

Lessons Learned and Challenges for Nuclear Power in South Korea after Fukushima Nuclear Disaster

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Workshop "What Fukushima nuclear disaster brought about in Asia?"

The University of Tokyo, Tokyo, Japan

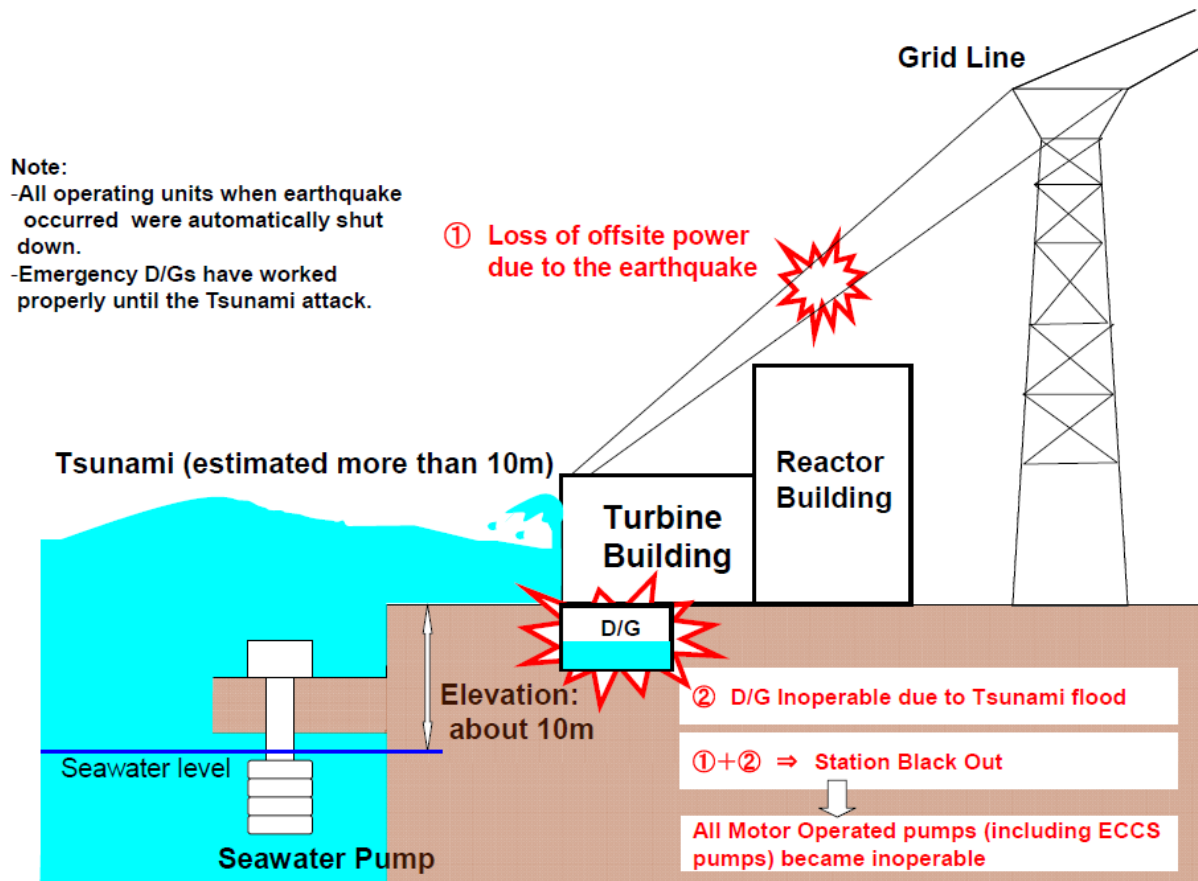
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Contents

- Fukushima Accident
- Lessons Learned from Fukushima Accident
- Status and Prospect of Nuclear Power in South Korea
- Actions Taken in South Korea after Fukushima Accidents
- Challenges of Nuclear Power in South Korea
- Conclusions

