

East-Asian Nuclear Energy Forum

Safety Improvement in Korea :
Korean Approach for Post-Fukushima
Follow-up Measures

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I. Nuclear Energy in Korea



- **Currently 23 operating commercial nuclear reactors in Korea**
- **About 31% of the national total electricity supply by nuclear power generation**
- **Almost 70% of Korean support nuclear energy even though the Fukushima accident has occurred.**
 - ✓ 2011, 62.4% -> 2012, 67.8%
- **However Korean public admit the necessity of nuclear energy, still it is required to reduce the nuclear risk through safety technology development and software upgrade.**

II. Characteristics of Accident

An illustration of a nuclear power plant with several containment domes and buildings, set against a blue sky with birds flying.

- ❖ **First Severe Accident caused by External Event (Extreme Natural Hazard)**
 - TMI and Chernobyl : Internal Event + Human Factor
 - Fukushima initiated by Tsunami over Design Base

- ❖ **Severe Accident in Multi-Unit under Long-term Duration**
 - Hydrogen Explosion at Unit 1, 3 & 4
 - Core Melt and Containment Failure at Unit 1, 2 & 3
 - Safety Issues at Spent Fuel Pool

- ❖ **Large Release of Radioactive Material and Contamination of Atmosphere, Land and Sea**
 - Approximately 10~20% of Radioactive Material Release Chernobyl
 - No Casualty, But Severe Contamination

III. Lessons Learned



- **Strengthening the Defense in Depth**
- **Consideration of casualties, environment pollution, economical and social crisis for Nuclear Safety Objectives**
- **Re-organizing and harmonization of standards for radiological safety and emergency evacuation with international standards**
- **Strong Regulatory and Industrial Infrastructure**
 - ✓ Independence and competence of regulatory body
 - ✓ Competent operating organization with the best practices

III. Lessons Learned



- **Prevention of Severe Accidents**
 - ✓ Countermeasures against extreme natural conditions
 - ✓ Strengthening of redundancy and reliability of power supply systems
 - ✓ Enhancement of passive safety for reliability of decay heat removal
 - ✓ Re-assessment and strengthening of spent fuel storage facility safety characteristics

- **Mitigation of Severe Accidents**
 - ✓ Securing of realistic capabilities for various severe accidents
 - ✓ Improvement of accident management procedures in consideration of extreme events
 - ✓ Enhancement of plant monitoring systems for accident management

III. Lessons Learned

A stylized illustration of a nuclear power plant with several containment domes and buildings, set against a blue sky with white clouds and a few birds flying. The illustration is positioned at the top right of the slide, partially overlapping the title area.

▪ Emergency Response

- ✓ Enhancement of emergency response system for external events
- ✓ Cultivation of emergency response facilities for worsen condition with accident consequence
- ✓ Radiation monitoring and evaluation of radioactivity release
- ✓ Enhancement of communication systems for emergency
- ✓ Ensuring the information of neighboring country's nuclear power plants and evaluation of accident effects

▪ Safety Culture

- ✓ Independent evaluation and practice of safety culture
- ✓ Boosting up nuclear safety research and benefit sharing
- ✓ Improvement of understanding for radiological effects

III. Lessons Learned

❖ Comprehensive safety review

- Fukushima Daiichi Accident has caused Korean government and nuclear industry to perform a comprehensive safety review of nuclear power plant against an exceptional natural disaster
- Based on the review, safety improvements beyond the design basis of the plants have been identified
- Design Bases Extension are reviewed and expected to be implemented in limited issues.

