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Korean Approach for Enhancement of Nuclear Safety in Response of Fukushima Accident

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Key Yong Sung
(K109sky@kins.re.kr)

Korea Institute of Nuclear Safety
Nuclear Safety and Security Commission

Overview of Presentation

PART-I

- **Korean Response to Fukushima Accident**

PART-II

- **Summary of Issues for Discussion**

Attachments

- **Results of Special Safety Inspection**

Part I

Korean Actions for Nuclear Safety After Fukushima Accident

Plant Status in Korea

- Operating Plants : 21 plants
  - Over 30 years : 1 unit(Kori-1), Continued Operation from 2009
  - 20~30 years : 8 units
    - CO license before Dec.2012 : 1 unit
  - Less than 20 years : 12 units

- New Plants
  - Under construction : 7 plants
    - At the final stage of OL : 3 units (SKN-2, SWN-1/2)
    - At the beginning stage of FSAR (OL) : 2 units (SKN-3/4)
    - At the final stage of PSAR (CP) : 2 units (SUN-1/2)
  - On planning : 4 plants (SKN-5/6, SWN-3/4)

Table. Operating plants in Korea

Unit	Type	Net capacity (MWe)	Commercial Operation	Planned Close
Kori-1	PWR-W/H	587	4/78	2017
Kori-2	PWR-W/H	650	7/83	
Wolsong-1	PHWR-CANDU	679	4/83	Under CO license
Kori-3 / 4	PWR-W/H	950	9/85, 4/86	
Yonggwang-1 / 2	PWR-W/H	950	8/86, 6/87	
Ulchin-1 / 2	PWR-FR	950	9/88, 9/89	
Yonggwang-3 /4	PWR(System 80)	1000	12/95, 3/96	
Wolsong-2 / 3 /4	PHWR-CANDU	700	7/97, 7/98, 10/99	
Ulchin-3 / 4	OPR-1000	1000	8/98, 12/99	
Yonggwang-5 / 6	OPR-1000	1000	5/02, 12/02	
Ulchin-5 / 6	OPR-1000	1000	7/04, 8/05	
Shin Kori(SKN)- 1	OPR-1000	1000	8/10	
Total : 21		18,716		

OPR : Optimized Pressurized Reactor (Previously named as KSNP)

Table. New plants in Korea

Unit	Type	Net Capacity (MWe)	Start Construction	Commercial Operation
Shin Kori(SKN) -2	OPR-1000	1000	6/07	12/2011(delayed)
Shin Wolsong(SWN)-1	OPR-1000	1000	11/07	3/2012(delayed)
Shin Wolsong- 2	OPR-1000	1000	9/08	1/2013
Shin Kori(SKN)- 3	APR-1400	1350	10/08	9/2013
Shin Kori- 4	APR-1400	1350	9/09	9/2014
Shin Ulchin(SUN)- 1	APR-1400	1350	3/11(delayed)	12/2015
Shin Ulchin- 2	APR-1400	1350	3/12(delayed)	12/2016
Shin Kori- 5	APR-1400	1350	Planned	
Shin Kori- 6	APR-1400	1350	Planned	
Shin Wolsong- 3	APR-1400	1350	Planned	
Shin Wolsong- 4	APR-1400	1350	Planned	
Design Certification	APR+	~1500	'12.1 (DC Start)	
Design Certification	SMART	~100	'11.1 (DC Start)	

APR : Advanced Pressurized Reactor , SMART : System-integrated Modular Advanced Reactor

History of Actions

Date	Major Activities
Mar.11.	F-S accident, Setting-up Emergency Response Center at KINS
Mar.16~18	Korean Utility's voluntary inspection
Mar.21	Minister Order following recommendation of Nuclear Safety Committee in MEST
Mar.21~Apr.30	Special Safety Inspection(Site inspection : March28~Apr.15, Review of Finding : Apr.16~Apr.30)
Apr.22~May 3	Supplementary Inspection for an oldest unit (Kori-1)
May 6	• Decision of execution of SSI results by NSC • Submission the Implementation plan in two months & progress report every six months
May27~Jun.30	Meeting for explaining the SSI results to resident and civil representatives of each plant site
July 5	Licensee's implementation plan submitted to RB
Jul.6 ~ Sep.30	Discussion between licensee and RB on the detailed schedule, process and methods of each recommendation to operating plants

History of Actions

Date	Major Activities
Jul.10~Jul.22	IAEA IRRS Mission, Discussion in PI-0(Special Module for F-S accident)
Aug ~ Oct.	Discussion on the detailed schedule, process and methods of each recommendation to the plants under construction
Oct.26	Establishment of New Regulatory Organization (MEST→ NSSC)
May~ Present	• Follow-up other countries' activities ▪ IAEA, JAPAN, USA, EU, CANADA..

Strategy for Enhancing Reactor Safety

The phase-in actions are taken to ensure adequate protections from extreme natural phenomena in response to the Fukushima Accident.

- Short-term Actions
  - Utility's self-inspection of operating nuclear power plants right after F-S accident
    - Specifying the protecting measures against extreme natural disasters
  - Implementation of 「Special Safety Inspection(SSI) of operating NPPs」 in consideration of utility's self-inspection results
    - Addressing the action items (recommendations) for safety improvement
- Mid-term Actions (Current Stage)
  - Establishment and conduct of a detailed implementation plan responding to the action items
  - In-depth evaluation on the F-S accident(RB), and review of other countries' actions
    - Backfitting of lessons-learned and insights to Korean NPPs as practicable.
- Long-term Actions
  - Amendment of regulatory requirements like law, regulatory standards and guides with consideration of the events beyond design basis.
  - Continuous applications of the international lessons-learned

Special Safety Inspection

- Legal Basis for SSI
  - Atomic Energy Act, Article 103 (2) and (3)
    - (2)~~ Government official can inspect the site if it is deemed specifically necessary for the safety of facility ~~
    - (3) If the Minister of Nuclear Safety and Security Commission finds as a result of the inspection conducted under Paragraph (2) that there are matters contrary to this Act or the international commitment, he may order corrective or complementary measures.
  - Recommended by the Nuclear Safety Committee(Nuclear Safety Advisory Committee) on Mar.21.

