

The ROK's Nuclear Energy Development and Spent Fuel Management Plans and Options

Jungmin KANG
Visiting Professor, KAIST

Presentation given at
2012 Resilience and Security of Spent Fuel in East Asia
WORKING GROUP MEETING
Australian Embassy (19th floor, Kyobo Building), Seoul, ROK
April 13-15, 2012

Status & Prospects of Nuclear Power



Figure. NPPs sites in the ROK

Status & Prospects of Nuclear Power (cont)

Table. Current and planned nuclear power in the ROK

Site	Unit	Type	Capacity (MWe)	Initial Operation
Kori	Kori-1	PWR	587	Apr. 1978
	Kori-2	PWR	650	Jul. 1983
	Kori-3	PWR	950	Sept. 1985
	Kori-4	PWR	950	Apr. 1986
	Shin-Kori-1	PWR	1000	Dec. 2010
	Shin-Kori-2	PWR	1000	Dec. 2011
Shin-Kori	Shin-Kori-3	PWR	1400	Sept. 2013
	Shin-Kori-4	PWR	1400	Sept. 2014
	Shin-Kori-5	PWR	1400	Dec. 2018
	Shin-Kori-6	PWR	1400	Dec. 2019
	Shin-Kori-7	PWR	1400	Jun. 2022
	Shin-Kori-8	PWR	1400	Jun. 2023
Yonggwang	Yonggwang-1	PWR	950	Aug. 1986
	Yonggwang-2	PWR	950	Jun. 1987
	Yonggwang-3	PWR	1000	Mar. 1995
	Yonggwang-4	PWR	1000	Jan. 1996
	Yonggwang-5	PWR	1000	Apr. 2002
	Yonggwang-6	PWR	1000	Oct. 2002
Ulchin	Ulchin-1	PWR	950	Sept. 1988
	Ulchin-2	PWR	950	Sept. 1989
	Ulchin-3	PWR	1000	Aug. 1998
	Ulchin-4	PWR	1000	Dec. 1999
	Ulchin-5	PWR	1000	Jul. 2004
	Ulchin-6	PWR	1000	Jun. 2005
	Shin-Ulchin-1	PWR	1400	Dec. 2015
	Shin-Ulchin-2	PWR	1400	Dec. 2016
	Shin-Ulchin-3	PWR	1400	Jun. 2020
	Shin-Ulchin-4	PWR	1400	Jun. 2021
Wolsong	Wolsong-1	CANDU	679	Apr. 1983
	Wolsong-2	CANDU	700	Jul. 1997
	Wolsong-3	CANDU	700	Jul. 1998
	Wolsong-4	CANDU	700	Oct. 1999
Wolsong	Shin-Wolsong-1	PWR	1000	Mar. 2012
	Shin-Wolsong-2	PWR	1000	Jan. 2013

Reactors at Kori



Figure. The Kori nuclear power plants site (Google Earth, October 10, 2010)

Reactors at Yonggwang



Figure. The Yonggwang nuclear power plants site (Google Earth, October 10, 2010)

Reactors at Ulchin



Figure. The Ulchin nuclear power plants site (Google Earth, October 10, 2010)

