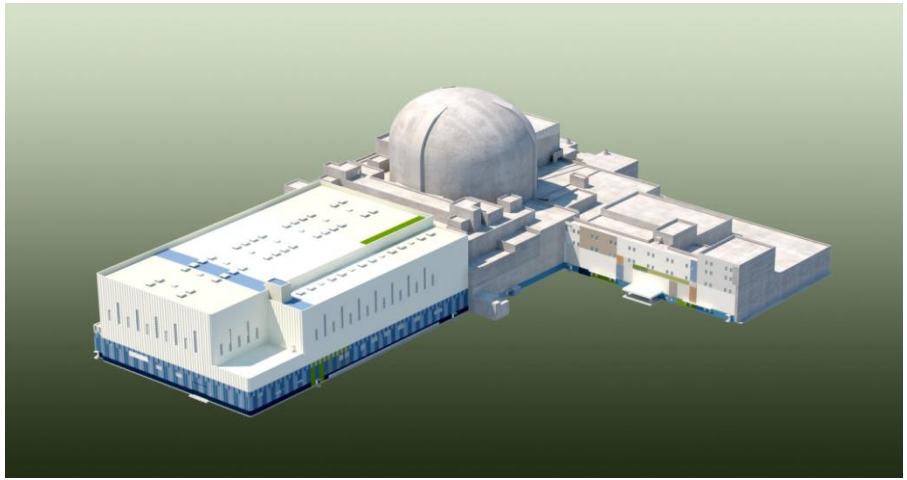
A Brief Overview of the APR1400 Commissioning



KHNP

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Sang Won Lee

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Nuclear Power Plants in Korea

In Operation	25 Units	23,116 MW
Under Construction	5 Units	7,000 MW
Planning	4 Units	5,800 MW

Chunji 1,2

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

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

Wolsong 1,2,3,4
(PHWR)