Overview of SSI

- SSI performed to 21 operating NPPs, a research reactor and fuel cycle facility (Mar.21~Apr.30)
  - 6 inspection areas, 73 experts
  - Supplementary inspection for the oldest unit (Kori-1)(Apr.22 ~May3)
    - Unexpected shutdown due to failure of 4.16kV breaker during SSI (Apr.12)
- Basic Principle of SSI
  - Defense-In-Depth approach to ensure that core melting is prevented and the undue risk to the public is minimized
    - By assuming the scenario of **"Earthquake→ Tsunami→ Power loss→ Extreme severe accident"**

Defense	Principles for Inspection
1st Defense	• Prevention of the expansion of effects from natural phenomena
2nd Defense	• Prevention of the event progress toward severe accidents
3rd Defense	• Mitigation of severe accident consequences

Overview of SSI

- The scope of the SSI
  - consisting of the following 6 areas and 27 inspection items deduced on the basis of the inspection principles
  - (Area 1) Design of structures and equipment against earthquakes and coastal flooding
  - (Area 2) Integrity of electrical power, cooling, and fire protection systems in case of inundation
  - (Area 3) Counter measures against severe accidents
  - (Area 4) Emergency response and emergency medical systems
  - (Area 5) Long-term in-service plants
  - (Area 6) Research reactors and nuclear fuel cycle facilities
- Inspection Results
  - Total of 50 long- and short-term recommendations were deduced including ones from supplementary inspection to Kori-1
    - **46 for Operating plants**
      - **33 : common application to all Operating and New plants,**
      - **13 : for specific plants and oldest plant**
    - 4 for a research reactor and a fuel facility

Major Recommendations
(The 1st Defense)

- **Ensuring Protection from an Extreme Earthquake**

  (Goals for improvement) Protection of safety components and equipment from the large earthquake beyond design basis

  - (1-1) Installing an automatic seismic trip system
  - (1-2) Improving the seismic capacity of the safe shutdown systems
  - (1-3) Investigation and study on the maximum potential earthquake for NPP sites
  - (1-4) Improving seismic capacity of facilities in the main control room (MCR)

- **Ensuring Protection from an Extreme Tsunami**

  (Goals for improvement) Protection of the plant site from the large tsunami beyond design basis

  - (2-1) Extension of the height of the sea wall for the Kori site
  - (2-3) Investigation and study on the design basis sea water level of NPP sites

  ✓ **Blue : short-term action(~'12), Black : long-term action(~'15)**

Major Recommendations
(The 2nd Defense)

- **Securing Electric Power and Reactor Cooling Capability**

  (Goals for improvement)
  - Securing the essential power supply through the protection of electric power systems
  - Securing the performance of main cooling systems and the ultimate heat sink facilities
  - Securing the cooling capability of the primary and secondary system without power

  (Recommendations)
  - (2-2) Installation of waterproof gates and discharge pumps
  - (2-4) Enhancement of sea water intake capability and reinforcement of facilities in preparation for coastal flooding
  - (3-1) Securing the availability of a portable electric power generator vehicle and batteries, etc.
  - (3-2) Upgrading design basis of AAC diesel generator
  - (3-6) Preparing measures of the inundation prevention and restoration of the ultimate heat sink
  - (3-10) Improving fire protection facilities and response capability of plant firefighting teams.
  - (4-3) Installation of reactor injection flow paths for emergency cooling water injection from external sources .

- **Securing Cooling Capability of Spent Fuel Pool**

  (Goal for improvement) Securing the SFP cooling capability even in the worst conditions
  - (3-5) Ensuring countermeasures against loss of the spent fuel pool cooling function

Major Recommendations
(The 3rd Defense)

- **Strengthening severe accident mitigation facilities and its response strategy**

  (Goals for improvement)

  - Securing the reactor cavity cooling capability under the conditions of severe accident
  - Providing measures for preventing containment building failure due to pressure increase and hydrogen explosion
  - Strengthening training and strategy for severe accident management

  (Recommendations)

  - (4-1) Installation of passive hydrogen removal equipment
  - (4-2) Installation of filtered vent system or depressurizing facilities in the containment buildings.
  - (4-3) Installation of reactor injection flow paths for emergency cooling water injection from external sources .
  - (4-4) Reinforcing education and training for severe accidents
  - (4-5) Revision of the Severe Accident Management Guidelines to enhance effectiveness
  - (4-6) Development of Low-Power Shutdown Severe Accident Management Guidelines

Major Recommendations
(The 3rd Defense)

- **Strengthening Emergency Preparedness Capability against Extreme Accidents**

  (Goals for improvement)
  - Enhancing the protection of the residents around a site against extreme accidents
  - Enhancing the emergency response capability to the multi-units accidents and prolonged emergency situations
  - Securing emergency response facilities under extreme earthquake and tsunami

  (Recommendations)
  - (5-1) Securing additional radiation protection equipment for protecting residents near the NPP
  - (5-2) Amending the emergency plan to include such events as a simultaneous emergency at multiple units
  - (5-3) Securing additional protective equipment in preparation for a prolonged emergency
  - (5-5) Reinforcing radiation emergency exercises.
  - (5-6) Devising a means for securing necessary information in the event that there is a prolonged loss of electrical power.
  - (5-7) Securing countermeasures for protecting maintenance workers.
  - (5-8) Improving the emergency response facilities.
  - (5-9) Amending the information disclosure procedure in the event of a radiation emergency.
  - (5-11) Reinforcing the performance of emergency alarm facilities

