Perspective on Korean Nuclear Energy after the Fukushima Accident

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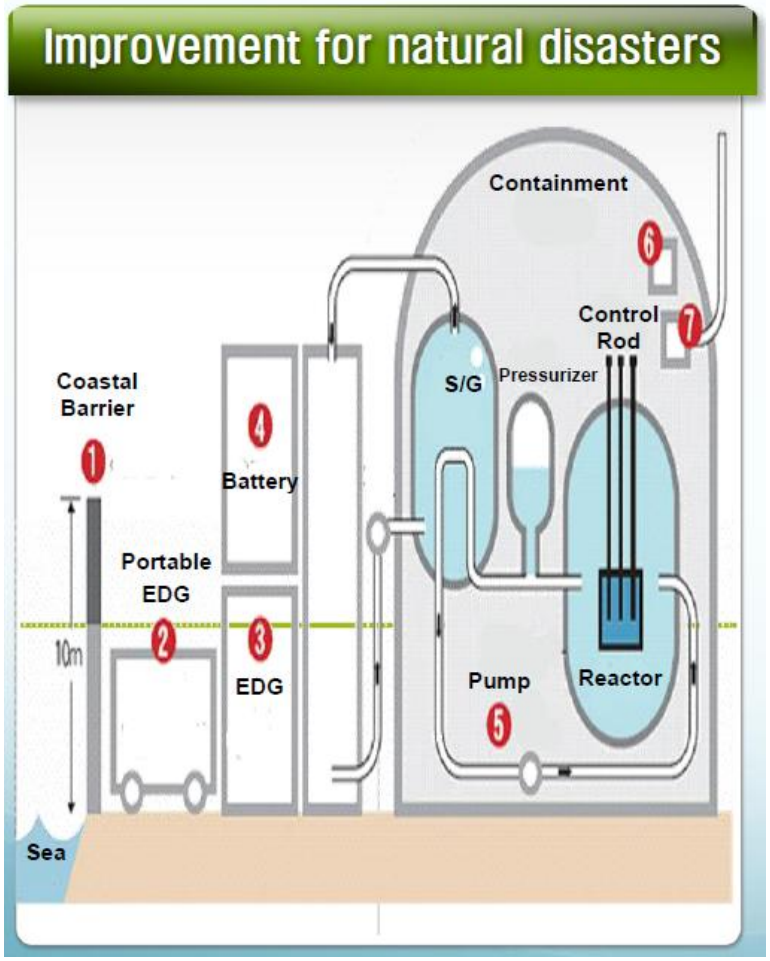
Response after the Fukushima accident

Response after the Fukushima accident

- Special Safety Inspection including 50 short and long term plans
  - Special safety inspection was performed to 21 operating NPPs and 1 research reactor
  - Unlikely worst case scenario was considered including
    - Extreme natural disaster (earthquake + tsunami)
    - Loss of off-site power and failure of emergency DGs
    - Severe accident
- The National Assembly passed the revised Nuclear Act, Nuclear Safety Act on June 29, 2011.
- The Nuclear Safety Commission moved out of MEST, placed directly under the President.

