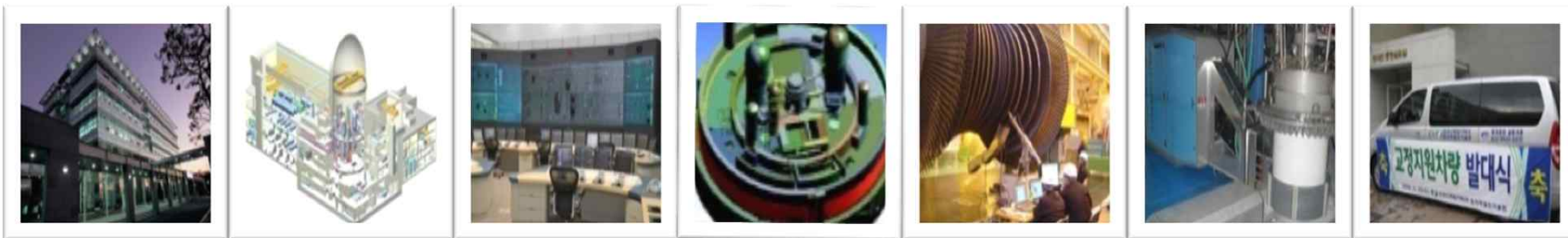


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아래쪽은 미로

KHNP Dose Reduction



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

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- II. Regulatory Framework in Korea**
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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%(26GW)**
of the national installed capacity(86.9GW)
 - ✓ all the nuclear power (23.8%)
- ❖ **Electricity Generation : 28.2%(145TWh)**
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