Fukushima Accident

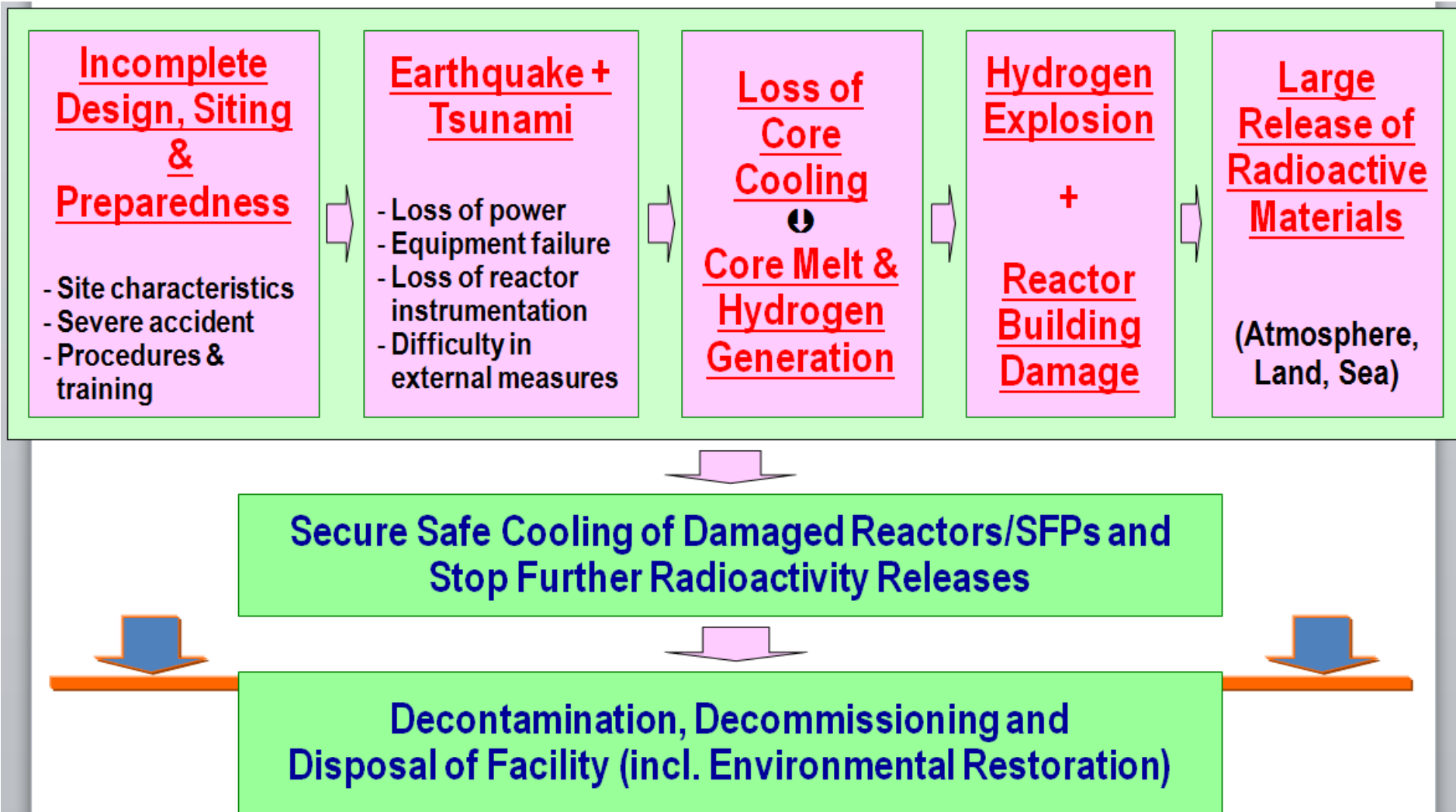
- East Japan Earthquake and Tsunami
 - 3/11/2011, 14:46, Magnitude 9.0, Tsunami Height > 14m
- Initiation of the Accident



(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Fukushima Accident (cont)

Progress of the Accident



(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Fukushima Accident (cont)

- Key Characteristics of the Accident
 - Severe Accident Initiated by an Extreme Natural Disaster
 - TMI & Chernobyl: Design/equipment failure + human factors
 - Fukushima: Natural disaster+ siting/design/equipment failure + human factors
 - Prolonged losses in electricity supply & safety-related equipment due to earthquake/tsunami
 - Severe Accident in Multiple Units and for a Long Time
 - Extensive core melting in three (3) reactors
 - Large-scale hydrogen explosion in three (3) reactor buildings
 - Damage in reactor vessels and primary containment vessels
 - Threat to the integrity of spent fuels in SFPs
 - Several months in escaping from very urgent situation
 - Environmental Contamination and Societal Crisis due to Large Release of Radioactive Materials
 - Large radioactivity release: ~20% of Chernobyl, INES Level 7
 - No immediate casualty due to radiation exposure
 - Extensive contamination, large no. of evacuees, several decades for restoration → societal crisis and enormous economic impact

Lessons Learned from Fukushima Accident

- Lessons - Safety Approaches and Systems
 - Improvement and strengthening of defense in depth strategy
 - Consideration of societal crisis aspects in nuclear safety objectives
 - Further improvements of regulation and standards for radiation safety and emergency evacuation
 - Strengthened independence & expertise of regulatory bodies
 - Emphasized role and enhanced capability of operating organizations in assuring NPP safety

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Lessons Learned from Fukushima Accident (cont)