Reactors at Wolsong

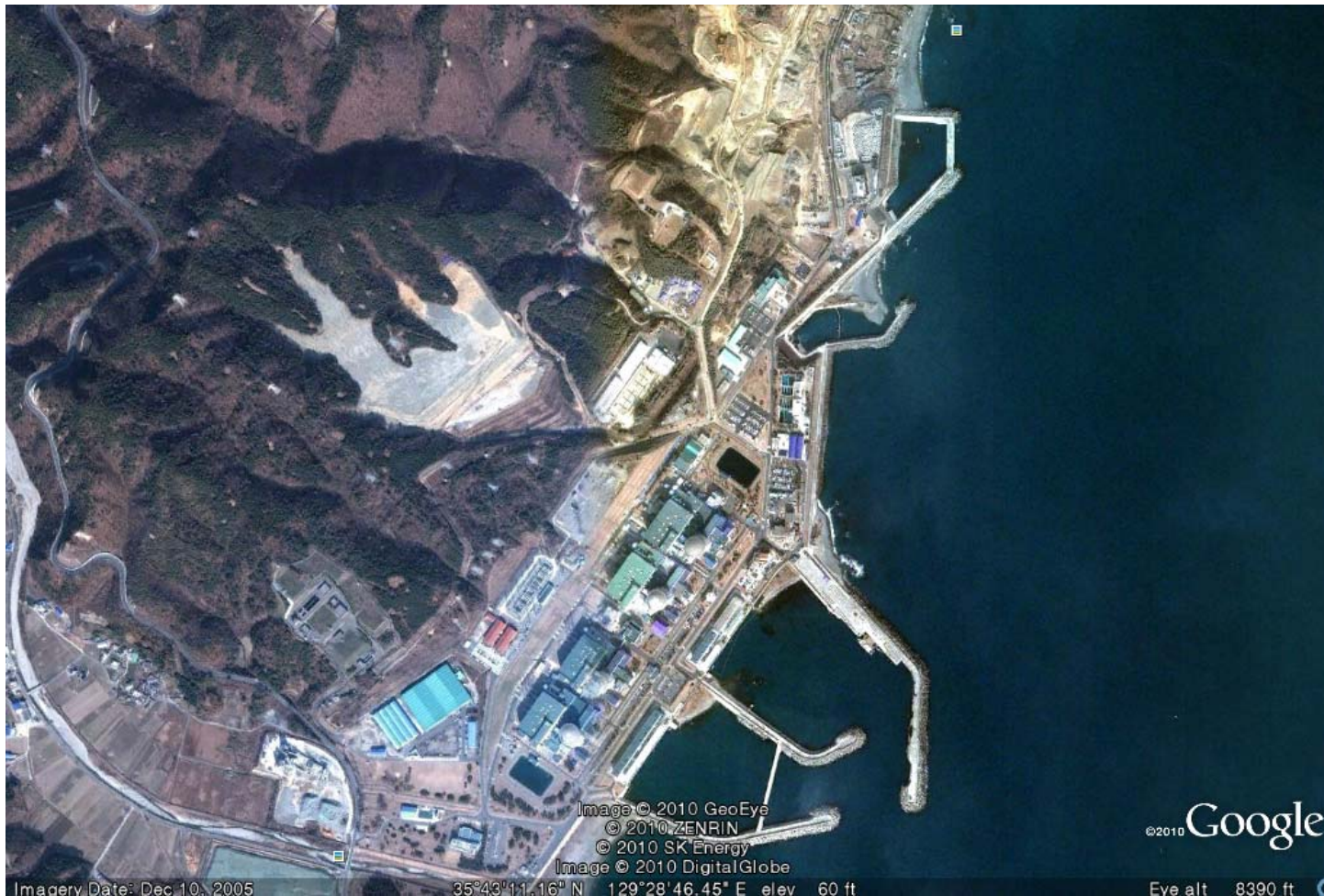


Figure. The Wolsong nuclear power plants site (Google Earth, October 10, 2010)

Status & Prospects of Nuclear Power (cont)

- Kori site: 6 PWRs in operation;
- Shin-Kori site: 6 PWRs under construction
- Yonggwang site: 6 PWRs in operation
- Ulchin site: 6 PWRs in operation;
- 4 PWRs under construction
- Wolsung site: 4 CANDUs in operation;
- 1 PWR in operation;
- 1 PWR under construction

	2012	2020	2030
# of PWR (GWe)	18 (17.9)	27 (28.7)	35 (39.9)
# of CANDU (GWe)	4 (2.8)	4 (2.8)	4 (2.8)
# of NPPs (GWe)	22 (20.7)	31 (31.5)	39 (42.7)

Status & Prospects of Nuclear Power (cont)