Changes after the Fukushima accident



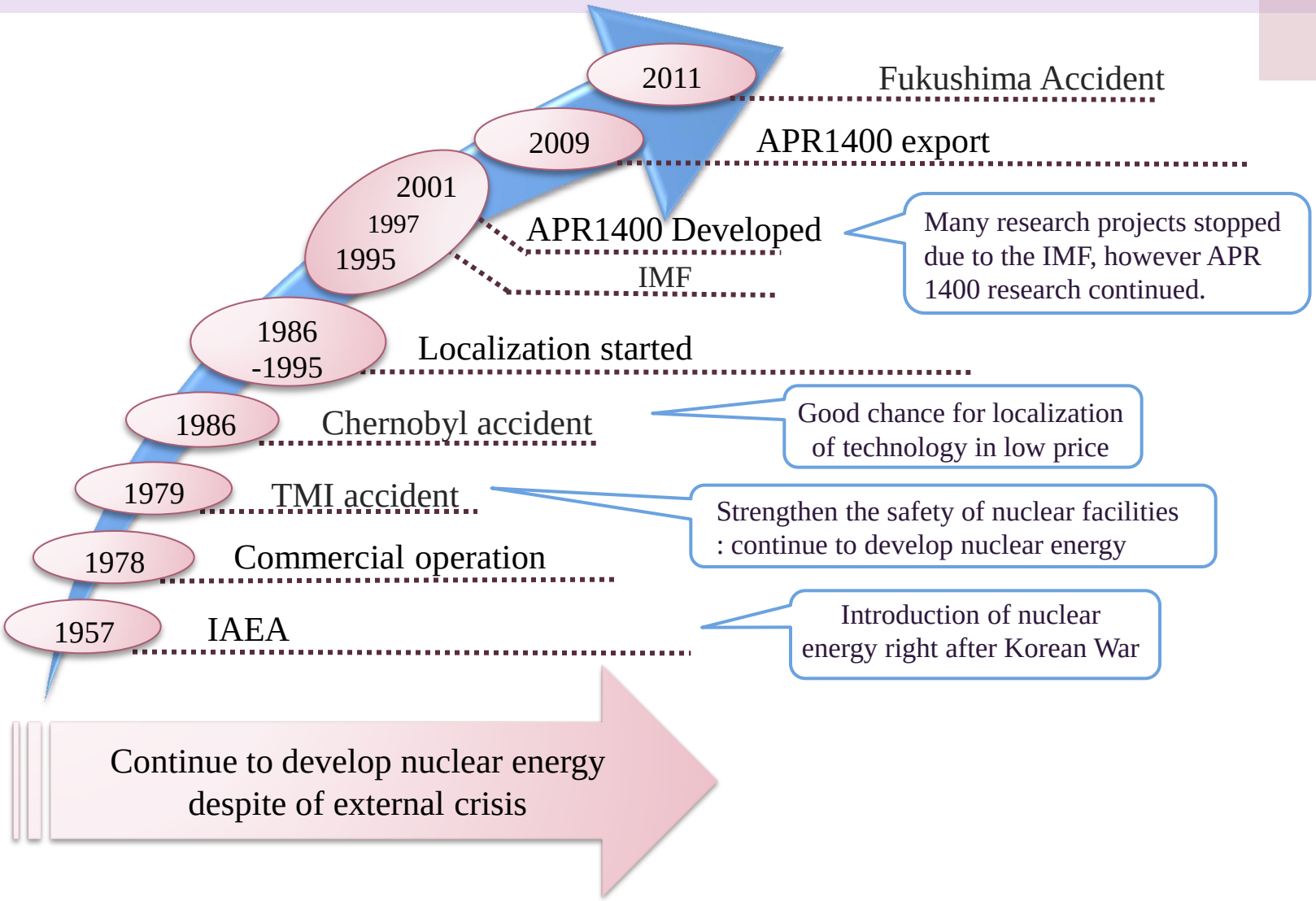
- 50 short and long term action plans
  - Making the coastal barrier higher
  - Preparing a vehicle with portable EDG at each site
  - Installing watertight doors at EDG building
  - Securing the emergency battery power safe from flooding
  - Waterproofing pumps
  - Installing passive H2 removal systems operating without electricity
  - Installing venting or depressurization equipment

Prospects

Prospects for the Post-Fukushima

- Near term
  - Expects some slowdown on the nuclear energy
    - Safety enhancement of the nuclear energy
    - Communication with the public is a key
    - Highly sensitive to national policy
- Mid-long term
  - Expansion of nuclear energy based on :
    - The increase in the energy demand
    - Energy security
    - Global warming
    - Preparing for post oil-era

History of Korean Nuclear Energy



Dawning of Nuclear Age in Korea

1950-1953 : Korean War

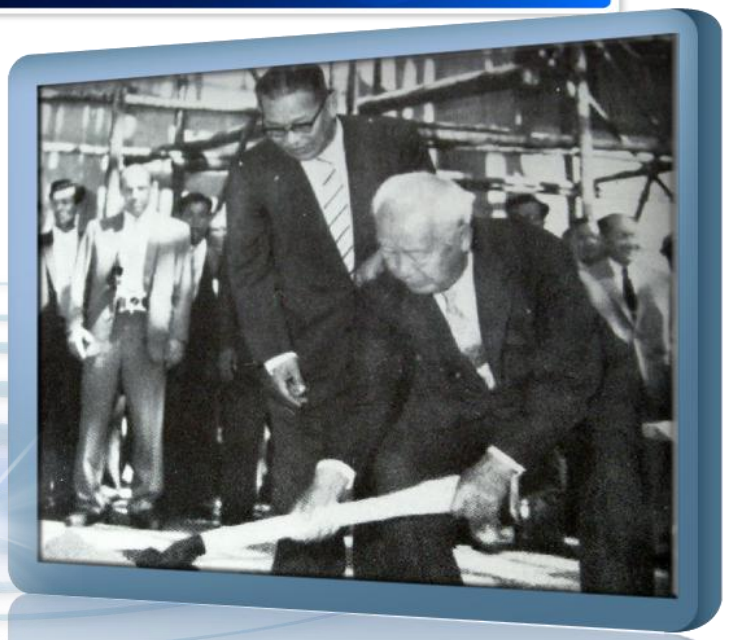
1958: Nuclear Eng. Dept of Hanyang Univ.

1959: Nuclear Eng. Dept of Seoul National Univ.

1959: Korea Atomic Energy Research Institute

The 1st Research Reactor in Korea, TRIGA Mark II

The 1st president of Korea in the ground breaking ceremony (1959.7.14)



Generating Nuclear Electricity in Korea

Kori - the site of the 1st Korean NPP : before (top) and now (bottom).