- Lessons - Prevention of Severe Accidents
 - Enhanced capability against natural disasters
 - Improvements in diversity & reliability of emergency power supply systems
 - Reliable decay heat removal by strengthened passive safety
 - Risk informed design and operation of NPPs
 - Reassessment & enhancement of the safety of spent fuel storage

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Lessons Learned from Fukushima Accident (cont)

- Lessons - Mitigation of Severe Accidents
 - Practical countermeasures against severe accidents
 - Improvement of NPP procedures, covering up to extreme severe accident scenarios: Imagine the unimaginable
 - Enhancement of NPP instrumentation to provide reliable information during accidents
 - Role of creative experts for events outside the scope of existing procedures

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Lessons Learned from Fukushima Accident (cont)

- Lessons - Emergency Response Systems
 - Strengthening of emergency response system against large-scale accidents
 - Reinforcement of emergency response facilities incorporating deteriorated conditions
 - Reliable monitoring & assessment of radiation & radioactivity
 - Enhanced medical systems for radiation emergency
 - Exposure management of emergency workers
 - Crisis communication
 - Preparedness for accidents at neighboring countries

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Lessons Learned from Fukushima Accident (cont)

- Lessons - Other Aspects
 - Strengthening of safety culture, including an independent assessment system
 - Effective nuclear safety research and sharing of research outputs
 - Efforts to enhance public understanding on radiations and their effects

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Lessons Learned from Fukushima Accident (cont)

- Fukushima Accident Asks Us:
 - To Escape from Self Satisfaction or Over-Confidence on NPP Safety
 - To Strengthen Countermeasures against External Events as well as Internal Equipment Failures
 - Consider very low-likelihood natural events in design
 - Prepare against prolonged loss of AC power
 - To Strengthen Countermeasures against Severe Accidents
 - Reliable measurement of plant parameters even for severe accidents
 - Severe accident mitigation features including hydrogen control
 - Consideration of severe accident in procedures and operator training
 - Emergency planning and exercise against worst scenarios
 - To Strengthen the Communication of Safety Information

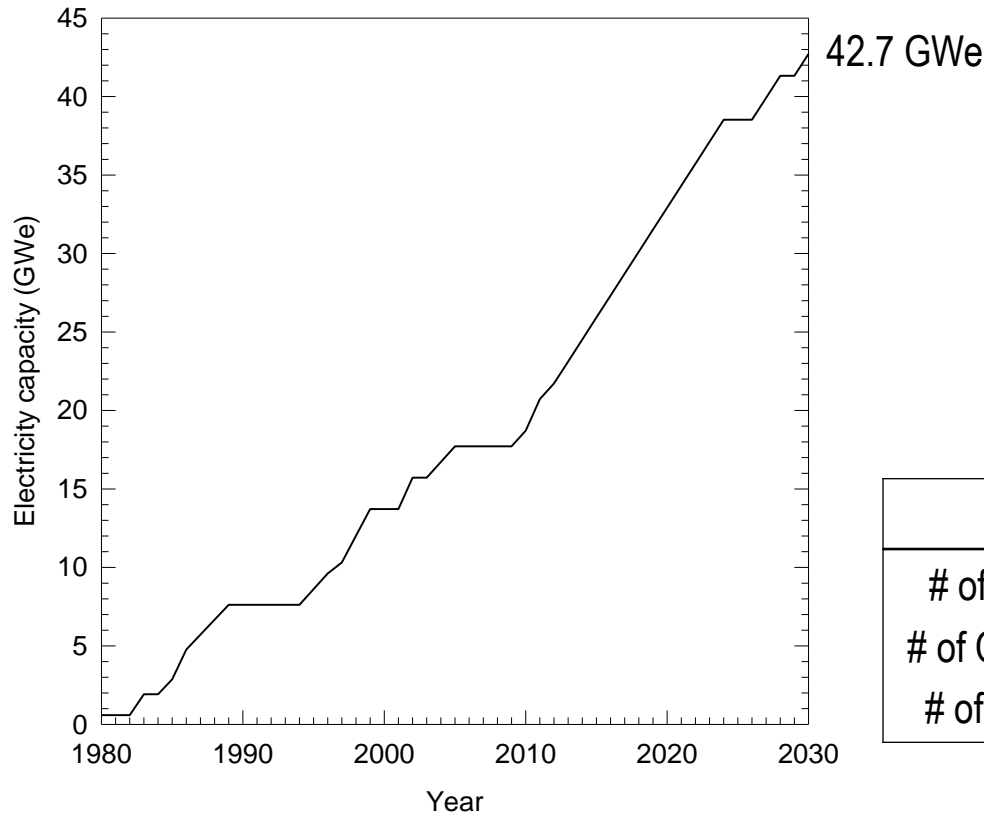
(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Status and Prospect of Nuclear Power in South Korea



(Quoted from material by Hoon-Pyo Hong, MEST, January 2013)

