Introduction and Development of Nuclear Power Technology: *The Korean Experience*

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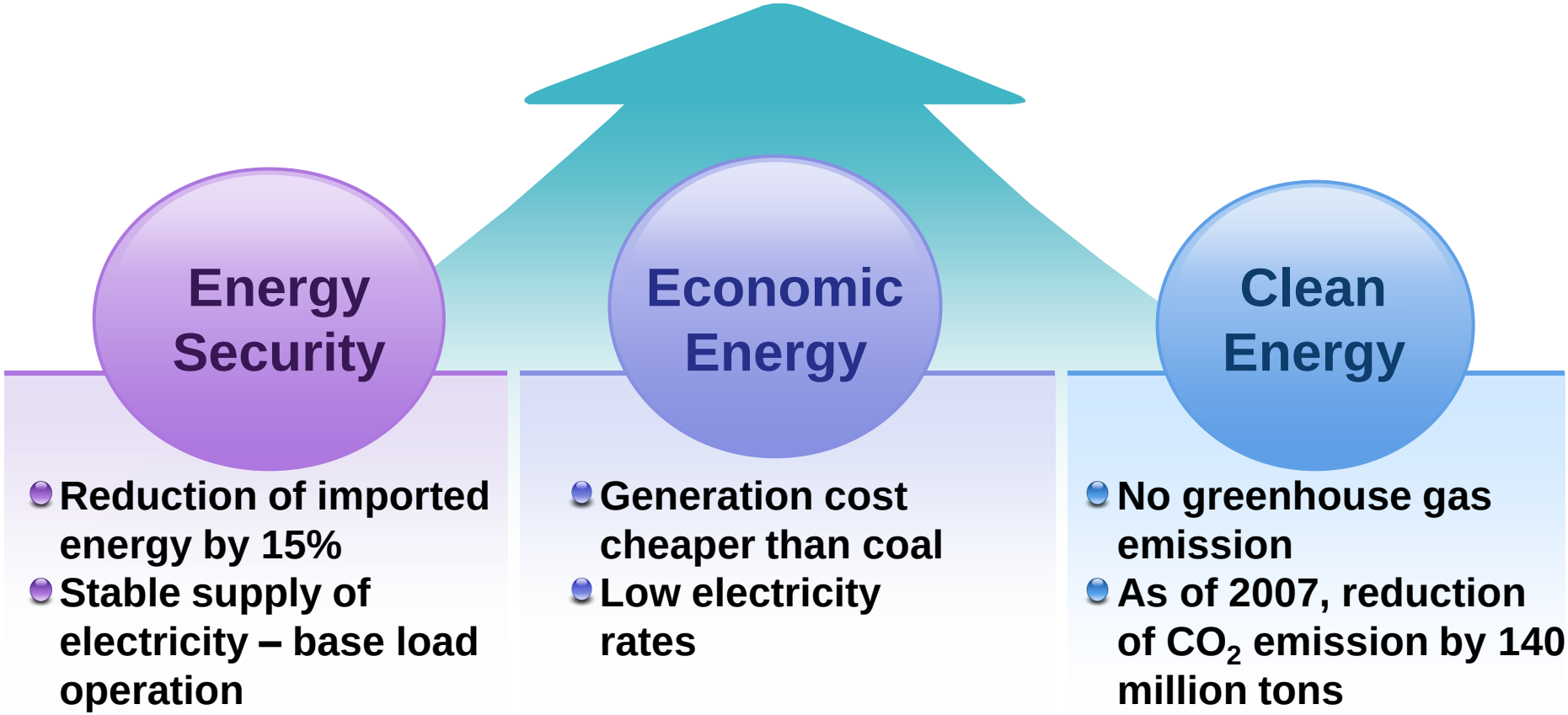
1. Status of Nuclear Power in Korea

Why Now Nuclear Renaissance?

- **Proven safety/economy over past half-century**
  - **End to Chernobyl/TMI syndrome**
- **Tangible solution to global warming, GHG reduction**
- **Low-carbon, green growth economy**
  - **Hybrid/electric/hydrogen cars**
  - **New massive electricity generation required**
- **Insecurity over oil/gas supply**

Role of Nuclear Power in Korea

Sustainable Economic Growth

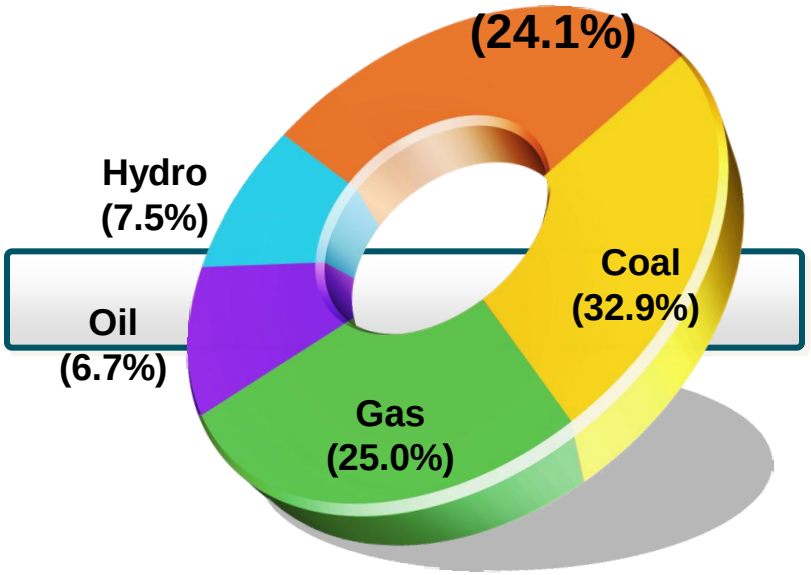


Status of Electric Power in Korea

World's 5th Largest Nuclear Power Generating Country

*As of the end of 2009

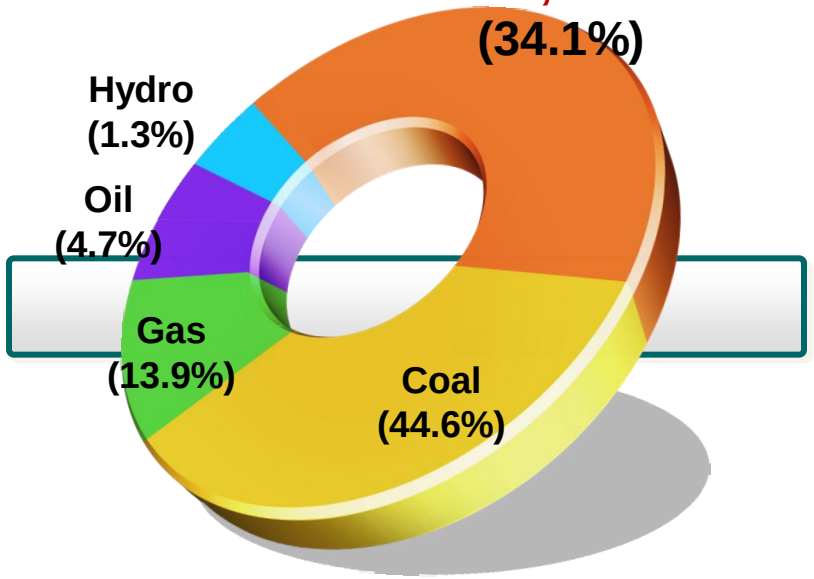
Installed Capacity



*Others : 2,728 MW(3.7%)