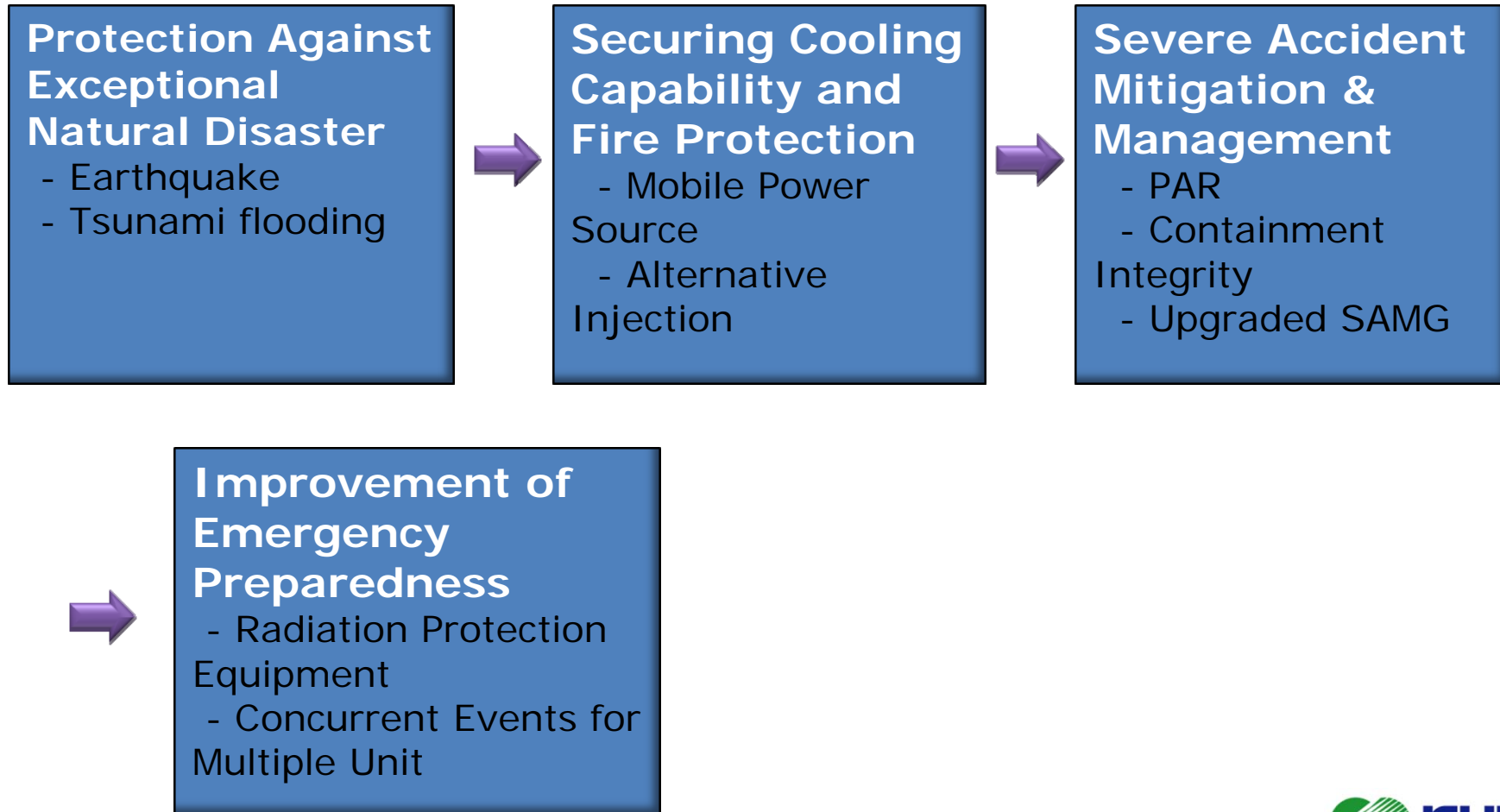
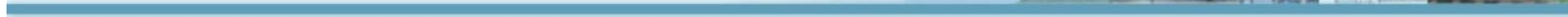
III. Lessons Learned



❖ Expected Extension of Design Basis in Future

Design Basis Regulatory Requirements	Beyond-Design Basis Regulatory Requirements	Beyond-Design Basis Fukushima Daiichi Events
<ul style="list-style-type: none"> • Design Basis Events: Anticipated Operating Postulated Accidents • External Challenges: Earthquake, Flooding 	<ul style="list-style-type: none"> • Anticipated Transient Without Scram (ATWS): 10 CFR 50.62 • Station Blackout(SBO): 10 CFR 50.63 	<ul style="list-style-type: none"> • Earthquake (9.0) vs Design (8.2) • Concurrent Tsunami Wave vs Design • Prolonged SBO • Multiunit Events

