"Experiences of Development of Sustainable Nuclear Energy Systems in the Republic of Korea"

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Current Status of Energy Supply in Korea

96.4 % of energy resources were imported in 2011

Year 2011

Korea’s Energy Consumption

World rank 9th

- Energy Consumption : 240 Mtoe

Korea’s Energy & Oil Import

- Energy Import : 231 Mtoe
  (USD 141 Billion, 33 % in total import)
- Oil Import : 159 Mtoe = 865 Million bbl
  (USD 86 Billion)

* IEA, Energy balance of OECD countries 2004-2005
Status of Electric Power in Korea

Installed Capacity

- Nuclear: 5,492 MW (8.0%)
- Coal: 6,808 MW (10.0%)
- Gas: 17,436 MW (25.5%)
- Hydro: 20,465 MW (30.0%)
- Oil: 17,716 MW (26.0%)

*The others: 351 MW (0.5%)
Total: 68,268 MW

Electricity Generation

- Nuclear: 5,042 GWh (1.3%)
- Coal: 21,215 GWh (5.3%)
- Gas: 78,427 GWh (19.5%)
- Oil: 154,674 GWh (38.4%)
- Hydro: 142,937 GWh (35.5%)

*The others: 829 GWh (0.2%)
Total: 403,124 GWh

(As of the end of 2007)
Status & Prospects of the Nuclear Power Programs in Korea

- Now 21 NPPs (18.7 GW) are in operation & 7 NPPs under construction.
  - About 40 NPPs (59 % of total electricity) will be operated in 2030.
- Low & Medium Level Waste Facility is under Construction.
Performance of NPP in Korea

Capacity Factor (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity Factor (Korea)</th>
<th>Capacity Factor (World Average)</th>
<th>Unplanned shutdown / Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.9</td>
<td>90.3</td>
<td>77.8</td>
<td>0.6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>C.F.(%)</th>
<th>shutdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>87.2</td>
<td>1.6</td>
</tr>
<tr>
<td>87.4</td>
<td>0.9</td>
</tr>
<tr>
<td>87.3</td>
<td>1.1</td>
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<tr>
<td>87.5</td>
<td>0.9</td>
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<td>87.6</td>
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<td>93.2</td>
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<td>92.7</td>
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shutdown: unplanned shutdown / Unit

Unit: 0.6

Capacity Factor (Korea) 90.9

Capacity Factor (World Average) 77.8

Unplanned shutdown / Unit 0.6
Nuclear Technology Development Roadmap in Korea

<table>
<thead>
<tr>
<th><strong>1980s</strong></th>
<th><strong>1990s</strong></th>
<th><strong>2000s</strong></th>
<th><strong>2010s</strong></th>
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<tbody>
<tr>
<td>PWR Fuel Indigenization</td>
<td>PWR System Design Technology Self-Reliance</td>
<td>Development of Prototype SFR/VHTGR</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Export APR1400 &amp; Research Reactor 2009/2010</td>
<td>Present</td>
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</tbody>
</table>
Nuclear Reactor Development Milestone in Korea

1st Phase: Gen II
- Turn-key base
- 600 MWe

2nd Phase: Gen III
- Standardization
- KSNP (OPR1000)
- 1,000 MWe

3rd Phase: Gen III+
- Evolutionary PWRs
- APR1400
- SMART

4th Phase: Gen IV
- Revolutionary
- SFR: recycle SF and waste minimization
- VHTR for hydrogen production

Timeline:
- 1970s
- 1980s
- 1990s
- 2000s
- 2010s
- 2020s
- 2030s ~
The 1st Nuclear Power Projects in Korea

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

1st unit of Nuclear power plant started to build in 1971

- Turn Key basis
- 587MWe
- Commercial operation in 1978
- Life extension after 30 years operation (2007.12)
Evolutionary NPP Technology Development in Korea

Evolution of Korea’s self-reliance

1970’s
Introduction of Nuclear Power
Turn-key led by Foreign Contractors

1 PWR

1980’s
Accumulation of NPP Technology
Non-Turn Key Approach
- Prime contractors
  - foreign → local

8 PWRs + 1 PHWR

1990’s
Technology Self-Reliance
Development and Operation of OPR1000

12 PWRs + 4 PHWRs
(Including 4 OPRs)

2000’s
Development of Advanced Reactor
Development of APR 1400

16 PWRs + 4 PHWRs
(Including 8 OPRs)

* OPR1000 (Optimized Power Reactor 1,000)
* APR1400 (Advanced Power Reactor 1,400)
Local Participation in Nuclear Power Projects in Korea

**Localization Results in Korea**

### Engineering(%)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Kori #1</th>
<th>Kori #2</th>
<th>Wolsong #1</th>
<th>Kori #3,4</th>
<th>Yonggwang #1,2</th>
<th>Ulchin #1,2</th>
<th>Yonggwang #3,4</th>
<th>Ulchin #3,4</th>
<th>Yonggwang #5,6</th>
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<tbody>
<tr>
<td>1st Stage</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>37</td>
<td>44</td>
<td>46</td>
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<tr>
<td>2nd Stage</td>
<td>8</td>
<td>13</td>
<td>14</td>
<td>29</td>
<td>35</td>
<td>40</td>
<td>74</td>
<td>75</td>
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<tr>
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**Ratio(%)**