Total : 73,470 MW

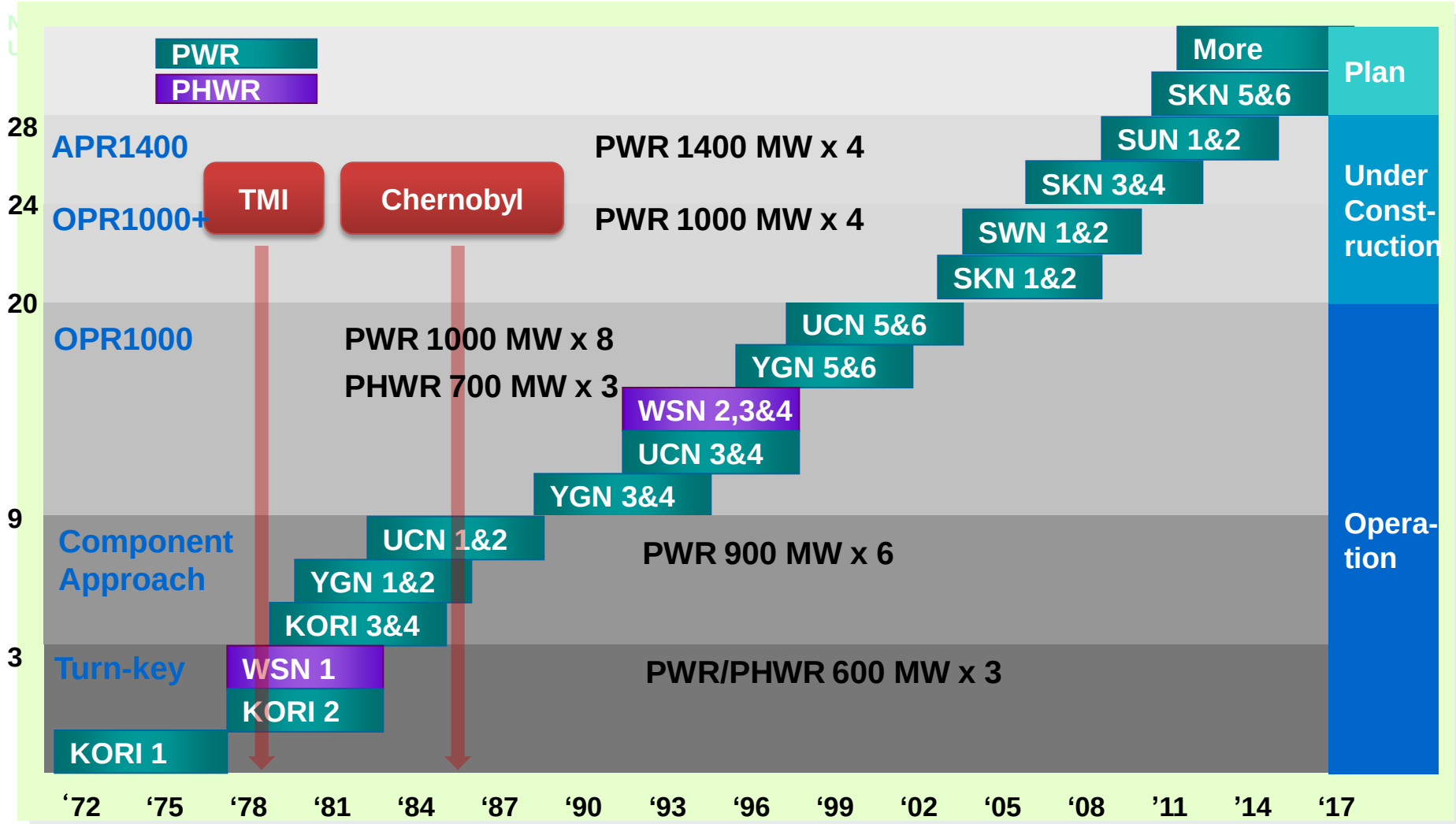
Electricity Generation



*Others : 5,928 GWh(1.4%)

Total : 433,311 GWh

Nuclear Power Plants Chronology



Nuclear Power Plants in Korea

(as of the end of 2009) (Unit : MW)

Site	In Operation	Under Const.	Total
Kori	4 (3,137)	4 (4,800)	8 (7,937)
Wolsong	4 (2,779)	2 (2,000)	6 (4,779)
Yonggwang	6 (5,900)	-	6 (5,900)
Ulchin	6 (5,900)	2 (2,800)	8 (8,700)
Total	20 (17,716)	8 (9,600)	28 (27,316)

In Operation
20 units
(17,716 MW)

Under Construction
8 units
(9,600 MW)

Under Planning
10 units
(15,400 MW)

Status of NPP Operation in Korea

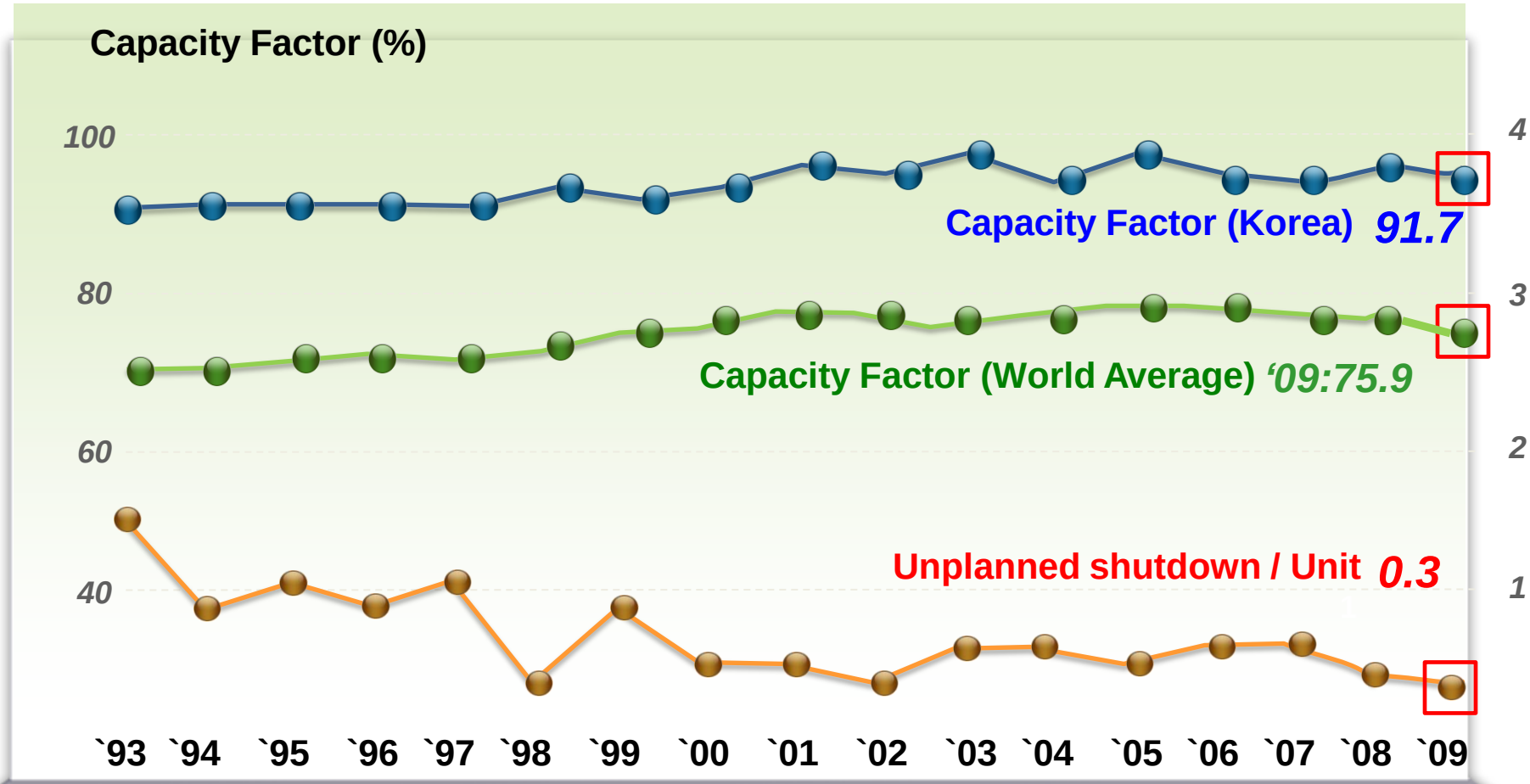
- **Kori Site**
  - PWR 600 MW(WEC) x 2
  - PWR 900 MW(WEC) x 2

