깨끗한 에너지
아름다운 미래

KHNP Dose Reduction

September 23, 2014

Sung Jun Maeng

KHNP-CRI
KOREA HYDRO & NUCLEAR POWER CO., LTD
Central Research Institute

Contents

Overview of KHNP

- Korea Hydro & Nuclear Power Co., Ltd -

KHNP

[As of Dec. 2013]

- **The Largest** Power Company Owned by the Government
- No. of Employees : **9,587**
- Installed Capacity : **29.9%**(26 GW)
  of the national installed capacity(86.9GW)
  - ✓ all the nuclear power (23.8%)
- Electricity Generation : **28.2%**(145 TWh)
  of the total national electricity generation(515.2TWh)
  - ✓ Nuclear : 26.9%
- Revenue in 2013 : **B$ 6.09**

Map of Nuclear Power Plants in Korea

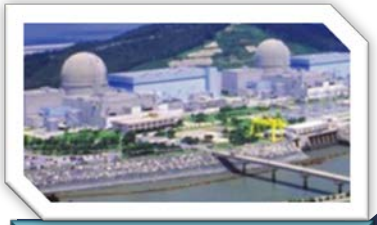
In Operation	23 Units	20,716 MW
Under Construction	5 Units	6,600 MW
Planning	6 Units	8,600 MW

Hanul 1,2,3,4,5,6

Shin-Hanul 1,2
Shin-Hanul 3,4

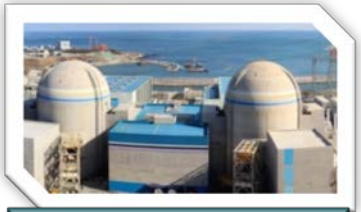
Wolsong 1,2,3,4
(PHWR)

