshock with a local magnitude of 5.1 occurred around 19:44, September 12, 2016 was followed by a main earthquake with a local magnitude of 5.8 around 20:32 on the same day. Additionally, an earthquake with a local magnitude of 5.4 occurred in Pohang on Nov. 15, 2017 (hereafter Pohang earthquake). This earthquake was the second largest earthquake after the Gyeongju earthquake. At the request of the NSSC, the KHNP conducted a seismic safety assessment of NPPs from March 2017 to May 2018 to review the safety of Shin-Kori Unit 4 as part of efforts to obtain the operating license.

The Gyeongju earthquake had no impact on the safety of NPPs at Kori site; however, with regard to the operating license of Shin-Kori Unit 4, it was necessary to conduct the seismic safety assessment to verify the conservatism of a design basis earthquake using information on recent earthquakes. The assessment was performed using a strong ground motion simulation program which was designed to generate ground accelerations and response spectrum with consideration of the shape of the fault. The adequacy of the program was verified by comparing the simulated foreshock and the main earthquake of the Gyeongju earthquake with on-site observation data. Under consulting with experts in Korea, data input to the program and maximum potential earthquake, etc. were determined and a logic tree was generated and the ground motion of the site was assessed for every possible case. Depending on a logic tree method, the PGA(Peak Ground Acceleration) calculated from the maximum potential earthquake was 0.06 g. Therefore, it was concluded that the safe shutdown earthquake of Shin-Kori Unit 4 (0.3g) was not affected by the calculated PGA and response spectrum.

The Pohang earthquake had no impact on NPPs at Kori site too; however, the same assessment was performed to verify the effect of the Pohang earthquake on the site safety of Shin-Kori Unit 2, using information on recent earthquakes. The PGA calculated using the same process as the Gyeongju earthquake was 0.026g, below 0.3g of the safe shutdown earthquake of Shin-Kori Unit 4.

As the largest earthquake after commencement of instrumental earthquake observation occurred in Korea which was known relatively safe from an earthquake and another large earthquake occurred again in Pohang, public concerns over earthquakes and the seismic safety of NPPs have grown remarkably. Especially as the earthquakes occurred from 29km (Gyeongju earthquake) and 45km (Pohang earthquake) away from the Wolsong site, it was necessary to conduct the assessment to ease public concerns over NPPs. At that point, the maximum potential earthquake from the seismic sources of the Gyeongju and Pohang earthquakes was generated and based on which, the safety of NPPs was assessed.

It was not easy to obtain information on the induced faults of the Gyeongju and Pohang earthquakes because they were caused by the underground faults. Nevertheless, geological and seismic experts in Korea identified the induced faults and the maximum potential earthquake for the assessment and opened it exactly to the public and assessed the seismic safety of NPPs using a scientific approach.

17.2.2 R&Ds for Assessment of Design Earthquake of Nuclear Power Plant Sites.

As mentioned earlier, the NSSC has been implementing a R&D project (titled "Seismic Source Characterization of Gyeongju Earthquake for Re-assessment of Design Earthquake of Nuclear Power Plant Sites") as part of efforts to improve the seismic safety of NPPs as the Gyeongju earthquake (local magnitude of 5.8) occurred on Sept. 12, 2016. The below-listed projects have been implemented by KINS to define the characteristics of the seismic source of the Gyeongju earthquake including the feasibility of design earthquake of Nuclear Power Plant Sites, and to review the calculation method of ground motion with an intention to develop technical standards on assessment of ground motion with consideration of the characteristics of the seismic source of the Gyeongju earthquake and on assessment of the geology, seismology and site safety of Nuclear Power Plant Sites.

- Analysis of national and international technical standards on the investigation and evaluation of geology, seismology and geotechnical engineering characteristics with regard to determination on design earthquake of Nuclear Power Plant Sites
- Analysis and establishment of database with the results of investigation of faults and seismological study performed for Nuclear Power Plant Sites nearby the seismic source of Gyeongju earthquake
- Development of technical standards on assessment of design basis through the seismic characterization of seismic source of Gyeongju earthquake and the review of the calculation method of maximum ground motion at Nuclear Power Plant Sites
- Development of technical standards on assessment of geology, seismology and site safety of Nuclear Power Plant Sites.

· Article 18. · Design and Construction

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

1. 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;
2. the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
3. 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.

18.1 Contents of Implementation

18.1.1 Related Regulations

The licensing procedure for the design and construction of reactor facilities is described in Section 7.1 of this report. The criteria for a CP of reactor facilities are specified in the NSA as follows:.

- technical capability necessary for construction of reactor facilities shall be secured;
- the location, structures, and components of reactor facilities shall conform to the technical standards provided in the NSSC Regulation in such 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 the environment due to radioactive materials which may accompany the construction of reactor facilities shall be satisfied;
- the Quality Assurance manual shall be in compliance with standards specified in the NSSC Regulation; and
- the decommissioning plan shall be in compliance with standards specified in the NSSC Regulation.

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

18.1.2 Implementation of Defense-in-depth

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

- securing sufficient design margins;
- securing independence, redundancy, and diversity;
- applying single failure criteria;
- multiple barrier concept;
- fail-safe concept;
- interlock concept; and
- in-service testability

Irrespective of a reactor type, systems, structures, and components (SSCs) of reactor facilities designed in consideration of the below internal and external events at the stage of siting, as specified in the nuclear related 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: Natural and artificial hazards caused by Earthquakes, floods, typhoons, inflammables, poisonous gas, and so on.

Reactor facilities are designed based on the defense-in-depth principle as a safety design concept against internal and external events as mentioned above. Its major contents for the defense-in-depth are as follows:

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

- Reactor facilities are designed so that even if any abnormal state occurs due to any failure 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 progressing into a severe accident.
- Reactor facilities are designed to have multiple barriers, such as the fuel pellet, the fuel clad, the reactor vessel, the reactor coolant pressure boundary, and the containment building so that the release of any radioactive materials into the environment is prevented.
- The NSA (revised in 2015) defines the accident management at NPPs including severe accident, stipulating that, even in the event of a multiple failure accident or an extreme hazard occurs, the integrity of the containment building should be maintained by preventing progression into a severe accident, and mitigating the consequences of a severe accident, based on the concept of defense in-depth. Accordingly, measures necessary for severe accident prevention and mitigation should be assessed, defined and provided for a NPP to be constructed.

18.1.3 Application of Proven Technologies

Under the basic principle that technologies incorporated into the design of reactor facilities should 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 reactor facilities under construction or in operation in Korea with technologies proven by operating experiences or qualified by testing or analysis inside or outside of the country.

New design features with enhanced safety have been adopted after verification of their performance for improved safety. For example, APR1400 under construction has adopted the design of direct vessel injection of emergency cooling water. The performance of the design has been already proven by verification tests conducted for several years at the Korea Atomic Energy Research Institute using the thermal hydraulic test facility. In addition, the passive auxiliary feedwater system has been tested to verify cooling performance of the components in the system by conducting the separate effect test on a small scale and a large scale integral effect 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.

18.1.4 Man-Machine Interface Design in Consideration of Human Factors

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

- On the basis of regulatory standards and guidances on human factors engineering applicable to the construction stage of a plant, human factors engineering is systematically implemented through a human factors engineering program review model(HFERPM) for each step of the design process which ranges from planning, analysis, designing to verification &and validation as defined in the safety analysis report. In addition, the design principles and standards of human factors engineering described in the FSAR are applied consistently even when the design of reactor facilities in operation is changed.
- 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 facilities. 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 arrangement, and layout of control board.

In particular, the APR-1400 NPP features an advanced control room with digital I&C systems based an integrated network to control and monitor nuclear power plant equipment through a state-of-the-art technology-based computer display. In addition, the display-based man-machine interface system such as large display panel, operator console, software controller and computerized procedure system provides continuously important information on safety and plant operation for operators to recognize plant conditions and conduct operation activities easily. As such, the requirements of human factors engineering was incorporated and considered from the early stage of design process.

- The man-machine interface system of the remote shutdown room is designed following human factors engineering guidelines just as same as the MCR to shut down a plant safely when the main control room becomes inhabitable.
- Any design change made to the MMIS of the MCR and the remote shutdown room of NPP

in operation is conducted after their compliance to the principle and guidances of human factors engineering is verified through a human factors engineering review. In addition, a review of the adequacy of changes in operator tasks is conducted to avoid human errors which may result from a design change. The adequacy review is also performed of plans for procedure revision and training to help operators respond to changed or newly added tasks.

18.1.5 Prevention and Mitigation of Accidents

(1) Design and Provisions for Accident Preventions

In order to prevent any accident from occurring at reactor facilities, the followings are reflected in the design.

- 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 operation of the reactor shutdown system and the engineered safety features. The reactor protection system is designed with redundancy, diversity, and independence 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.