1st unit of Nuclear power plant started its construction in 1972

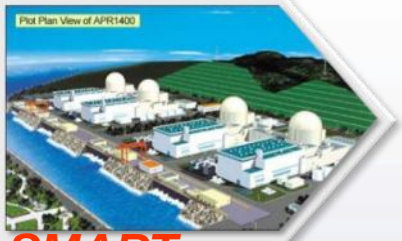
- **Turn Key basis**
- **587MWe**
- **Commercial operation in 1978**
- **Life extension after 30 years operation (2007.12)**

Korean Nuclear Reactor Systems

Kori NPP

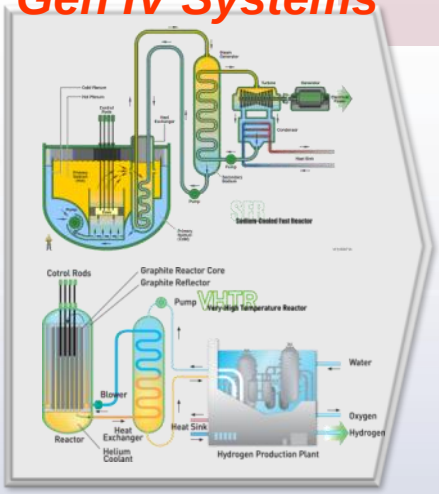
OPR1000

APR1400
APR+



SMART

Gen IV Systems



1st Phase : Gen II

- *Turn-key base*
- *600 MWe*

2nd Phase : Gen III

- *Standardization (KSNP)*
- *Optimization (OPR1000)*
- *1,000 MWe*

3rd Phase : Gen III+

- *Evolutionary PWRs*
  - *APR1400*
  - *APR+*
  - *SMART(330MWt)*

4th Phase : Gen IV

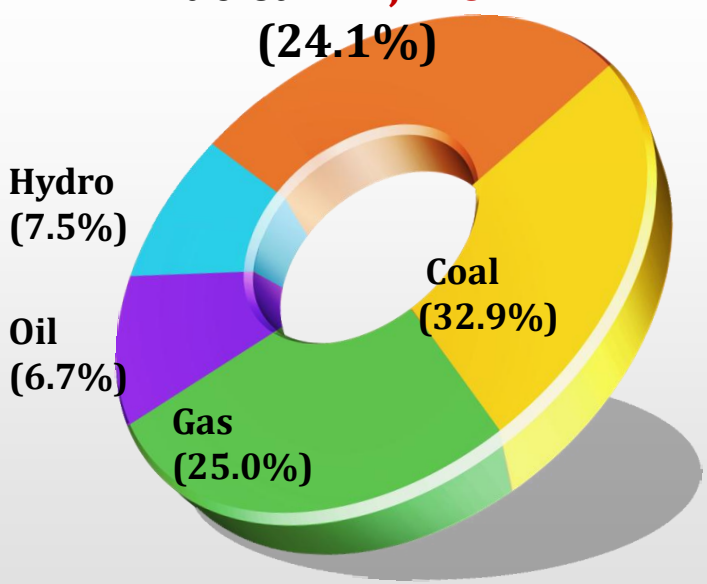
- *Revolutionary*
  - *SFR : U recycle and waste minimization*
  - *VHTR : Hydrogen production*

1970s	1980s	1990s	2000s	2010s	2020s	2030s	

Status of Electric Power in Korea

*As of the end of 2009

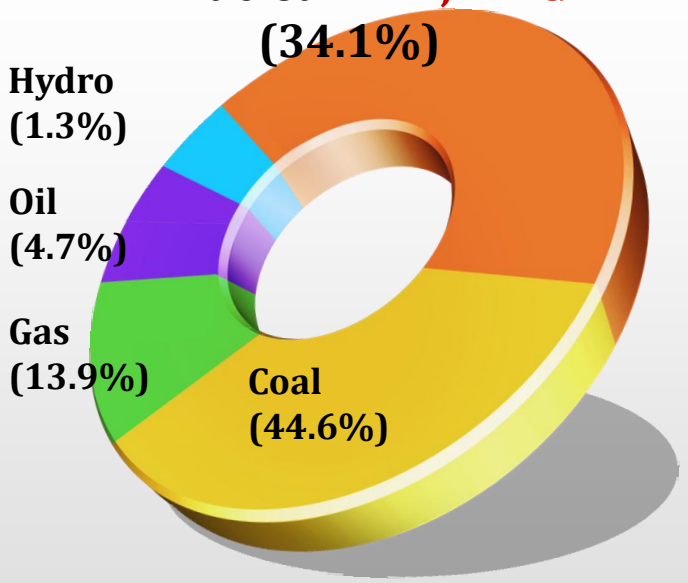
Installed Capacity



*Others : 2,728 MW(3.7%)

Total : 73,470 MW

Electricity Generation



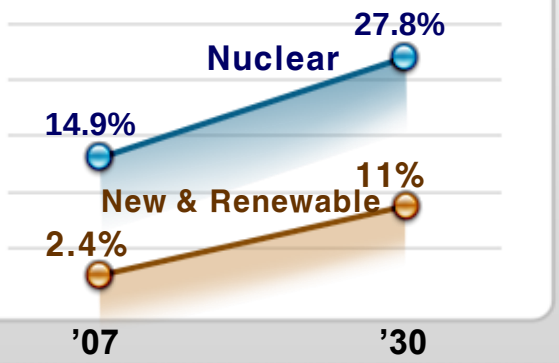
*Others : 5,928 GWh(1.4%)

