

# MACCS code application activities in Korea Institute of Nuclear Safety (KINS)



Yong-Jin Lee, Kuk-Hee Lim, Yong-Jin Cho



한국원자력안전기술원  
KOREA INSTITUTE OF NUCLEAR SAFETY

# Outline



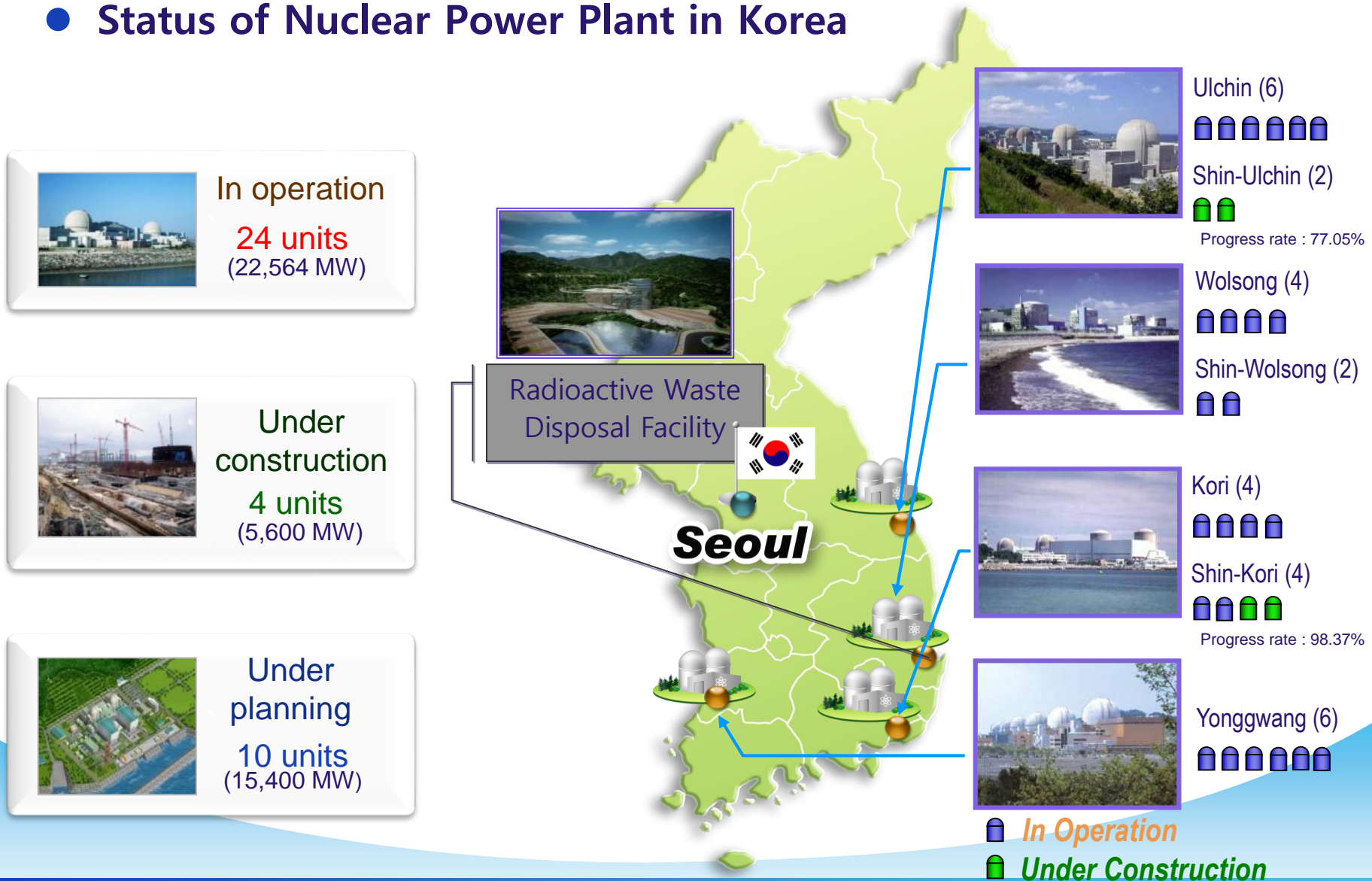