(2) Design and Provisions for Accident Mitigation

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

In case of a core damage, emergency response personnel at the main control room (MCR) and the technical support center (TSC) of a NPP should carry out mitigation measures following the procedures defined in SAMGs in order to prevent an escalation of the accident. Emergency organizations are also arranged according to a radiation emergency plan. Such emergency organizations and mitigation strategies should be specifically incorporated into the accident management program submitted by June 2019. The accident management program should comprehensively describe considerations for accident mitigation such as accident management strategies, implementation system for accident management, severe accident prevention and mitigation, and accident impact assessment.

(3) Compliance of IAEA Standards for New NPPs

An accident management program should be submitted together with an application for OL of a new NPP. The plan should include the results of assessing the design and performance of systems and equipment necessary for prevention and mitigation of severe accident based on the defense in-depth principle specified by IAEA INSAG-10. Through the assessment on the capability of severe accident prevention, it should be verified that a NPP is provided with response means so that any significant damage to nuclear fuels can be avoided even in the event of a multi-failure accident and/or natural & artificial hazard which exceeds design basis. It should be also verified by an assessment on the capability of severe accident mitigation that a plant is provided with response means to protect the function of the containment building from different threats so that a large or early release of radioactive materials can be avoided. In addition, the plan should address the results of accident impact assessment to prove that radiation exposure to local residents in the boundary of a plant is kept below the limit during the phase of severe accident prevention and mitigation. By verifying that a new plant has a sufficient level of capability to prevent and mitigate a severe accident, it can be guaranteed that the goals presented in the Principle 1 of Vienna Declaration on Nuclear Safety can be achieved. Especially with regard to recently revised

IAEA SSR-2/1 (Rev.1), an assessment of a multiple failure accident and a natural hazard that exceeds design basis, systems for severe accident prevention & mitigation, and additional equipment for emergency power supply have been incorporated in the design of APR 1400, etc.

18.2 Recent Activities and Improvement and Recent Improvement

18.2.1 Post-Fukushima Measures

Six action items on severe accident identified by the safety inspection of Korean NPPs after the Fukushima accident in 2011 have been, in most cases, completed. Four action items including installation of containment filtered ventilation or depressurization system additionally identified in the 1st half of 2016 as well as eight long-term action items are under implementation with a target of completion by 2012.

- (2-2) Installation of water-proof doors and underwater drain pumps
- (3-8) Provision of anti-flooding measures for main steam safety valve rooms and emergency feedwater pump rooms
- (4-2) Installation of containment filtered vent or depressurization system
- (3-A1) Installation of safety class level, temperature & radiation instrumentation in the SFP
- (Add-1) Reinforcement of equipment against extreme hazards (Natural+Artificial Hazards)
- (Add-2) Operation of emergency response organizations to respond to and manage a severe accident
- (Add-3) Construction of emergency control center necessary to protect, command & control emergency response personnel

In addition, the followings were requested and reflected into the design to prevent any accident from occurring at the reactor facilities

- Establishment and implementation of procedure for managing and maintaining systematically equipment qualifications such as identification of list of equipment for seismic and environmental qualifications, documentation, database creation for all operating NPPs that perform a PSR.
- In order to address USNRC GSI regarding blockage on containment recirculation sump, a performance assessment of all NPPs was completed in accordance with regulatory requirements. Accordingly, advanced strainer and intercepter are planned to be installed for all NPPs by 2019 to secure emergency core cooling in the event of LOCA.

- Design modification of diverse protection systems of Shin-Hanul Units 1&2 in the process of OL reviewing to assure the implementation of protective functions against common mode failures of reactor protection system
- Reinforcement of the thickness of the wall structure of the reactor and auxiliary buildings of Shin-Kori Units 5&6, APR 1400 against intentional crash of a large commercial aircraft.
- Installation of AAC DG for each PWR plant to improve the capability to cope with SBO.
- Improved reliability of actuation of the pressurizer power operated relief valves through a design change to use the instrument air system commonly at both Kori Unit 1 and 2.
- Design changes of Wolsong Unit 1 such as sealing of the openings between fire areas and alarm to monitor turbine building flooding.
- Installation of a cross-tie between both trains of auxiliary feedwater system and duplication of power source to auxiliary feedwater control valves of Shin-Kori Units 1&2.
- Installation of PARs at all NPPs in operation and under construction in Mar. 2015.
- Shin-Kori 3&4 and Shin-Hanul 1&2 adopted independent 4-trains of safe shutdown systems, installation of In-vessel Refueling Water Storage Tank (IRWST), and increase capacity of Batteries for prevention of severe accident. Also they adopted Emergency Containment Spray Backup System (ECSBS) and Reactor Cavity Flooding System (RCFS) for mitigation of severe accident.

Besides, as a need to assess the safety of construction and operation of multi-units at one site has been raised after the Fukushima accident, the NSSC embarked on a 5-year project to develop a regulatory technology for multi-unit risk with participation of KINS, academia and researches, and also joined in the IAEA's international joint research.

18.2.2 Improvement in Interface between Safety and Security (Common Issue 10)

As part of effort to strengthen the interface between expert organizations for nuclear safety and security, the NSSC has held technical meeting between Korean Institute of Nuclear Safety (KINS) and Korea Institute of Nuclear Nonproliferation and Control (KINAC) on a quarterly basis since 2017 to proactively address vulnerabilities in the safety-security interface and to enable mutually compensatory regulations. Examples of projects jointly conducted by the two institutes are “Development of security, and review and inspection of operating environment of digital-based safety-class I&C system”, “Review and inspection of cyber security of critical digital assets related to safety, security and emergency response” under the Act on Physical Protection and Radiological Emergency, and “Review of impact on safety functions when cybersecurity requirements apply to safety-class I&C system." the overview of the technical meetings are shown in Table 18-1.

| Table 18-1 | Status of Technical Meeting on Safety-Security Interface

Date	Descriptions
Feb. 2, 2017	(Q1) Review of regulatory interface of cybersecurity of nuclear installations and discussion on collaboration on regulatory information of NPPs under construction
Apr. 21, 2017	(Q2) Discussion on communications between safety and non-safety systems and discussion on directions for review and inspection of nuclear installations
July 7, 2017	(Q3) Experience sharing regarding regulatory inspection of nuclear installations and review of safety-security interface for implementation of cybersecurity regulations
Oct. 24, 2017	(Q4) Review of safety-security interface issues for electromagnetic pulse (EMP) protection and implementation of special inspection of cybersecurity of nuclear installations.
Apr. 5, 2018	(Q1) Information sharing regarding KINAC review of cybersecurity regulations and KINS review of operating license of Shin-Hanul Units 1&2
July 5, 2018	(Q2) Information sharing regarding KINAC's plan to improve the efficiency of cybersecurity regulatory system and KINS' position on severe accident regulations
Sept. 11, 2018	(Q3) Information sharing regarding the technical research on EMP risk and cybersecurity issues related to Shin-Kori Unit 2 reactor trip
Dec. 4, 2018	(Q4) Information sharing regarding regulatory review issues of NPPs in operation and under construction and regulatory position on the application of wireless communication technology to safety systems
Mar. 6, 2019	(Q1) Information sharing regarding KINAC's findings related to cybersecurity and KINS review of SDOE of I&C system
May 29, 2019	(Q2) Information sharing regarding KINAC review of cybersecurity of Kijang research reactor and KINS review issues related to I&C system and discussion on a need for cooperation following design change

Besides, nuclear safety researches are planned to be conducted to establish a verification test system to assess the safety-security interface of digital I&C system, and to develop regulatory technologies for safety and security verification as part of efforts to be prepared against new types of cyber security threat raised with a rapid development of IT technologies.

· Article 19 · Operation

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

1. 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;
2. 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;
3. operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;
4. procedures are established for responding to anticipated operational occurrences and to accidents;
5. necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;
6. incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;
7. 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;
8. 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.

19.1 Contents of Implementation

19.1.1 Related Regulations

The licensing procedures for operating reactor facilities are referred to in Article 7 of this report.

The criteria for an OL for reactor facilities 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 standards, as prescribed by the Regulation of the NSSC, in such 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 due to radioactive materials which may accompany the operation of a nuclear power reactor and related facilities, according to the Presidential Decree; and
- the contents of a quality assurance manual, decommissioning plan, accident management program is to meet the criteria provided in the Regulation of the NSSC.

The technical standards entrusted by the NSA are defined in the Regulation on Technical Standards of Nuclear Reactor Facilities, etc. which are technical standards on operation; technical standards for structure, equipment and performance; and technical standards for the quality assurance manual. Regarding reactor operation, NSSC Notice No. 2017-5 (Standard Format and Content of Technical Specifications for Operation) describes in detail regulatory requirements of Technical Specifications for Operation.

In order to issue an OL, the NSSC reviews FSAR, Technical Specifications for Operation, Quality Assurance Manual, and Operational Technical Capability Specifications and conducts a Pre-Operational Inspection to confirm that requirements regarding the design, operational capability and safety of a NPP are all satisfied.

