Current Status in Korean NPPs

ALARA mini-workshop
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Nuclear Energy: Current

Nuclear Power Generation Capacity (19 NPPs)

2004.12.

Classification	Nuclear Power (40 %)			
	Kori	Yong gwang	Ulchin	Wolsong
Operation Units	4	6	5 (6)	4
Reactor Type	PWR	PWR	PWR	PHWR
Capacity(MW)	3,137	5,900	4,900	2,779
Total Cap.(MW)	16,716			

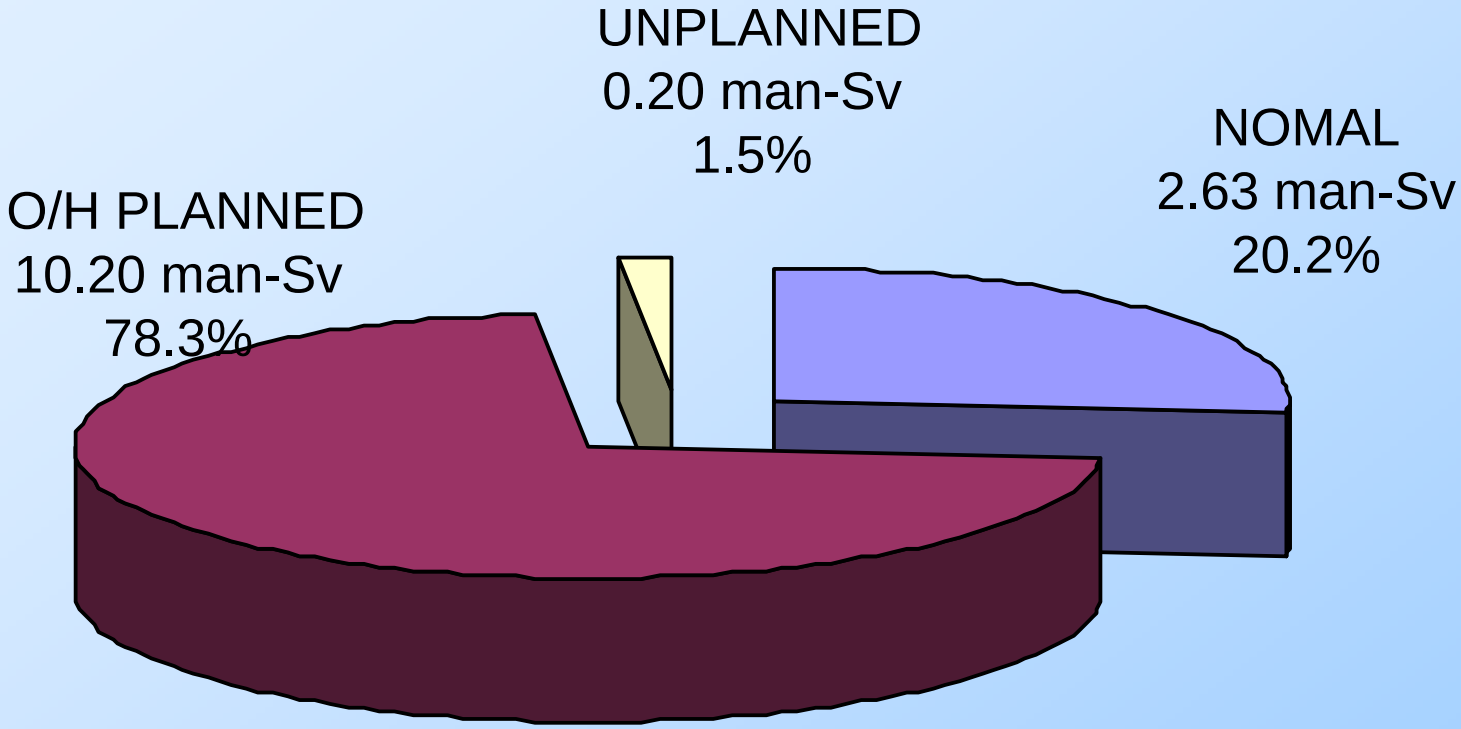
New Issues on Nuclear Energy in Korea as of Nov. 2005