Follow-Up Actions

< Follow-up of SSI Implementation >

- **Operating plants**
  - Utility's comprehensive implementation plan for 46 recommendations applicable to operating NPPs was prepared
    - 23 Short-term(until '12) & 23 Long-term actions (until '15)
    - Submission of progress report every 6 months to RB
    - Detailed schedule and items are under discussion with RB
  - SAMGs will be revised along with the design changes taken by the implementation plan and reviewed by RB

- **Operating plants near Continued Operation**
  - Most recommendations shall be completed before CO licensing
  - Detailed approach and schedule under discussion with RB

Follow-Up Actions (Cont'd)

< Follow-up of SSI Implementation >

- **New plants (1/2)**
  - SSI recommendations shall be applied to new plants as well.
    - 33 out of 46 recommendations for operating NPPs are commonly applicable to the both of new and operating plants
  - For new plants at the beginning of OL or during CP
    - Implementation of 33 items before OL
    - Detailed design change if necessary and review will be performed at the stage of OL
    - Corresponding plant specific SAMGs shall be established and submitted to RB before OL

Follow-Up Actions (Cont'd)

< Follow-up of SSI Implementation >

- **New plants (2/2)**
  - For new plants at the final stage of Operating License
    - Following improvements shall be implemented prior to Operating License(OL) or Commercial Operation(CO)
      - Installation of cooling water flow path to Spent Fuel Pool
      - Preparation of portable 480V DG to supply power to essential equipment (temporary)
      - Installation of primary and secondary injection flow paths for emergency cooling water supply
      - Installation of hydrogen removal system (PAR)
      - Reinforcement of education and training for severe accidents
      - Amendment of emergency plan to include such events as a simultaneous emergency at multiple units
    - The remaining recommendations shall be implemented earlier than the operating plants
    - Above improvements shall be reflected to the corresponding plant specific SAMGs

Follow-Up Actions (Cont'd)

< RB Activities >

- Regulatory Review of Utility's implementation plan of SSI recommendations
  - Development of review and inspection guides for recommendations
  - Periodic inspection to check the progress and the adequacy of installation if necessary
- Revision of the 1st Comprehensive Nuclear Safety Plan
  - Reflection of regulatory positions of New Korean RB(NSSC)
  - Revision of regulation direction and roadmap after F-S accident
- Some projects launched this year
  - In-depth Analysis of the F-S accident to study insights
  - Preparation of revised regulatory requirements with consideration of BDBA

Follow-Up Actions (Cont'd)

- Establishment of Legal Requirements near future
  - Currently, legal requirements for severe accident analysis and PSA not exist
  - Amendment of legal requirements, regulatory standards and guides in consideration of beyond design basis accidents (DEC)
    - Applicable References : IAEA NS-R-1(DEC), US EDMG, Lessons-learned from other countries
- Follow-up of lessons-learned from other countries
  - NRC TF Report
  - Japan National Reports
  - EU Stress Test Report
  - CANADA CNSC TF Report
- International cooperations for finding and sharing lessons-learned