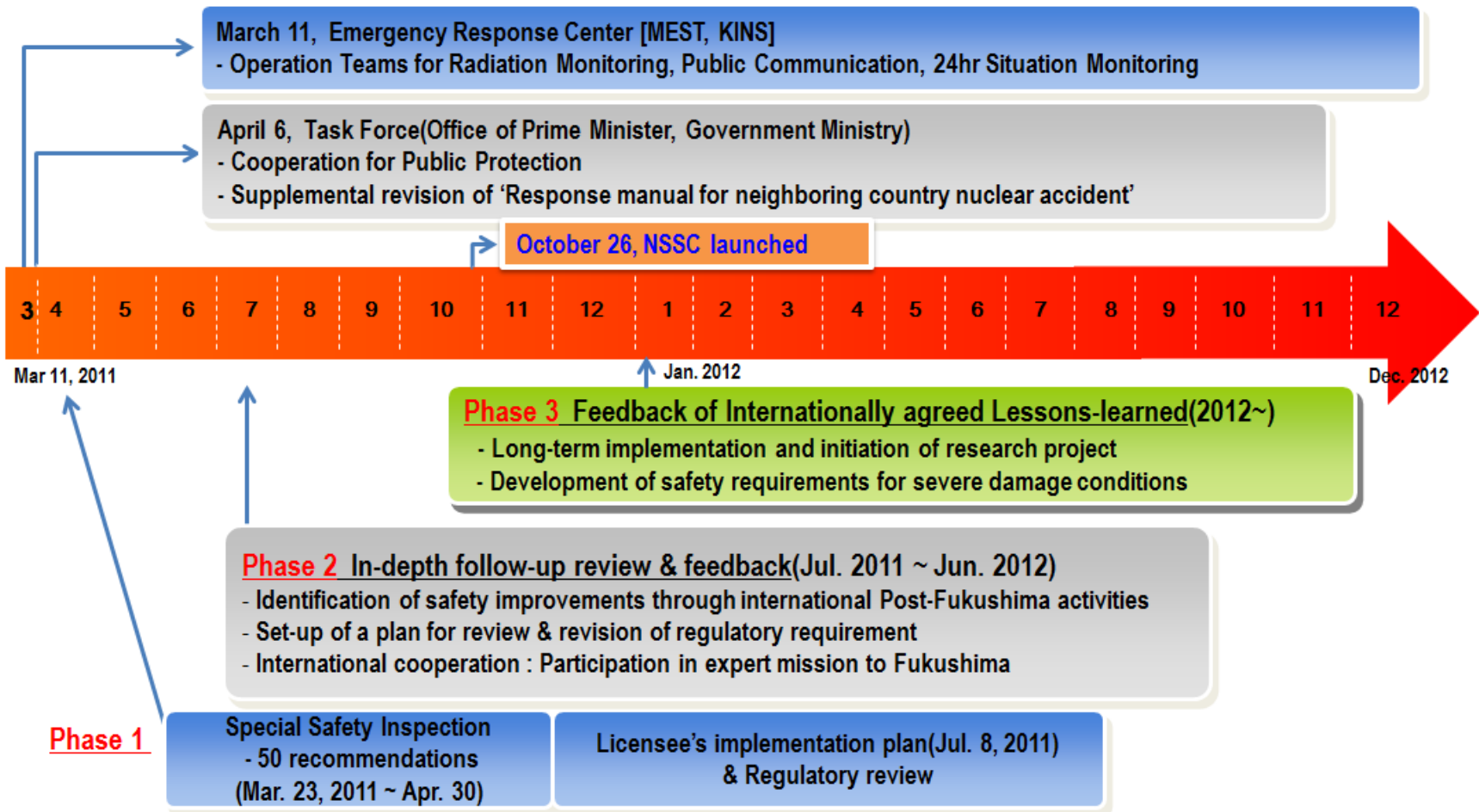
Status and Prospect of Nuclear Power in South Korea (cont)



	2012	2020	2030
# of PWR (GWe)	19 (18.9)	27 (28.7)	35 (39.9)
# of CANDU (GWe)	4 (2.8)	4 (2.8)	4 (2.8)
# of NPPs (GWe)	23 (21.7)	31 (31.5)	39 (42.7)

Figure. Installed nuclear capacity in South Korea (1980-2030)

Actions Taken in South Korea after Fukushima Accidents



(Quoted from material by Chang-Sun Kang of NSSC, April 2012)

Actions Taken in South Korea after Fukushima Accidents (cont)