**Environmental Changes and Needs**

**Current states**

**Future Plan & Concluding remarks**

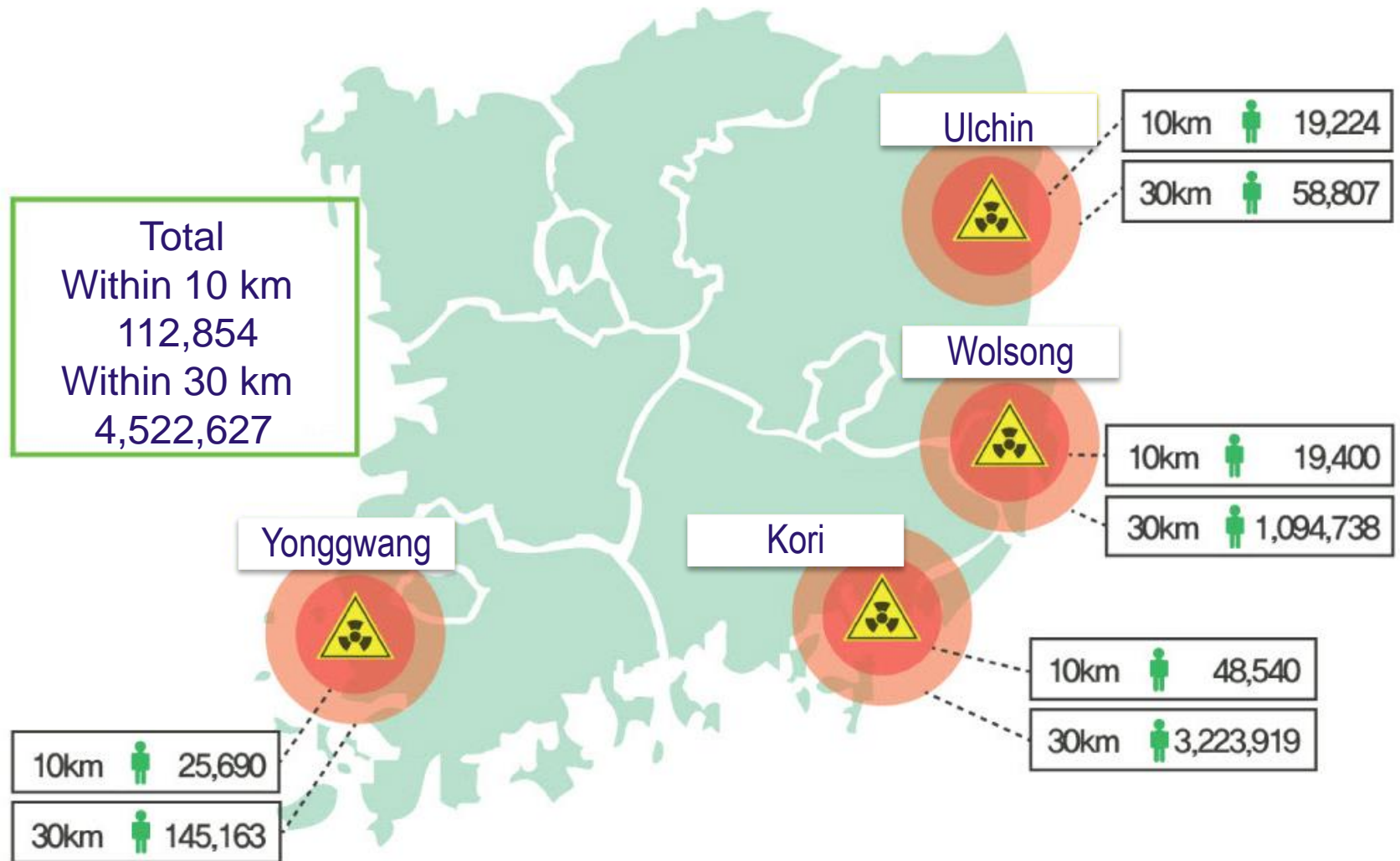
# Environmental Changes and Needs (1/3)