19.1.2 Safety Analysis and Commissioning Program for Authorization of Initial Operation of Nuclear Installations

In order to obtain initial authorization to operate reactor facilities, the operator should obtain a construction permit and an operating license from the regulatory body according to the licensing procedure provided in the NSA. Following this, the KHNP conducts comprehensive and systematic safety assessments of reactor facilities 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 the reactor facilities are constructed in conformity with the permit conditions. The SARs, the safety assessments for issuing a CP and an OL and the Pre-Operational Inspection are described in detail in Article 7 and 14 of this report.

The KHNP formulates and implements a commissioning program stepwise to verify that systems and components including the reactor coolant system can be operated as designed and meet safety requirements. 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.

19.1.3 Limiting Conditions for Operation

The NSA stipulates that the operator of reactor facilities shall submit a Technical Specifications for Operation as an attachment to the application for an OL, so as to define matters essential to safe operation of reactor facilities. In the specifications, limiting conditions for operation (LCO), set points, and surveillance requirements which are required for safety operation of reactor facilities are specified for each operation mode and for each system. The technical background for each LCO should be also included in this specification. The Standard Technical Specifications for Korean Standard Nuclear Plant type, Westinghouse type, and CANDU type reactors have been developed and applied in the applicable plants, and for Framatome type reactors is under regulatory review.

The contents of the Standard Technical Specifications for Operation are outlined in Table 19-1.

| Table 19-1 | Major Contents of Standard Technical Specification for Operation (Based on Korean Standard Nuclear Plant Reactor)

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

The safety limits and limiting conditions for operation are established with sufficient safety margins through the deterministic accident analysis of the above mentioned SAR.

19.1.4 Operation, Maintenance, Inspection and Testing Procedures

In accordance with the Regulation on Technical Standards of Nuclear Reactor Facilities, etc., the KHNP prescribes in the Technical Specifications for Operation that the written procedures listed below should be prepared, observed, managed and periodically reviewed, and conducts the operation, maintenance, inspection and testing of reactor facilities, based on related procedures.

- 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 reactor facilities are to be deliberated by the PNSC and implemented after obtaining approval from the plant manager. The FSAR prescribes that the same process shall apply in case that any change is to be made to the approved procedures. Latest procedures are accessible to all plant employees using an information management system.

19.1.5 Strategies and Procedures for Accident Response

〈Development of Procedures and Guidances to Prevent or Mitigate a Severe Accident (EOP, SAMG)〉

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 Guidances: accident management guide to link the Emergency Operating Procedure with the Emergency Plan

The KHNP establishes emergency operating procedures (EOPs) which are intended to provide actions necessary to prevent a core damage, mitigate an accident and put the plant back to a stable state when a reactor trip occurs or is required. EOPs are event- and symptom-based and are composed of as follows:

- Standard Post Trip Action (SPTA)
- Diagnostic Actions (DA)
- Optimal Recovery Guideline (ORG)
- Functional Recovery Guideline (FRG)

By working through EOPs when an accident occurs, a NPP is able to maintain or restore the safety functions of a reactor so as to avoid entry into a severe accident with core meltdown. In spite of that, a NPP establishes severe accident management guidances (SAMGs) from a perspective of in-depth defence. SAMGs are designed to maintain or restore the containment function of a containment building to keep radioactive materials being released offsite with an aim to protect the public, and the overview of SMAGs is shown in the below Table 19-2.

| Table 19-2 | Overview of SAMGs

ID	Title	Overview
Emergency-01	MCR Guideline	Provision of guidelines for MCR to implement strategies prior to launch of TSC
Control-01	Diagnostic flowchart	Provision of guidelines for TSC to conduct a diagnosis of plant conditions and implement strategies
Mitigation-01	Injection into Steam Generator	Heat removal of a reactor and prevention of SG tube creep rupture, etc.
Mitigation-02	Depressurization of RCS	Prevention of direct containment heating by high pressure melt injection, etc.
Mitigation-03	Injection into RCS	In-vessel core cooling
Mitigation-04	Injection into Containment	Reactor vessel cooling, minimization of radioactive materials on the containment atmosphere, etc.
Mitigation-05	Control of Fission Product Release	Reduction of risk of off-site exposure during an accident period
Mitigation-06	Control of Containment Conditions	Prevention of containment building damage by high containment temperature & pressure
Mitigation-07	Control of Containment Hydrogen	Prevention of hydrogen combustion inside the containment building
Termination-01	Termination of Severe Accident Management	Provision of guidelines for plant recovery actions after termination of severe accident management

〈Establishment of procedures and guidances to manage accident situations at multi-unit facilities or a multi-unit site (EOP, SAMG, ERP)〉

A NPP establishes coping equipment and operating procedures to avoid a severe accident with core meltdown when a multi-failure accident or extreme hazard that exceeds design basis occurs. Even if a severe accident occurs, a NPP, based on the in-depth defense principle, has also coping equipment and guidances to maintain or restore the containment function of the containment building so as to keep radioactive materials being released into the environment.

Once entering a severe accident, a NPP takes operator actions in accordance with SAMGs to maintain or restore the containment function from a threat like explosion of combustible gas.

In addition, the KHNP puts in place Multi-barrier Accident Scope STrategy (MACST) which is Korea's unique strategy to keep an accident from progressing sufficiently and safely even if an accident occurs simultaneously at multiple units in one site due to extreme hazards, as is the case with the Fukushima accident. MACST is designed to keep an accident from progressing and a reactor in a safe and stable state using mobile safety equipment even if fixed safety equipment of multiple units becomes unavailable due to extreme hazards. At normal times, mobile safety equipment for MACST is stored in an integrated storage building which is located safe from an accident in the plant such as flooding and fire. The KHNP develops MACST operating guidances (MOG) to maintain or restore the safety function of a plant using MACST equipment.

Pursuant to Act on Physical Protection and Radiological Emergency, the KHNP puts in place a radiological emergency plan for each site to protect the health of plant employee and local residents and to minimize property damage.

The radiological emergency plans describes matters regarding formation and operation of emergency response organisations, conditions for declaration of state of emergency, initial emergency response actions, response procedures for each emergency action level, accident assessment, report & information disclosure, protection of employees and the public, etc. necessary for accident management and prevention of accident escalation, when a radiological emergency accident occurs or is feared to occur. The formation and operation of emergency organizations against a multi-unit emergency is also included in the plan.

〈Status of Development of accident management program〉

In order to strengthen the safety management of severe accident after the Fukushima daiichi accident, the NSA was revised and announced in June 2014 and the nuclear operator is planned to submit an accident management program of each NPP to the regulatory body by June 2019.

- accident management program: a comprehensive plan describing a list of possible accidents including severe accident, accident coping equipment, the results of accident management capabilities including deterministic & probabilistic accident assessments, accident management strategies and implementation for earthquake & other extreme hazards and severe accident

19.1.6 Engineering and Technical Support

There are organizations that provide engineering and technical support to the KHNP 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 has internal technical support organizations and systems under their control. The Central Research Institute under the KHNP is responsible for the support of the construction and operation of the nuclear facilities, the study and analysis of nuclear technical information, the R&D for the management of radioactive wastes.

Under the contract of emergency recovery services with Westinghouse Electric Co., Siemens, GE 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.

19.1.7 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 there is any danger in reactor facilities or radioactive materials due to earthquakes, fire or other disasters,
- if any failure occurs in reactor facilities,
- if radiation hazards occur,
- if the radioactive material in transportation or packing leaks or is destroyed by a fire or any other incidents.

The NSSC Notice No. 2108-3 (Regulations on Reporting and Public Announcement of Accidents and Incidents for Nuclear Power Utilization Facilities) stipulates matters regarding the objects, methods, and procedures of the reporting and the classifications of the incident reporting system. If an incident or accident occurs, then the operator should report it to the NSSC within a specified time limit and post the related information on the internet. The NSSC dispatches a special inspection team composed of KINS experts to the plant if needed and requests the operator to take additional corrective actions to prevent recurrence, based on the inspection report.

The NSSC establishes and operates the "Nuclear Event Scale Evaluation Committee" to evaluate events which occurs at commercial or research reactors in a systematic manner. The scale of events is rated in accordance with INES(International Nuclear Event Scale). For three years from 2016 to 2018, a total of 32 events occurred at NPPs including a research reactor, and among which, four events were rated into Level 1 (Anomaly) and the rest of them into Level 0 (Deviation). Table 19-3 shows the INES levels of events for 10 years from 2009 to 2018.

| Table 19-3 | INES Levels of Events (2009-2018)

Scale \ Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Level 0	9	13	11	15	5	8	4	14	4	10	93
Level 1	1		2	1	4	4	1	2	1	1	17
Level 2 & above		1		1							2
Total	10	14	13	17	9	12	5	16	5	11	112

As part of efforts to ensure transparency to the public, KINS has developed a web-based system named Operational Performance Information System for Nuclear Power Plants (OPIS) for the purpose of information disclosure to the public. The system is designed to manage and publicize information on incidents and accidents in operating nuclear facilities, INES levels of events and safety performance indicators.