- **Ulchin Site**
  - PWR 900 MW(FRA) x 2
  - PWR 1000 MW(OPR1000) x 4

- **Wolsong Site**
  - PHWR 600 MW(CANDU) x 1
  - PHWR 700 MW(CANDU) x 3

- **Younggwang Site**
  - PWR 900 MW(WEC) x 2
  - PWR 1000 MW(OPR1000) x 4

Performance of Operating plant



C.F.(%)	87.2	87.4	87.3	87.5	87.6	90.3	88.3	90.4	93.2	92.7	94.2	91.4	95.5	92.3	90.3	93.4	91.7
shutdown	1.6	0.9	1.1	0.9	1.1	0.4	0.9	0.5	0.5	0.4	0.6	0.6	0.5	0.6	0.6	0.35	0.3

Status of NPP Construction in Korea

OPR1000 Project

PWR 1000 MWe –Korean Standard NPP

Shin-Kori #1,2

- Progress Rate : 98%
- Completion : Dec. 31, 2010

Shin- Wolseong #1,2

- Progress Rate : 80%
- Completion : Mar. 31, 2012

APR1400 Project

PWR 1400 MWe –Korean Standard NPP

Shin-Kori #3,4

- Progress Rate : 58%
- Completion : Sept. 2013

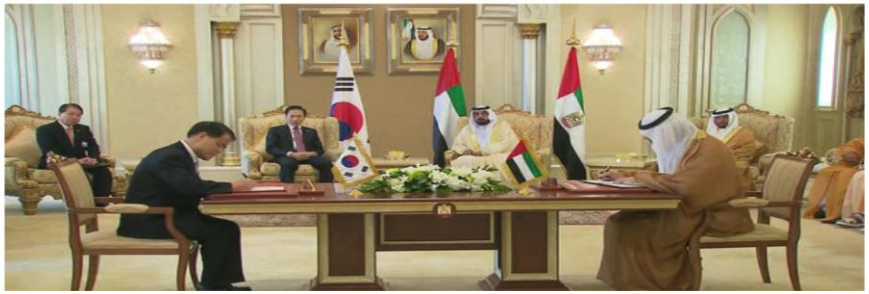
Shin- Ulchin #1,2

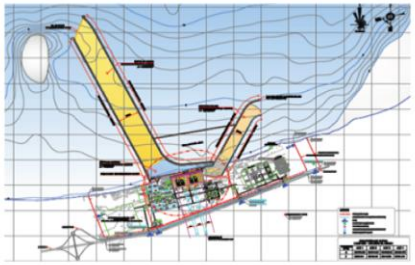
- Excavation : June 2010
- Completion : Dec. 2015

Status of NPP Overseas Construction

UAE BRAKA NPP

- PWR 1400 MW(APR1400) x 4 Units
- 2009.12 – 2017.05 (2020.5)





Jordan Research & Training Reactor

- 5MW Open-Tank-in-Pool Type Reactor
- 2010.03 – 2015.02

Long-Term National Energy Plan in Korea

Low-carbon, green growth is mapped out as Korea's new national vision for a post-oil era

< 4 Strategies>

- Low energy consumption
- Increasing clean energy
- Boosting green energy industry
- Supply of affordable energy

Increasing the share of nuclear power generation

34% ('09) → 59% ('30)

About 40 nuclear power plants will be in operation in 2030

2.Experience of Commercial NPP Development

Korean Reactor Technology Strategy

1970s	1980s	1990s	2000s	2010s
Turn-key Approach	Component Approach	Technological Self-reliance	Technological Level-up	Technological Advance
				
Introduction of NPP	Establishment of Localization (`~'85)	OPR1000 Development (`95)	APR1400 Development (`02)	Nu-tech 2012
▪ Kori 1 ▪ Wolsong 1 ▪ Kori 2	▪ Kori 3&4 ▪ Ulchin 1&2 ▪ Yonggwang 1&2	▪ Yonggwang 3,4,5,6 ▪ Ulchin 3,4,5,6 ▪ Shin-Kori 1,2 ▪ Shin-Wolsong 1,2	▪ Shin-Kori 3,4 ▪ Shin-Ulchin 1,2	▪ APR+ ▪ SMART

Korean Standard Nuclear Power Plants

OPR1000

Optimized Power Reactor 1000

Proven Technology

Power : 1,000 MWe

Life Time : 40 years

Const. : 51 months

Seismic : 0.2g (5.6)*

APR1400

Advanced Power Reactor 1400

Evolutionary Gen-III Reactor

Power : 1,400 MWe

Life Time : 60 years

Const. : 54 months

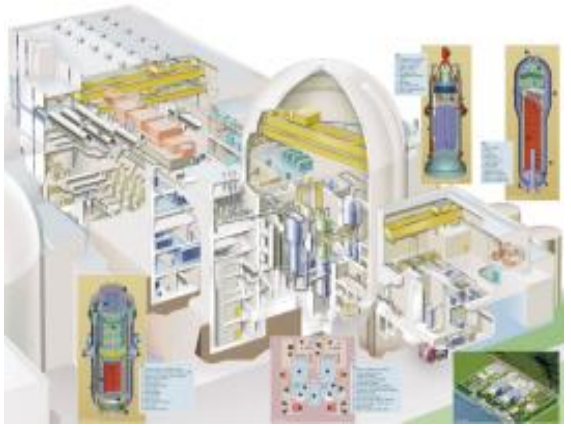
Seismic : 0.3g (7.0)*

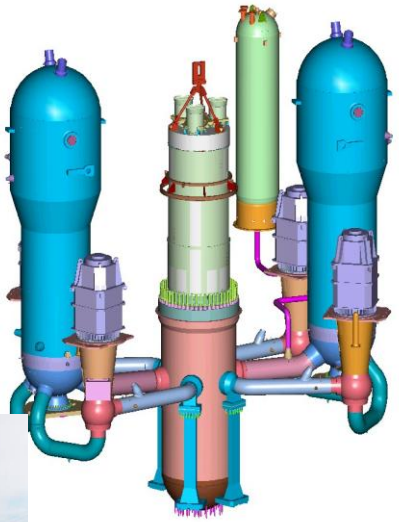
Advanced Power Reactor 1000 development currently underway

Optimized Power Reactor (OPR) 1000

Safer and More Reliable Technology

- High-level of Safety / Performance Proven by Operation
- Standardized Design
- Cost Competitiveness
- Improved Operability, Maintainability and Reliability
- 8 Units in Operation, 4 Units Under Construction
- Design Upgrade to APR1000 in Progress (60 Years, 0.3g, 40 months Construction, Etc.)