Shin -Wolsong 1,2

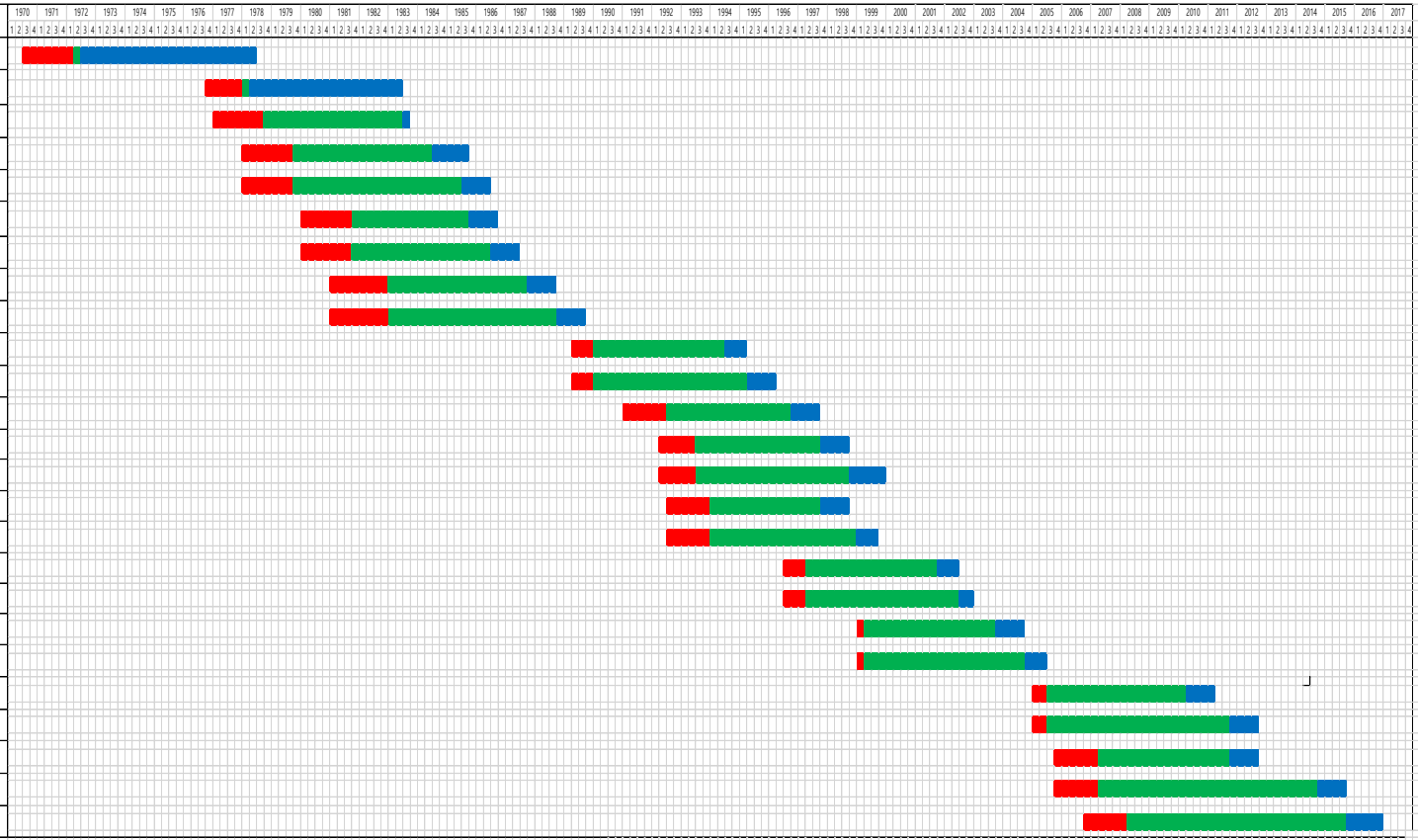
Hanbit 1,2,3,4,5,6

Kori 1,2,3,4
Shin-Kori 1,2,3

Shin-Kori 4
Shin-Kori 5,6

Construction Terms of Each NPP in Korea

Units	Reactor Type	Starting	CP	OL	Commercial Operation
Kori #1	PWR	1970-09-01	1972-05-01	1972-05-01	1978-04-01
Wolsung #1	PHWR	1976-11-01	1978-02-01	1978-02-01	1983-04-01
Kori #2	PWR	1977-03-01	1978-11-01	1983-08-01	1983-07-01
Kori #3	PWR	1978-02-01	1979-12-01	1984-09-01	1985-09-01
Kori #4	PWR	1978-02-01	1979-12-01	1985-08-01	1986-04-01
Hanbit #1	PWR	1980-03-01	1981-12-01	1985-12-01	1986-08-01
Hanbit #2	PWR	1980-03-01	1981-12-01	1986-09-01	1987-06-01
Hanul #1	PWR-Framatom	1981-01-01	1983-01-01	1987-12-01	1988-09-01
Hanul #2	PWR-Framatom	1981-01-01	1983-01-01	1988-12-01	1989-09-01
Hanbit #3	PWR	1989-06-01	1989-12-01	1994-09-01	1995-03-01
Hanbit #4	PWR	1989-06-01	1989-12-01	1995-06-01	1996-01-01
Wolsung #2	PHWR	1991-01-01	1992-08-01	1996-11-01	1997-07-01
Hanul #3	PWR	1992-05-01	1993-07-01	1997-11-01	1998-08-01
Hanul #4	PWR	1992-05-01	1993-07-01	1998-10-01	1999-12-01
Wolsung #3	PHWR	1992-09-01	1994-02-01	1997-12-01	1998-07-01
Wolsung #4	PHWR	1992-09-01	1994-02-01	1999-02-01	1999-10-01
Hanbit #5	PWR	1996-09-01	1997-06-01	2001-10-01	2002-05-01
Hanbit #6	PWR	1996-09-01	1997-06-01	2002-07-01	2002-12-01
Hanul #5	PWR	1999-01-01	1999-05-01	2003-10-01	2004-07-01
Hanul #6	PWR	1999-01-01	1999-05-01	2004-11-01	2005-04-01
SKN #1	PWR	2005-01-01	2005-07-01	2010-05-01	2011-02-01
SKN #2	PWR	2005-01-01	2005-07-01	2011-12-01	2012-07-01
SWN #1	PWR	2005-10-01	2007-06-01	2011-12-01	2012-07-01
SWN #2	PWR	2005-10-01	2007-06-01	2014-11-01	2015-07-01
SKN #3	PWR	2006-12-01	2008-04-01	2015-10-01	2016-12-01