- Establishment of Strategy to promote RI use (‘04～’08)
- Atomic Act and follow up regulation (‘03.6)
  - RT, PET, Cyclotron, etc.
- Security and Emergency Preparedness
  - Atomic Act (‘03.5)
  - Infrastructure to response against Terror & Sabotage
  - Strengthening national organization to response against radiation accidents or disaster
  - Safeguard inspection (→KINS)
- Disposal Site for Radioactive Waste (LLRW) :
  - **Kyungjoo (close to Wolsung NPP area)**

20 OPERATIONAL NPPS as of Nov. 2005

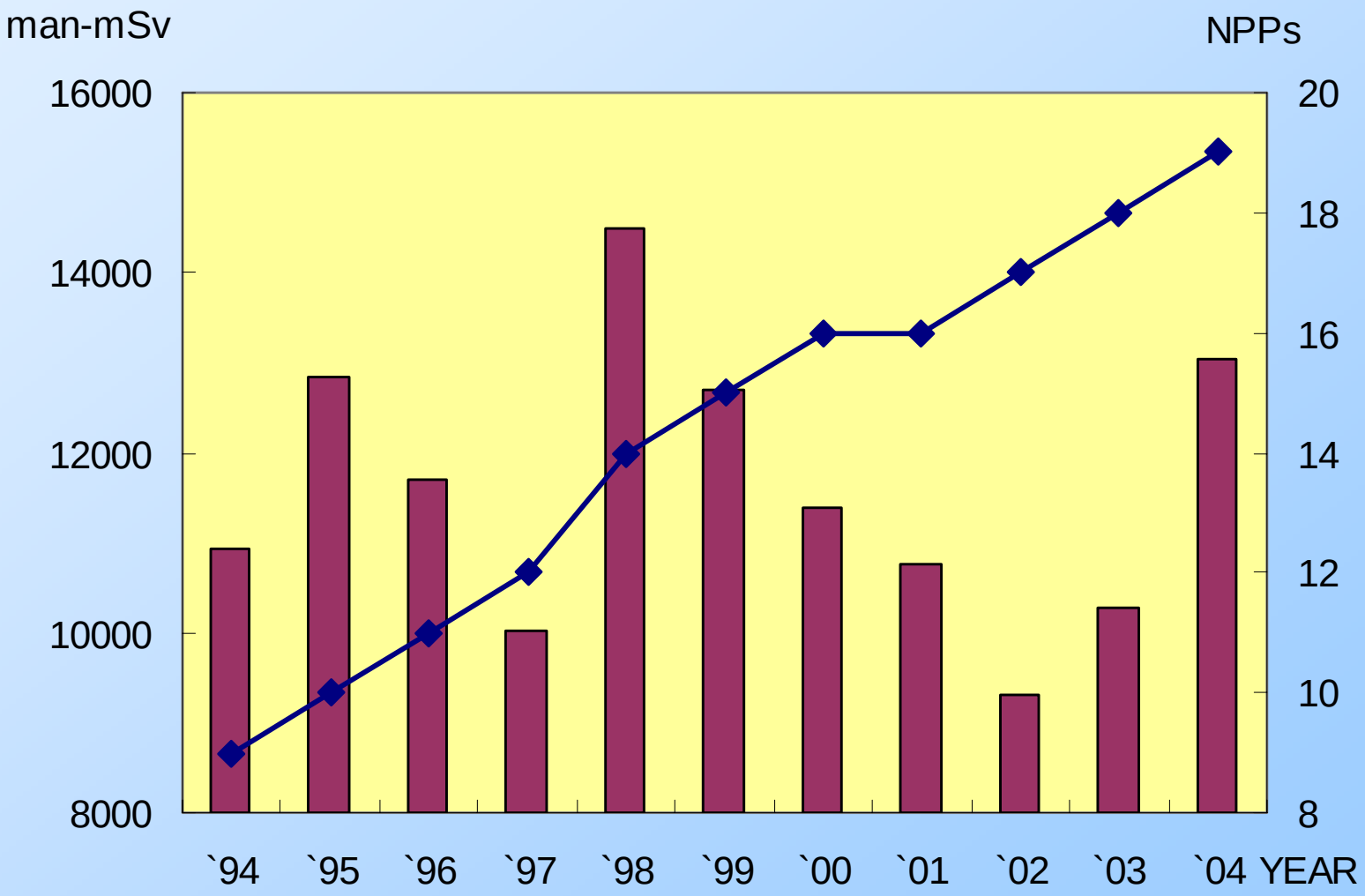
NAME		CAPACITY (MWe)	TYPE	GRID	COMMERCIAL
KORI (KR)	1	587	PWR	'77. 6. 26	'78. 4. 29
	2	650	〃	'83. 4. 22	'83. 7. 25
	3	950	〃	'85. 1. 22	'85. 9. 30
	4	950	〃	'85. 11. 15	'86. 4. 29
WOLSUNG (WLS)	1	679	CANDU	'82. 12. 31	'83. 4. 22
	2	700	〃	'97. 4. 1	'97. 7. 1
	3	700	〃	'98. 3. 25	'98. 7. 1
	4	700	〃	'99. 5. 21	'99. 10. 1
YOUNGKWANG (YKG)	1	950	PWR	'86. 3. 5	'86. 8. 25
	2	950	〃	'86. 11. 11	'87. 6. 10
	3	1,000	〃	'94. 10. 30	'95. 3. 31
	4	1,000	〃	'95. 7. 18	'96. 1. 1
	5	1,000	〃	'01. 12. 19	'02. 5. 21
	6	1,000	〃	'02. 9. 16	'02. 12. 24
WOOLJIN (WLJ)	1	950	〃	'88. 4. 7	'88. 9. 10
	2	950	〃	'89. 4. 14	'89. 9. 30
	3	1,000	〃	'98. 1. 6	'98. 8. 11
	4	1,000	〃	'98. 12. 28	'99. 12. 31
	5	1,000	〃	'03. 12. 18	'04. 7. 29
	6	1,000	〃	'05. 1. 7	('05. 6.)