Shin -Wolsong 1
Shin -Wolsong 2



Hanbit 1,2,3,4,5,6

Kori 1,2,3,4

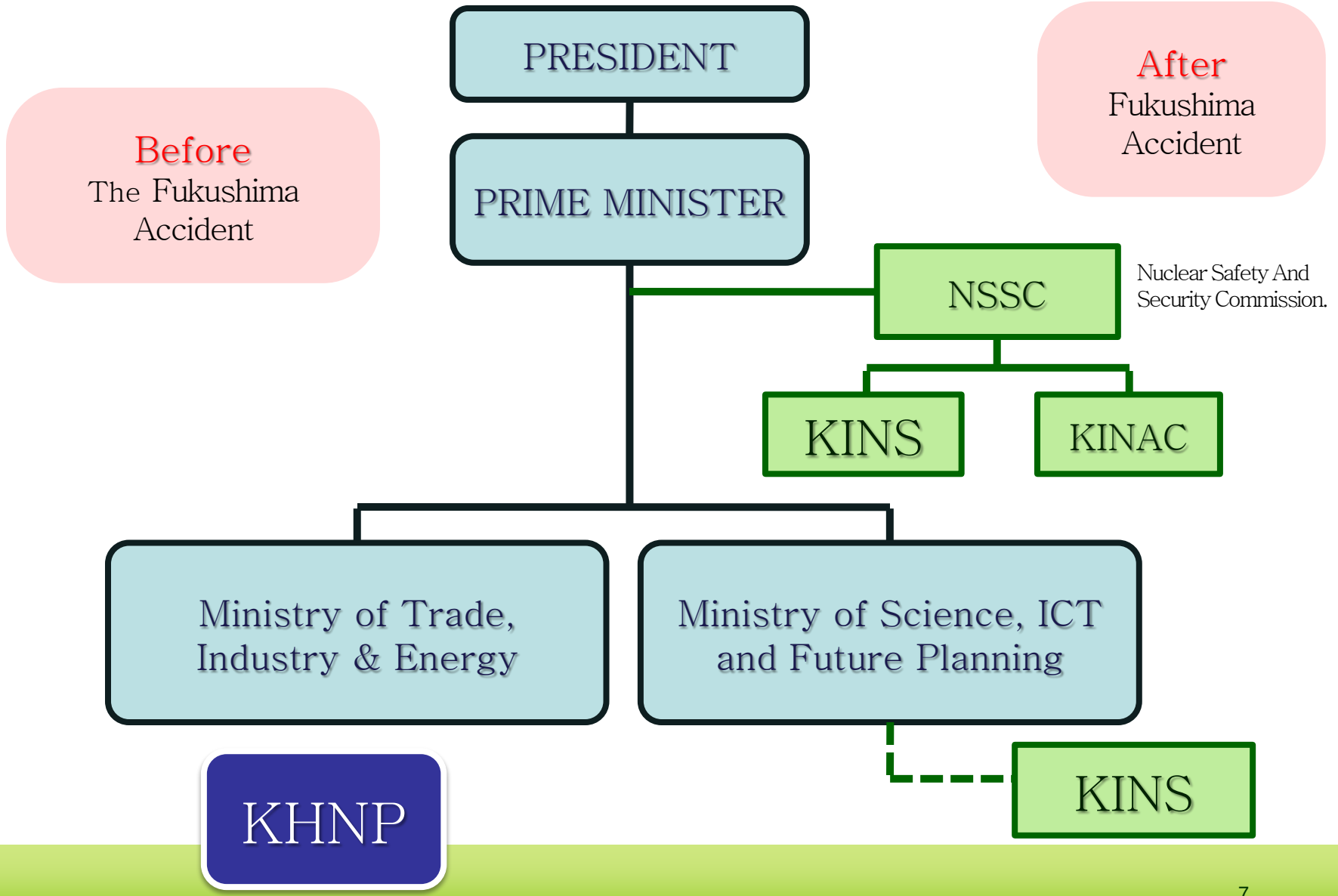


Shin-Kori 1,2
Shin-Kori 3,4
Shin-Kori 5,6
Shin-Kori 7,8

Regulatory Framework

In Korea

Organization



KHNP Phased Dose Reduction Plan

Background of Dose Reduction

❖ Initial Background

- In Preparation for Codification of **ICRP60**(1990) into the Korean Regulation
  - ✓ Annual Dose Limit : 5 rem/y → 2 rem/y

❖ Status of CRE in 1990

- 210 manrem/unit year(PWR)
  - ✓ World average : 176 manrem/unit year
- No of workers with **2 rem/y** + : 1~2%

❖ Continuous Driving Force

- Annual evaluation of KHNP and the CEO based on CRE performance by the government
- Increase in Dose Rate of the Primary System
- Increase in Maintenance Works for Safer Operation

1st Phase Reduction(1/2)

◆ CRE Goal : 190 → 120 manrem/unit year (1992~2000)

Category	Reduction Measures
Operation Procedures & Facility/Equipment Improvements	▪ High pH Operation : pH 6.9-7.4 (Li 0.7-2.2 ppm)
	▪ Microfiltration of RCS : 5 → 1um
	▪ Removal of RTD Bypass Valves
	▪ Replacement of the Primary System : SG tubes with Low Cobalt Alloy Construction
	▪ Refurbishment of In-Core Instrumentation
	▪ Automatic Drum Decontamination System
Automatic/Robotic Maintenance Tools	▪ New SG ECT Equipment
	▪ SG Bolts Tension/Detensioners : Manual → Half automatic
	▪ SG Nozzle Dam/Torque Wrencher
	▪ Automatic Rx Stud Bolt/Nut/Hole Cleaners
	▪ Improvement of Rx Cono-Seal Tensioner

1st Phase Reduction(2/2)

Category	Reduction Measures
Radiation Work Management	▪ Active Implementation of ALARA Program
	▪ Modification of High Radiation Work Procedures
	▪ Development of Temporary High Radiation Work Procedures
	▪ Penalty on Work Procedure Violators
	▪ RP Contracts(during On Line) Made
Employee Training	▪ Qualification of RP Contractors
	▪ Encouragement of CHP for RP Department
	▪ Launching of Advanced RP Training Courses

2nd Phase Reduction(1/2)

◆ CRE Goal : 90 → 75 marrem/unit year (2001~2010)