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



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



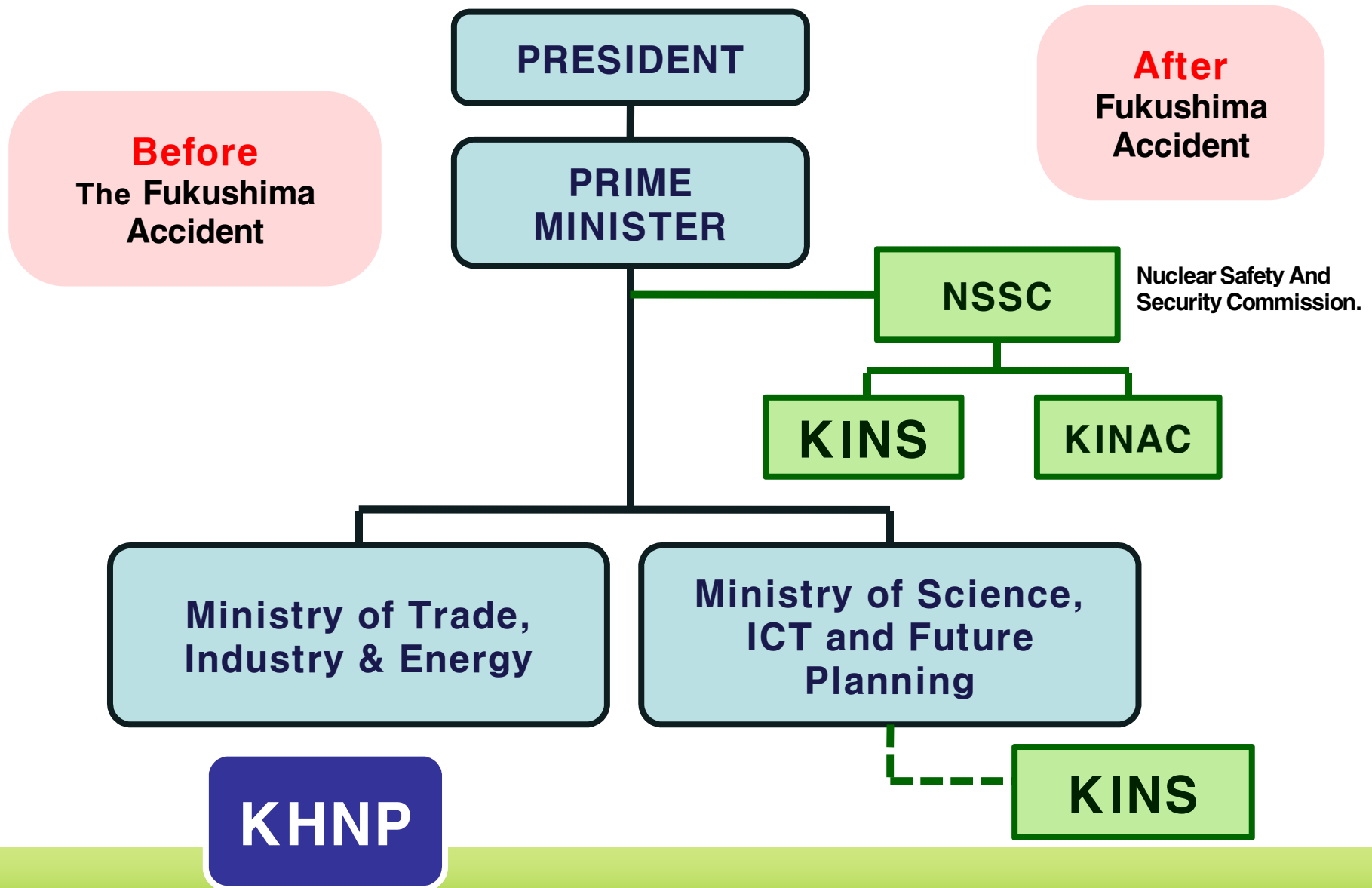
Kori 1,2,3,4



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

Regulatory Framework In Korea

Organization



Basic Regulations

❖ Radiation Protection

- Basis : ICRP60, IAEA Safety Standards Series No. RS-G-1.1
- Dose limits
 - ✓ Occupational dose limits : 20 mSv/y
 - ✓ Public dose limits : 1 mSv/y

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 man·rem/unit year(PWR)
 - ✓ World average : 176 man·rem/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 man·rem/unit year** (1992~2000)

Category	Reduction Measures
Operation Procedures & Facility/Equipment Improvements	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ 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 man·rem/unit year (2001~2010)

Category	Reduction Measures
Source Term Reduction	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ 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

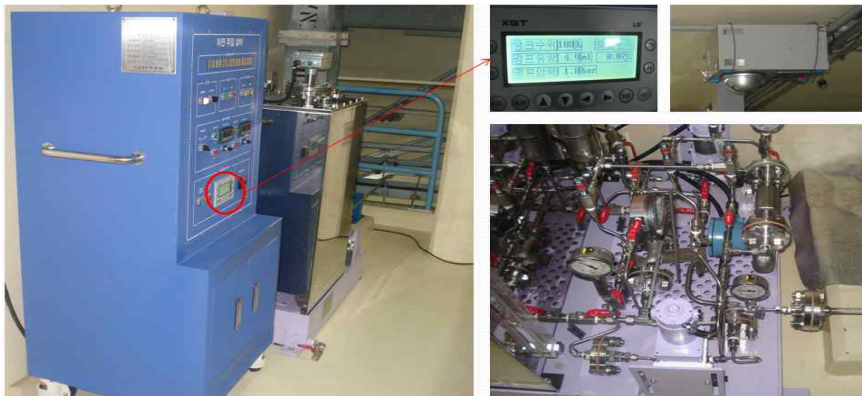
◆ CRE Goal : 61 → 49 man·rem/unit year (2008~2016)