Total : 433,311 GWh

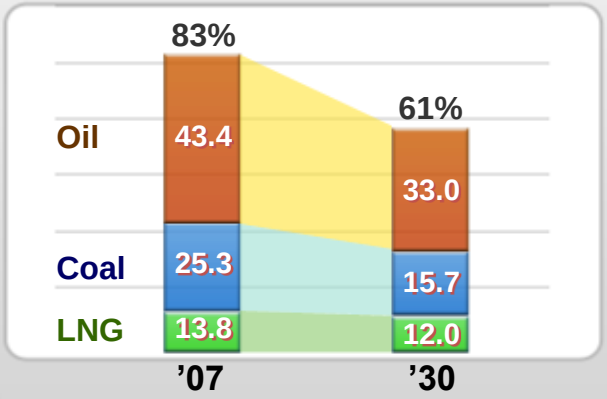
Policy Target for Green Growth

National Energy Basic Plan(Aug.'08) → **Minimizing Energy Use/ Low-Carbon Energy Mix**

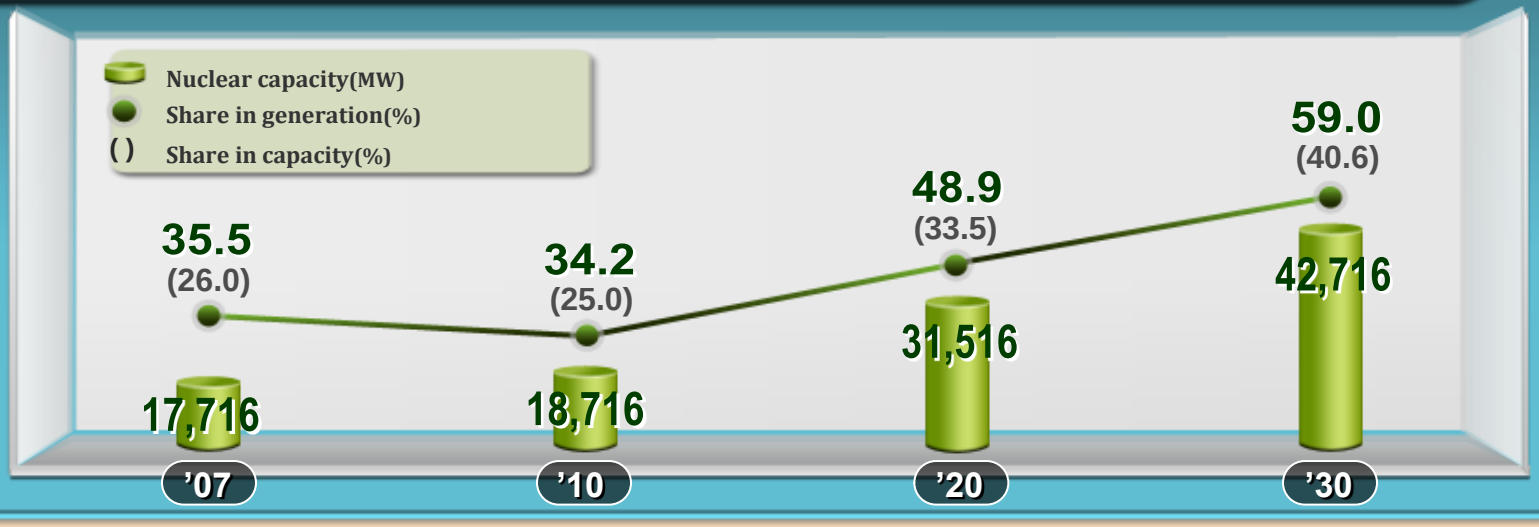
Share of Clean Energy



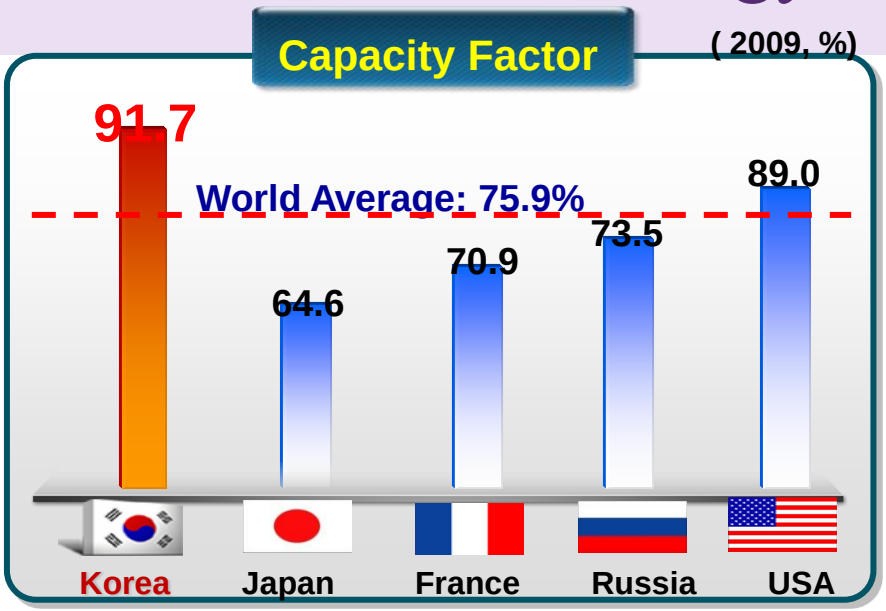
Share of Fossil Energy

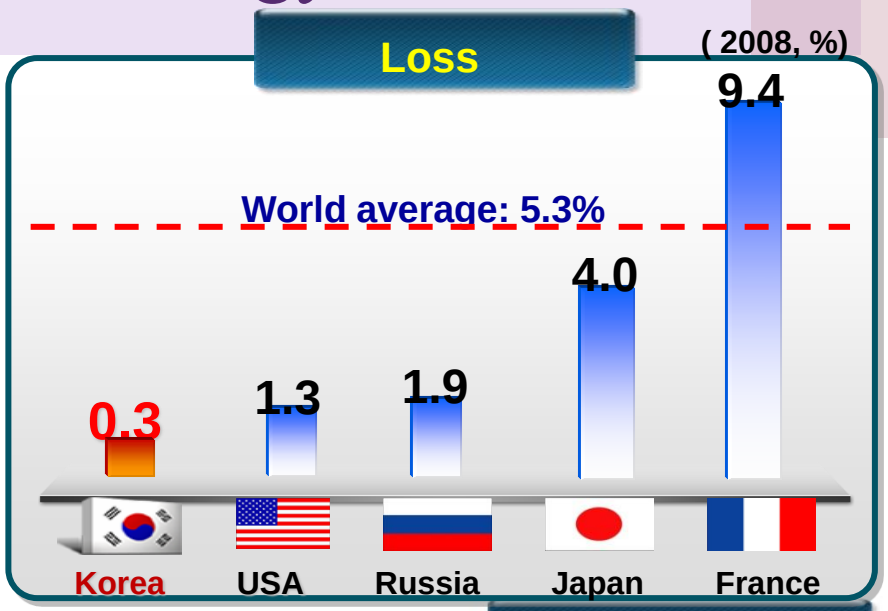


Nuclear share in fuel mix of power generation : 35%(2007) →59%(2030)



Nuclear Energy Technology ……





- Korea's capacity factor recorded 91.7% as of 2009 which is 15% higher than the world average.
- For the unplanned capability loss factor, Korea marked the lowest with 0.3% per year which is also far less than that of major countries.

Nuclear Energy Policy

Nuclear Energy Policy

- The direction of 4th nuclear energy promotion plan

Nuclear Energy Policy

Direction of 6 Top Policies

- Enhancement of safety in nuclear power utilization to gain the public trust
- Expansion of nuclear energy utilization for low carbon green growth
- Enhancement of international transparency and sustainable nuclear energy system
- Establishment of nuclear leading base and improvement of international status
- Jump to the world-leading radiation-technology country by integrating with the high technology
- Green growth encouragement by enhancing the international status of reactor technology and creating the new export area

Direction of Policy 1 : Enhancement of safety in nuclear power utilization to gain the public trust

Objective : The securement of the top class nuclear safety competency

Reaction on Fukushima Accident	• Deduction of safety precaution considering Fukushima accident • Nuclear accident management system	1-1 Implementation of safety enhancing plan with the lessons learned from Fukushima accident (Nuclear Safety Commission)
Improvement of operating NPP safety	•Advancement of NPP safe-operation technology and enhancement of radiation and radioactivity management system	1-2 Enhancement of operating NPP safety management and safe-operation technology