## ● Status of Nuclear Power Plant in Korea



# Environmental Changes and Needs (2/3)

- Population Distribution around Nuclear Power Plants



# Environmental Changes and Needs (3/3)

## ● Status of PSA Model

Plants	Type	Scope (Internal & External)	First	Update
Kori 1	WH 2-loop	FP* Lv 1,2	'02.11	'07.05
Kori 2	WH 2-loop	FP Lv 1,2	'03.12	'07.06
Kori 3,4	WH 3-loop	FP Lv 1,2	'92.08 (Lv 1 only)	'03.06
Hanbit 1,2	WH 3-loop	FP Lv 1,2	'92.08 (Lv 1 only)	'03.12
Hanbit 3,4	CE	FP Lv 1,2	'94.02	'04.12
Hanbit 5,6	KSNP	FP Lv 1,2 + LPSD** Lv 1 Internal	'00.12	'05.12
Hanul 1,2	Framatom 3-loop	FP Lv 1,2	'05.12	-
Hanul 3,4	KSNP	FP Lv 1,2	'97.10	'04.12
Hanul 5,6	KSNP	FP Lv 1,2 + LPSD Lv 1 Internal	'02.06	'06.06
Wolsong 1	CANDU 6	FP Lv 1,2	'03.12	'07.12
Wolsong 2,3,4	CANDU 6	FP Lv 1,2	'97.10	'06.12
Shin-kori 1,2	OPR1000	FP Lv 1,2 + LPSD Lv 1 Internal	'10.12	-
Shin-wolsong 1,2	OPR1000	FP Lv 1,2 + LPSD Lv 1 Internal	'10.12	-
Shin-kori 3,4	APR1400	FP Lv 1,2,3 + LPSD Lv 1	'13.01	-
Shin-hanul 1,2	APR1400	FP Lv 1,2,3 + LPSD Lv 1	In progress (for OL)	-
Shin-kori 5,6	APR1400	FP Lv 1,2	'15.01 (for CP)	-

\* FP : Full Power

\*\* LPSD : Low Power & Shutdown



# Current States (1/8)

## 1. Level 3 PSA review for NPP

- ✓ Confirm proper input data in MACCS2
  - (1) How to use weather data
  - (2) Atmospheric dispersion model & Deposition calculations
  - (3) Whether proper exposure pathways are considered or not
  - (4) Proper Emergency Response
  - (5) Feasibility of health risk calculation and utilizing data
- ✓ Compare MACCS2 results with Safety Goal
  - Risk calculation using MACCS2 code to ensure Safety Goal

Category	Safety Goal in KINS	Safety Goal in NRC	Note
Early Fatality	4.0E-07/yr	5.0E-07/yr	Based on 0.1% rule
Cancer Fatality	1.0E-06/yr	2.0E-06/yr	

# Current States (2/8)

## 1. Level 3 PSA review for NPP

### ✓ MACCS2 Main results : Early Fatality Risk & Cancer Fatality Risk

Source Term Category	Early Fatality Risk (Base Case)	Early Fatality Risk (Sensitivity Analysis Case)
1	1.20E-09	1.20E-09
2	2.97E-09	2.97E-09
3	8.76E-12	8.76E-12
4	1.77E-09	1.77E-09
5	4.30E-10	4.30E-10
6	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00
8	1.23E-09	2.53E-09
9	1.13E-12	1.13E-12
10	4.58E-12	4.58E-12
11	1.17E-10	1.17E-10
12	4.63E-09	4.65E-09
13	7.60E-11	7.65E-11
14	4.82E-13	5.08E-13
15	0.00E+00	1.18E-09
16	4.51E-09	4.54E-09
17	0.00E+00	1.54E-09
Total	1.69E-08	2.10E-08