- Equipment
- Engineering
Construction Experience of NPP in Korea

Construction - Time Schedule

OPR1000

Shin-Ulchin #3
- First Concrete Pour: 21M
- Set Rx. Vessel: 22M
- CHT: 4M
- HFT: 5M
- Fuel Load: 5M
- CO: 9M
- Total: 61M

Younggwang #5
- First Concrete Pour: 22M
- Set Rx. Vessel: 20M
- CHT: 5M
- HFT: 5M
- Fuel Load: 7M
- CO: 59M

Shin-Ulchin #6
- First Concrete Pour: 21M
- Set Rx. Vessel: 18M
- CHT: 4M
- HFT: 6M
- CO: 55M

Shin-Kori 1&2
- First Concrete Pour: 19M
- Set Rx. Vessel: 17M
- CHT: 4M
- HFT: 7M
- CO: 51M

Wolsong 1&2
- First Concrete Pour: 17M
- Set Rx. Vessel: 16M
- CHT: 4M
- HFT: 6M
- CO: 47M

ARP1400

Shin-Kori 3&4
- First Concrete Pour: 20M
- Set Rx. Vessel: 19M
- CHT: 4M
- HFT: 8M
- CO: 55M

Nth Plant
- First Concrete Pour: 17M
- Set Rx. Vessel: 17M
- CHT: 4M
- HFT: 6.5M
- CO: 48M
Nuclear Related Organizations in Korea

- **Nuclear Safety & Security Commission**
- **Atomic Energy Commission**
- **President**
- **Prime Minister**
- **MEST (Ministry of Education, Science & Technology)**
- **Scientific Technology Commission**
  - Ministry of Knowledge & Economy
  - Ministry of Foreign Affairs & Trade
  - Ministry of Planning & Budget

**Nuclear Industries**
- Utility: KEPCO
- NPP Owner: KHNP
- NPP Designer: KOPEC
- Fuel Supplier: KNFC
- Manufacturer: DOOSAN

**Academia**
- Universities
- Other Research Institutes

**Public**
- News Media, NGOs, Local Society

**KAERI**
- National R&D program

**KINS**
- Safety & Regulation

**MEST**
- Ministry of Knowledge & Economy
- Ministry of Foreign Affairs & Trade
- Ministry of Planning & Budget
Nuclear Industry in Korea
Status of Construction of NPPs in Korea & UAE

• 10 APR 1400 (1400 MW) are under construction:
  - 6 in Korea & 4 in UAE, which was exported in December 2009.
• Average construction period is aimed to be 48 months.
CANDU Fuel Technology Development in Korea

- R&D Facility Set-up at KAERI (1978)
- Governmental Decision to Localize CANDU–PHWR Fuel (1981)
  - Initiation of R&D Project Funded by Government & KEPCO

- Expansion of Fabrication Capacity to Full Domestic Supply of CANDU–PHWR Units
  - 1988: 100 MTU/yr
  - Since 1998: 400 MTU/yr
PWR Fuel Technology Development in Korea

- Korea Nuclear Fuel Company Formed (1982)
- Technology Inducement Contract with KWU (1985)
  - KAERI/KWU for PWR Fuel Design
  - KNFC/KWU for PWR Fuel Fabrication
  - Introduction of Joint Design Concept
  - Joint R&D
- First Delivery of Domestic Fuel (1989)
Pyroprocess Fuel Development in Korea

- Development through international collaboration
- Reduction of waste volume by a factor 100
- Utilization of U by a factor of 100
Participation in INPRO

Korea participated in INPRO in 2001
Shared experience of DUPIC fuel cycle development in PRADA
Participation in GIF

- Korea joined GIF as a charter member in 2001
- Korea participated in development of SFR & VHTGR
Participation in IFNEC(GNEP)

• Korea joined GNEP (IFNEC) as a member.
Export of APR-1400 to UAE

• On 27 December, 2009, UAE Picked ROK as Nuclear Partner:
  - Emirates Nuclear Energy Corporation (ENEC) signed contract with Korea Electric Power Corporation (KEPCO) to built 4 APR-1400.
Export of Research Reactor to Jordan

- Jordan & ROK signed on 30 March 2010 to build 5 MWth Research Reactor (JRTR) at the Jordan University of Science and Technology.

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<thead>
<tr>
<th>JRTR Project Summary</th>
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<tbody>
<tr>
<td><strong>Scope of Supply</strong></td>
</tr>
<tr>
<td><strong>Owner</strong></td>
</tr>
<tr>
<td><strong>Contractor</strong></td>
</tr>
<tr>
<td><strong>Project Period</strong></td>
</tr>
<tr>
<td><strong>Site</strong></td>
</tr>
</tbody>
</table>
Thank you for your kind attention!