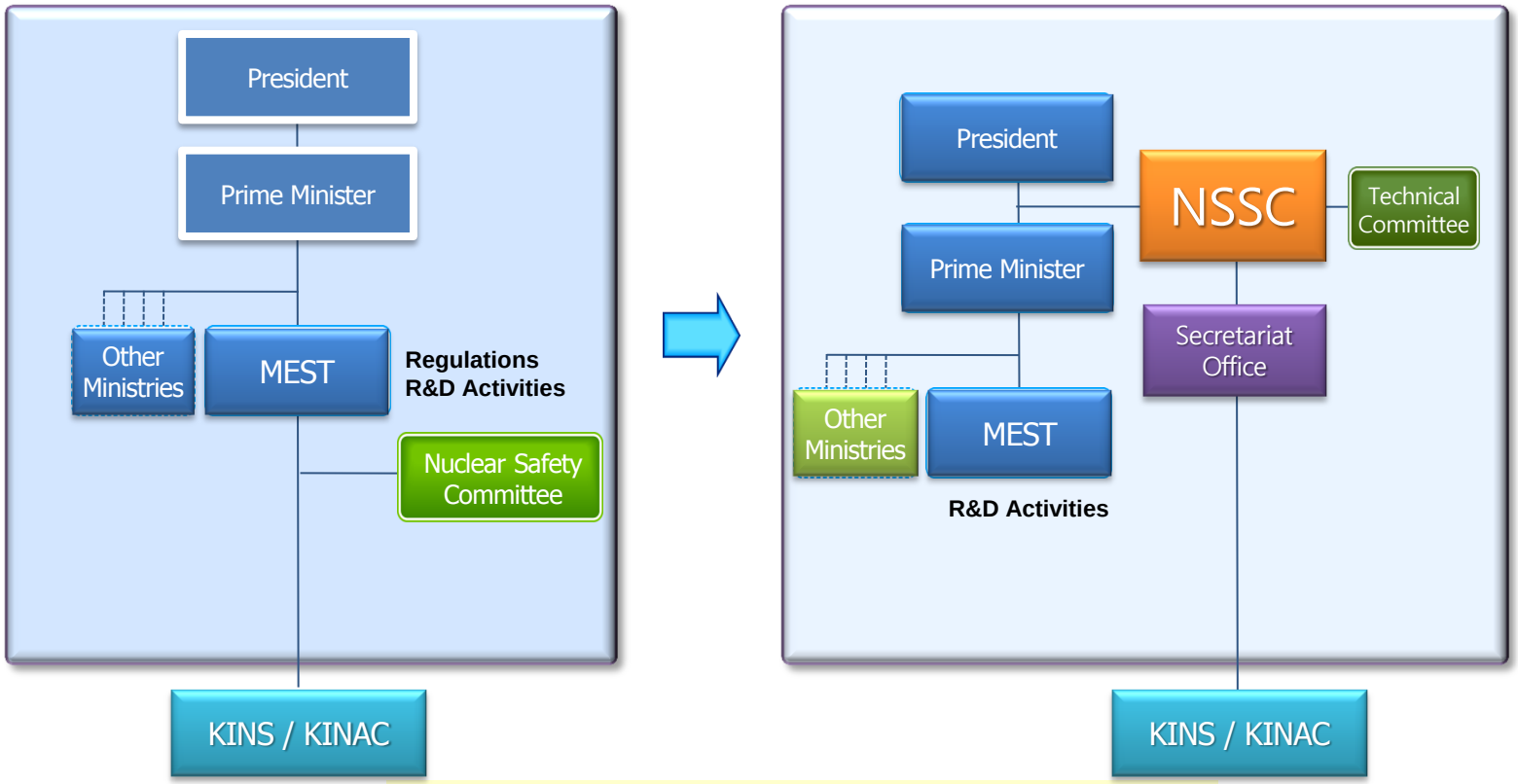
The Change of Regulatory Body

Establishment of NSSC (Nuclear safety and Security Commission)

- Jun. 2011, Bill to Establish NSSC, passed at the National Assembly
- Official launching on Oct. 26, 2011
- Independent, standalone government agency (Minister level)
- Responsible for nuclear safety, security and safeguards (3S)
- Reports directly to the President

Organizational Changes

- NSSC is a dedicated regulatory body, supported by KINS/KINAC
- MEST's role is now restricted to R&D activities



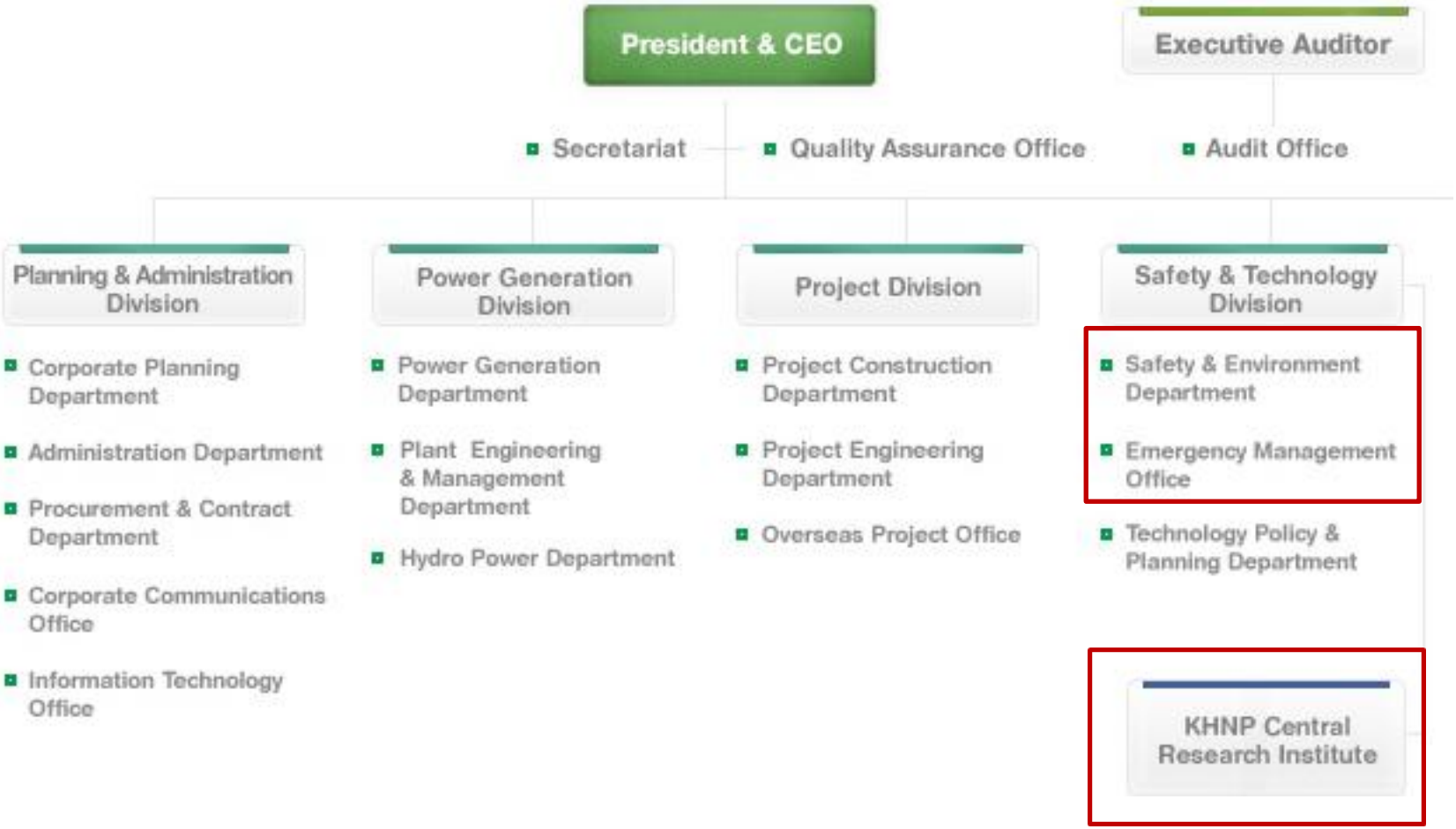
NSSC: Nuclear Safety and Security Commission
KINS: Korea Institute of Nuclear Safety
KINAC: Korea Institute of Nuclear Nonproliferation and Control

KHNP Organizational Change

- New organization established in KHNP HQ in Jun.2011
  - Safety & Environment Department
    → Post Fukushima Team
  - Emergency Management Office
    → Disaster & Industry Safety Team
    → Radiation Emergency Preparedness Team
    → Emergency Planning Officer