<Total Early Fatality Risk (1 mile)>

Source Term Category	Cancer Fatality Risk (Base Case)	Cancer Fatality Risk (Sensitivity Analysis Case)
1	3.00E-11	3.00E-11
2	1.32E-11	1.32E-11
3	1.50E-13	1.50E-13
4	2.74E-11	2.74E-11
5	3.21E-12	3.21E-12
6	9.33E-18	9.33E-18
7	6.82E-14	6.82E-14
8	1.42E-11	2.18E-11
9	2.60E-14	2.66E-14
10	7.93E-14	7.93E-14
11	1.01E-12	1.01E-12
12	7.32E-11	7.32E-11
13	1.17E-12	1.17E-12
14	1.06E-14	1.09E-14
15	8.40E-13	1.87E-12
16	1.15E-10	1.15E-10
17	8.19E-13	2.33E-11
Total	2.80E-10	3.12E-10

<Total Cancer Fatality Risk (10 mile)>

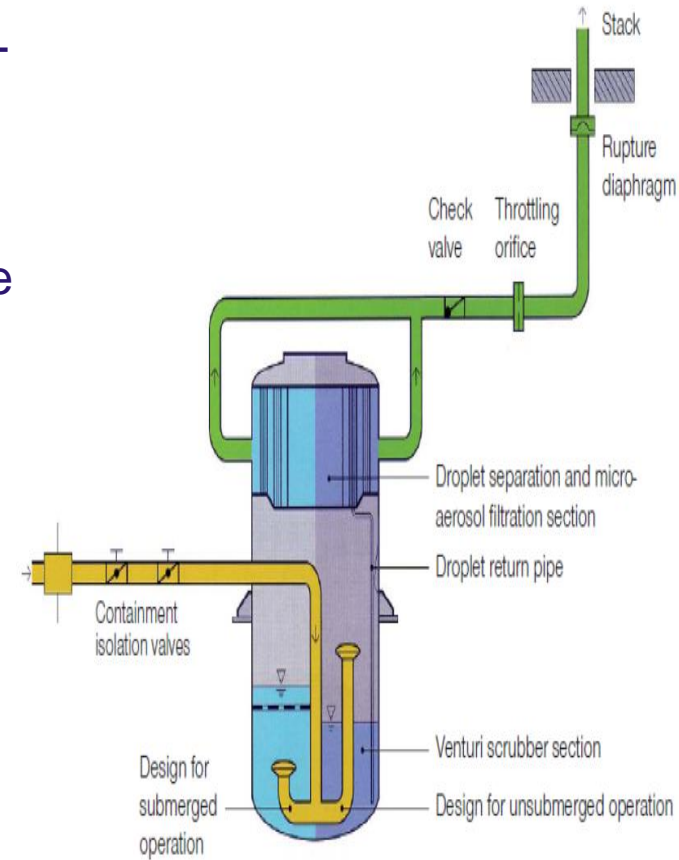
\* Base Case : Using a fixed containment failure time, regardless of the characteristics of each STC.

\* Sensitivity Analysis Case : Evaluating offsite consequence based on each containment failure time for STC8 ~ STC17

# Current States (3/8)

## 2. Evaluation of Containment Filtered Venting System (CFVS) for the CANDU Reactor

- ✓ Installation of CFVS at Wolsong unit 1 as the Post-Fukushima action.
- ✓ CFVS exhausts non-condensable gas and water vapor through a large filter system to outside of the Containment.
  - pros : ① Prevent Containment damage,  
② Trapping most of radionuclide except for inert gas
  - cons : Off-site release of radioactive materials due to external exhaust
- ✓ For CFVS performance test,
  - Containment thermal-hydraulic behavior analysis using MELCOR code
  - Off-Site Consequence Analysis using MACCS2 code