Category	Reduction Measures
Source Term Reduction	▪ Chemical Decontamination on the Primary System
	▪ Optimization of Shutdown Chemistry
	▪ Installation of The Tritium Removal System
	▪ Minimization of Corrosion Products
Improvement of Facility Maintenance Equipment	▪ Removal of the RTD Bypass Pipes
	▪ Installation of the One piece Rx Head Assembly
	▪ Improvement of the In-core Thermocouple System
	▪ Improvement of the Out Core Instrumentation
	▪ Modification of SG Nozzle Dam : Bolts → Air Expansion

2nd Phase Reduction(2/2)

Category	Reduction Measures
Operation and Administration System	▪ Improvement of the Internal Exposure Evaluation Program
	▪ Adoption of ALARA Review System During Construction
	▪ Best ALARA Awards
	▪ Replacement of Old Radiation Measuring Equipment

3rd Phase Reduction

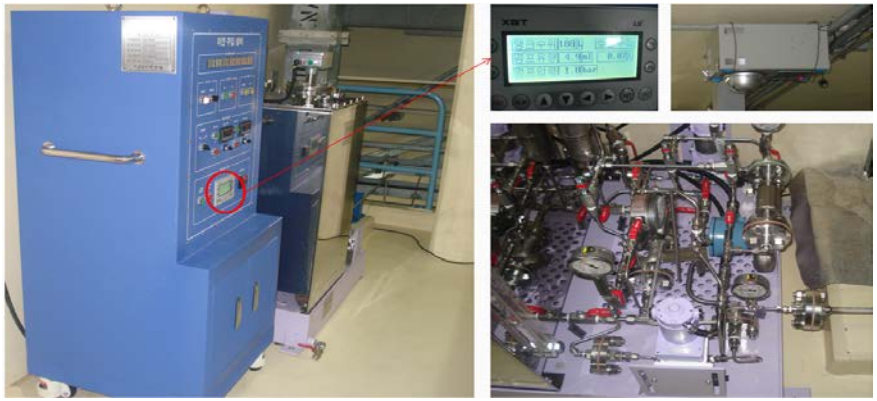
◆ **CRE Goal : 61 → 49** manrem/unit year (2008~2016)

Category	Reduction Measures
Radiation Safety Management System	▪ Self-Assessment on RP
	▪ Operation of the Peer Group
	▪ Performance Indicator of RP
	▪ Improvement of the Basic Radiation
	▪ Workers'Training Program
Source Term Reduction	▪ Zn Injection
	▪ Ultra Sonic Fuel Cleaning
	▪ Standard Guideline for Shutdown Chemistry
Facility /Equipment	▪ Installation of the Permanent
	▪ Rx Cavity Sealing
	▪ Simplification of the Rx Upper Assembly
Outage Management	▪ Adoption of Recommendation by Consulting on the RP system during Outage
	▪ Operation of the Outage Control Center
	▪ Daily Dose Performance Indicator
	▪ Remote Monitoring system at High Radiation Area

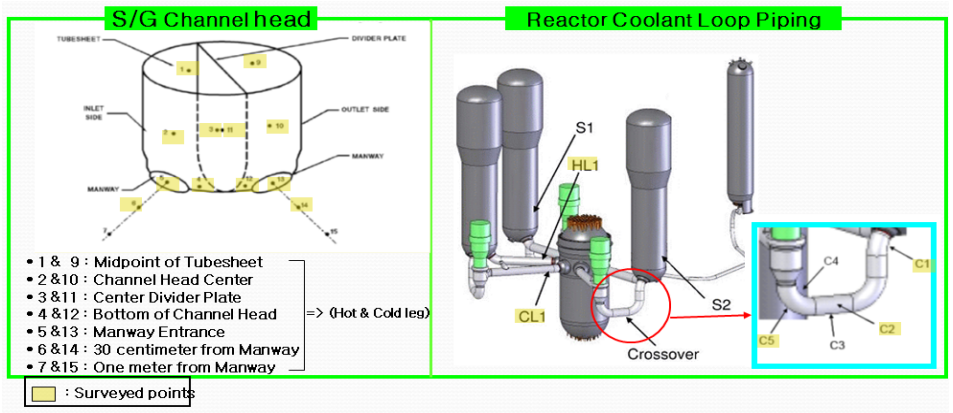
Case of Best Source Term Reduction

Zinc Application

- Dose Reduction Achieved at Hanul 1
  : 44.4 % (RCS Loop & S/G Channel Head)
- Zinc injection at all KHNP PWRs (15 units) by 2016