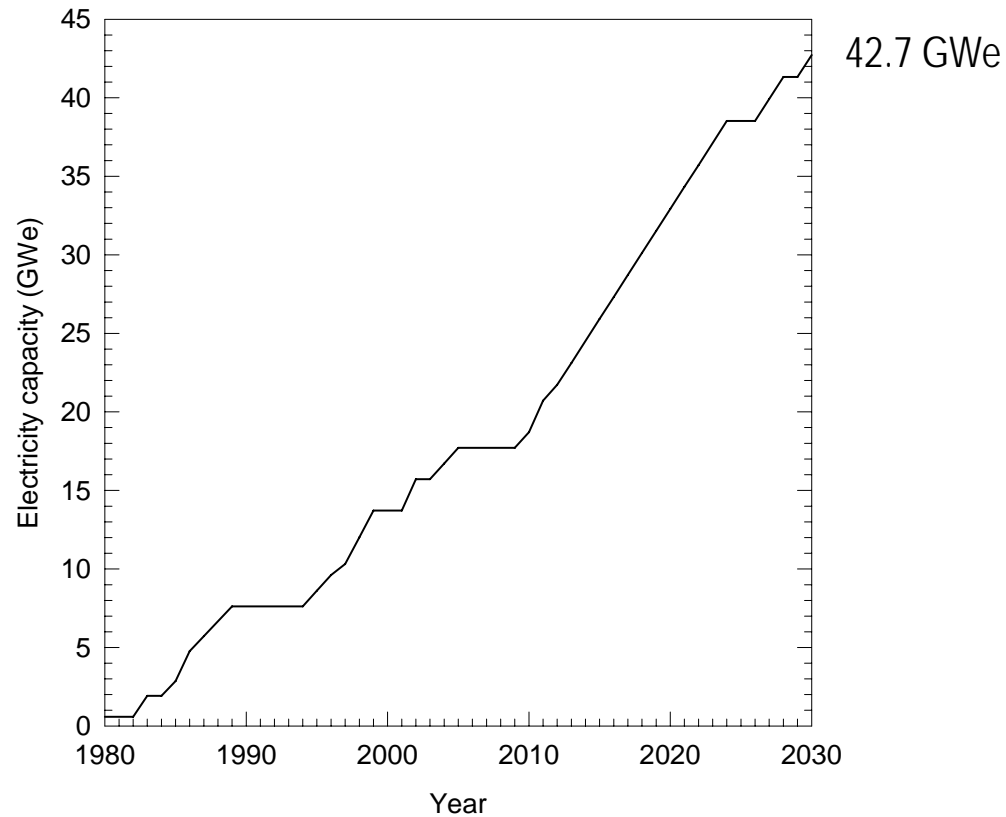
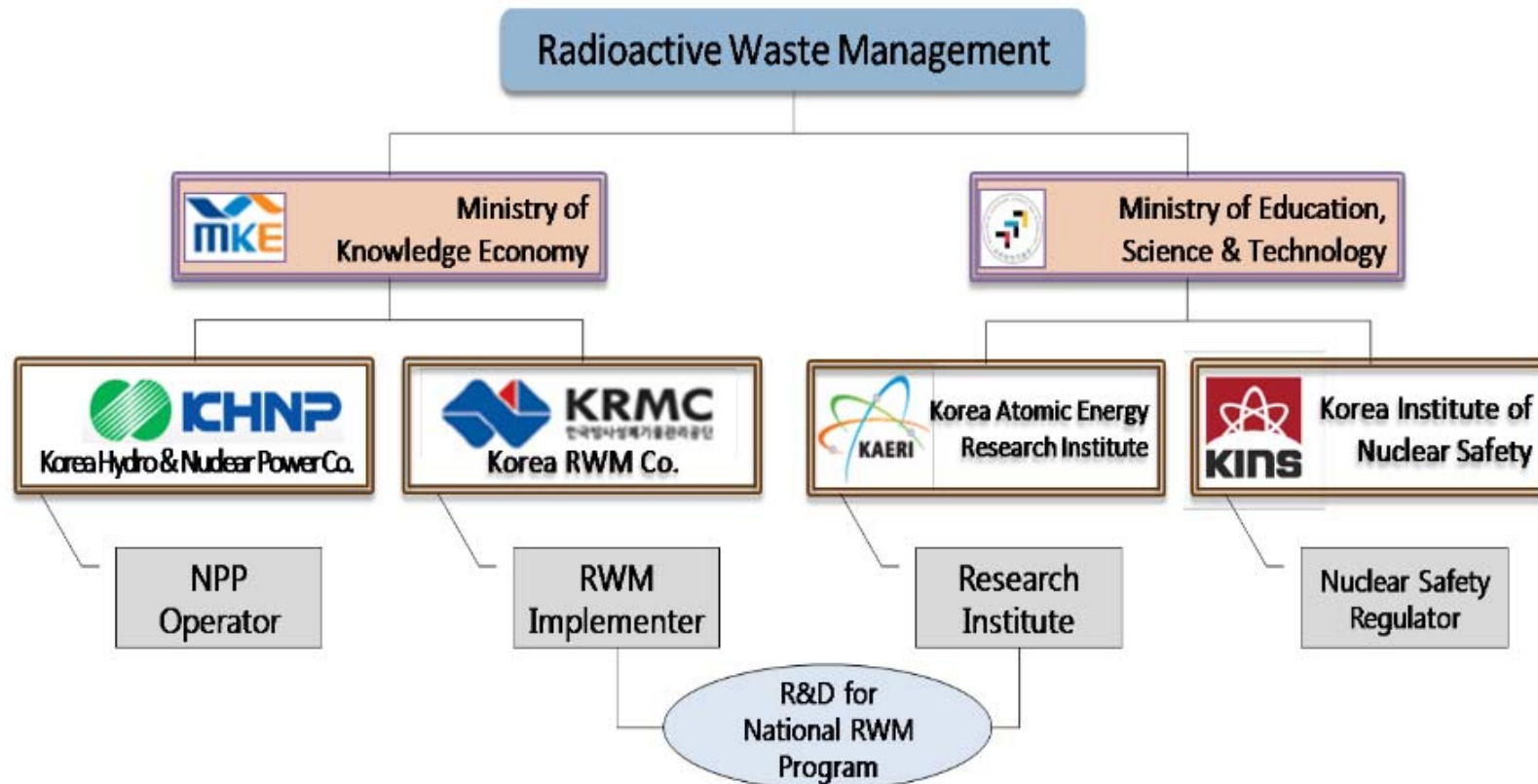