DOSE DISTRIBUTION IN 2004

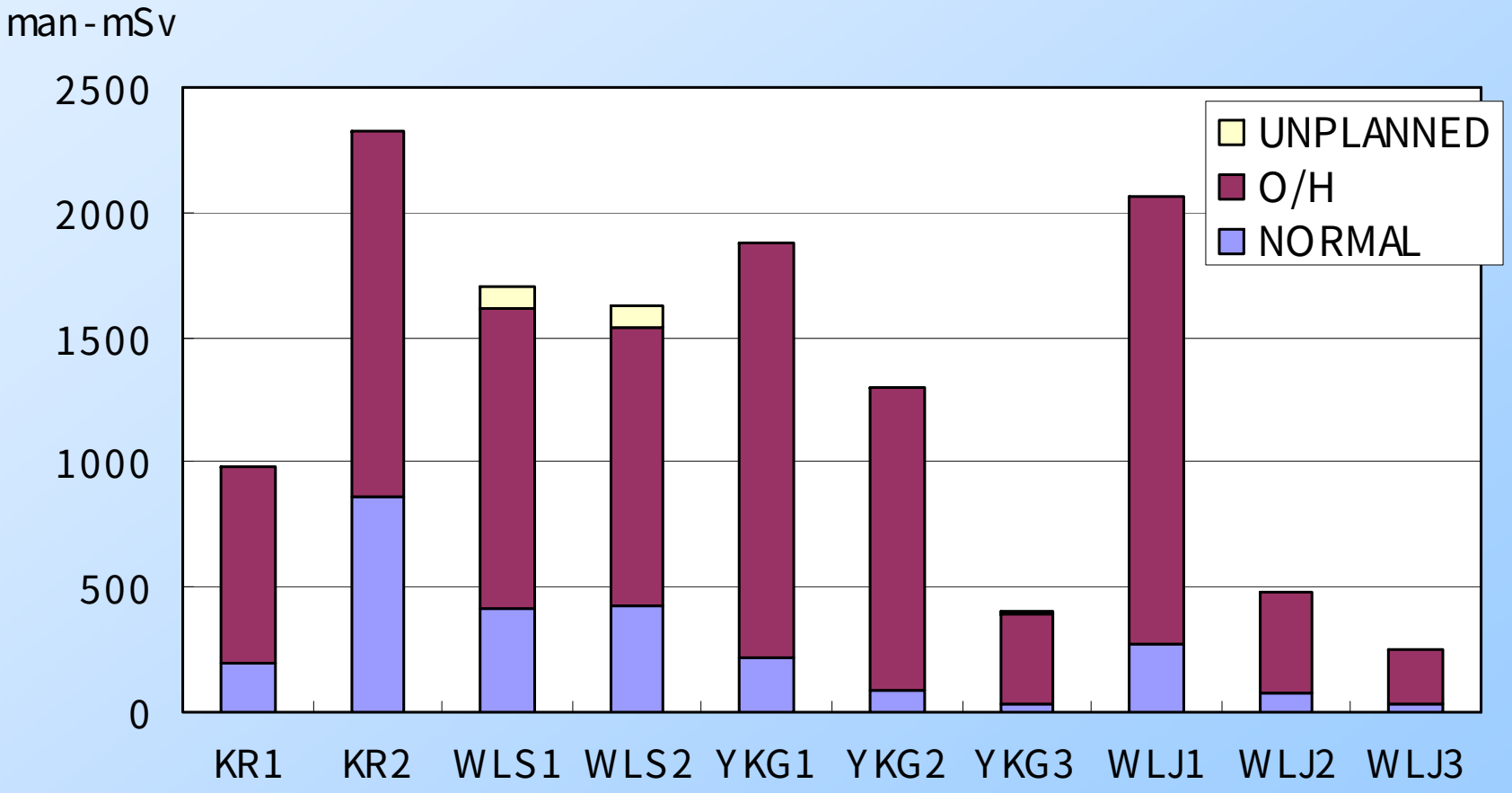


TOTAL DOSE: 13.03 man-Sv
WORKERS: 9867 PERSONS
O/H PLANNED: 18 REACTORS
AVERAGE DOSE PER REACTOR: 0.686 man-Sv
AVERAGE INDIVIDUAL DOSE: 1.32 mSv