- Identification of Vulnerability and Safety Improvements
 - Special Safety Inspection (SSI) on NPPs (2011.3-4)
 - Determine Safety Improvements vs. Fukushima (2011.5-7)
- Strengthened Regulatory System
 - IAEA Integrated Regulatory Review Service (IRRS) Review Mission including Post-Fukushima Actions (2011.7)
 - Establishment of Nuclear Safety and Security Commission (NSSC) (2011.10)
 - Refinement of Safety Inspection System (2012.4)
- Public Outreach and International Cooperation
 - Strengthening Environmental Radiation Monitoring
 - Daily Briefing at Press Conference and Web-pages
 - Cooperation with Neighboring Countries
 - Korea-Japan-China Cooperation, including Top Regulators' Meeting (TRM)

Actions Taken in South Korea after Fukushima Accidents (cont)

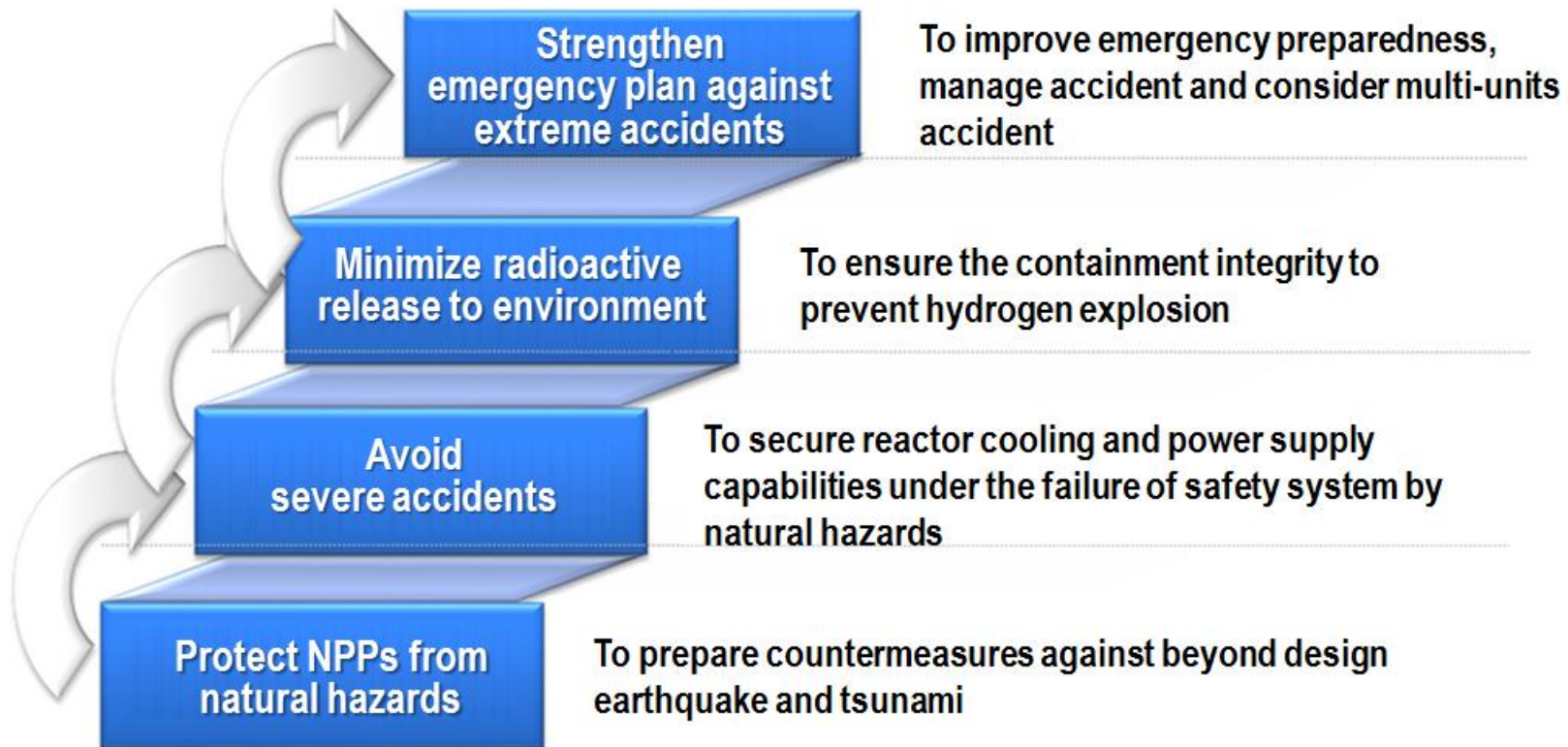
- Special Safety Inspection (SSI) by Regulatory Body
 - March 23 ~ April 30, 2011; 73 Experts
 - 21 Operating NPPs, 1 Research Reactor, and Emergency Medical System
 - Main Focus on Unlikely Worst Case Scenarios, including
 - Extreme natural disaster (earthquake + tsunami)
 - Loss of off-site power and failure of emergency DGs (SBO)
 - Severe accident
- Objectives
 - How well are the NPPs designed against natural disasters ?
 - How well can they mitigate the severe accident ?
 - How much effective are the emergency response systems in place ?