Figure. Installed nuclear capacity in South Korea(1980-2030)

Radioactive Waste Management Act

- Has been effective since Jan 1, 2009.
- Establishing a new organization and fund for radioactive waste management.
 - Korea Radioactive Waste Management Company (KRMC)
 - Radioactive Waste Management Fund

Radioactive Waste Management Organizations



- (Quoted from a presentation material of Jongwon Choi of KAERI on Nov. 4, 2010)

National Policy on Spent Fuel

- At its 253rd meeting in 2004, the Atomic Energy Committee (AEC) announced that national policy for spent fuel management would be decided later in consideration of progress of domestic and international technology development, and that spent fuel would be stored at a reactor site by 2016 under KHNP's responsibility.
- Since South Korea has not decided whether to directly dispose of or recycle spent fuel, currently, it has no national plan on geologic disposal of spent fuel either.

Generation of Spent Fuel and Shortage of Spent Fuel Storage Capacity

- Inventory of Spent Fuels

- Discharging about 290 metric tons of heavy metal (tHM) of PWR spent fuels from 16 PWRs per year and about 380 tHM of HWR spent fuels from 4 HWRs per year

Site	Reactor type	# of reactors	Inventory of spent fuel (tHM) as of the end of 2009
Kori	PWR	4	1,762
Ulchin	PWR	6	1,401
Yonggwang	PWR	6	1,704
Wolsong	HWR	4	5,894

- Shortage of On-site Spent Fuel Storage Capacities

- Interim storage of spent fuel is a hot issue as its at-reactor spent fuel storage pools become saturated.
 - KHNP, a utility company argues that the storage pools at its three PWRs sites, Kori, Ulchin and Yonggwang are projected to be full by 2016, 2018 and 2021 respectively while its HWRs site, Wolsong is projected to be full by 2017 considering current on-site dry storage.
 - It has been said that on-site spent fuel storage expansion is challenge due to an anticipated strong opposition by local communities.