Major Construction Schedule of SKN Unit 3

Activities	SKN Unit 3	SKN Unit 1
Earth Breaking	Apr. 2008	Oct. 2005
First Concrete	Nov. 2008	Apr. 2006
Reactor Install	Aug. 2010	Apr. 2008
Initial Electric Power Supply	Jul. 2011	Nov. 2008
CHT	May 2012	Sep. 2009
SIT/ILRT	Jul. 2012	Nov. 2009
HFT	Nov. 2012	Feb. 2010
Fuel Loading	Nov. 2015	Jun. 2010
Commercial Operation	Dec. 2016	Dec. 2010

Pre-Core Hot Functional Test

- Maintain test conditions of 291.3℃, 158.2kg/㎠ using RCP friction heat and pressurizer heaters.
- 55 Pre-Core Hot Functional Test
  - ➢ Three system cleaning test procedures including Main Steam System (SG to MSIV)
  - ➢ Six cold pre-op test procedures including IRWST In-Plant Test
  - ➢ Forty six hot functional test procedures including Pressurizer performance test

Post-Core Test

Test	Objectives	Accept. Criteria
Load Rejection	To demonstrate full load rejections from 50, 80 and 100% powers without initiating RPS and ESFAS and primary and secondary PSVs	No RPS/ESFAS initiation No 1st/2nd PSV open
Loss of a Main Feedwater Pump	NSSS can accommodate the loss of one MFWP at 60% and 95% power	No Rx. Trip No 1st/2nd PSV open
Turbine Trip and Natural Circulation	No initiation of RPCS with TBN trip at the 100% power	RCS Pr.: 156~160kg/cm^2 No 1st/2nd PSV open
Control System Checkout Test	To demonstrate automatic operations of FWCS and RRS during transient conditions	Level: ±2% s.p. T_{avg} : ±1.1℃ s.p.
Loss of Off-Site Power	The reactor can be shutdown and maintained in a HSB condition following a loss of all AC powers.	HSB for 30 min.

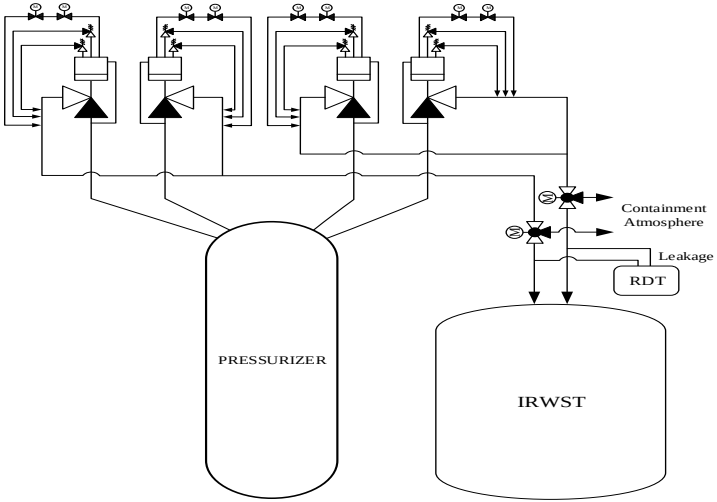
Post-Core Test

Test	Objectives	Results
ADV/TBV Capacity	To demonstrate the capacity of ADV and TBV	ADV: 6~11% TBV: less than 11%
Unit Load Transient	Unit Load can be changed at the specified rates	No Rx. Trip No 1st/2nd PSV open
100-50-100% Power Load Cycle	NSSS accommodates a 100-50-100% power load cycle transient	No Rx. Trip No 1st/2nd PSV open No ESFAS initiation
Shutdown from Outside MCB	To demonstrate to trip the reactor and maintain Hot Standby from Remote Shutdown Panel	HSB for 30 min.
Plant Acceptance Test	To satisfy the contractual warranty of the plant power	4000MWt