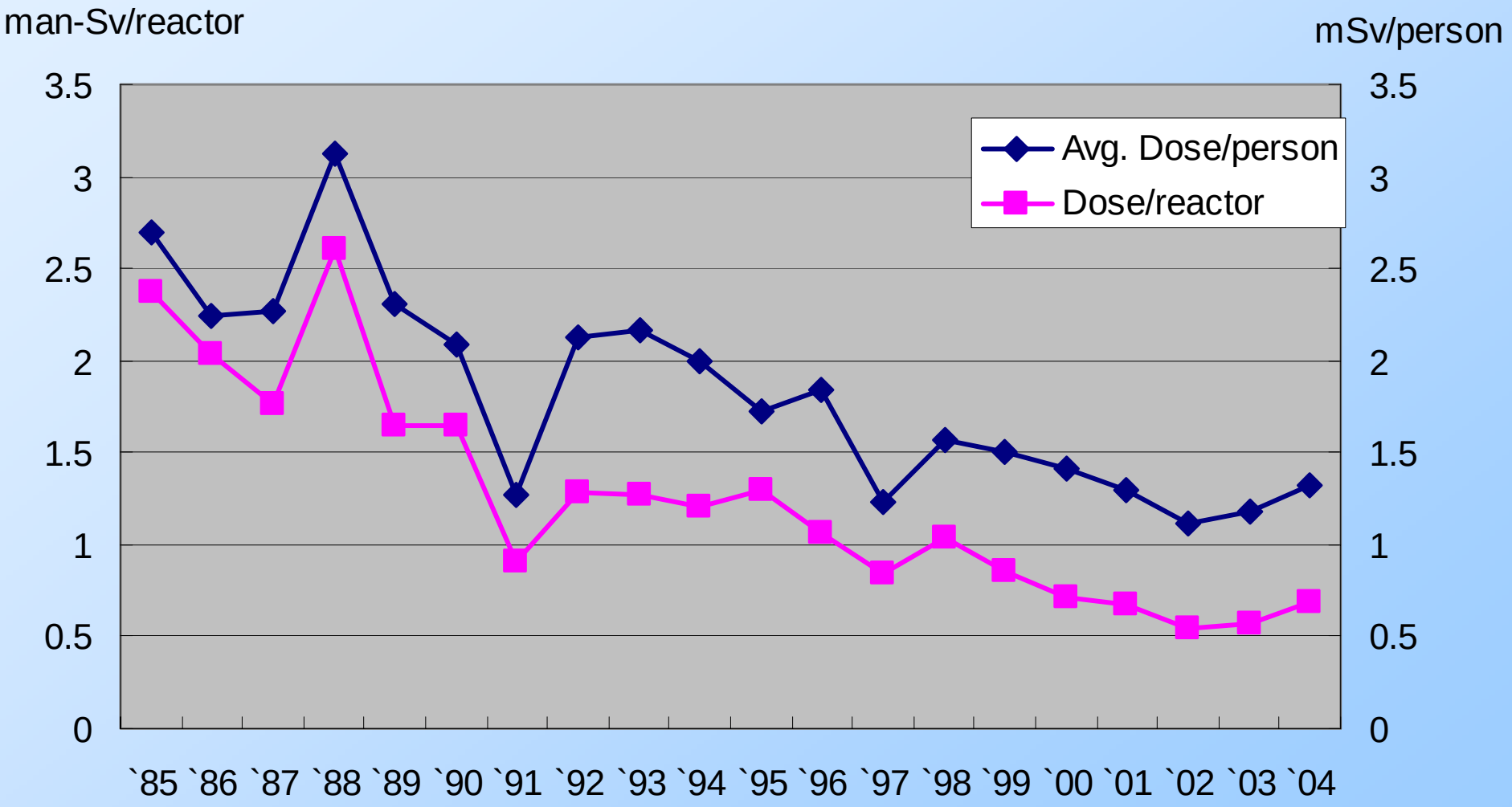
TOTAL DOSE TREND AND NPP INCREMENT



DOSE DISTRIBUTION BY UNITS



EVOLUTION OF DOSE TREND



DISTRIBUTION OF EXPOSED WORKERS IN EACH SITE ACCORDING TO THE DOSE BOUNDARY

UNIT		DISTRIBUTION (mSv)										TOTAL
		ZERO	0.01∼0.1	0.1∼1	1∼2	2∼3	3∼5	5∼10	10∼15	15∼20	>20	
KR	1	831	53	315	121	61	71	33	2	0	0	1,487
	2	433	274	446	170	131	115	102	19	9	0	1,699
WLS	1	541	184	336	126	65	74	85	29	0	0	1,440
	2	418	121	321	179	94	65	78	15	2	0	1,293
YKG	1	678	30	342	156	87	104	91	24	0	0	1,512
	2	799	15	307	115	76	75	60	9	1	0	1,457
	3	841	166	423	62	24	17	4	-	-	-	1,537
WLJ	1	556	71	300	175	95	137	75	31	1	-	1,441
	2	705	42	234	93	28	32	7	0	0	0	1,141
	3	1296	30	111	39	11	15	11	0	0	0	1,513
TOTAL (MAN)		4,929	661	1901	692	362	422	546	253	101	0	9,867