Projections of Spent Fuel

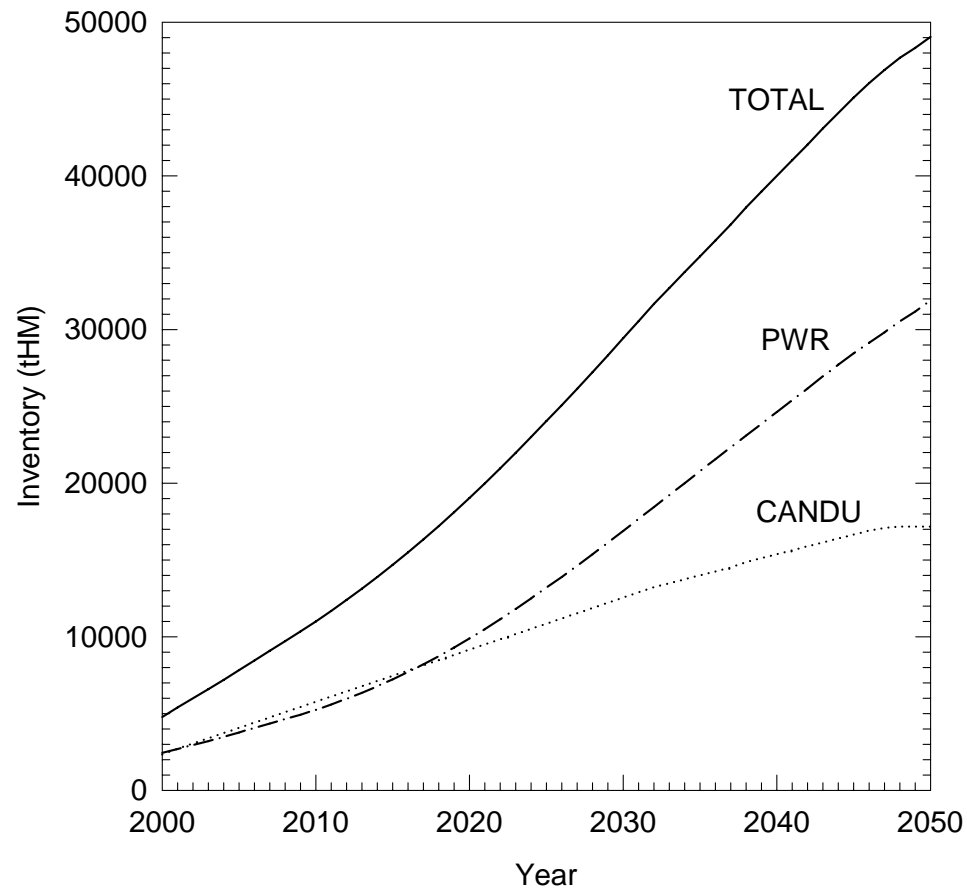


Figure. Cumulative inventory of spent fuel generation in South Korea (2000-2050)

Spent Fuel Storage at Kori

- When KHNP has stated that the spent fuel pools at Kori will be full in 2016, it just had considered intra-site transshipment of spent fuel among pools of old 4 reactors, i.e., Kori unit 1 to unit 4 on the site.
- The old spent fuel in the pools of the old 4 reactors can be shifted to the pools of new two reactors, i.e., Shin-Kori unit 1 and unit 2 being built on the same site. If implemented, this extends the saturation year from 2016 to 2023.