Every year, KINS has also publicized a report which compiled the results of investigation of reportable events and their INES levles of the previous year as part of the operating experience feedback system inside the regulatory body.

19.1.8 Collection, Analysis, and Exchange of Operating Experience

Domestic and foreign operating experiences related to safety, cases of accidents, and findings of safety-related researches are to be reflected in operation and construction of reactor facilities through the request 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 lessons-learned from the reactor vessel head degradation of Davis-Besse nuclear power plant, a loss of feedwater accident at Mihama nuclear power plants in Japan and a loss of off-site power at Forsmark nuclear power plant in Sweden, and the Fukushima Nuclear Power plant accident which have been ordered to be reflected in all domestic reactor facilities.

KINS has developed Nuclear Regulation Tracer (R-Tracer), a database of operating experiences for commercial reactor facilities to manage systematically information on accidents and incidents, implementation of corrective actions to prevent recurrence, entry into Technical Specifications and domestic & overseas OEs. The R-Tracer serves as a base means for operating experience feedback system of the regulatory body.

The NSSC and KINS, with participation of the KHNP, have held “The Workshop on the Operating Experiences Feedback” every year since 2003 to share and distribute domestic and foreign operating experiences.

The NSSC and KINS have also participated in operating experience feedback meetings hosted by international organizations such as IAEA IRS, and OECD/NEA WGOE, and intergovernmental meeting such as Joint Korea-China Committee to collect overseas operating experiences and share Korean operating experiences. The collected information is shared within the regulatory body and utilized for regulatory activities.

For efficient utilization and management of domestic and overseas operating experiences, the KHNP has developed and operated the Procedure for Utilization and Management of Domestic & Overseas Operating Experiences. Moreover, the operator established the KHNP

Nuclear Information System (KONIS) in 1999 to prepare, collect, distribute and utilize not only domestic but also overseas operating experiences via IAEA and WANO in a comprehensive manner. The effectiveness of the OE utilization & management system has been diagnosed and improved every two years, and OE Presentations have been held every year to promote utilization and exchange of domestic & overseas OEs.

In cases that it is found necessary to modify reactor facilities 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 operation of reactor facilities should 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 KHNP has joined the World Association of Nuclear Operators (WANO), PWR Owner's Group, Framatome Owner's Group, and CANDU Owner's Group to promote information exchange and cooperation among operators of reactor facilities. The operator has also actively participated in related workshops and seminars to exchange information and establish a human network and entered into a technical agreement with major institutes including overseas electric power companies to share related technologies and experiences. Furthermore, the operator has collected and processed effective information from international nuclear organizations (IAEA, WANO, etc.), and stored and utilized them in its operating experience management system.

19.2 Recent Activities and Improvement

19.2.1 Minimization Treatment, and Storage of Radioactive Waste

Article 66 (Radioactive Waste Management Program) of the Regulations on Technical Standards of 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. (For further details, refer to the National Report on joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.)

19.2.2 Correction of Nonconformity of Simulated Post Weld Heat Treatment and Impact Test after Replacement of Safety Class Valve

During the 2nd regulatory periodic inspection of Shin-Wolsong Unit 2 in 2018, nonconformities of the simulated post weld heat treatment (S-PWHT) and the impact test for main steam atmosphere dump valves (MSADVs) were found, which led to an extensive inspection of all NPPs. As a result, nonconformities of the S-PWHT were discovered at 45 valves installed in 10 KSNP reactors and nonconformities of the impact test were revealed at 136 valves installed in 9 KSNP reactors, 1 APR1400 and 1 CANDU reactor. As the safety class valves of the operating NPPs didn't meet safety class specifications, fine as an administrative punishment for failure to meet licensing requirements were decided at the 84th NSSC on June 28, 2018. At the same time, establishment of effective recurrence prevention measures was requested. Accordingly, the KHNP developed and reported to the NSSC in December 2018 recurrence prevention measures which included strengthening procurement specifications and manufacturing management and conducting an integrated inspection of safety class valves of operating NPPs.

19.2.3 Revision of Regulations on Reporting and Public Announcement of Accidents and Incidents for Nuclear Power Utilization Facilities (NSSC Notice)

In 2018, the Notice was revised in such way to enable the regulatory body to identify and disclose initial information of a reportable event objectively with an intention to improve transparency and trust to the public, and to request the operators to report immediately (within 30 minutes) any event which requires prompt actions, thereby protecting the public or preventing environmental contamination.

Annex

Annex A. Data on Korea Nuclear Installation
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· Annex A · Data on Korea Nuclear Installation

| Table A-1 | Nuclear Power Plant in Operation

(2018년 12월말 기준)(As of December 2018)

Station Name	Reactor Type	Capacity (MWe)	Operator	NSSS Supplier	Connected to Grid	Commercial Operation
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	2016.12.20

* Wolsong Unit 1 : Under shutdown mode for permanent shutdown

| Table A-2 | Nuclear Power Plant under Construction (5Units)

(As of December, 20182018년 12월말 기준)

Station Name	Reactor Type	Capacity (MWe)	Operator	NSSS Supplier	Start of Construction	Applied for operating license	Approval of Operating License
Shin-Kori Unit 4	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2007.9	2011.6	2019.2(예정)
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	-
Shin-Kori Unit 5	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2016.6	-	-
Shin-Kori Unit 6	PWR	1,400	KHNP	DHIC/ KEPCO E&C	2016.6	-	-

| Table A-3 | Nuclear Power Plant under permanent shutdown (1 Unit)

(As of end of December, 20182018년 12월말 기준)

Station Name	Reactor Type	Capacity (MWe)	Operator	NSSS Supplier	Start of Construction	Start of Commercial Operation	Date of Permanent Shutdown
Kori Unit 1	PWR	587	KHNP	WH	1971.8	1978.4.29	2017.6.18

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 · 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 C. · Laws related to Regulation on Safety of Nuclear Facilities

Title	Description	Government Body
Nuclear Safety Act	Umbrella law regarding nuclear safety regulation	NSSC
Korea Institute of Nuclear Safety Act	Law regarding establishment and operation of KINS	NSSC
Act on Physical Protection and Radiological Emergency	Law regarding establishment of a system for physical protection for the safe control/operation of nuclear materials and nuclear facilities, and establishment and implementation of radiological disaster control system	NSSC
Nuclear Liability Act	To prescribe matters concerning liability for nuclear damage arising from the operation, etc. of nuclear reactors	NSSC
Act on Governmental Contract for Nuclear Damage Compensation	To provide matters concerning indemnity agreements for nuclear damage compensation	NSSC
Act on Establishment and Operation of the Nuclear Safety and Security Commission	To provide matters on establishment and operation of the NSSC	NSSC
Nuclear Energy Promotion Act	To provide for matters concerning the research, development, production and use of nuclear energy	Ministry of Science and ICT
Framework Act on Environmental Policy	A mother law for policies to preserve the environment	Ministry of Environment
Environmental Impact Assessment Act	To define the scope of and procedure for environmental impact assessment pursuant to Framework Act on Environmental Policy	Ministry of Environment
Fire Services Act	To provide matters for preventing, being alert to, and suppressing fires	National Fire Agency
Building Act	To provide general matters regarding building	Ministry of Land, Infrastructure, and Transport
Framework Act on civil Defense	To provide general matters regarding civil defense	Ministry of the Interior and Safety
Framework Act on Disasters and Safety Management	To prescribe the basic principles and system of national disaster management	Ministry of the Interior and Safety

Annex D Contents of Nuclear Safety Act

Contents		Description
Chapter I	General Provisions	Purpose of the NSA and definitions of terms used
Chapter II	Establishment and Execution of Comprehensive Nuclear Safety Plan	Establishment and execution of the comprehensive plan, Nuclear safety-specialized institution, establishment of the KINAC and KINS, Implementation of nuclear safety research and development projects
Chapter III	Construction and Operation of Nuclear Reactor and Related Facilities	Standards of construction permit and operating license for nuclear reactor and related facilities and nuclear research reactor, licensing procedure, submittal documents, inspection, records and keeping, revocation of permit, suspension, etc. of use of nuclear power reactor and related facilities, decommissioning, penalty, etc.
Section 1	Construction of Nuclear Power Reactor and Related Facilities	
Section 2	Operation of Nuclear Power Reactor and Related Facilities	
Section 3	Construction and Operation of Nuclear Research Reactor, etc.	
Chapter IV	Nuclear Fuel Cycle Business and Use of Nuclear Material, etc.	Procedure & standards for permit, procedure and method for inspection, etc. for nuclear fuel cycle business and use of nuclear fuel
Section 1	Nuclear Fuel Cycle Business	
Section 2	Use of Nuclear Material	
Chapter 5	Radioisotope and Radiation Generating Device	Procedure & standards for permit, procedure and method for inspection, etc.
Chapter VI	Disposal and Transport	Permit for construction and operation and inspection of disposal facility, etc.
Chapter VII	Dosimeter Reading, etc.	Registration and inspection of dosimeter reading service provider
Chapter VIII	License and Examination	Examination for license, issuance of licenser, etc.
Chapter IX	Regulation and Supervision	Establishment of exclusion area, measure to prevent radiation damage, etc.
Chapter X	Supplementary Provisions	Conditions for permit or designation, approval of topical report, protection of employee, gathering of residents' opinion, education and training, etc.
Chapter XI	Penal Provisions	penal provisions, fine, sentencing guidelines, etc.
Addenda		Enforcement date, transitional measures, relationship to other Acts