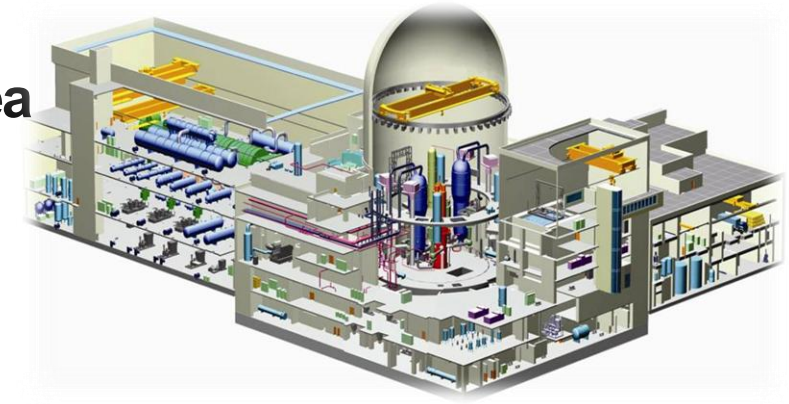




Advanced Power Reactor (APR) 1400

Evolutionary Gen III Technology

- Offering significant advances in safety and economics
- Design addressed the expectation of utilities for ALWR
- Design complies with up-to-date regulatory requirements of Korea and US, IAEA requirements
- Severe accident mitigation design features
- 4 units currently under construction in Korea
- Construction of 4 units started in the UAE



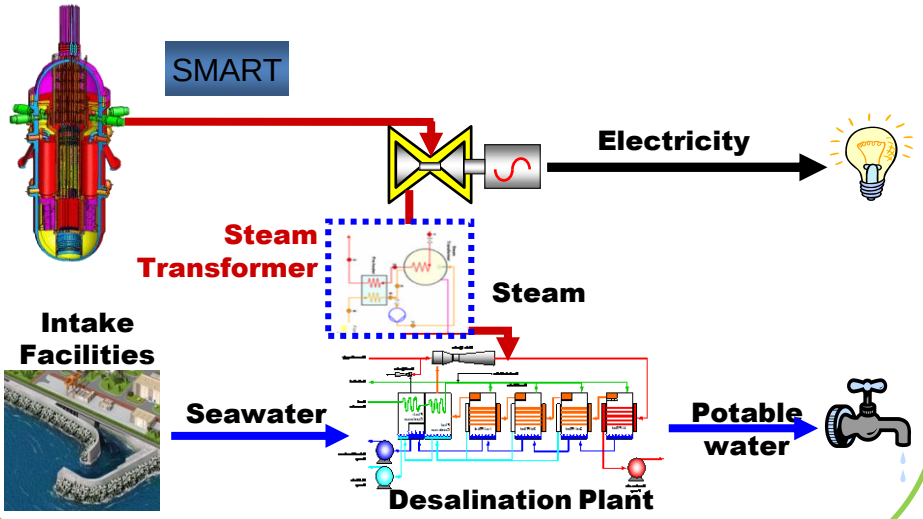
Development of New Technology

APR+ (Plus)

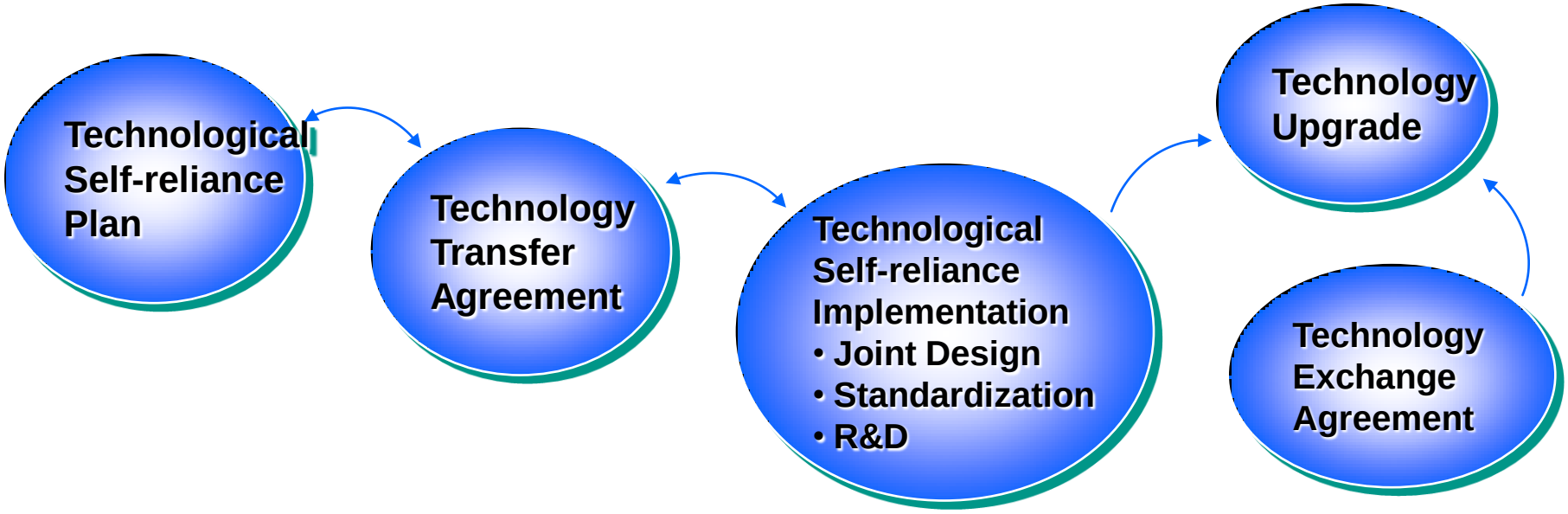
- Technology Advancement to GEN III Reactor
- Significant Enhancement of Safety and Economics
  - Electrical Power > 1500MWe
  - Safety Goals
    - CDF < 10-6/ RY
    - CFF < 10-7/RY
  - Construction Period < 36 Months

SMART

- Advanced multi-purpose small size reactor (330MWt)
- Sufficient to supply both fresh water and electricity for a city of 100,000 population
- Stable for small and localized power system