Spent Fuel Storage at Ulchin

- When KHNP has stated that the spent fuel pools at Ulchin will be full in 2018, it just had considered intra-site transshipment of spent fuel among pools of old 6 reactors, i.e., Ulchin unit 1 to unit 6 on the site.
- The old spent fuel in the pools of the old 6 reactors can be shifted to the pools of new four reactors, i.e., Shin-Ulchin unit 1 to unit 4 being built on some of the same site. If implemented, this extends the saturation year from 2018 to 2028.

Spent Fuel Storage at Yongggwang

- KHNP has stated that the spent fuel pools at Yongggwang will be full in 2021, considering re-racking of storage pools. There is no plan of new deployment of NPPs at Yongggwang at least by 2024.

Spent Fuel Storage at Wolsong

- According to a law entitled “Special Act on Support for Areas Hosting Low and Intermediate Level Radioactive Waste (LILW) Disposal Facility” in 2005, spent fuel related facilities cannot be built in the local area that hosts the LILW site, containing Wolsong site.
- Some of South Korean nuclear experts argue that it means that no more dry storage facilities are to be built after 2017 when current dry storage will be full.
- However, Korea Radioactive Waste Management Corporation (KRMC) argues that those dry storage facilities at Wolsong are tentative ones, not for interim storage that are banned by the special Act of LILW.
- KHNP expanded capacities of dry storage at Wolsong by 680 tHM in 1990, 907 tHM in 1998, 680 tHM in 2002, 1134 tHM in 2006 and 3528 tHM in February 2010.
- Whether or not dry storage facilities at Wolsong violate the special Act of LILW is still controversial and needs to be clear.

Dry Storage Facilities at Wolsong



Figure. Concrete silo and MACSTOR/KN-400 at Wolsong (Google Earth, October 10, 2010)

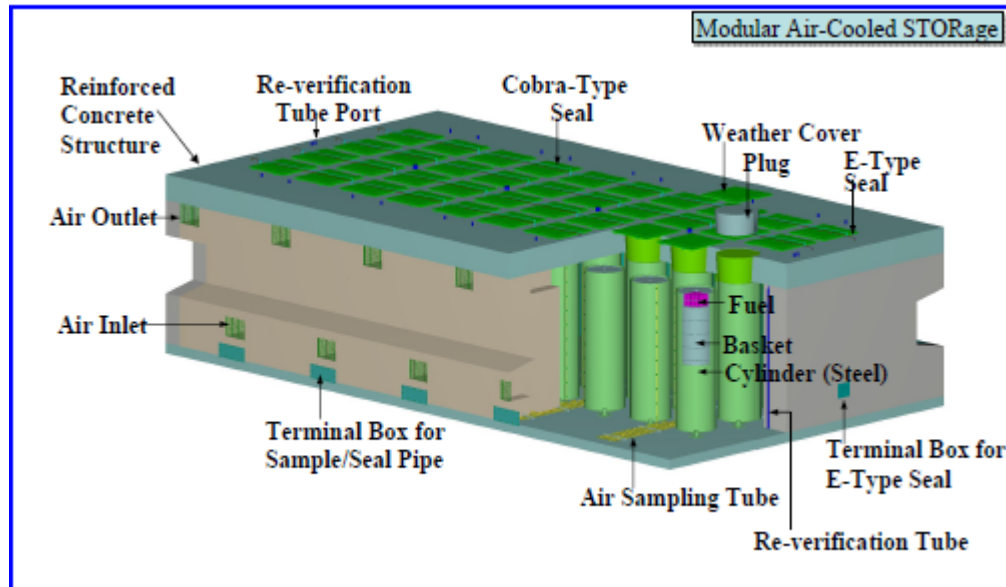
Concrete Silo at Wolsong

- Concrete Silo
 - Storage capacity: 10.4 tHM
 - Out diameter: 3.1 m
 - Height: 6.5 m
- 300 concrete silos (3,120 tHM) have been installed at Wolsong since 1990.



MACSTOR/KN-400 at Wolsong

- MACSTOR/KN-400
 - Storage capacity: 461 tHM
 - Dimension: 22 m (L) x 12.5 m (W) x 7.5 m (H)
 - Height: 6.5 m
- 7 MACSTOR/KN-400 modules (3,227 tHM) have been installed at Wolsong since 1990.