Experience : Leakage of POSRV (1/2)

- **Pilot Operated Safety Relief Valve (POSRV) Function**

  - RCS Overpressure Protection with Spring Loaded Pilot Valve(SLPV)
    - Discharge to IRWST to protect the RCS
  - Rapid Depressurization with Motor Operated Pilot Valves (MOPVs)
    - Discharge to IRWST to allow Feed and Bleed Operation for Total Loss of Feed Water (TLOFW)
    - Discharge to containment to respond to a severe accident



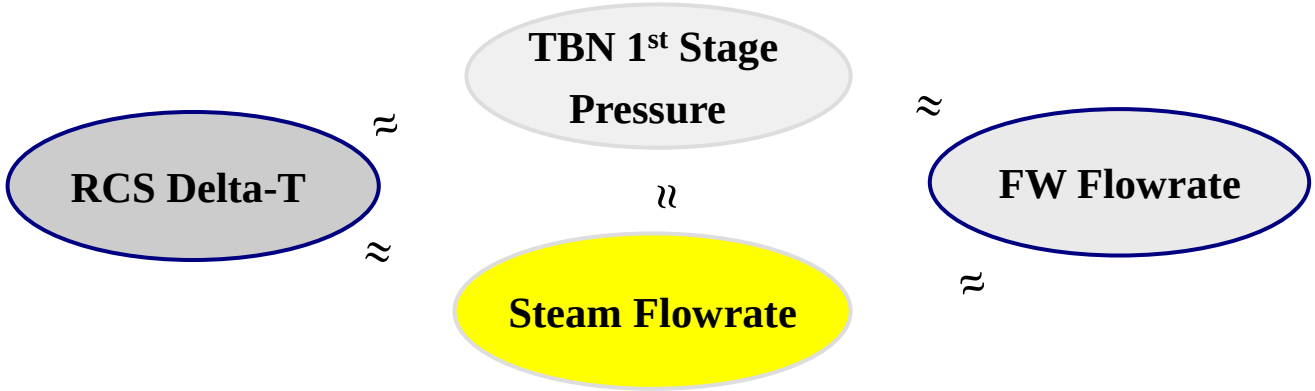
Schematic Flow Diagram of POSRV

Experience : Leakage of POSRV (2/2)

- **Background**
  - ➢ During the Power Ascension Test, leakage from POSRVs was identified.
    - The water level of RDT(Reactor Drain Tank) was increased.
    - The temperatures of outlet were higher then 65 ℃
- **Root Cause**
  - ➢ Non-uniform temperature distribution in the valve
    - high heat-up rate (enhancing the temperature gradient)
    - the pressurizer solid state during the startup
- **Mitigation options**
  - Adapting Low heat-up rate
  - Avoid the pressurizer solid state during the startup

Experience : Power Discrepancy in SKN 3 (1/2)

- **NPP Power Measurement**
  - Since there is no accurate, direct method of measuring the energy released by the nuclear fuel, the only method used for calculating the energy balance is the direct measurement of the energy output, losses and credits.
- **Secondary Calorimetric Power calculated in the COLSS**
  - If the measuring feedwater (FW) flowrate is accurate during the normal plant operation, the following parameters are balanced with each other.



Experience : Power Discrepancy in SKN 3 (2/2)

- **Background**
  - ➢ During the Power Ascension Test, Reactor thermal power reached at 95%, the T/G electrical power reached at 1455 Mwe, around 100%.
  - ➢ Discrepancy between the NSSS thermal power and T/G electrical power

- **Find the Cause**
  - ➢ The FW Venturi DP Measurement faults
    - Discrepancy the FW flow between the FW flow measuring channels
    - The measured DP of the venturi is indicated smaller than the estimated value
    - The secondary calorimetric power is smaller than expected.

- **Decide the replacement of the Flow Elements for the SKN 3&4**

Summaries

- The start-up operation of the first APR1400 reactor, SKN Unit 3, has been performed successfully.
- SKN Unit 3 runs well without any troubles since its commercial operation in Dec. 2016.

Thank you!