Technological Self-reliance



Nuclear Power Industries

Regulatory

KINS

Nuclear Safety
Licensing
Inspection

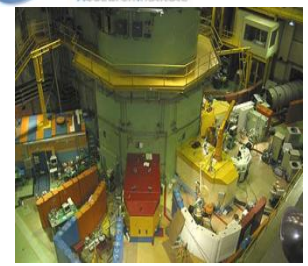
Leading Company

KEPCO

- Leading Role
- Financing Capability
- Global Experience
- Project Management

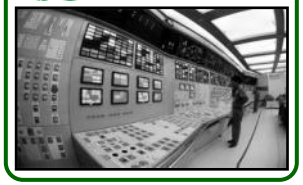
Research and Development

KAERI Korea Atomic Energy Research Institute



Operation and Management

KHNP



Design and Engineering

KEPCO E&C

Nuclear Fuel

KEPCO NF

Maintenance and Services

KEPCO KPS

Equipment Manufacturing

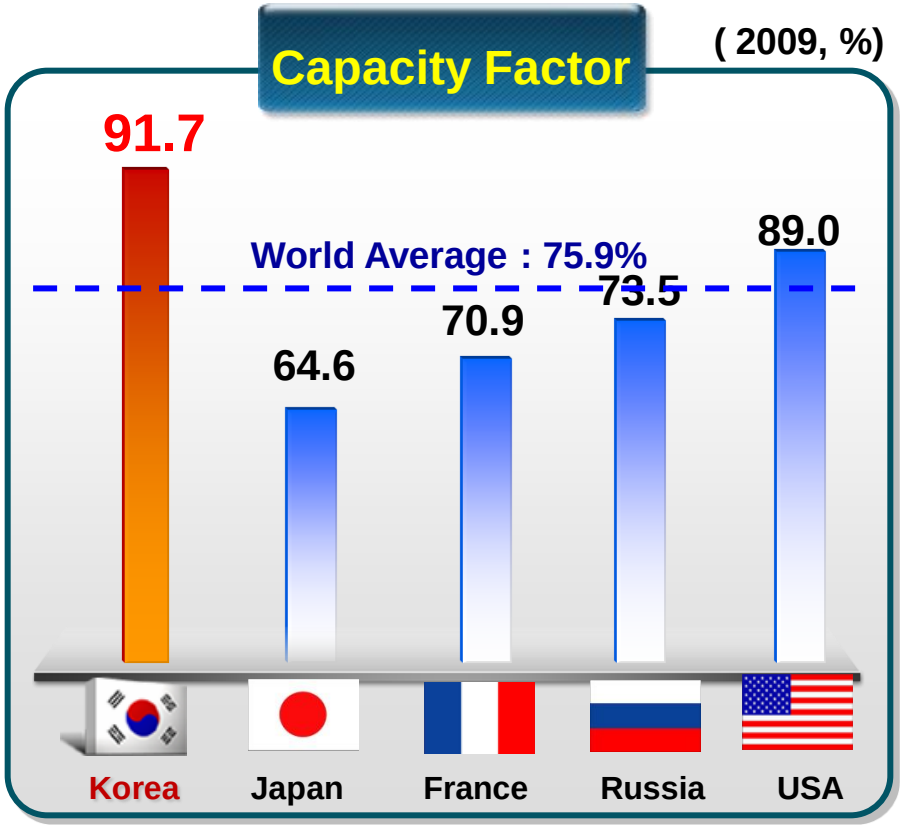
DOOSAN

Construction

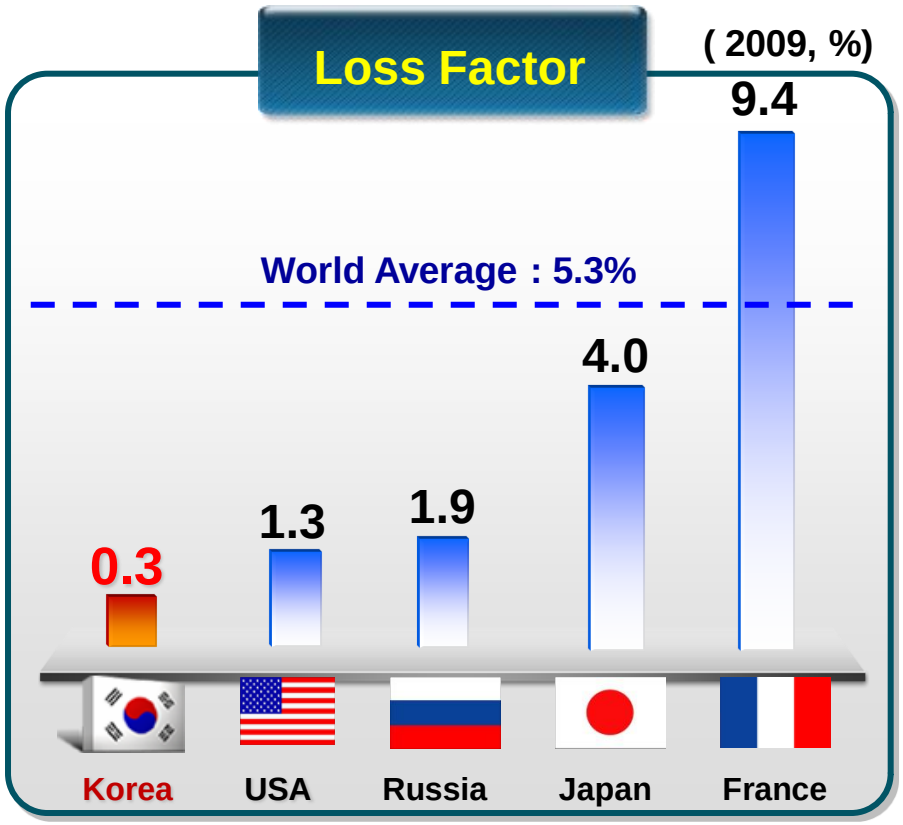
SAMSUNG
HYUNDAI ENGINEERING & CONSTRUCTION CO.,LTD
GS E&C
DAEWOO E&C
DAELIM Best Value, Better Life
SK 건설

3. Competitiveness of Korean Nuclear Technology

Top Global-level Capacity for NPP Operation



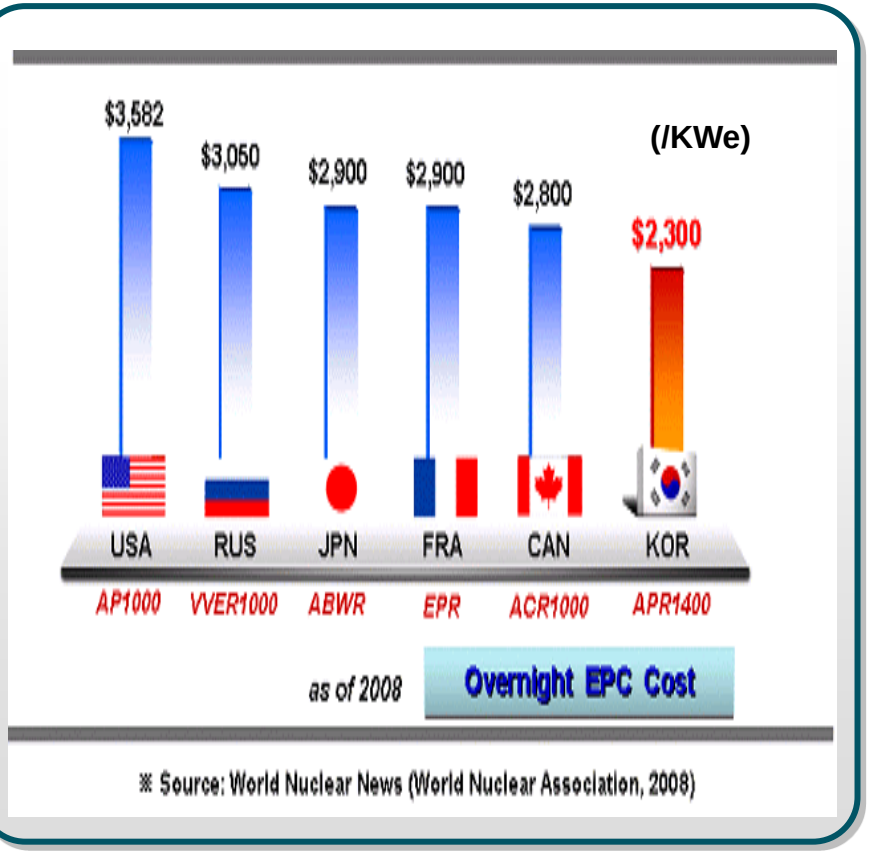
※ Nucleonics Week(2010.4)



※ Loss factor: Ratio of the unplanned energy losses to the reference energy generation, IAEA