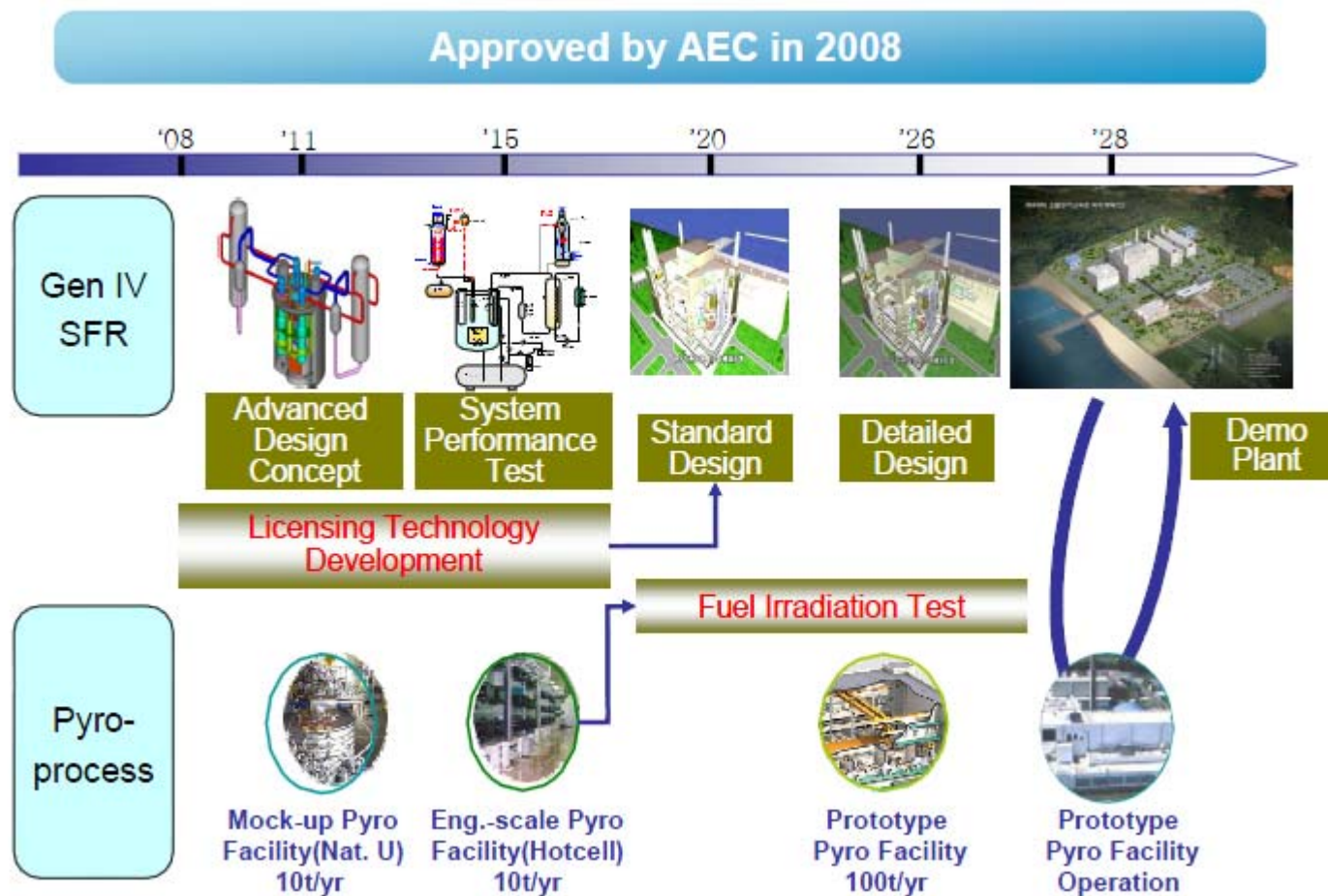
Current, Planned and Potential Spent Fuel Storage Capacity through 2021