Category	Reduction Measures
Radiation Safety Management System	<ul style="list-style-type: none"> ▪ Self-Assessment on RP ▪ Operation of the Peer Group ▪ Performance Indicator of RP ▪ Improvement of the Basic Radiation ▪ Workers' Training Program
Source Term Reduction	<ul style="list-style-type: none"> ▪ Zn Injection ▪ Ultra Sonic Fuel Cleaning ▪ Standard Guideline for Shutdown Chemistry
Facility /Equipment	<ul style="list-style-type: none"> ▪ Installation of the Permanent ▪ Rx Cavity Sealing ▪ Simplification of the Rx Upper Assembly
Outage Management	<ul style="list-style-type: none"> ▪ 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

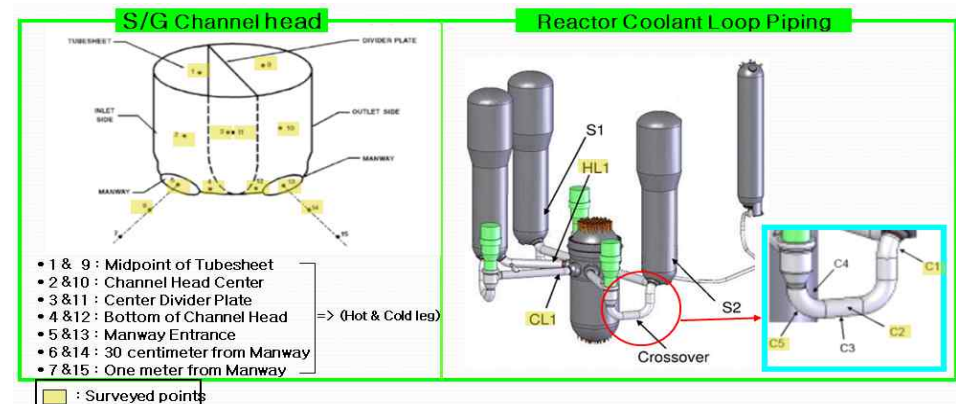
Case of Best Source Term Reduction

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

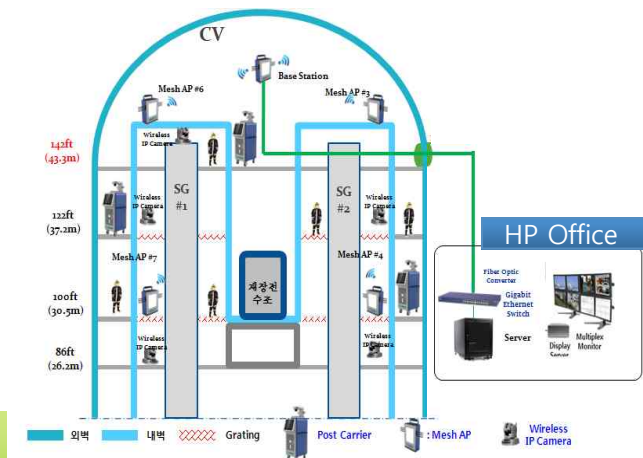


Survey Points at Hanul #1

Case of Best Improvements

Advanced Remote Radiation Monitoring System