Enhancement of safety technology	•Need of multiple disaster management capability •Increase of the need for core technology	1-3 Enhancement of competency for safety technology including management of large scale natural disaster
Gain public acceptance	•Need to gain agreement of regional community for nuclear facilities installation	1-4 Nuclear safety culture and promotion of public trust

Direction of Policy 2 : Expansion of nuclear energy utilization for low carbon green growth

Objective : Right-time construction of NPP and securement of nuclear fuel resource according to generation plan

National green growth policy	• Continuous nuclear usage	2-1 Increase of nuclear power proportion
International energy situation	• CO2 reduction, oil-free movement • Energy independency enhancement	2-2 Stable nuclear fuel supply
expansion of nuclear usage	• Nuclear hydrogen for emerging hydrogen economics • utilization of process heat	2-3 Diversification of nuclear energy usage

Direction of Policy 3 : Enhancement of international transparency and sustainable nuclear energy system

Objective : Enhancement of international transparency for nuclear usage and securement of leading non-proliferation technology

Transparency and non-proliferation enhancement	• 4 principles of peaceful nuclear use • Technology development and system establishment of reuse of nuclear resources	3-1 Enhancement of transparency and non-proliferation
Future nuclear system development	• Establishment of long-term plan for future nuclear system • Nuclear non-proliferation pyro-processing and SFR development	3-2 Demonstration of future nuclear system technology
Eco-friendly radioactive waste management	• Imminent saturation of interim storage capacity due to continuous accumulation of SNFs	3-3 Eco-friendly management system establishment for total fuel cycle of radioactive waste