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Actions Taken in South Korea after Fukushima Accidents (cont)

- Approaches of SSI

Defense-in-Depth Actions to secure safety of NPPs against extreme natural hazards



(Quoted from material by Chang-Sun Kang of NSSC, April 2012)

Actions Taken in South Korea after Fukushima Accidents (cont)

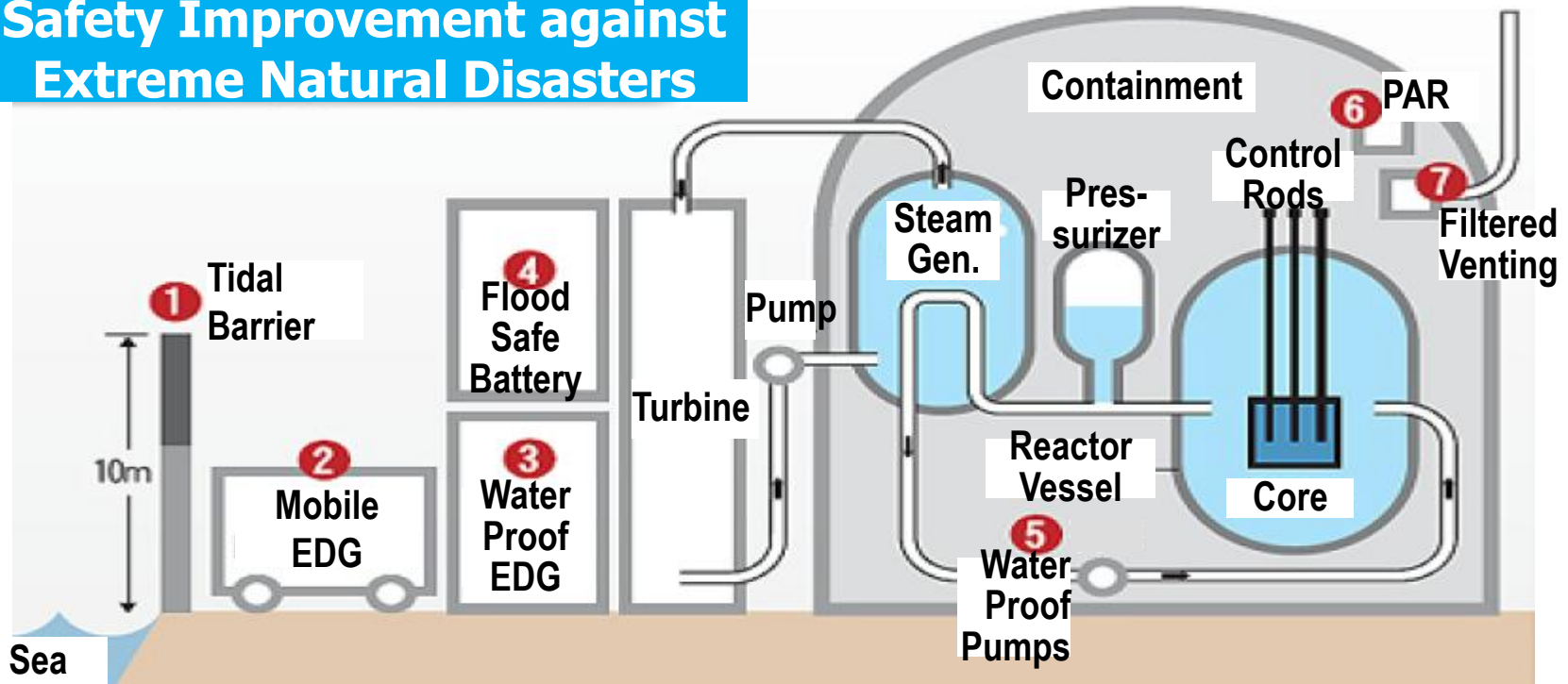
- Outcomes of the SSI
 - No Imminent Risks to Operating Nuclear Facilities
 - 50 Action Items to Further Strengthen Defense in Depth
 - To minimize the impact of extreme natural disaster
 - To make available emergency power and ultimate heat sink
 - To ensure containment building integrity and emergency response capability
 - Examples of Action Items
 - Re-evaluation of seismic capability of safe shutdown system
 - Installation of a mobile emergency generator and battery
 - Installation of passive hydrogen removal equipment
 - Modification of 'radiological emergency plan' considering multiple emergency, etc.