<Schematic diagram of AREVA CFVS>

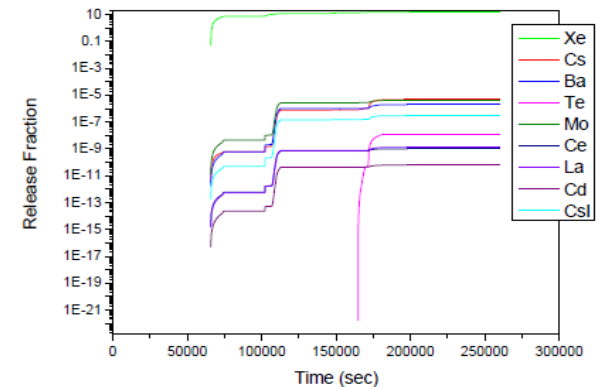


# Current States (4/8)

## 2. Evaluation of Containment Filtered Venting System (CFVS) for the CANDU Reactor

- Off-Site Consequence Analysis
- ✓ Calculation to verify the Effectiveness of CFVS
- ✓ Apply Decontamination Factors of AREVA CFVS
- ✓ Using Site-specific data

(Source Term, Weather, population, land fraction, etc)



<Radionuclides Release Fraction with CFVS>

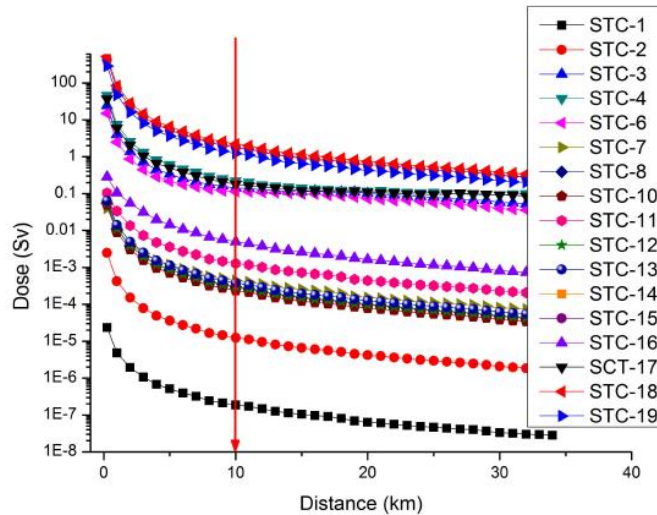
	Inert Gas	Aerosols	Molecular iodine	Organic iodine	Iodine oxide aerosol
Korea	1	1000	10	1	500
USA	1	10	-	-	-
France	1	1,000	10	1	500
Germany	1	1,000	10	1	-
Sweden	1	500(BWR) 1,500(PWR)	100(BWR) 500(PWR)	-	-
Swiss	1	1,000 (Requirement)	100 (Requirement)	-	-

<Decontamination factors for CFVS>

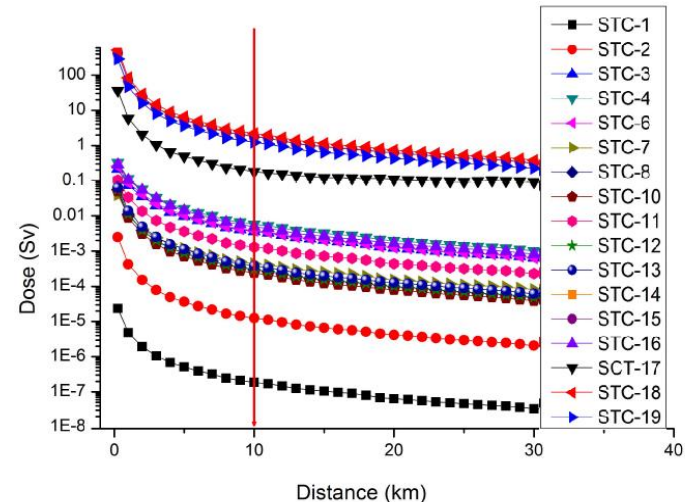
# Current States (5/8)

## 2. Evaluation of Containment Filtered Venting System (CFVS) for the CANDU Reactor

### ✓ MACCS2 Results at Wolsong NPP with CFVS



<Effective Dose for all STC without CFVS>



<Effective Dose for all STC with CFVS>

	Internal	Earthquake	Fire
Without CFVS	1.72E-06	3.00E-07	2.25E-07
With CFVS	1.70E-06	1.78E-07	2.09E-07
Reduction rate	1.5%	40.6%	7.2%

< Risk Comparison results for CFVS >

# Current States (6/8)

## 3. Research project - 'Offsite Radiation Effect Assessment'

- ✓ Improvement of current Input data appropriated to Korean domestic condition.
  - Some topics are selected to discuss.
- : Diffusion coefficient, Mixed layer height, Plume rise effect, Surface roughness, Deposition model, Source term, Dose conversion factor, Health physic model, Population protection action, Shielding factor.
- ✓ Sensitivity Analysis between existing results (NUREG-1150, SOARCA) and modified input variables.