- KHNP Central Research Institute
  → Merge of existing research institutes in electric power company (Nuclear area) : Aug. 2011
  → Enhancing research and supports for F-S follow-up actions

Korean Utility(KHNP) Organization



Part-II

Issues for Discussion

Assessment of Safety Margin

- SSI Recommendations ← Defense-in-depth approach
  - ❖ Assumption of the defense failures (No consideration of frequency of scenarios)
    - (2-2) Installation of waterproof gates and discharge pumps
    - (3-1) Securing the availability of a portable electric power generator vehicle and batteries, etc.
    - (4-3) Installation of reactor injection flow paths for emergency cooling water injection from external sources .
    - (4-2) Installation of filtered vent system or depressurizing facilities in the containment buildings
- Some recommendations require margin analysis
  - (1-3) Investigation and study on the maximum potential earthquake for NPP sites
    - Conducting a comprehensive reassessment of the maximum potential earthquake at NPP sites (all plants)
  - (2-3) Investigation and study on the design basis sea water level of NPP sites
    - Investigation and study on the design basis sea water level with enough conservatism in input data that was used to evaluate and determine the existing design basis sea water level. (consideration of conservatism : simultaneous occurrence of seismic gaps, super typhoon, and so on.) (all plants)

Consideration of External Events

- Consequence of combined events(EQ+Tsu.) could bound expected combined initiating events
  - Regulatory position : Regardless of combined initiating events, both of prevention and mitigation defense of severe accidents must be secured
- Combined events (EQ or attack + Fire) should be considered in light of
  - availability of fire engines, water inventory, connections with other fire stations, simultaneous accidents in multi-units, Emergency plan..
- Several recommendations for fire protection made to support the reinforcement of firefighting team and its capability in site
  - (3-9) Improving the fire protection plan and reinforcing cooperation systems
    - Improving the fire protection plan, (i.e., establishing effective cooperation systems during fire mobilization, and measures for large fire, etc.) (all plants).
    - Reinforcing cooperation systems between the internal and external fire stations of the plant (all plants).
  - (3-10) Improving fire protection facilities and response capability of plant firefighting teams.
    - Securing alternative water sources, capable of having ties with the fire trucks, in preparation for lack of firefighting water sources in a plant due to tsunami (all plants).
    - Maintaining the minimum numbers of experts to operate chemical fire trucks (All plants).

Deterministic and Probabilistic approach

- PRA for external events in Korea (present)
  - Seismic PSA, Flooding and Fire PSA (Internally caused)
  - Combined initiating events(e.g, EQ+Fire)→ very unlikely (negligible)
- In SAR,
  - Airplane crash, Earthquake with high magnitude, Tsunami, other natural phenomena → negligible (< 1.0e-6/ry)
- Some recommendations to study
  - (1-3) Investigation and study on the maximum potential earthquake for NPP sites
    - Conducting a comprehensive reassessment of the maximum potential earthquake at NPP sites (all plants)
  - (2-3) Investigation and study on the design basis sea water level of NPP sites
    - Investigation and study on the design basis sea water level with enough conservatism in input data that was used to evaluate and determine the existing design basis sea water level. (consideration of conservatism : simultaneous occurrence of seismic gaps, super typhoon, and so on.) (all plants)

Transparency, public understanding

- KINS explained the SSI results to the residents and civil representatives of each plant site after SSI (May 27-Jun. 30)
- All records of committee/commission are publicized at the home pages(NSSC, KINS)
  - including utility's summarized progress reports, KINS review and inspection report, etc.
- **NSSC's Direction**

Review of Licensee's Reports

- Licensee's comprehensive implementation plan for SSI recommendations was already submitted to RB
  - 23 Short-term(until '12) & 23 Long-term actions (until '15)
  - Detailed schedule and items are under discussion with RB (almost done)
- Submission of progress report
  - Every 6 months to RB. The 1st submission is expected in Jan. 2012
- Regulatory Body
  - Set-up the detailed regulatory positions on each recommendations
    - Goals and intentions for recommendations must be met
  - Preparation of review guidelines and inspection guidelines if necessary
  - Regulatory researches for some new installations needed
  - Frequent meeting with licensee needed to discuss the scope, schedule, approach, and so on
  - ❖ Advantages of one licensee : consistency and flexibility, rapid decision making,..

Effect of Plant Conditions

- In Korea,
  - Operating Plants : 21 plants
    - CO license before Dec.2012 : 1 unit
  - Under construction : 7 plants
    - At the final stage of OL : 3 units (SKN-2, SWN-1/2)
    - At the beginning stage of FSAR (OL) : 2 units (SKN-3/4)
    - At the final stage of PSAR (CP) : 2 units (SUN-1/2)
  - All SSI recommendations must be applied to all plants
    - Implementation date is differently applied : operating/New/CO
    - Improvements required to meet the SSI goals and intentions even at the aged units.
    - Alternative methods are supposed to be allowable with justification
- Regular Regulations
  - PSR is a way to check periodically the aging effect and effectiveness of backfitting of F-S lessons-learned : Long-term base(10 years)
  - Periodic Regulatory Inspections : Short-term base (~18 Months)

Practicability of Emergency Measures

- No considerations for the simultaneous accident at multi-units in one site
- Emergency exercise focused on the evacuation of the residents
  - Impractical and perfunctory exercise to prevent and mitigate SA
- Some recommendations issued
  - (5-2) Amending the emergency plan to include such events as a simultaneous emergency at multiple units .
    - include emergency response organization that can be implemented at simultaneous natural disaster emergencies at multiple units.
  - (5-5) Reinforcing radiation emergency exercises.
    - Develop a practical scenario including natural disaster, such as earthquake and tsunami, and utilize for emergency exercise and further increasing emergency response capabilities through unannounced blind exercises. (applied to: all NPPs).