· Annex E · Regulations and NSSC Notices on Technical Standards Related on Reactor Facilities

No.	ID No.	Title
1	NSSC Regulation-22	Regulation on Technical Standards of Nuclear Reactor Facilities
2	NSSC Regulation-23	Regulation on Technical Standards of Radiation Safety Control, etc.
3	2017-05	Standard Format and Content of Radiation Environmental Report for nuclear Power Utilization Facilities
4	2017-15	Technical Standards for Locations of Nuclear Reactor Facilities
5	2017-16	Regulation on Preparation of Evaluation Statement of Environmental Impact by Radiation at Nuclear Facilities
6	2017-17	Regulation on Survey of Radiation Environment and Assessment of Radiological Impact on Environment in Vicinity of Nuclear Power Utilization Facilities
7	2017-18	Regulation on Other Facilities related to Safety of Nuclear Reactor
8	2017-19	Regulation on Control of Inspection Findings of Nuclear Power Utilization Facilities
9	2017-20	Material Surveillance Criteria for Reactor Pressure Vessel
10	2018-06	Regulation on Safety Classification and Applicable Codes and Standards for Nuclear Reactor Facilities
11	2016-11	Regulation on In-Service Inspection of Nuclear Reactor Facilities
12	2018-03	Regulation on Reporting and Public Announcement of Accidents and Incidents for Nuclear Power Utilization Facilities
13	2016-12	Standards for Safety Valves and Relief Valves of Nuclear Reactor Facilities
14	2017-23	Standards for Performance of Emergency Core Cooling System of Pressurized Light Water Reactor
15	2018-05	Standards for Leakage Rate Tests of Reactor Containment
16	2016-13	Detailed Requirements for Quality Assurance of Nuclear Reactor Facilities
17	2018-07	Regulations on Pre-Service Inspection of Nuclear Reactor Facilities
18	2017-26	Technical Standards for Investigation and Evaluation of Meteorological Conditions of Nuclear Reactor Facility Sites
19	2017-27	Technical Standards for Investigation and Evaluation of Hydrological and Oceanographic Characteristics of Nuclear Reactor Facility Sites.
20	2018-08	Regulations on Establishment and Implementation of Fire Protection Program

No.	ID No.	Title
21	2018-09	Technical Standards for Fire Hazard Analysis
22	2016-14	Regulations on In-Service Inspection of the Safety-related Pump and Valve
23	2017-28	Regulations on Items and Method of Periodic Inspection for Nuclear Reactor Facilities
24	2017-29	Guidelines on Application of Technical Standards for Assessment of Continued Operation of Nuclear Reactor Facilities beyond Design Life
25	2017-30	Regulation on Consultations due to Installation of Industrial Facilities, etc. around the Nuclear Facilities
26	2019-09	Regulation on Preparation of Technical Ability Description concerning Installation and Operation of Nuclear Reactor Facilities
27	2016-31	Regulation on Verification and Calibration of Instrumentation and Radiation Detector for Nuclear Reactor Facilities
28	2017-32	Regulation on Inspection of Vendors etc. of Safety elated Equipment for Nuclear Reactor Facilities
29	2018-02	Regulation on Reporting of Nonconformities
30	2018-10	Regulation on Preparation of Decommissioning Plan etc. for Nuclear Utilization Facilities
31	2017-34	Detailed Standards on Scope of Accident Management and Evaluation of Accident Management Capability
32	2017-35	Regulation on Method for Preparation of accident management program
33	2016-32	Regulation on Methods for Verification and Inspection, etc of Decommissioning Status of Nuclear Utilization Facilities
34	2016-33	Standards on Reuse of Site and Remaining Building after Completion of Decommissioning of Nuclear Utilization Facilities
35	2017-04	Standards on Preparation of Discharge Plan for Liquid and Gaseous Radioactive Materials, etc. of Nuclear Power Operator and Related Facilities
36	2017-36	Standards for Protection Against Radiation

Anne F Major revisions of Nuclear Safety-related Laws (2016~2018)

Title	Revision Date	Major revisions
Nuclear Safety Act	Oct. 24, 2017	- To establish a procedure for reporting the succession of the status of the installer of a nuclear power reactor
Nuclear Safety Act	Dec. 19, 2017	- To prescribe safety measures and exclusion of application for nuclear power reactors, etc, and subjects to exemption from design approval and inspection of radiation equipment - To require the nuclear enterpriser, etc. to get persons subject to education on nuclear control to receive the education
Enforcement Decree of The Nuclear Safety Act	April 12, 2016	- To require medical checkup and basic training for persons with frequent access to the RCA - To lower annual exposure limits for persons with frequent access and less-than eight year old persons subject to education and training with reference to international standards
Enforcement Decree of the Act on Physical Protection and Radiological Emergency	May 31, 2016	- To prescribe details on requirement for protection from intrusion by electronic means - To provide a procedure for approving regulations on computer and information system security
Enforcement Decree of the Nuclear Safety Act	June 21, 2016	- To prescribe information subject to active disclosure of information and method for information disclosure - To clarify responsibilities of Korea Foundation of Nuclear Safety
Enforcement Regulation of the Nuclear Safety Act	June 30, 2016	- To include a plan for preparing an accident management program as a document to be submitted when applying for a construction permit or standard design approval of a nuclear reactor power and related facilities - To prescribe matters to be included in an accident management program such as scope, equipment, and training and education
Regulation on Technical Standards for Reactor Facilities, etc.	June 30, 2016	- To provide technical standards regarding management of accidents including severe accident
Enforcement Regulation of the Nuclear Safety Act	Aug. 8, 2016	- To prescribe matters regarding timing for medical checkup and training program for persons with frequent access - Matters regarding reporting, package and inspection of transport of low- and intermediate-level radioactive wastes larger than a certain scale

Title	Revision Date	Major revisions
Enforcement Decree of the Nuclear Safety Act	Dec. 22, 2016	- To define a period of post-closure management of a radioactive waste disposal facility for each type of disposal - To include a duty to refer reasons for disqualification of a construction permit, etc. of a nuclear power reactor and related facilities in the list of duties inevitably requiring handling of sensitive information and personally identifiable information
Regulation on Technical Standards for Radiation Safety Control, etc.	Dec. 23, 2016	- To prescribe standards for post-closure management of radioactive waste disposal facilities
Enforcement Regulation of the Nuclear Safety Act	Feb. 3, 2017	- To add matters regarding liquid and gaseous radioactive materials in the discharge plan
Enforcement Regulation of the Nuclear Safety Act	Oct. 24, 2017	- Matters regarding establishment of a procedure for reporting the succession of the status of the installer of a nuclear power reactor
Korea Institute Of Nuclear Safety Act	Oct. 24, 2017	- To prescribe reasons for disqualification of directors to enhance the independence and autonomy of BOD
Act on the Physical Protection and Radiological Emergency	Dec. 19, 2017	- To prescribe that the president of KINS, if needed, establish and operator an information system necessary for radiological impact assessment, etc in preparation for occurrence of radiological disaster, etc.
Act On Establishment and Operation Of the Nuclear Safety And Security Commission	Dec. 19, 2017	- To prescribe that the term of a member newly appointed or commissioned due to the vacancy of his/her predecessor, shall be the remaining term of the predecessor
Enforcement Regulation of the Nuclear Safety Act	May 3, 2018	- To prescribe that radiation workers who receive training under the Occupational Heath and Safety Act are considered received job training for the same hours - To prescribe that some part of medical checkup will be exempted for those who take a medical checkup against radiological harmful factors under the Enforcement Regulation of the Occupational Health and Safety Act
Enforcement Decree of the Nuclear Safety Act	June 19, 2018	- To prescribe that a refresher training for a supervisor or special license taken by persons with two and more nuclear related licenses is considered the same one for general license, etc. to fix inefficiency resulting from redundant training

· Annex G · Major Events (2016~2018)

1. Automatic trip of Hanbit Unit 1 turbine generator and reactor due to loss of condenser vacuum

Around 05:00, Feb. 27, 2016 (Sat.), the turbine generator and the reactor of Hanbit Unit 1 in normal operation tripped automatically due to loss of condenser vacuum, and during the resultant transient, a turbine-driven auxiliary feedwater pump tripped due to over speed.