	Distance from NPP	Index	Existing Results	Sensitivity Analysis Results	Change rate (%)
Source term 1	0 - 80.5 km	Cancer Fatality	1.72E+03	1.64E+03	-4.65
	0 - 16.1 km	Early Fatality	1.34E+01	7.10E+00	-47.01
	0 - 16.1 km	Cancer Fatality	3.87E+02	3.22E+02	-16.8

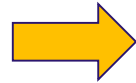
< Preliminary Sensitivity Analysis results for Surface Roughness >

# Current States (7/8)

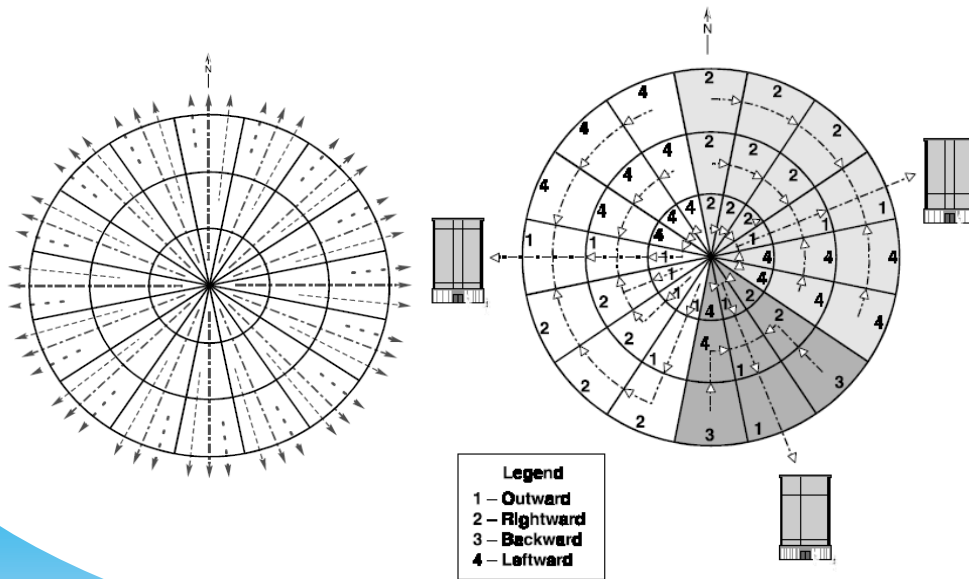
## 3. Research project - 'Offsite Radiation Effect Assessment'

### ✓ Evacuation pathway modeling using network method

- Past
  - Radial Evacuation Model
  - Use the Pre-set Data



- Plan
  - Network Evacuation Model (Similar to SOARCA)
  - Use the Site-specific data (According to Radiological Emergency Plan)