Attachment

The Results of Special Safety Inspection in Korea
(Inspection Areas & Recommendations)

1. Design of structures and equipment against earthquakes

< Inspection Areas >

- Seismic capacity of Seismic Category I structures and equipment
  - Maintenance of structures and equipment
  - Effect of design change or additionally installed facilities on the existing facilities
  - Adequacy of the anchorage of equipment, and the potential of interference between the major equipment and adjacent facilities
- Operability of the seismic monitoring system
  - Operability of the seismic monitoring and alarm system
  - Adequacy of the data input in the seismic monitoring system as shutdown criteria in the event of an earthquake
- Adequacy and feasibility of corresponding measures upon the occurrence of an earthquake
- Measures for securing extended margin against strong earthquakes exceeding the design earthquake (SSE)

Recommendations

- (1-1) Installing an automatic seismic trip system
  - Installing systems needed to automatically trip the plants when detecting an earthquake above a certain seismic level (0.18g) (applied to all plants)
- (1-2) Improving the seismic capacity of the safe shutdown systems
  - Upgrading the seismic capacity of the safe shutdown systems to the design earthquake level of advanced NPPs (0.3g) in preparation for an earthquake exceeding the design basis (all plants)
- (1-3) Investigation and study on the maximum potential earthquake for NPP sites
  - Conducting a comprehensive reassessment of the maximum potential earthquake at NPP sites (all plants)
- (1-4) Improving seismic capacity of facilities in the main control room (MCR)
  - Improving the seismic capacity of the seismic alarm window in the MCR (all plants)
  - Prevention of ceiling and lighting facility drop and fixing of office appliances to protect the operator in the MCR (applied to Kori Unit 1 to 4)
- (1-5) Improving the seismic capacity of the entrance bridge to the Wolsong site
  - Enhancing the seismic capacity of the entrance bridge near the back gate to the Wolsong site (applied to Wolsong Unit 1 to 4)

2. Design of structures and equipment against coastal flooding

<Inspection Areas>

- Adequacy of plant design against tsunami and storm surge
  - Adequacy of site elevation in preparation for coastal flooding (considering an earthquake, storm, etc.)
  - Resistant capability of safety-related structures against coastal flooding
  - Capability of the intake structure to provide sufficient cooling water under low water level
- Measures for securing enhanced margin against coastal flooding exceeding the design basis

Recommendations

- (2-1) Extension of the height of the sea wall for the Kori site
  - Extension of the sea wall height for the Kori site, whose freeboard is relatively low, to increase the height level equivalent to other sites (10m) (Kori site)
- (2-2) Installation of waterproof gates and discharge pumps
  - Installing seismically designed waterproof gates and waterproof discharge pumps in the structures containing emergency power systems and major safety systems for inundation protection. (including the inundation protection measures on penetrations such as ventilation louver or openings, etc.) (all plants)
- (2-3) Investigation and study on the design basis sea water level of NPP sites
  - Investigation and study on the design basis sea water level with enough conservatism in input data that was used to evaluate and determine the existing design basis sea water level. (consideration of conservatism : simultaneous occurrence of seismic gaps, super typhoon, and so on.) (all plants)
- (2-4) Enhancement of sea water intake capability and reinforcement of facilities in preparation for coastal flooding
  - Enhancement of intake capability of component cooling sea water pumps (rearranging the bell mouse location of the intake pumps and maintaining the minimum sea water level by installing a submerged dam), which should be based on the results of improvement item (2-3), (all plants)
  - Moving the warehouse keeping spare parts and replacements to a safe place that is away from inundation in the event of severe coastal flooding (Kori Units #1 and #2)

3. Integrity of electric power, cooling, and fire protection systems in inundation

<Inspection Areas>

- Adequacy of electric power systems against design basis earthquake and tsunami
  - EDG, AAC diesel generators, batteries, etc.
- Adequacy of cooling systems against design basis earthquake and tsunami
  - Nuclear service cooling water system, spent fuel pool cooling systems, etc.
- Measures to secure the functions of electric power systems against beyond design basis earthquakes and tsunamis
  - Adequacy of the restoration plans upon loss of power sources due to an earthquake
  - Restoration measures upon the inundation of emergency power sources and connected system, and battery capacity, etc.
  - Adequacy of the location of electric power supply connections that may be vulnerable to inundation
- Measures to secure the functions of cooling systems against beyond design basis earthquake and tsunami
  - Securing the function of the ultimate heat sink
  - Measures for the long-term loss of cooling functions of the spent fuel pool
  - Integrity of the cooling water sources installed outside and the storage tanks containing toxic substances
- Adequacy of the fire protection facilities and the emergency response capability of firefighting organization

Recommendations

<Electric Power Systems >

- (3-1) Securing the availability of a portable electric power generator vehicle and batteries, etc.
  - Equipping with one vehicle-mounted portable emergency power generator and batteries (including charger and cables) per site, and placing them in a safe location away from inundation to cope with the long-term SBO caused by site inundation. Securing temporary connections for portable electrical power sources (all plants)
- (3-2) Upgrading design basis of AAC diesel generator
  - Upgrading the AAC diesel generator's design basis (increasing capacity, diversifying its cooling methods, ensuring one-day fuel storage) (all plants)
- (3-3) Fastening the spare transformers with anchor bolts and modifying the fuel injection ports of emergency power supply systems
  - Fastening spare transformers with anchor bolts to prevent damage and / or floating away of spare transformers owing to a large earthquake or tsunami (all plants)
  - Repositioning the injection port of the fuel storage tank of the emergency power supply system (EPS) to a position higher than the ground surface in Wolsong site, where the injection port was originally installed in a position lower than the ground surface (Wolsong plants)
- (3-4) Improving the management of switchyard facilities
  - Clarifying the responsibility for managing switchyard facilities and establishing the procedure for quick restoration following the loss of offsite power through the cooperation of KEPCO. (all plants)