Direction of Policy 4 : Leading technology development, human resource training, enhancement of international cooperation

Objective : Establishment of technological and human base to secure the leadership in international nuclear society and enhancement of international cooperation

Core technology development	• Advanced countries focus on innovative nuclear system and core technology such as advanced reactors	4-1 Establishment of nuclear future growth base by developing the leading technology
Nuclear professionals training	• Insufficient professional manpower due to increase of nuclear usage and export is expected	4-2 Innovation of global nuclear human resource training system
Establishment of Nuclear international cooperation strategy	• Status change from demander to supplier due to export	4-3 Enhancement of nuclear global leadership

Direction of Policy 5 : Jump to the world-leading radiation-technology country by integrating with the high technology

Objective : Systematic enhancement of radiation base, application and infrastructure

High-tech industry of 21st century	• 4 principles of peaceful nuclear use • Technology development and system establishment of impossible reuse of nuclear resources	5-1 Enhancement of radiation strategy base-technology and creation of innovative core technology
Radiation industry market expansion	• Increase of radiation technology utilization in various fields • Industrialization of national radiation technology in early-development level	5-2 Integration of radiation technology to create the high value industry
Establish infra-structure for radiation use	• Need for solution to unstable supply of medical isotopes • Need for expansion of base research facilities and support system	5-3 Enhancement of radiation technology infrastructure to world level

Direction of Policy 6 : Green growth encouragement by enhancing the international status of reactor technology and creating the new export area

Objective : Expansion of export and development of industry for Jump to world top 3 reactor export country

Market share expansion of advanced countries	• Reorganization of export support organization • Market share expansion tries by developing new type of advanced reactor	6-1 Enhancement of export competitiveness for nuclear technology
Sustainable nuclear technology development	• NuTech2012 establishment • NuTech 2030 under establishment	6-2 Making Nuclear industry as a growth driver
Prospection of niche market establishment	• Small-medium size reactor market establishment and expansion • Research reactor demand occurrence	6-3 Establishment of nuclear export base

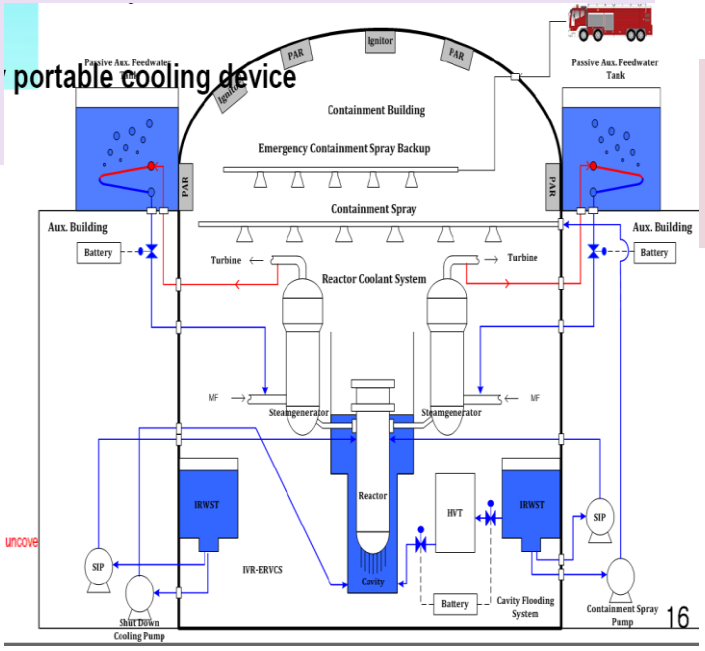
Major Research Program

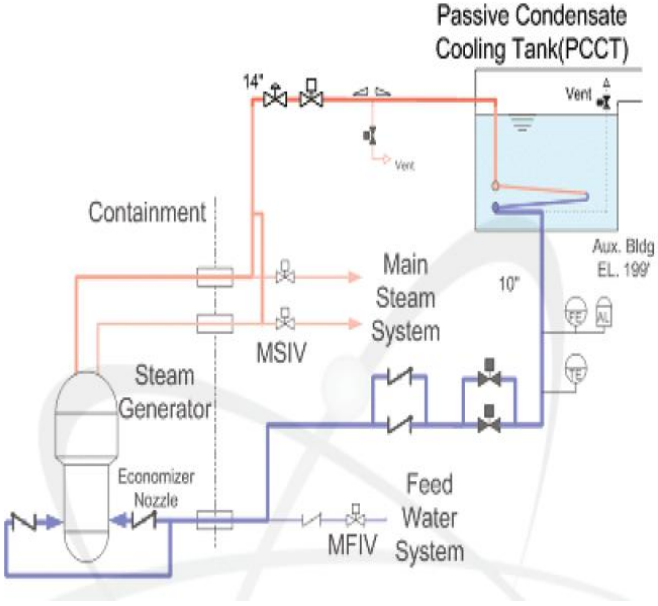
Major Nuclear Energy Research Program

- Nuclear Safety Research
  - Thermal-Hydraulics and Passive Safety
  - PSA and so on
- Advanced PWR
  - APR1400, APR+
- Small and Modular Reactor
  - SMART, SMART+
- Sustainable Nuclear Energy
  - SFR, Pyro-processing, Waste Management
- Others
  - HTGR, Radiation Utilization, Basic Research