As a result of investigation, the event was found to occur as follows: 1) the condenser A expansion joint seal water low-level alarm went off; 2) a damage to the condenser A expansion joint was found; 3) a loss of condenser vacuum led to a start of additional vacuum pump and urgent repair work of the damaged area; 4) the turbine generator and the reactor tripped automatically by a condenser low-vacuum alarm; and afterwards, a turbine driven auxiliary feedwater pump (TBD · AFWP) started automatically by a steam generator level low-low signal, however, shortly thereafter, tripped due to over speed.

With the exception of trip of one TBD AFWP and failure of transfer to non-safety bus 4.16kV, major systems and components operated normally as designed (including reactor scram) so that key operating parameters of primary and secondary systems such as RCS temperature & pressure and SG level & pressure were stably kept in hot standby conditions. The operator assumed that the damage to the condenser expansion joint was caused by aging degradation after a long-term use with no replacement and inspection, and the TBD AFWP tripped due to over speed resulting from rapid opening of TBD AFWP steam supply valve (HV-128).

As short-term actions relating to the condenser expansion joint, the operator 1) completed the full replacement and performance test of the condenser expansion joint; 2) strengthened the preventive maintenance of the condenser expansion joint; and 3) set the replacement period of the condenser expansion joint. The operator also established a long-term action plan which includes: 1) develop an expansion joint inspection plan for all NPPs, 2) conduct a review to find an optimized operating method for expansion joints; and 3) improve the corrective action program to manage mid- and long-term action items. As short-term actions regarding TBD AFWP, the operator completed 1) the maintenance of the steam supply valve and 2) the operability test of TBD AFWP, and established a long-term plan which includes: 1) shorten the intervals for steam supply valve maintenance and diagnostic test; 2) change the type of the steam supply valve disc; and 3) define performance criteria for steam supply valve rapid opening to avoid over speed. As a result of reviewing them, it was concluded that they are appropriate for reducing the possibility of similar event recurrence. This event was classified into IAEA INES Level at the 2nd nuclear event scale evaluation committee in 2016.

2. Manual Trip of Hanul Unit 5 Reactor due to Maintenance of Reactor HJTC Ventilation Opening

Around 22:55, December 19, 2016 (Mon.), leak from the ventilation opening of the heated junction thermocouple (HJTC) of Hanul Unit 5 in normal operation was found. Judging that it was not possible to maintain the leaky area during normal operation, the operator tripped the reactor manually at 08:00, December 20, 2016.

After the reactor trip, the plant was cooled down and entered into a cold shutdown state and then the leaky ventilation opening was inspected and maintained. It was confirmed that critical safety functions including heat removal before and after the reactor trip were properly kept and no radioactive material was released to the environment.

As a result of investigation, it was found that the leakage was caused by a damage to a ventilation ball (4.7 mm of diameter, stainless steel) with a sealing function for the HJTC ventilation opening. It was also confirmed that the leak rate was about 0.055gpm, below the operating limits in the Technical Specifications (10gpm of identified leak and 1gpm of unidentified leak), which required no actions to limit operation such as a reactor trip. In addition, it was estimated that a total of 888.8ℓ of coolant was leaked to inside the containment building until isolation of the leaky area after RCS cooldown. The leaked coolant is, in general, treated by the liquid radioactive waste system together with condensate collected in the containment sump. It was found that the damage to the vent ball was caused by an inadequate material of the vent ball. The stainless steel vent ball was mistakenly installed in the borated water environment due to insufficient material control, which caused corrosion and resultant leakage. As short-term actions, the operator completed 1) a boric acid corrosion evaluation and boric acid cristalization removal; 2) a rod control system integrity and function test; 3) a HJTC vent ball replacement and a sensor integrity inspection; 4) improvement of HJTC/CEDM maintenance procedure such as strengthening assembly & disassembly procedures and post-vent leak inspection; 5) development of leak monitoring plan for operating NPPs; 6) Upgrading of the quality class of HJTC sealing components from S to A and training and experience sharing on classification of quality class; and 7) verification of adequacy of classification of quality class. The operator also developed a long-term plan including: 1) develop a standard procedure to respond to a minor leak from RCS (0.05gpm); 2) revise a standard guidance for quality class management; 3) strengthen material procurement management; 4) develop a checklist for procurement of urgent materials; and 5) develop a quality class review plan for safety class equipment components and new & changed materials. As a result of reviewing them comprehensively, it was concluded that causes for the event were identified and corrected, and recurrence prevention measures were properly established. The event was classified into IAEA INES Level 1 at the 2nd nuclear event scale evaluation committee in 2017.

3. Manual Reactor Trip of Kori Unit 4 Due to Maintenance of the Leaky Welded Area of Drain Valve of Steam Generator A Water Box Drain Line

Around 23:24, March 27, 201, a coolant leakage was found from the welded area of the steam generator A drain valve (BB-V070) of Kori Unit 4 in normal operation. Pursuant to LCO 3.4.13 and required actions in the Technical Specifications, the reactor was tripped and put into a cold shutdown state (Operation Mode 5).

As a result of field investigation, a circumferential penetration (crack) with about 10mm in maximum length and 6mm in depth was found at the socket weld area of the drain valve (BB-V070). As a result of comprehensively reviewing the results of cause analysis by KAERI and the engineering opinions of Westinghouse as a original designer, it was confirmed that a design change, etc. caused a change in the natural frequency of the drain, which led to vibration and resonance during operation and resultant accumulation of cycle fatigue, resulting in the penetration defect at the socket weld area. The natural frequency of the drain line was changed due to a change in the installation shape of the steam generator drain nozzle when its material was changed from Inconel 600 to 690 in March 2006 as well as an adjustment in the length of the drain line made when the drain valve was replaced in May 2010.

As some of reactor coolant was leaked via the defected area to inside the containment building (about 413.86L of leak amount estimated), KINS checked containment radiation monitors, environmental radioactivity monitors around the plant, and worker exposure rate to confirm radiological impact. As a result, it was concluded that the radiological impact of the leak was minor, taking into account that the radioactivity concentration in the RCS was relatively low and changes in the radiation level around the containment building and the plant were small.

As short-term actions, the operator completed 1) revision of procedure for coolant leakage inspection and evaluation; 2) improvement of recurrence prevention measure process in the standard procedure; 3) design change of removal and plugging of the steam generator water box drain line; 4) non-destructive inspection of similar socket weld areas of Kori Units 3&4; 5) Adequacy review and follow up actions of corrective actions for reportable events for the past 10 years; and 6) establishment of re-assessment of vibration when a design or shape is changed. The operator also established a long-term plan including 1) improve the design of the water box drain line for other plants of same reactor type; 2) develop a standard guidance to manage the RCS socket weld area and incorporate it into a long-term in-service inspection plan; 3) expand a small pore socket weld area inspection even to the RCS tie line which may cause a manual trip; and 4) conduct an engineering evaluation and review of installation requirements for safety-class, less than two inch piping supports. As a result of reviewing them, it was concluded that corrective and recurrence prevention measures were based on causes identified and judged to be appropriate. The event was classified into IAEA INES Level 1 at 4th nuclear event scale evaluation meeting in 2017.

4. Wolsong Unit 3 Coolant Leak due to Erroneous Manipulation of Pressurizer Drain Vale during Outage

Around 18:43, June 11, 2018 when the reactor was shut down and the RCS was cooled down and depressurized for 16th planned outage of Wolsong Unit 3, the pressurized drain valve (3332-V14) which was left closed was manually opened and resultant leakage set off an alarm from a leak detector inside the containment building.

As a result of field investigation, it was found that a field operator mistook and opened the pressurizer drain valve (3332-V14) for the equalizing valve ((3332-V19) of the pressurizer isolation valve (3332-MV1) when taking actions to isolate the pressurizer. The erroneous opening of the drain valve was founded to be caused by shortfalls in the management of valve labels, management of locking device of major valves and use of human error prevention tools. More specifically, it was analyzed that the human error was caused by insufficient education and training on compliance of operator fundamentals, internalization of human error prevention tools, and identification and manipulation of local components.

As consequences for the erroneous opening of the drain valve, about 4,078kg of reactor coolant was leaked to inside the reactor building, and among which, about 3,819kg was collected and about 259.1kg was released outside the reactor building (Estimation period: June 11 to 21, 2018). Accordingly, it was confirmed that the amount of tritium contained in the released heavy water was estimated to be 1.25×1013Bq, which was about 0.055% of the annual release limit (2.25×1016Bq).

With regard to a radiological impact from the leakage, KINS reviewed the results of worker exposure assessment, the results of offsite environmental sampling analysis, and the trends of indicated values of containment radiation monitors and environmental radiation monitors around the plant. As a result, it was confirmed the maximum worker exposure was estimated 2.53 mSv which was about 13% of the annual control limit of the KHNP and the maximum concentration level of tritium in air sample was measured at about 11% of the effluent control limit. Besides tritium, radioactive materials were all confirmed to be below the lower limits of detection through the review of measurement records from the effluent monitors. It was also confirmed that changes in indicated values of containment radiation monitors and environmental radiation monitors around the plant were small.