< Radial Model >

< Network Model >

Grid num	Town	Sub	Assemble Area	Population	Evacuation Section	Destination
Direction (SW)						
2 (2~5km)	ChangAn	JwaChun, ShiLang	JwaChun E.S.	1,803	(Route 14) JwaChun → ③ → Gilang	DeaChung E.S.
		ImLang	ImLang Beach	695	(Route 60, Local Road 19) ImLang → ③ → ChulMa	ChulMa E.S.
	IlKwang	MunDung, ChilAm	ChilAm E.S.	1,404	(Route 14, Local Road 13) IlKwang → ⑤ → BaSong	Gilang E.S.
3 (5~8km)	IlKwang	EChun, HwaChun, DangGok	Village hall	1,139	(Route 14, Local Road 31) IlKwang → ⑥, ⑦ → SongJung	SongJung E.S.
		ShinPyung	ChilAm E.S.	898	(Route 14, Local Road 13)	BanSong W.M.S
		Idong	Village hall	470	IlKwang → ⑤, ⑥ → BanSong	
		IChonSeo	IlKwang E.S.	1,957	(Route 14) IlKwang → ⑥ → BanSong	Dong-Busan Univ.
4 (8km~)	IlKwang	SamSung 1 SamSung 2	Town Office	1,566	(Route 14) IlKwang → ⑧ → Gilang, SongJung	NaeRi E.S.
		SamDuk HoengGye	IlKwang E.S.	242		SongJung E.S.
		HooDong	Village hall	100		
Direction (W)						
0 (~1km)	ChangAn	GilCheon	WolNae E.S	1,749	(Route 31, 14, Local Road 60) ChangAn → ③ → Gilang	Gilang M.S
1 (1~2km)	ChangAn	WolNae	WolNae E.S	1,507	(Route 31, 14, Local Road 60) ChangAn → ③ → Gilang	DeaChung M.S
2 (2~5km)	ChangAn	JwaDong	Village hall	236	(Local Road 60) JwaDong → ③ → WolPyung	WolPyung E.S
3 (5~8km)	ChangAn	SunAm Naeduk DukSan	Village hall	304	(Route 14, Local Road 14) ChangAn → ② → Gilang	Gilang H.S
4 (8km~)	JungKwan	SeoPun YeRim	Village hall	424	(Local Road 60, 17, 19) JungKwan → ChulMa → ④ → BanSong	Dong-Busan Univ.

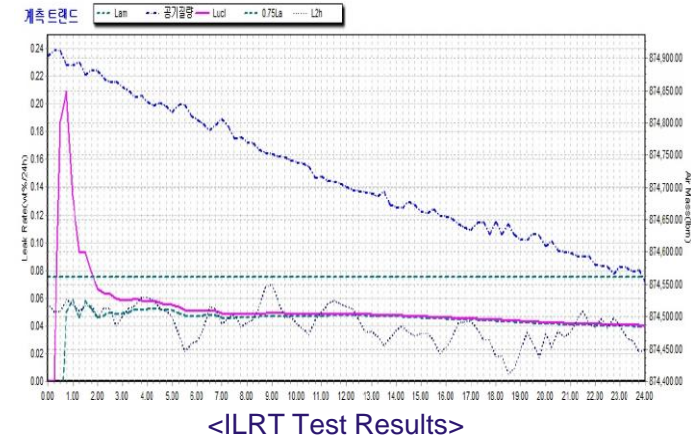
< Evacuation Pathway for Kori NPP >

# Current States (8/8)

## 4. ILRT(Integrated Leak Rate Test) interval extension

### ✓ Requirements

1. Comprehensive Safety Assessment results related to ILRT
2. Two or more recent ILRT results
3. LLRT(Local Leak Rate Test) results and operating experience associated with containment leak during above period



- ✓ MACCS2 results are one of the essential reports to permit ILRT interval extension
  - Compare MACCS2 results with Safety Goal using newly updated data & Methodology
- ✓ After passing the review process, applicants can extend ILRT interval from 5 year to 10 year



# Future Plan & Concluding Remarks

## ➤ **Future Plan**

- ✓ PSA will be mandatory regulatory requirements related to Severe Accident Legislation in Korea. (by 2016)
- ✓ Establish Level 3 PSA review plan using MACCS2 code (Similar to ESRP)
- ✓ Modify various input data suitable to Korean domestic condition (Complex terrain)
- ✓ Final destination is development of Korean MACCS code

## ➤ **Concluding Remarks**

- ✓ Current states
  - No Systematic regulatory procedure for Level 3 PSA that use MACCS2 code in Korea
  - Level 3 PSA review, Newly installed system Evaluation, Research project, ILRT interval extension.



# Thank you !

E-MAIL : [K730lyj@kins.re.kr](mailto:K730lyj@kins.re.kr)