Site	Unit	Type	Capacity (GWe)	Operation (year.month)	Pool storage capacity ² (tons)		
					Existing	Increase	
						Planned	Potential additional
Kori PWRs	Kori-1	PWR	0.587	1978. 4	158.8		
	Kori-2	PWR	0.650	1983. 7	327.6		
	Kori-3	PWR	0.950	1985. 9	270.9	696.4	
	Kori-4	PWR	0.950	1986. 4	270.9	697.4	
	Shin-Kori-1	PWR	1.000	2010.12	428.7		1024.5
	Shin-Kori -2	PWR	1.000	2011.12	428.7		1024.5
	Shin-Kori -3 ^c	PWR	1.400	2013. 9	625.7		1480.1
	Shin-Kori -4 ^c	PWR	1.400	2014. 9	625.7		1480.1
	Shin-Kori -5 ^c	PWR	1.400	2018.12	625.7		1480.1
Shin-Kori -6 ^c	PWR	1.400	2019.12	625.7		1480.1	
Yonggwang PWRs	Yonggwang-1	PWR	0.950	1986. 8	270.9	697.4	
	Yonggwang-2	PWR	0.950	1987. 6	270.9	186.8	509.7
	Yonggwang-3	PWR	1.000	1995. 3	215.4	268.3	323.4
	Yonggwang-4	PWR	1.000	1996. 1	215.4	268.3	323.4
	Yonggwang-5	PWR	1.000	2002. 5	224.9	203.8 ^b	407.1
	Yonggwang-6	PWR	1.000	2002.12	224.9	203.8 ^b	407.1
Ulchin PWRs	Ulchin-1	PWR	0.950	1988. 9	144.9	297.7	
	Ulchin-2	PWR	0.950	1989. 9	144.9	273.7	
	Ulchin-3	PWR	1.000	1998. 8	215.4	352.6	239.1
	Ulchin-4	PWR	1.000	1999. 12	215.4	352.6	239.1
	Ulchin-5	PWR	1.000	2004. 7	224.9		610.9
	Ulchin-6	PWR	1.000	2005. 4	224.9		610.9
	Shin-Ulchin-1	PWR	1.400	2015. 12	625.7		1480.1
	Shin-Ulchin-2	PWR	1.400	2016. 12	625.7		1480.1
	Shin-Ulchin-3	PWR	1.400	2020. 6	625.7		1480.1
Shin-Ulchin-4	PWR	1.400	2021. 6	625.7		1480.1	
Wolsong CANDUs	Wolsong-1	HWR	0.679	1983. 4	842.7	6,929, dry storage as of February 2010	
	Wolsong-2	HWR	0.700	1997. 7	736.8		
	Wolsong-3	HWR	0.700	736.8	736.8		
	Wolsong-4	HWR	0.700	1999. 10	736.8		
Wolsong PWRs	Shin-Wolsong-1	PWR	1.000	2012. 3	504.8		1024.5
	Shin-Wolsong-2	PWR	1.000	2013. 1	504.8		1024.5

Modified Saturation Time of Spent Fuel Storage

- “Alternatives and Roadmap of Spent Fuel Management in South Korea” on Aug. 19, 2011
 - Performed by an expert group composed of members of South Korea’s nuclear establishment (Korean Nuclear Society, Korean Radioactive Waste Society and Green Korea 21)
 - The storage pools at sites, Kori, Ulchin and Yonggwang, Wolsong are projected to be full by 2028, 2028, 2024 and 2025, considering re-racking and transshipment between NPPs at PWRs sites and installing two additional MACSTOR/KN-400 modules at Wolsong.

KAERI's Plan on Pyroprocessing and Fast Reactors



- (Quoted from a presentation material of Hansoo Lee of KAERI in 2010)

Concluding Remarks

- Interim storage of spent fuel would be key factor affecting nuclear fuel cycle activities and development in the ROK in the coming years.
- A 10-year US-ROK joint study on pyroprocessing, which has started in 2012, would affect future nuclear fuel cycle activities and development in the ROK.