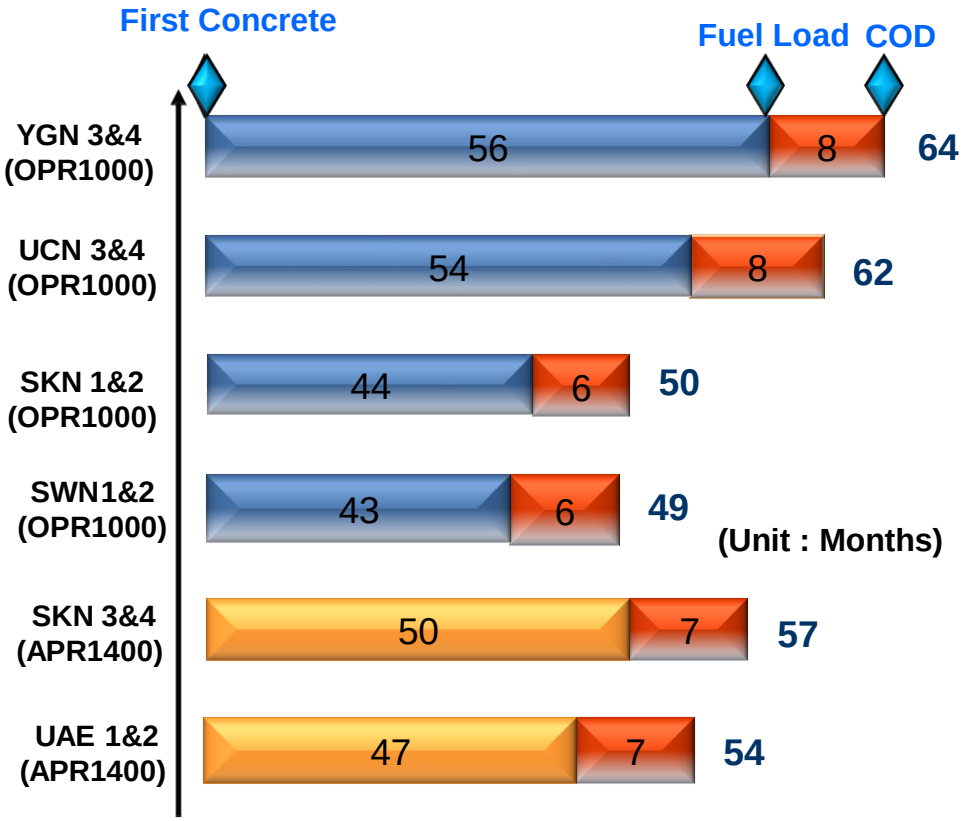
Top Global-level Capacity for NPP Construction

Construction Cost



※ Source: World Nuclear News (World Nuclear Association, 2008)