Based on causes identified, the operator completed short-term actions including 1) revision of guidance for management of component labelling and identification (operation-2014-04), complete inspection of valve labels and labelling to components with no label; 2) revision of a guidance for locking device management and additional installation of locking devices; 3) a change in the operating method for the coolant drain pump inlet strainer 4) an improvement in training and procedures for improving the competency of field operators; and 5) define a group of two rule for human error prevention. The operator also develops a long-term plan including: 1) install CCTVs additionally in the potential coolant leak areas; 2) create an alarm for D2O collection tank level increase rate; 3) review and revise the emergency operating procedure (Increasing concentration of tritium in the reactor building) to change the point of time to shutdown the containment ventilation system and to isolate the isolation valve; 4) clarify the steps requiring 'concurrent verification in the one group or two rule; 5) strengthen the operator refresher training (training centers) and on-the-job training (plant); 6) conduct WANO technical support mission on operator fundamentals, and 7) develop and implement a plan for evaluation of effectiveness of management of operating organizations and human factors. As a result of reviewing them, it was concluded that causes for the event were identified and corrected and recurrent prevention measures were based on identified causes and judged to be appropriate. The event was classified into IAEA INES Level 1 at the 4th nuclear event scale evaluation committed in 2018.

Annex H List of Agreements and MOUs

Table H-1 | List of Agreements and MOUs Signed by the NSSC

Contracted Party	Type	Effective Date
Arab Emirates, Federal Authority for Nuclear Regulation (FANR, Regulatory Body)	Agreement	Dec. 20, 2011
Canada, Canadian Nuclear Safety Commission (CNSC, Regulatory Body)	MOU	Apr. 16, 2012
Finland, Radiation and Nuclear Safety Authority (STUK, Regulatory Body)	Arrangement	May 4, 2012
United States, Nuclear Regulatory Commission (NRC)	Arrangement	Sept. 18, 2012 Sept. 20, 2017
France, Autorité de sûreté nucléaire (ASN)	Arrangement	Dec. 19, 2012 Sept. 19, 2017
Sweden, Swedish Radiation Safety Authority (SSM)	MOU	Sept. 23, 2014
Germany, Federal Ministry for the Environment (BMUB)	Joint Declaration	Sept. 24, 2014
Jordan, Energy and Minerals Regulatory Commission (EMRC)	MOU	Dec. 22, 2014
Vietnam, Vietnam Agency for Radiation and Nuclear Safety (VARANS)	MOU	Sept. 15, 2015
China, National Nuclear Safety Administration (NNSA)	Special Agreement	Oct. 23, 2015
Russia, Rostechnadzor (RTN)	Arrangement	Sept. 19, 2018
Saudi Arabia, King Abdullah City for Atomic and Renewable Energy (K.A.CAREO)	MOU	Nov. 22, 2016
Thailand, Office of Atoms for Peace (OAP)	MOU	Sept. 19, 2018

| Table H-2 | List of Agreements and MOUs Signed by KINS

Contracted Party		Type	Effective Date
United States, Nuclear Regulatory Commission (NRC)		MOC	Mar. 8, 2011
France, Institute of Radiation Protection & Nuclear Safety (IRSN)		Cooperation Agreement	Sept. 24, 1990 Revised on Mar. 25, 2019
Romania, National Commission for Nuclear Activities Control (CANCAN)		MOU	Sept. 21, 1996
		Additional Arrangement	Dec. 1, 2006
Finland Radiation and Nuclear Safety Authority (STUB)		Arrangement	Sept. 8, 2006
Indonesia, Nuclear Energy Regulatory Agency (BAPETEN)		Arrangement	Nov. 20, 2006
Jordan, Energy and Minerals Regulatory Commission (EMRC)		MOU	Sept. 26, 2014
Republic of South Africa, The National Nuclear Regulator (NNR)		MOU	Dec. 11, 2011
King Abdullah City for Atomic and Renewable Energy (K.A.CARE) of Saudi Arabia		Arrangement	Oct. 20, 2017
Japan	Japan Chemical Analysis Center (JCAC)	MOU	Mar. 3, 1989 Revised on July 9, 1991
	National Institute of Radiological Sciences (NIRS)	MOU	Oct. 15, 2009
China	National Nuclear Safety Administration (NNSA)	Arrangement	Apr. 17, 1996 Revised on Dec. 4, 2000
	Nuclear and Radiation Safety Center (NSC)	MOU	Nov. 30, 2015
	National Nuclear Emergency Response Technical Advisory Center (NNERTAC)	MOU	Nov. 30, 2015
Vietnam	Vietnam Agency for Radiation and Nuclear Safety (VARANS)	MOU	Jan. 29, 2007
	University of Dalat	MOU	Jan. 31, 2007
Arab Emirates	Federal Authority for Nuclear Regulation (FANR)	MOU	May 25, 2010
	Khalifa University of Science, Technology and Research		Dec. 18, 2011

· Annex I · Good Practices and Advices Identified by IAEA Stress Test

| Table I-1 | Good Practices

No.	Descriptions
1	The framework of the PSR is used to update the probabilistic seismic hazard assessment and S-PSA and then the updated results is used to confirm adequacy of the SSE and margin earthquake severity and return period
2	Insights from external events probabilistic safety assessment are used to support the stress test program
3	Times available for operator actions before cliff edge effects occur have been thoroughly analyzed and this estimate contributes to give credibility of the proposed strategies and confidence in their implementation.
4	Systematic approach to the human performance assessment under accidental conditions is used for optimization of the field operator actions

| Table I-2 | Advices (No violation of safety requirements and guidances, but advices on safety improvement)

No.	Descriptions
1	It is advised to implement design modifications and the installation of fixed equipment where this possibility is practically and reasonably achievable.
2	It is advised to secure some hypotheses (e.g. leak rate at the RCPs seals) by considering the international practices and up to date knowledge and methodologies.
3	It is advised to perform an assessment of on-site radiological situation for the bounding scenario with simultaneous severe accident on all units on site and using the outcome of this assessment to update the analyses performed for emergency preparedness and operational coping capability.
4	It is advised to consider in safety evaluation and document in the ST report impact of beyond design basis extreme wind to blockage of the access road for the mobile equipment in case of collapse of the towers supporting transmission lines.
5	Evidence that acceptable environmental conditions could be maintained in the rooms housing CVCS pumps and ESFAS while the essential chilled water and the CCWS systems are not available is not documented in the report. It is advised that additional information shown during the meeting about room temperature evolution supporting the validity of the strategy is provided in the report.
6	It is advised to clearly stated that all the essential safety functions defined in the stress test specifications have been screened and their accomplishment analyzed.
7	It is advised to review the updated PSHA by a review team including international experts, for providing sufficient confidence in the PSHA results.
8	It is advised to improve documentation by including a section describing the screening process (initial list of all potential hazards, screening criteria and results).

No.	Descriptions
9	It will be beneficial for future applications to determine a more realistic plant-level HCLPF capacity (above 0.3g), instead of a lower bound estimate (0.3g).
10	It is advised to identify vulnerabilities in the implementation of the defence in depth in the design and to propose safety improvements of the current design of safety systems to make the likelihood of their total failure as low as reasonably achievable.
11	It is advised that the additional information provided during the meeting in relation to the integrity of the radwaste building under extreme natural hazards is included in the report.
12	It is advised not to limit the assessments to power operation but to extend the analyses to all plant states authorized by the specified limits and conditions for normal operation.
13	It is advised to extend the assessment of severe accident mitigation strategies in the Stress Tests report to incorporate aspects of cliff-edge effect analyses at least from the point of view of RPV failure and minimisation of the radiological impact on site. It is advised that severe accident coping strategies provided in the Stress Tests report (scenario analysed) are enhanced and analytically justified to provide for larger margins, i.e. taking into account mitigation capability to cope with failed RPV as well as with control of containment conditions.
14	It is advised to extend the assessment of means for severe accident management after the RPV failure in Stress Test analysis to incorporate mobile equipment and analytically justify that sufficient margins are provided taking into account mitigation capability to cope with failed RPV.
15	It is advised to extend the assessment of severe accident mitigation strategies in the Stress Tests report from the point of view of the minimisation of the radiological impact on site. Thus severe accident coping strategies provided in the Stress Tests report (scenario analysed) might be enhanced and analytically justified to provide for larger margins, i.e. taking into account mitigation capability to control containment conditions and minimize radiological releases through containment boundary.
16	It is advised to extend the assessment of severe accident mitigation strategies in the Stress Tests report to have sufficient margins in the coping capability under the conditions evoked by the external hazard. Moreover, an analytical justification of capability to provide for the long-term stable state through reaching and maintaining exit conditions of SAMGs is expected to be provided.