Zinc Injection Skid

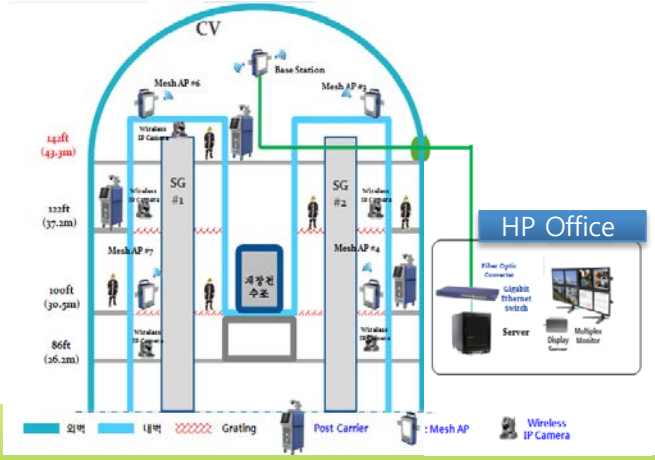


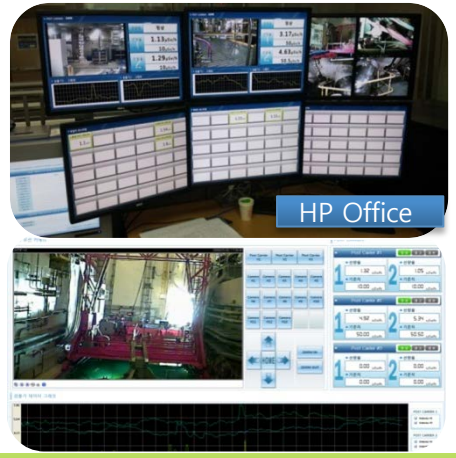
Survey Points at Hanul #1

Case of Best Improvements

Advanced Remote Radiation Monitoring System

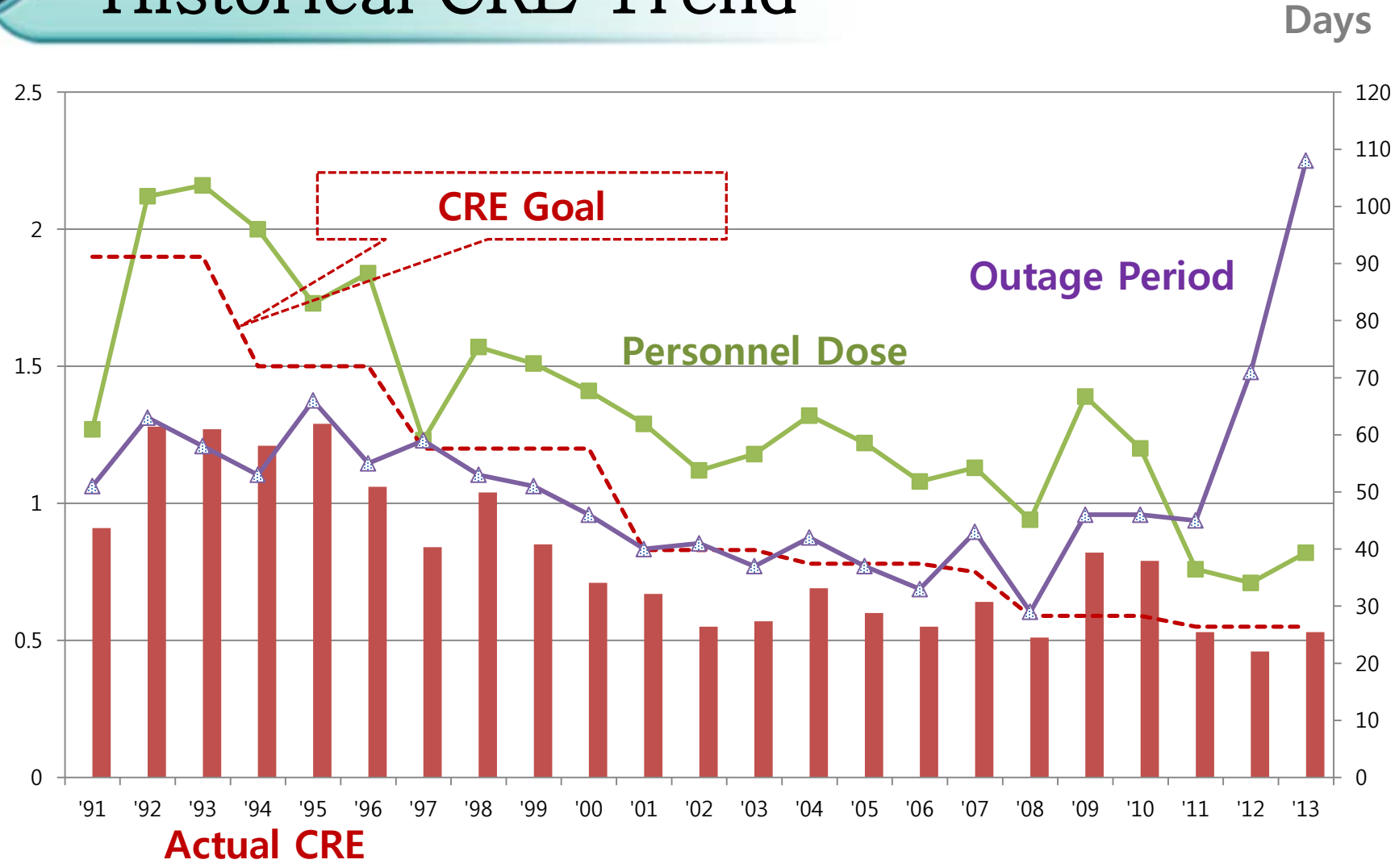
- Real-time Remote Radiation Monitoring at HP Office
- User-Friendly
  - ✓ Wireless Communication Equipped
  - ✓ Compact size : 60 % Smaller (335 cm^3 → 114 cm^3), 30 % Lighter
- Performance Demonstration carried out at Hanbit NPP
- President's Prize Awarded at the National Quality Competition





CRE Reduction Achieved

Historical CRE Trend



Introspection

There is no royal road to CRE reduction but

collaborative and continuous efforts with management commitment are essential.

Path Forward

4th Dose Reduction Plan(1/3)

1. Assessment of the Current Status

◆ CRE Reduction Study Jointly with EPRI in 2013

(As ALARA Supplemental Program)

◆ Strength

- Good Dose Minimization Process(Zn Injection, Fine Filtration, etc)
- Effective Cleanup of Reactor Coolant During Shutdown
- Good Morning Meeting to Keep Supervisions' Attention
- Excellence in Disseminating Plant Experiences to Other Plants
- Use of Actual Wrench Time for the Dose Estimate
- Higher Level of Headquarters Support and Involvement

4th Dose Reduction Plan(2/3)

◆ Recommendations

- ALARA Program and Implementation
  - Reduce ALARA Committee Review Criteria
- ALARA Culture
  - Enhancing Communication with Workers
- Hardware and Equipment Improvements
  - Use of RMT, Electronic Survey System
  - Temporary Shields
  - Rx Cavity Water Purification System

4th Dose Reduction Plan(3/3)

2. Benchmarking of US Plants with EPRI

- ◆ Benchmarking Visit to Palo Verde, Catawa, Farley
- ◆ August 15 ~ August 22, 2014
- ◆ 2 KHNP Staff, 2 EPRI staff

3. Internal Workshop on Dose Reduction

4. Finalizing Plan for Management Approval

- ❖ Goal : WANO Top Quartile