Recommendations

<Cooling Systems >

- (3-5) Ensuring countermeasures against loss of the spent fuel pool cooling function
  - Preparing a supplementary method of installing a connection point for supplying water by using a fire vehicle in preparation for loss of cooling pump and heat exchanger (all plants)
- (3-6) Preparing measures of the inundation prevention and restoration of the ultimate heat sink
  - Waterproofing of electrical components such as the motors and power cabinets of nuclear service cooling water (i.e. sea water) pumps to prevent damage from large storms and tsunami (all plants)
  - Securing spare parts for the motor and establishing restoration procedures for loss of function (all plants)
- (3-7) Preparing countermeasures for damage of outdoor tanks
  - Installing wall barriers to cope with potential damage to various cooling water tank and chemical substances tank caused by an earthquake and/or tsunami (all plants)
- (3-8) Preparing countermeasures for inundation of the main steam safety valve room and emergency water pump room
  - Preparing measures for the main steam safety valve room (Wolsong Units #2 to #4) and the emergency water pump room (Wolsong site), which are on the ground level and vulnerable from flooding and external damage (Wolsong site)

Recommendations

<Fire Protection >

- (3-9) Improving the fire protection plan and reinforcing cooperation systems
  - Improving the fire protection plan, (i.e., simplifying the requesting process for the support of external firefighting teams, improving access control, establishing effective cooperation systems during fire mobilization, and measures for large fire, etc.) (all plants).
  - Reinforcing cooperation systems between the internal and external fire stations of the plant, and reinforcing the firefighting capability of the adjacent 119 safety center and regional team (all plants).
- (3-10) Improving fire protection facilities and response capability of plant firefighting teams.
  - Securing alternative water sources, capable of having ties with the fire trucks, in preparation for lack of firefighting water sources in a plant due to tsunami (all plants).
  - Maintaining the minimum numbers of experts to operate chemical fire trucks owned by plant firefighting team (All plants).
- (3-11) Introducing a performance-based fire protection design.
  - Improving current fire protection design concept into performance–based design taking into account the plant characteristics for the optimization of fire suppression based on fire frequency and effects (all plants).

4. Countermeasures against severe accidents

<Inspection Area>

- Adequacy of facilities preventing and mitigating severe accidents
  - Hydrogen control, reactor coolant system depressurization and cooling capability, containment building depressurization capability, etc.
  - Equipment survivability of measuring instruments and devices under severe accident conditions.
- Adequacy of severe accidents strategies and accident management plans
  - Applicability and practicality of the SAMG
  - Management capability for severe accidents
- Adequacy of reactor cooling strategies in the event of SBO
  - Adequacy of strategies for feeding water to steam generators and a reactor core

Recommendations

- (4-1) Installation of passive hydrogen removal equipment
  - Installation of passive hydrogen removal equipment that can be operated without power supply (all plants except Kori unit #1).
  - Installation of on-line hydrogen monitoring system inside the containment buildings (applied to: Ulchin #1 / #2, Wolsong #1 to #4)
- (4-2) Installation of filtered vent system or depressurizing facilities in the containment buildings.
  - Installing filtered vent or depressurizing facilities to prevent the overpressure of a containment building during severe accidents (all plants).
- (4-3) Installation of reactor injection flow paths for emergency cooling water injection from external sources .
  - Installing primary and secondary injection flow paths in the primary and secondary systems for emergency cooling water injection in preparation for prolonged loss of cooling functions (all plants).

Recommendations (cont'd)

- (4-4) Reinforcing education and training for severe accidents
  - Reinforcing the operator training of SAMGs with tools simulating various severe accident scenarios and phenomena. Extension of the training time from 8 hours per two years to 10 hours per year (all plants).
- (4-5) Revision of the Severe Accident Management Guidelines to enhance effectiveness
  - Assessment of the validity and applicability of In-Vessel Retention / Excore Reactor Vessel Cooling strategy with revision of mitigation guidelines if necessary (all plants)
  - Assessment of equipment survivability with consideration of long-term SBO events, and development of procedure to supply power in case of severe accidents. (all plants).
- (4-6) Development of Low-Power Shutdown Severe Accident Management Guidelines
  - Developing the "Low-Power Shutdown Severe Accident Management Guidelines" through assessing low-power shutdown severe accident risks (all plants).

5. Emergency Response

<Inspection Areas>

- Emergency plan related to emergency action level, procedure and organization
  - Whether the plan adequately secures the criteria and procedure for declaring an emergency, organizing emergency organization, activating emergency organization, and securing the command and control system.
  - Whether the management criteria for emergency recovery workers and the number of radiation protection workers are appropriate.
- Emergency response facilities and equipment
  - Emergency response facilities of the NPP and the local government.
  - Emergency alarm facilities in and outside of the station.
  - Securing the status of protective appliances such as protective clothing and radiation monitors.

5. Emergency Response

<Inspection Areas>

- Operating status of systems for protecting residents in case of an emergency
  - SPDS and environmental radiation monitor
  - Cooperation with environmental radiation-monitoring center in case of site area emergency or general emergency.
  - Need for the additional installation of environmental radiation monitors.
  - Information disclosure procedure.
- Emergency medical systems
  - On-site response manual for emergency patients.
  - Contents of training course for emergency personnel and training records, maintenance records for response facilities, equipment, goods, and medicine for emergency responses.
- Exercise for confirming emergency response ability
  - Status of conducting exercise such as scenarios and records of exercise

Recommendations

- (5-1) Securing additional radiation protection equipment for protecting residents near the NPP .
  - Securing additional potassium iodide (KI), an increase from 120,000 portions to 500,000 portions and gas masks from 60,000 EA to 480,000 EA for protecting residents near NPPs in preparation for large accidents (applied to: all NPPs).
  - ※ (Securing basis) Increasing the population basis from residents within 10km around an NPP to population within 16km around an NPP.
- (5-2) Amending the emergency plan to include such events as a simultaneous emergency at multiple units .
  - - include emergency response organization that can be implemented at simultaneous natural disaster emergencies at multiple units.
- (5-3) Securing additional protective equipment in preparation for a prolonged emergency
  - Securing additional protection equipment such as protective clothing and gas mask filters at more than 200% of the current inventory and storing them in a secure place that will not flood (applied to: all NPPs).
- (5-5) Reinforcing radiation emergency exercises.
  - Develop a practical scenario including natural disaster, such as earthquake and tsunami, and utilize for emergency exercise and further increasing emergency response capabilities through unannounced blind exercises. (applied to: all NPPs).