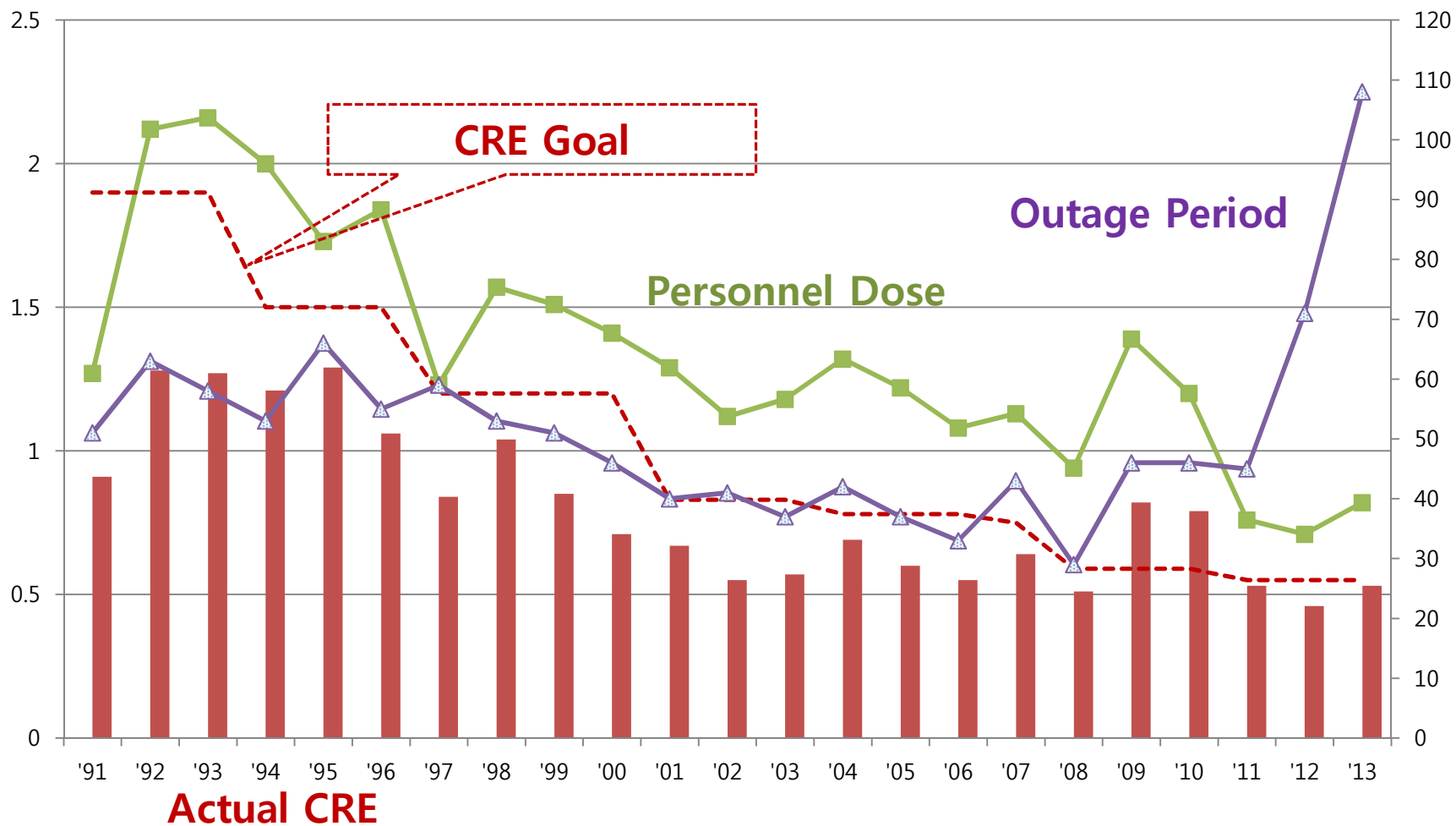
- Real-time Remote Radiation Monitoring at HP Office
- User-Friendly
 - ✓ **Wireless Communication** Equipped
 - ✓ Compact size : **60 % Smaller ($335 \text{ cm}^3 \rightarrow 114 \text{ cm}^3$), 30 % Lighter**
- Performance Demonstration carried out at Hanbit NPP
- President's Prize Awarded at the National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



CRE Reduction Achieved

Historical CRE Trend

Days



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 : 200 → 50 man · mSv**
- **ALARA Culture**
 - **Enhancing Communication with Workers(Daily Dose Reports)**
- **Hardware and Equipment Improvements**
 - **Expansion of RMT, Electronic Survey System with EPDs**
 - **Temporary Shields(Reactor Head, Waste Sorting Area Shield)**
 - **Rx Cavity 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 the Plan for CEO' s Approval

- ❖ **Goal : WANO Top Quartile**