Construction Period

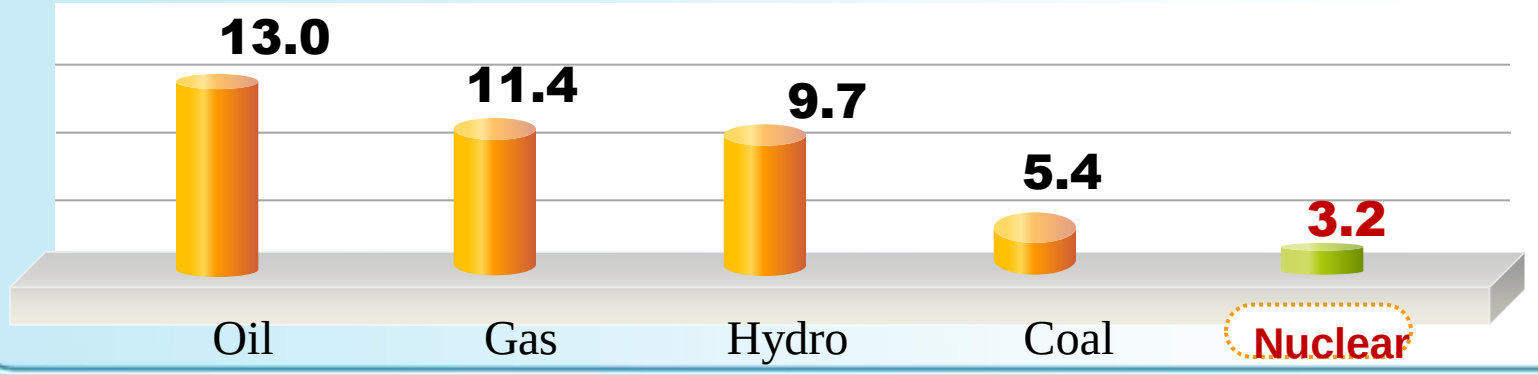


Cost Competitiveness of Korean NPP

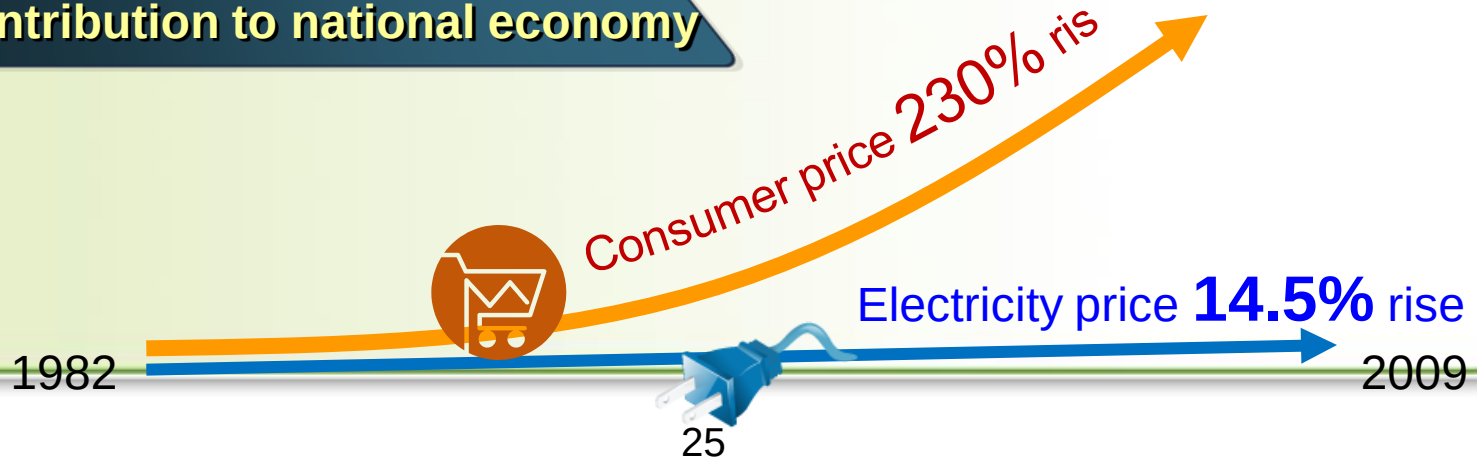
Economical efficiency

- **Sales price (¢/kWh) : Nuclear is the cheapest**

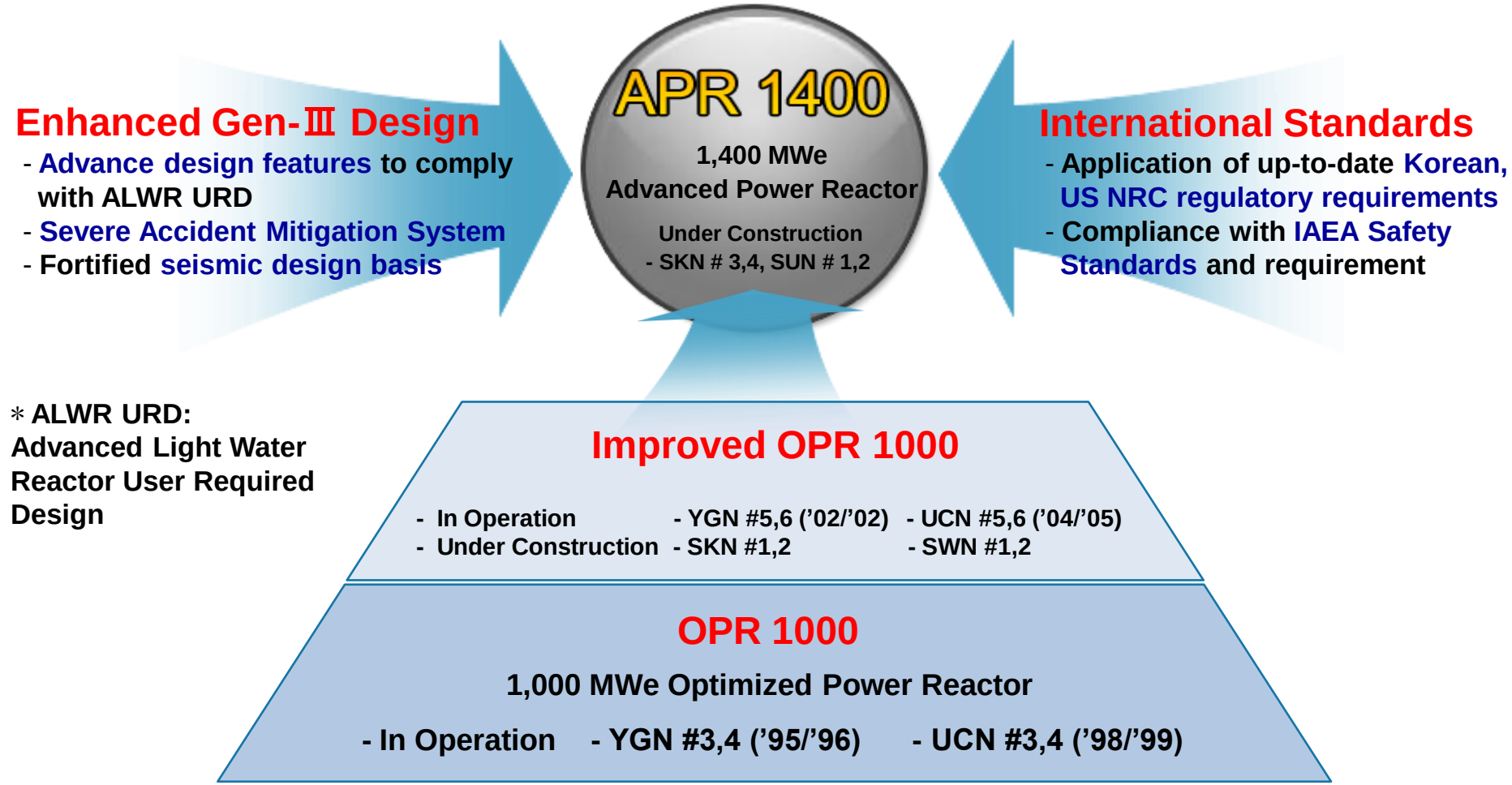
(Year 2009)



Contribution to national economy



High Level of Safety



* ALWR URD: Advanced Light Water Reactor User Required Design

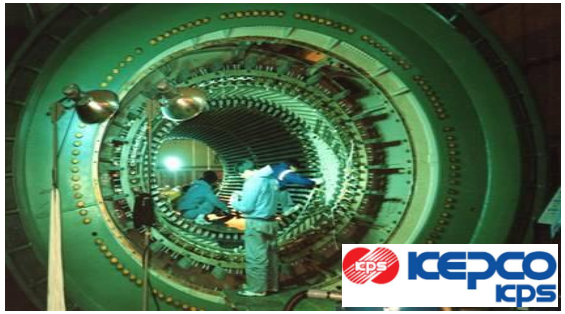
Robust Supply Chain

Manufacturing

Construction

Design & Engineering

KEPCO manages a strong supply chain for the entire nuclear life cycle from NPP design to equipment manufacturing, construction, nuclear fuel provision, operation and maintenance.

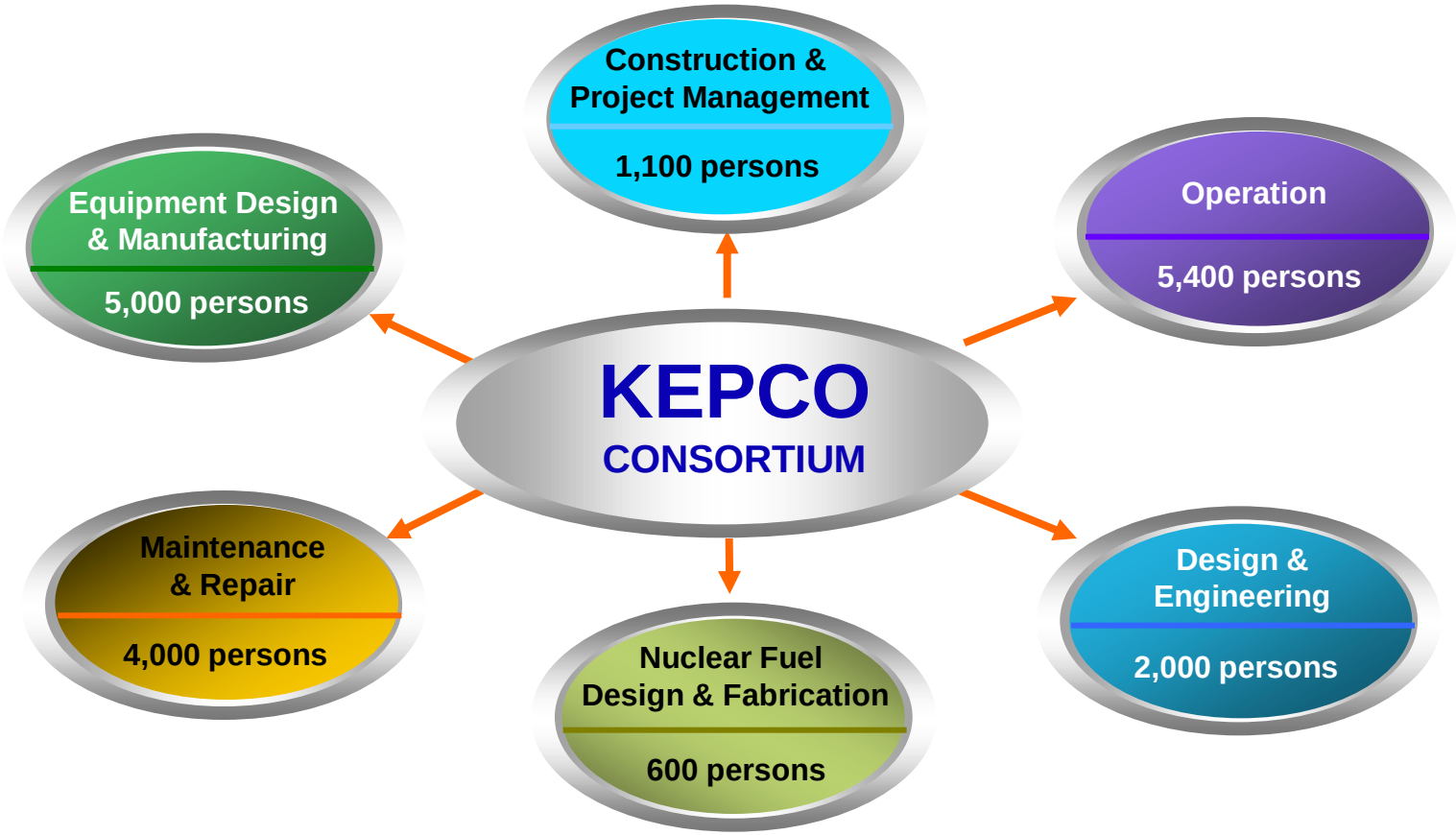


Commissioning & Operation

Nuclear Fuel

Maintenance

Competitive Human Resources



Korea nuclear industry maintains highly skilled manpower in the various fields of nuclear power based on its continuous NPP construction and operation.