Recommendations (cont'd)

- (5-6) Devising a means for securing necessary information in the event that there is a prolonged loss of electrical power.
  - Reinforcing the electrical power equipment of CFMS and SPDS to provide the necessary safety variables of the power plant as needed to protect residents (applied to: all NPPs).
  - Establishing inundation prevention measures for environment monitors near nuclear power plants in case of major tsunami and securing additional emergency electrical power in preparation for prolonged loss of electrical power (applied to: all NPPs).
- (5-7) Securing countermeasures for protecting maintenance workers.
  - amend the emergency plan to include the maintenance workers from KPS in the emergency organization so the workers can attend emergency prepared education and emergency exercises. (applied to: all NPPs).
  - Preparing standardized procedures (deciding on urgent radiation work and approval procedures) so that there is no confusion in protecting the workers who are performing urgent radiation work (applied to: all NPPs).
- (5-8) Improving the emergency response facilities.
  - Improve the seismic capacity of TSC and OSC (applied to: Kori NPP) and anti-inundation ability (applied to: Kori NPP,Yonggwang Units #1, #2) in preparation for tsunami and earthquakes that exceed site elevation.
  - Secure the proper area for TSC and OSC (applied to: Kori NPP, Ulchin Units #1, #2, Wolsong NPP) and emergency electrical power (applied to: all NPPs).

Recommendations (cont'd)

- (5-9) Amending the information disclosure procedure in the event of a radiation emergency.
  - Amend the radiation emergency plan and its related manual (risk response manual) so that concrete information (real-time information disclosure list, radiation contamination, and a guide to protecting residents) and the period of information disclosure provided to the press, people, and residents are included (applied to: all NPPs).
- (5-10) Evaluating protective measures for residents who live beyond the emergency plan zone.
  - Evaluate protective measures for residents, who live outside the emergency plan zone (EPZ), considering the simultaneous emergency at multiple units (applied to: all NPPs).
- (5-11) Reinforcing the performance of emergency alarm facilities
  - Securing emergency electrical power for the alarm facilities that have been installed in order to protect staff and residents who reside within 2km of the power plant in preparation for natural hazards that go beyond the design basis (applied to: all NPPs).

Long-Term In-service Plants

<Inspection Area>

- Adequacy of the aging management program.
- Monitoring the aging of the reactor vessel, steam generator, safety-related piping and support, and emergency diesel generator
- Adequacy of in-service management for the active equipment (pumps and valves)
- Utility's activity of quality assurance for major scram-inducing components
- Human factor management

Recommendations

- (6-1) Reinforcing regulatory safety inspections
  - Establishing and implementing mitigation measures and management plans for aging, and verifying adequacy during periodic inspections (Kori #1 to #4, Yonggwang #1 & #2, Ulchin #1 & #2, and Wolsong #1).
  - Adding new inspection items such as "monitoring the lifetime of the main components" that are related to the continued operation to the existing periodic inspection items. If necessary, extending the inspection period (Kori #1).
- (6-2) Reinforcing the in-service inspection of the main components and pipes.
  - Reducing the inspection period of the reactor vessel beltline welds (from 10 years to 5 years) (Kori #1).
  - Expanding the in-service inspection scope for class-1 piping (from 25% to 50%). (Kori #1)
- (6-3) Establishing and implementing an integrated aging management program
  - Establishing and implementing an integrated aging management program including processes of establishment, revision, and implementation (Kori Unit #1).
  - Installing a dedicated organization in charge of the aging management program (Kori Unit #1).
- (6-4) Reinforcing the management of the performance parameters of the main active components
  - Analyzing the trend of performance parameters of safety-related pumps and valves (Kori #1 & #2, Ulchin #1 & #2, Yonggwang #1 & #2, Wolsong #1 to #4).

Recommendations(cont'd)

- (6-5) Installing a fatigue monitoring system to reinforce quantitative fatigue management
  - Installing a fatigue monitoring system in long-term in-service plants, and reinforcing quantitative fatigue management (Kori #2, #3, #4, Yonggwang #1 & #2, Ulchin #1 &#2).
- (6-6) Reinforcing the integrity of the pressurizer lower head.
  - Reinforcing the fatigue integrity of the pressurizer lower head, which is caused by reactor coolant's inflow and outflow (Kori #2, #3, #4, Yonggwang #1 & #2, Ulchin #1 & #2).
- (6-7) Increasing the reliability of shutdown-inducing equipment.
  - Reflecting past fault experience and the root causes for faults to the preventive maintenance program to increase the reliability of shutdown-inducing equipment (all NPPs).
  - Reinforcing education and training for workers in the service companies and subcontractors to prevent human errors and to secure maintenance service quality, (all NPPs).
- (6-8) Evaluating the adequacy of human resources
  - Securing proper human resource at site for operation and maintenance (Kori Units #1, #2).
- (6-9) Increase the reliability of on-site power supply system.
  - Modifying the design of electrical bus system to separate the safety bus from non-safety bus for preventing the interference of non-safe bus.(Kori Unit #1)
- (6-10) Reinforcing the quality assurance on purchasing components important to safety
  - Reinforcing the quality requirements in the purchase specification is to avoid using defective parts that could induce the reactor shutdown (all plants)

Thanks for your Attentions