(Quoted from material by Won-Pil Baek of KAERI, January 2013)

Actions Taken in South Korea after Fukushima Accidents (cont)

- Major Improvement

Safety Improvement against Extreme Natural Disasters

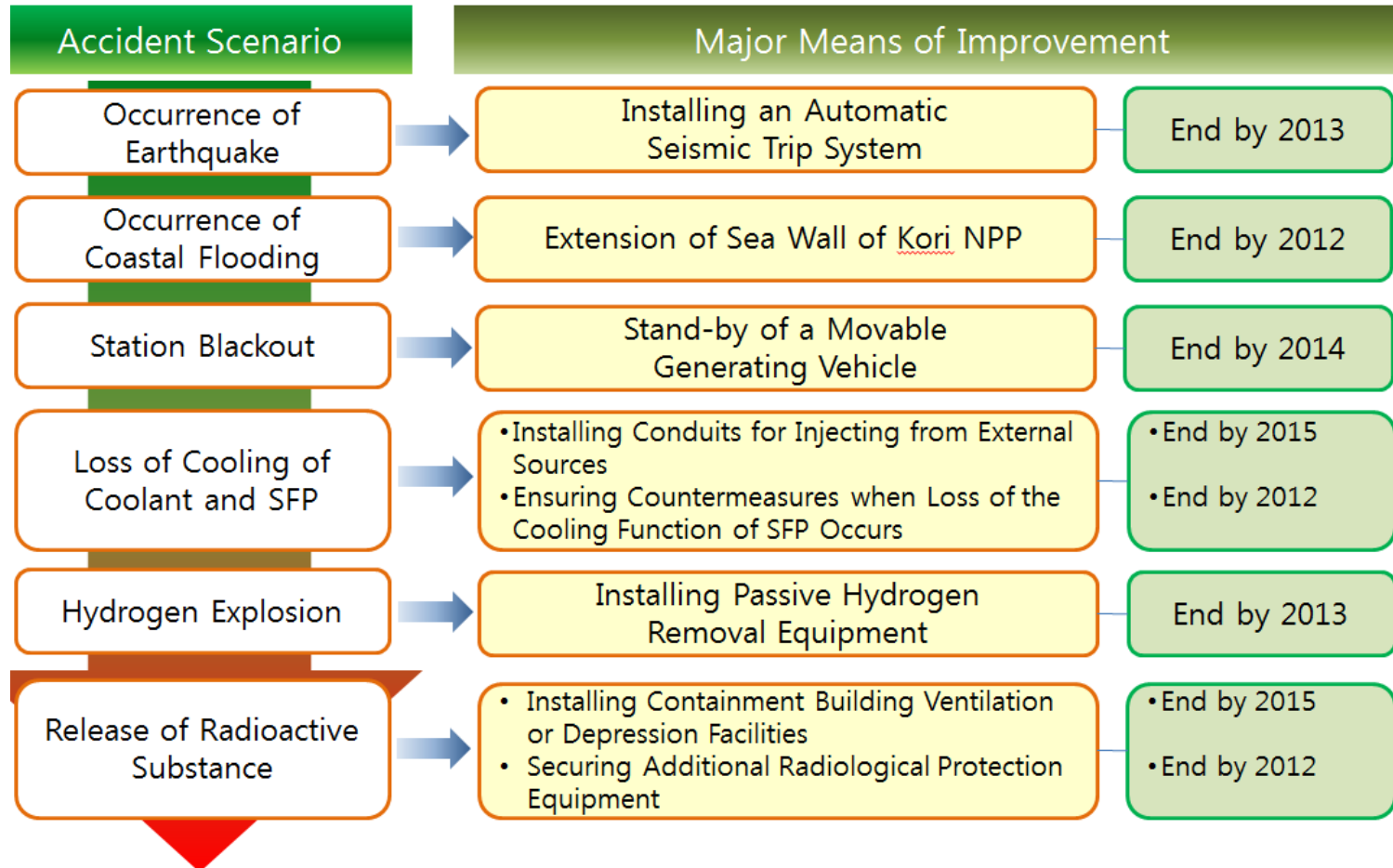


- ① Higher seawall of Kori site (7.5m→ 10m)
- ② Mobile emergency generator and battery
- ③ Watertight door
- ④ Placement of Emergency Diesel Generator and Alternative AC in higher location
- ⑤ Water-proof pump
- ⑥ Installation of passive hydrogen removal system
- ⑦ Installation of venting/depressurization device

(Quoted from material by Chang-Sun Kang of NSSC, April 2012)

Actions Taken in South Korea after Fukushima Accidents (cont)