IV. Safety Improvement Approach



IV. Safety Improvement Approach



- ❖ Protection Against Exceptional Natural Disaster
 - **Design of Structures and Equipment Against Earthquakes**
 - ✓ Reassessment of maximum potential earthquakes for nuclear plant sites
 - ✓ Installing an automatic seismic trip system
 - ✓ Improving the seismic capacity of the safe shutdown systems
 - ✓ Improving seismic capacity of equipment in main control rooms
 - ✓ Improving the seismic capacity of the entrance bridge to the Wolsong site
 - **Design of Structures and Equipment Against Coastal Flooding**
 - ✓ Investigation and study on the design basis sea water level of NPP sites
 - ✓ Extension of the height of the sea wall for the Kori site
 - ✓ Installation of waterproof gates and discharge pumps
 - ✓ Enhancement of sea water intake capability and reinforcement of facilities in preparation for coastal flooding

IV. Safety Improvement Approach



- ❖ **Securing Cooling Capability and Fire Protection**
 - **Securing availability of Mobile electric power generator vehicles and batteries, etc.**
 - **Upgrading design basis of AAC diesel generators**
 - **Fastening spare transformers with anchor bolts and modifying fuel injection ports of emergency power supply systems**
 - **Improving management of switchyard facilities**
 - **Ensuring countermeasures against loss of spent fuel pool cooling function**
 - **Developing measures for inundation prevention and restoration of ultimate heat sinks**
 - **Developing measures to prevent damage of outdoor tanks**
 - **Developing measures to prevent inundation of the main steam safety valve room and emergency feed water pump room**
 - **Improving fire protection plan and reinforcing cooperation**
 - **Improving fire protection facilities and response capability of plant fire fighting teams**
 - **Introducing performance-based fire protection design**

IV. Safety Improvement Approach



- ❖ Severe Accident Mitigation & Management
 - Installation of passive hydrogen removal equipment
 - Installation of filtered vent systems or depressurizing facilities in containment buildings
 - Installation of reactor injection flow paths for emergency cooling from external sources
 - Reinforcing education and training for severe accidents
 - Revision of Severe Accident Management Guidelines to enhance effectiveness
 - Development of low-power and shutdown Severe Accident Management Guidelines

IV. Safety Improvement Approach



- ❖ Improvement of Emergency Preparedness
 - Securing additional radiation protection equipment for residents near nuclear power plants
 - Amending emergency plans to address concurrent events at multiple units
 - Securing additional protective equipment in preparation for a prolonged emergency
 - Securing additional equipment for emergency medical institutes
 - Reinforcing radiation emergency exercises
 - Devising a means for securing necessary information in the event of a prolonged loss of electrical power
 - Securing countermeasures for protecting maintenance workers during emergency
 - Improving emergency response facilities
 - Amending information disclosure procedures for radiological emergency
 - Evaluating protective measures for residents beyond the emergency planning zone
 - Reinforcing performance of emergency alarm facilities

IV. Safety Improvement Approach



❖ Additional Improvements

- SFP instrumentation (level, temperature, radiation) to safety class
- Emergency communication tools (satellite phone, transceiver)
- Extensive damage mitigation guidelines, etc.
- Stress Test
 - * Bases for additional improvement
 - ✓ IAEA : The Great East Japan Earthquake Expert Mission('11.6)
 - ✓ Japanese Gov. : The Accident at Fukushima Nuclear Power Stations('11.6)
 - ✓ NRC(US) : The Task Force Review of the Fukushima Accident('11.7)
 - ✓ ASN(France) : Report by the French Nuclear Safety Authority('11.12)

IV. Safety Improvement Approach



❖ Status of Follow-up Measures(1/4)

▪ **Passive Autocatalytic Hydrogen Recombiner (PAR)**

- ✓ PARs have been installed in Kori 1 and some Korean NPP.
- ✓ PARs will be installed in all Korean NPPs within 2015.