4. Recommendations for Nuclear Power Programme

Recommendations

- Strong Government Support
- Human Resource Development
- Localization
- Selection of Technology
- Sharing Our Experience
- Look into the Future

Strong Government Support

- Establishment of nuclear power programme and long-term policy
- Government leadership with clear goals
- Ongoing investment and long term guarantee
  - Development of infrastructures and human resources
  - Establishment of regulatory framework
  - Localization plan
- Strong authority for the leader of the programme

Human Resource Development

- Early recognition of the importance of a well-trained and qualified staff
- Preparation of short and long-term human resource development programme
  - International cooperation: international programmes and collaboration with other countries
  - Adequate provisions for training in the project contract
  - Incentives for highly qualified people to secure necessary manpower
- Establishment of self-reliant education system

Localization

- **Scope of localization to be determined by considering**
  - **The long-term goal of nuclear power programme**
  - **Spill-over effect**
  - **Competitiveness of localized technology in the future**
- **Augmentation of the industry capability to implement localization**
- **Minimization of interfaces for effective localization and further development in the future**
- **Learning through project participation**
- **Technology transfer through project contracts**

Selection of Technology

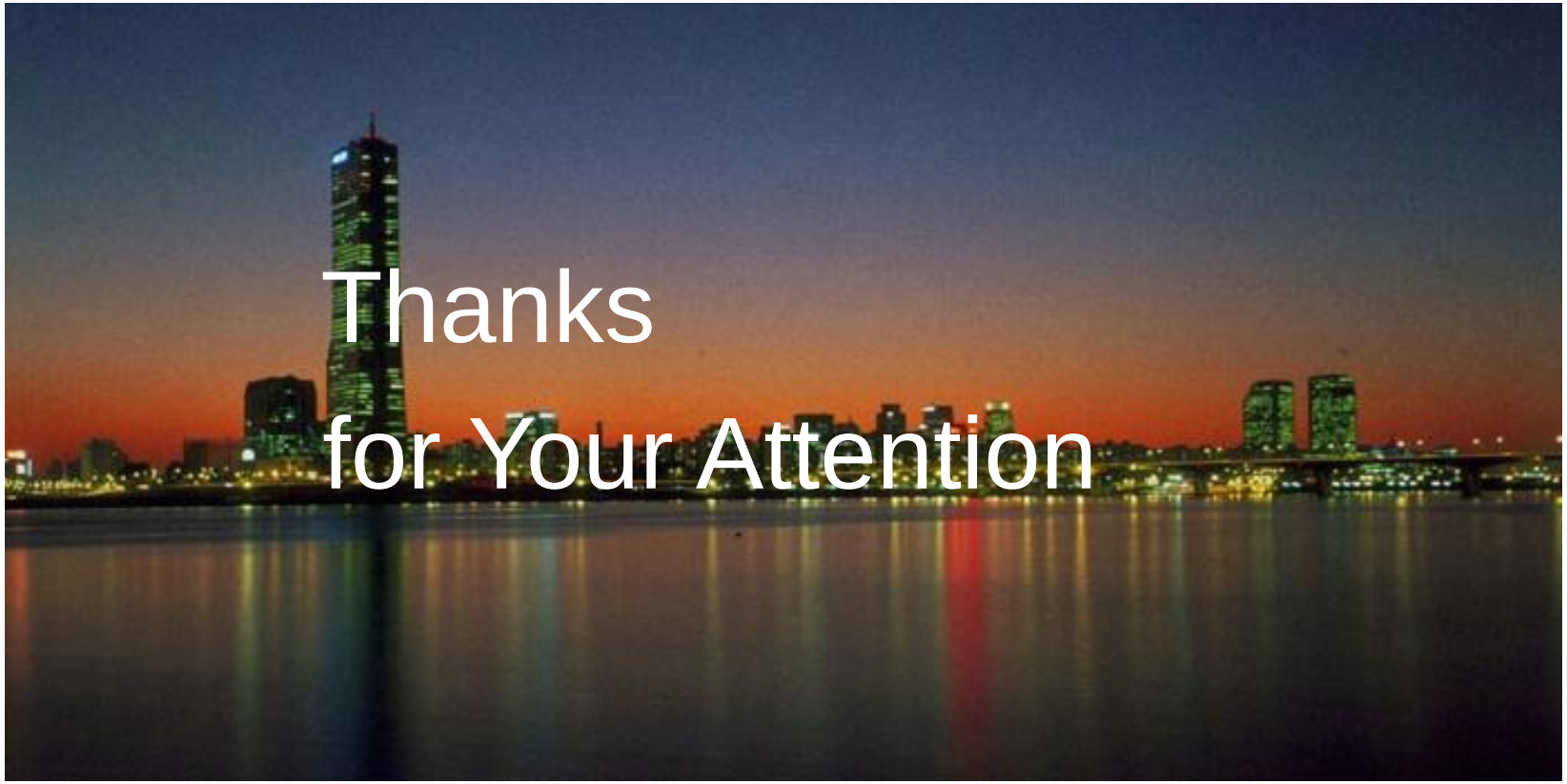
- **Proven technology to minimize technical and licensing uncertainties**
  - **Proven by operation**
  - **Proven by construction**
  - **Proven by licensing approval**
- **Vendor capabilities**
  - **To fulfill owner's requirements**
  - **To provide full scope services and long-term partnership**
  - **To meet the construction schedule as demonstrated in other recent projects**
  - **To provide reliable services for plant operation and training**

Sharing Our Experience

- **Korean nuclear industry - a success model for achieving technology self-reliance and further developing nuclear power**
- **Potential areas where Korean nuclear industry can assist Middle East & North Africa countries planning to introduce nuclear power:**
  - Planning for the introduction of commercial nuclear power
  - Development of human resources and training
    - Operation and maintenance
    - Development of a national academic program
  - Establishment of localization plans
    - Engineering, construction, manufacturing, fuel, etc.
  - Site characterization
  - Establishment of regulatory frame

Look into the Future

- **Further Enhancement of Plant Safety and Economics**
  - Enhance plant safety adopting more passive safety features
  - Up-rate reactor power and optimize the design
  - Improve construction schedule
- **Nuclear Manpower Buildup**
  - Attract young engineers
  - Provide more practical education programs
- **Public Acceptance of Nuclear Power**
  - Demonstrate continued safe and reliable operation
  - Maintain consistent public relations
  - Advocate nuclear energy as CO_2 emission free energy
- **Partnership with Neighbors**
  - Share with our neighbors Korea's experience



Thanks
for Your Attention