· Annex J · Actions Items for Safety Improvement and Safety Review of Korean NPPs against Large Earthquake

| Table J-1 | Implementation Status of Action Items for Safety Improvement against Large Earthquake (as of Late 2018)

Category	Action Items	Status
1. Improve a seismic response system		
① Strengthen the management of seismic monitoring system	(1-1) Conduct a performance inspection of seismic instrumentation of KHNP every 3 cycle (5 years)	Completed
	(1-2) Replace seismic instrumentations of KINS with new ones and verify them through an expert institution every 5 years	Completed
	(1-3) Improve a seismic warning system in such way to interlock PGA and response spectrum	Completed
	(1-4) Specify a reference seismograph in the FSAR	Completed
② Establish an implementation system for prompt reporting and action	(2-1) Include immediate reporting (30 minutes) of earthquake in the system	Completed
	(2-2) Establish a system in a long-term where values measured at seismic instrumentations are automatically notified to the regulatory body	Ongoing
	(2-3) Establish a system in such way to determine on plant shutdown within 2 hours and to shut down a plant manually within 4 hours after earthquake	Completed
	(2-4) Prepare a regulatory guide applicable to a PHWR plant	Completed
③ Disclose information transparently immediately after earthquake	(3-1) Disclose information within 60 minutes after earthquake (a magnitude of 3, within 100km)	Completed
2. Conduct a seismic reinforcement and a detailed assessment of seismic capacity of operating NPPs		
① Continue the reinforcement of seismic capacity of NPPs	(1-1) Improve the seismic capacity of safe shutdown systems to 0.3g	Ongoing
	(1-2) Conduct the seismic reinforcement of the outer wall of Hanaro reactor	Completed
② Conduct a detailed assessment of seismic capacity of critical systems	(2-1) Conduct a detailed assessment of seismic capacity of critical systems for each key function of a NPP * safe shutdown, core cooling, prevention of release of radioactive material ※ Development and implementation of plan for seismic capacity improvement	Completed

Category	Action Items	Status
3. Enhance the safety of seismic response for low and intermediate level radioactive waste management facility in Gyeongju		
① Improve the seismic capacity of major facilities of The second-stage near surface disposal facility	(1-1) Improve the seismic capacity of the disposal vault and the underground gallery (0.2g→0.3g)	Ongoing
② Secure the safety of major facilities in operation	(2-1) Re-confirm the seismic capacity of major facilities* * Silo, vertical shaft, Receipt & Storage Building, Rad Waste Building, Supporting Building	Ongoing
	(2-2) Duplicate the drain system and power supply system of the rock cavern disposal facility (Additional installation)	Ongoing
③ Strengthen a emergency response system	(3-1) Establish a remote monitoring system for seismic observation data	Completed
	(3-2) Create a database of characteristics of changes in the amount of discharge of ground water from the radioactive disposal facility	Ongoing
	(3-3) Install seismic accelerometers additionally on site in the disposal facility	Ongoing
4. 9.12 Conduct a detailed geological survey and a re-assessment of design basis of NPPs in seismic zones		
① 9.12 Conduct a detailed geological survey and a re-assessment of design basis of NPPs in seismic zones	(1-1) Study on seismic source characteristics in September 2016 for reassessment of design basis of NPPs	Ongoing
5. Build an emergency control center safe from earthquake		
① Build an emergency control center for each nuclear site	(1-1) Build a seismically isolated, emergency control center for each nuclear site ※ Radiation shielding, seismic design (seismic resistance 0.3g+seismic isolation 0.2g), capacity of 500 persons	Ongoing
6. Strengthen emergency response capabilities against earthquake, etc.		
① Reinforce manpower	(1-1) Operate a severe accident rapid response team of the KHNP	Completed
	(1-2) Reinforce the seismic manpower of the NSSC and KINS	Completed
② Strengthen education & training	(2-1) strengthen education & training	Ongoing

| Table J-2 | Implementation Status of (53) Actions Items of Special Safety Inspection of Korean NPPs (As of Late 2018)

ID.	Action Items	Due Date	Status
1-1	Installation of ASTS	2012	Completed
1-2	Improvement of the Seismic Capacity of Safe Shutdown Equipment	2018	Under review
1-3	Research and Study on Maximum Earthquake at Nuclear Power Plant Sites	2013	Completed
1-4	Installation of Seismic Class Earthquake Warning Light at MCR	2013	Completed
1-5	Improvement of Seismic Capacity of Access Bridge to Wolsong Site	2012	Completed
2-1	Extension of Height of Sea Wall for Kori Site	2014	Completed
2-2	Installation of Watertight Doors and Underwater Drain Pumps	2019	Ongoing
2-3	Research and Study of Design Basis Sea Level for Nuclear Power Plant Sites	2013	Completed
2-4	Improvement of Cooling Seawater Intake and Tsunami Prevention Facilities	2017	Completed
3-1	Procurement of Mobile Generators and Batteries	2015	Completed
3-2	Upgrading of AAC DG's Design Basis	2014	Completed
3-3	Fixation of Anchor bolts of Standby Transformer and Improvement of Fuel Injection Port to Emergency Electric Power Supply system of Wolsong NPPs	2012	Completed
3-4	Improvement of Ownership of Management of Switchyard Equipment	2013	Completed
3-5	Establishment of Countermeasures against Loss of SFP Cooling	2012	Completed
3-6	Establishment of Measures for Flood Prevention and Recovery of UHS Equipment	2013	Completed
3-7	Installation of Protective Walls for Yard Tanks	2015	Completed
3-8	Establishment of Flood Prevention Measures for MSSV room and Emergency Feedwater Pump Room	2019	Ongoing
3-9	Improvement of Fire Safety Management Plan and Cooperation System	2012	Completed
3-10	Improvement of Fire Protection Equipment and Response Capability of Site Fire Brigade	2015	Completed
3-11	Introduction of Nuclear Performance Based Fire Protection Design	2012	Completed
4-1	Installation of PARs (including hydrogen monitoring equipment)	2018	Ongoing
4-2	Installation of Containment Venting or Depressurization System	2020	Ongoing
4-3	Installation of External Injection Path of Emergency Cooling Water to Reactor	2018	Ongoing

ID.	Action Items	Due Date	Status
4-4	Enhancement of Severe Accident Training	2011	Completed
4-5	Revision of SAMGs	2012	Completed
4-6	Development of SAMG for Shutdown and Low-power Operation	2012	Completed
5-1	Additional Procurement of Radiation Protection Supplies for Residents nearby Nuclear Power Plant Sites	2012	Completed
5-2	Revision of Radiological Emergency Plan to incorporate multi-unit simultaneous emergency declaration	2011	Completed
5-3	Additional Procurement of Emergency Equipment for Prolonged Emergency	2012	Completed
5-4	Additional Procurement of Equipment for Emergency Medical Centers	2013	Completed
5-5	Enhancement of Radiological Emergency Drill	2012	Completed
5-6	Establishment of Ways to Obtain Essential Information during an ELAP	2013	Completed
5-7	Establishment of Protective Measures for Maintenance Workers	2012	Completed
5-8	Improvement of Emergency Response Facilities	2016	Completed
5-9	Revision of Procedures for Information Disclosure during Radiological Emergency	2012	Completed
5-10	Assessment of Public Protective Measures outside Emergency Planning Zone	2014	Completed
5-11	Reinforcement of Emergency Warning System	2014	Completed
6-1	Significant Strengthening of Safety Inspections including Periodic Inspection	2012	Completed
6-2	Strengthening of ISI of Major Components and Piping	2011	Completed
6-3	Development and Implementation of Integrated Management Plan for Aging Management Program	2012	Completed
6-4	Strengthening of Management of Performance Parameters for Major Active Components	2012	Completed
6-5	Installation of Fatigue Monitoring System for Enhancing Quantitative Fatigue Management	2017	Completed
6-6	Enhancement of Integrity of Pressurizer Lower Head against Fatigue	2012	Completed
6-7	Improvement of reliability of SPV Components	2012	Completed
6-8	Evaluation of Adequacy of Operational Personnel	2013	Completed
6-9	Improvement of Reliability of On-site Power Supply System	2013	Completed
6-10	Improvement of Inspection on Procurement Quality Assurance Program	2011	Completed
7-1	Evaluation of Seismic Capacity of Structures and Improvement of MCR	2012	Completed

ID.	Action Items	Due Date	Status
7-2	Re-evaluation of Flood Depth of Hanaro Research Reactor and Related Facilities	2011	Completed
7-3	Revision of Radiation Emergency Plan with Consideration of Complex Radiological Emergency Situation	2011	Completed
ADD-1	Reinforcement of Equipment against Extreme Hazards (Natural + Artificial Hazards)	2020	Ongoing
ADD-2	Establishment of Emergency Response Organization for Accident Response and Management in case of Severe Accident	2018	Completed
ADD-3	Establishment of Emergency Control Center	2022	Ongoing

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