▪ **Containment Integrity**

- ✓ Installation of containment venting or long-term depressurization system will be reviewed by 2012.
- ✓ Installed at Wolsung #1 : Containment Filtered Vent

IV. Safety Improvement Approach



❖ Status of Follow-up Measures(2/4)

▪ **Automatic Seismic Trip System (ASTS)**

- ✓ ASTS have been installed in Yongkwang #2 and Kori #4 and will be installed in all NPPs in 2013.

▪ **Extension of the height of the sea wall for Kori site**

- ✓ Wall design was completed in Oct and was installed in 2012.

IV. Safety Improvement Approach



❖ Status of Follow-up Measures(3/4)

▪ **Loss of Spent Fuel Pool Cooling Function**

- ✓ Procedure to fill the spent fuel pool up was revised in July 2011 and the connector to fire pump was installed in 2011.

▪ **Securing Availability of Mobile Electric Power Generator**

- ✓ Basic calculation to decide capacity of electric power has been performed Sep. 2011 and technical specification of procurement was written in 2012.

IV. Safety Improvement Approach



❖ Status of Follow-up Measures(4/4)

▪ **Installation of Water Proof Gates and Discharge Pumps**

- ✓ Design change contract for the areas of EDG, ACC building was issued in Oct. 2011.
- ✓ Installed at Wolsung #1

▪ **Ensuring Countermeasures Against Loss of Spent Fuel Pool Cooling Function**

- ✓ Design change contract to fill SFP up using fire pumps was issued in Oct. 2011.

V. Recommendation & conclusion



❖ Post-Fukushima Safety Enhancement

- Opportunity of escaping for overconfidence on nuclear safety
- Enhancement of reliability for nuclear facilities and response for external events(natural and artificial disaster)
 - ✓ Consideration of very low-likelihood natural events in design
 - ✓ Enhancement of response for prolonged AC power loss
- Enhancement of severe accident response
 - ✓ Reinforcement instrumentation capabilities of NPPs for severe accident
 - ✓ Severe accident mitigation features including hydrogen control
 - ✓ Consideration of severe accident in procedures and operator training
 - ✓ Strengthening emergency response capability against the worst scenarios
- Open nuclear safety information and enhancement communication systems

Severe accident-free 100 years with the proactive safety enhancement based on Fukushima Lessons

V. Recommendation & conclusion



❖ Recommendations for improvement nuclear safety (1)

(from Korea Nuclear Society Committee on Fukushima Accident)

- Positive promoting for enhancement of nuclear safety on operation NPPs including Post-Fukushima action
 - ✓ Open the progress of work, detailed analysis on the effect, continuous reflection of additional lessons learned etc.
- Enhancement of the role of regulatory body
 - ✓ Ensuring independence, world class professionalism and international leadership
- Development of unique safety philosophy, objective, principles and standards with the harmonization of international standards
- Strengthening the leading role of operating organization on the nuclear safety
 - ✓ Proactive action for safety, reinforcement of operating organization and ensuring of world class safety specialists

V. Recommendation & conclusion



❖ Recommendations for improvement nuclear safety (2)

(from Korea Nuclear Society Committee on Fukushima Accident)

- Development of advanced reactor based on the recent researches and Fukushima accident lessons
 - ✓ Passive safety, Enhancement of severe accident response, seismic structure, safety + security + physical protection
- Enhancement of nuclear reactor safety research and knowledge based Decision making
- Cultivation of safety culture
 - ✓ Firm will and concern of the top management , practical system
- Expansion of risk-informed plant operation and development
 - ✓ Risk-informed design, operation, maintenance ; Comprehensive consideration on internal, external elements
- International cooperation of nuclear safety with effectiveness
 - ✓ OECE/NEA, IAEA, Post-Fukushima action

V. Recommendation & conclusion



❖ Future Plan

- **Complete Post-Fukushima Follow-up Measures**
- **Harmonization for Post-Fukushima Safety Enhancements**
 - ✓ IAEA
 - ✓ Europe & Japan Stress Tests
 - ✓ Industry/Vendor - INPO, EPRI, etc
 - ✓ Regulatory Agency – NRC, KINS, etc
 - ✓ Laboratories, Universities
- **Development Passive/Innovative Safety Feature in Future**



Thank you!