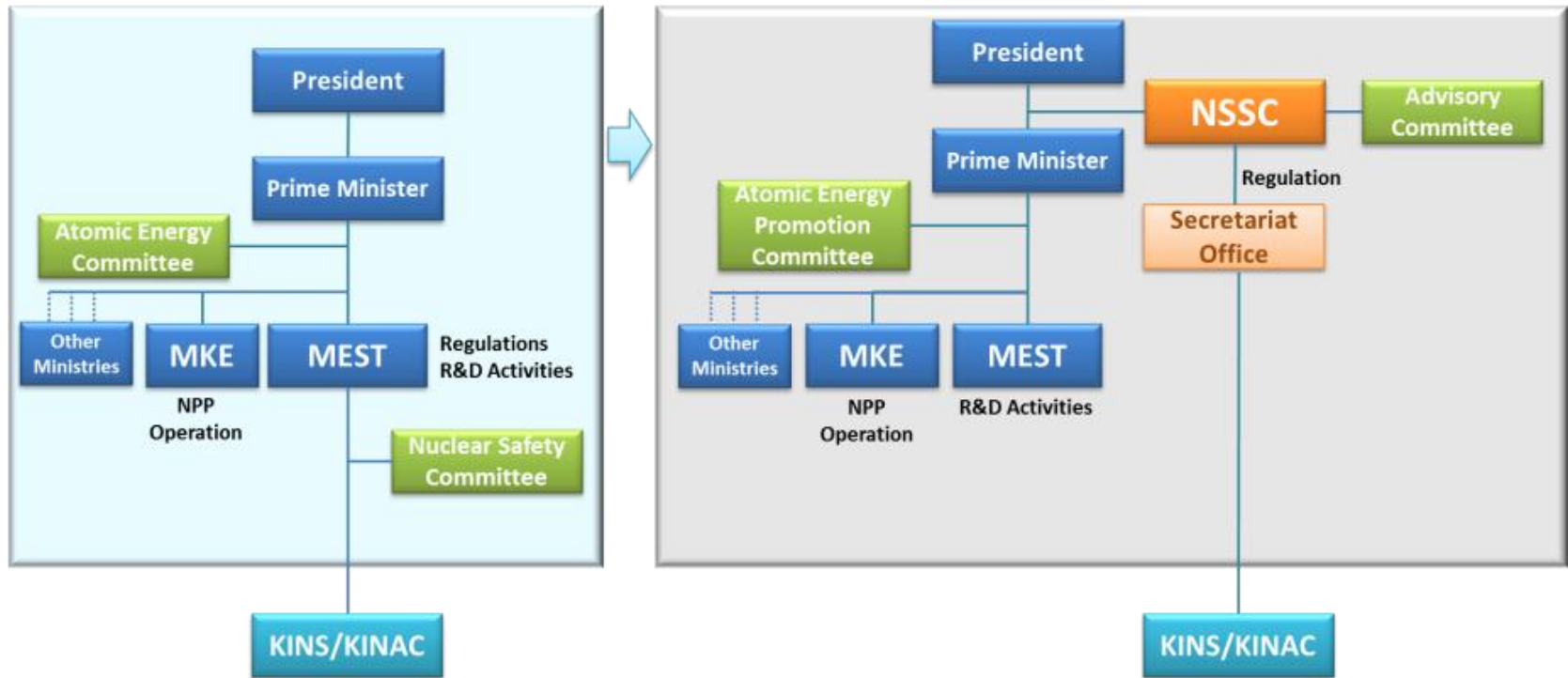
- Major Improvement Based on Follow-up Measures



(Quoted from material by Chang-Sun Kang of NSSC, September 2012)

Actions Taken in South Korea after Fukushima Accidents (cont)

- Nuclear Safety and Security Commission (NSSC)



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

(Quoted from material by Chang-Sun Kang of NSSC, October 2012)

Actions Taken in South Korea after Fukushima Accidents (cont)

- Specific Activities of NSSC

LICENSING
of Nuclear Facilities,
Materials & Activities

INSPECTION & ENFORCEMENT
of Nuclear Facilities,
Materials & Activities

INCIDENT & EMERGENCY
Preparedness & Response

NON-PROLIFERATION & SAFEGUARDS
for global peaceful uses of
nuclear energy

PHYSICAL PROTECTION
against malevolent acts
and terrorism

EXPORT & IMPORT CONTROL
of sensitive material and
technology

- Safety-related activities are technically supported by
- Security-related activities are supported by



(Quoted from material by Chang-Sun Kang of NSSC, April 2012)

Challenges of Nuclear Power in South Korea

- Draft legislation on “Nuclear Phase-out” by a numbers of National Assembly
- Publications of risk simulation report on postulated severe accident at NPPs by NGO
- Strong opposition to nuclear activities by local residents
 - Kori Unit 1 and Wolsong Unit 1
- Attitude of the Mass Media report raising suspicion

(Quoted from material by Kun-Woo Cho of KINS, January 2013)

Conclusions

- Fukushima disaster triggered South Korea to strengthen its NPPs safety unprecedentedly by incorporating measures based on lessons learned from the accident.
- Trust building among nuclear establishment and public needs to be more emphasized to resolve nuclear safety concerns of the public.
 - People cannot be safe without being feel safe.