Advanced PWR

- APR+
  - The APR+ is Korean type GEN III+ reactor on the basis of APR1400
  - Advanced Design Features
    - Passive Auxiliary Feedwater System (PAFS)
    - Off-site AC Power + EDG + AAC fail : DC Battery (8hrs, 72hrs for PAFS)
  - Safety Systems
    - 4 independent trains with DVI
    - Fluidic devices in safety injection tanks
    - In-containment refueling water storage tank (IRWST)
  - Major NSSS Parameters
    - Electric power (Total/Net), MWe : 1505/1560





Small and Modular Reactor

- SMART
  - All primary components, such as core, steam generators, main coolant pumps, and pressurizer are integrated into a single pressurized vessel with no piping used for the connection of these components.
  - The major economy improving features of SMART could be summarized as follows: system simplification, component modularization, factory fabrication and direct installation of components at the site, and the reduced construction time.

Safety	Core damage frequency	$< 10^{-7}$/reactor-year (RY)
	Radiation release frequency	$< 10^{-8}$/RY
Economics	Electricity generation cost	< Gas turbine
	Construction period	< 36 months
Performance	Availability	> 95%
	Reactor life	60 years

Table. Design goals of SMART

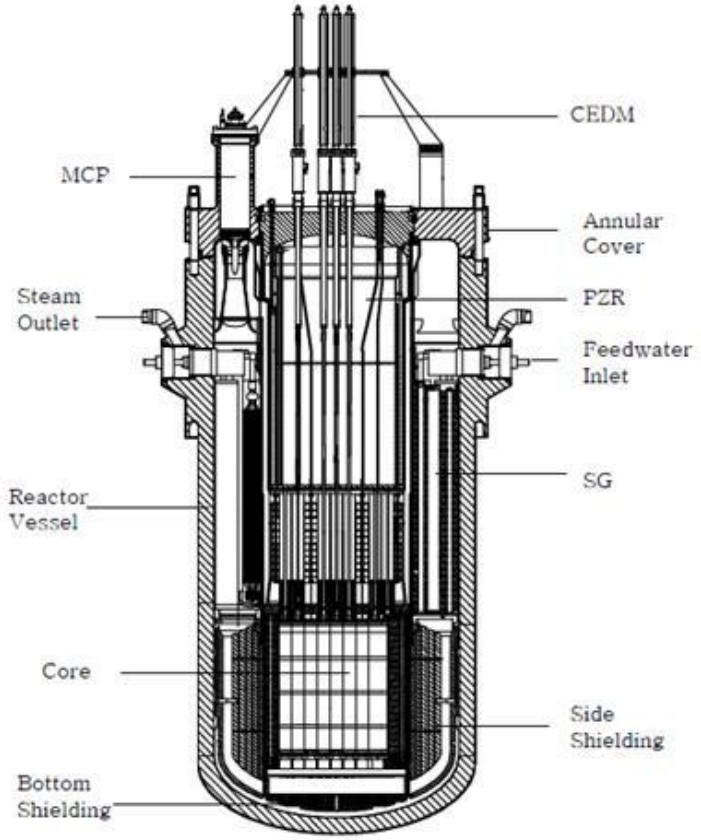
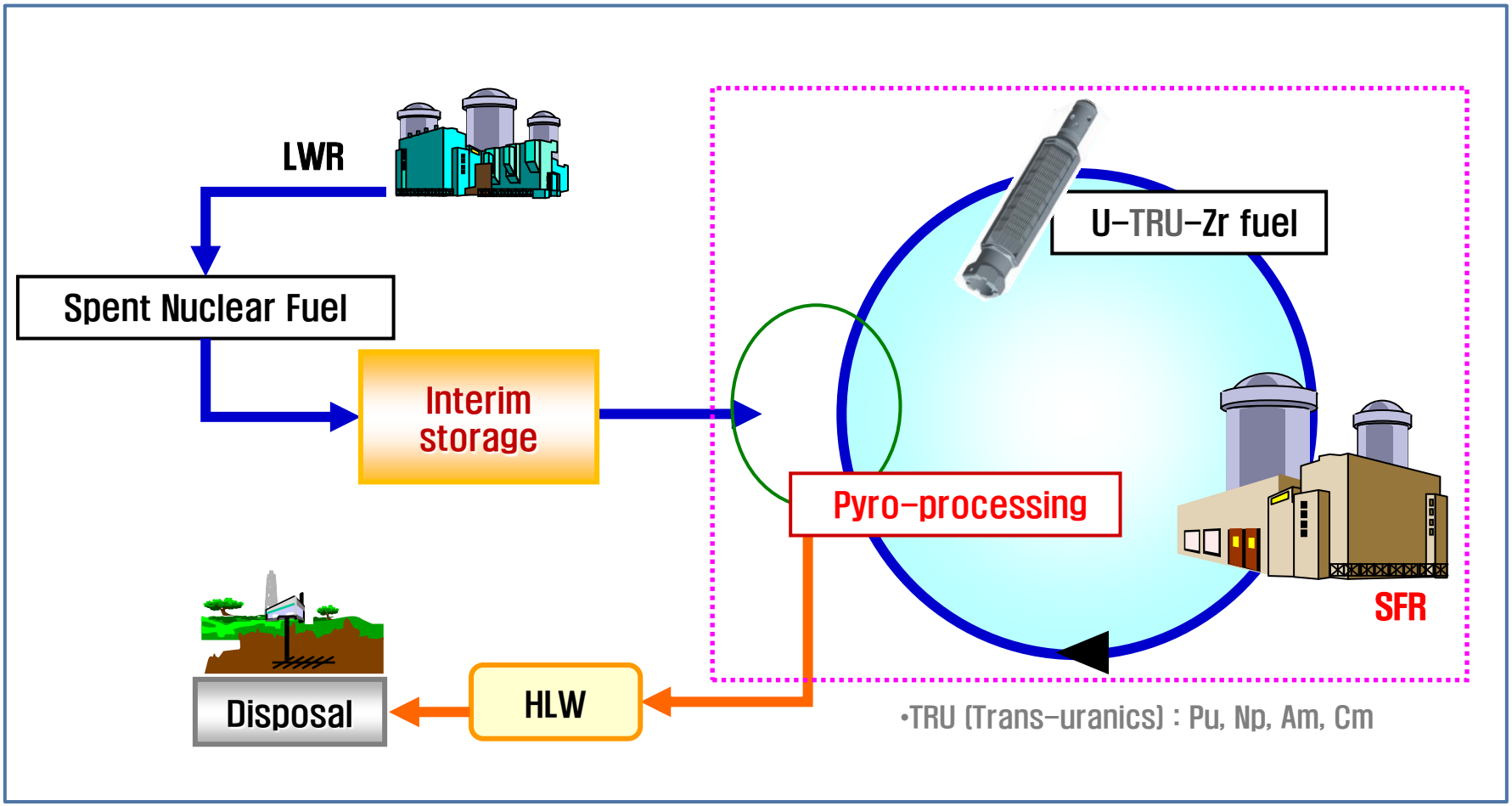


FIG. 1. Structural arrangement of the SMART RPV.

Future Nuclear System Development



Future Nuclear System Development

- SFR demonstration design
  - Sodium thermal-hydraulic test facility
  - Completion of metal fuel rod (U-Zr) prototype
- Proliferation resistant pyro-process technology
  - Inactive prove of pyro-process
  - Performance prove of pre-process and metal oxidation process
  - Safety technology for engineering scale pyro facility
- Korea-US co-work plan of pyro technology
  - Technological feasibility prove by pyro whole-process demonstration using US facility
  - Korea-US co-work on proliferation resistance enhancement technology
    - Pyro commercialization by feasibility prove and non-proliferation reliability & transparency enhancement

Eco-friendly radioactive waste management

- Policy development for total cycle radioactive waste management
  - Policy for 1st level of LILW disposal site construction (100,000 drum size), and 2nd level of expansion capacity decision
  - Policy for interim storage and transportation of SNF
  - Mid-long term roadmap development for final disposal of SNF and HLW
    - Public anxiety and uncertainties alleviation to support sound base of nuclear usage
- Technology development for interim storage of SNF, geologic disposal, and decontamination & decommissioning
  - Prototype system of SNF interim storage and Korean model development
  - 20% performance enhancement of engineering wall and program for geologic disposal
  - Technology for decontamination & decommissioning of NPPs
    - Technological independence of SNF transportation/storage
    - Public reliability enhancement by demonstration of safe HLW technology

Conclusions

- Korean government finished special safety inspection after the Fukushima accident
- Safety enhancement is made in software and hardware
  - More independent regulations
  - Action items after special inspection
- Nuclear power expansion is expected in the long-term
- Public acceptance is very important for further expansion of nuclear energy
- International cooperation is necessary for developing and sharing nuclear technology

PBNC, Nuclear Industry Summit & Nuclear Security Summit

- PBNC
  - 2012 18th Pacific Basin Nuclear Conference in Busan, Korea from March 18 to 23
  - Entitled as “Sustaining Nuclear Energy through Enhanced Safety and Security”
- Nuclear Industry Summit
  - Followed by 2012 Seoul Nuclear Industry Summit in Seoul, Korea from March 23 to 24
  - Entitled as “The Role of the Nuclear Industry in Enhancing Nuclear Security and Safety”
- Nuclear Security Summit
  - Highest-level conference in global nuclear security
  - Korea to host the second Nuclear Security Summit in 2012 proposed by US President Obama with unanimous support
  - 2012 Summit agenda -> broadened to include nuclear safety and radioactive materials in addition to nuclear security

Thank you