DOSE DISTRIBUTION VERSUS JOB TASK IN PWR

PWR JOB CODE		PWR TASK	WORKING HOUR (man-hr)	TOTAL ENTERANCE (PERONNS))	COLLECTIVE DOSE (man-mSv)			
					NORMAL	O/H	UNPLANNED	TOTAL
A		REFUELLING	37,122	17,595	34.48	173.94	1.48	209.9
B REACTOR VESSEL OR INTERNAL	B01 B04,B6	DISASSEMBLE & ASSEMBLE, STUD BOLT	17,037	7,689	0	683.53	4.95	688.48
	B05, B32	INSPECTION, MECH. UT	8,881	3,870	0.03	159.76	30.72	190.51
	B07 B21	IN_CORE DETECTOR, THIM	12,559	6,387	32.04	635.58	0.01	667.63
	B31, B99	OTHERS	14,633	7,970	4.40	209.02	130.94	344.36
C S/G PRIMARY SIDE	C01 C09	Man-way OPEN, CLOSE, etc.	2,450	1,175	1.13	142.20	0.68	144.01
	C11 C19	NOZZLE DAM	2,148	1,366	0.54	448.39	0	448.93
	C21 C29	ECT	8,415	4,390	15.19	369.76	0	384.95
	C31 C39	Tube	6,179	2,735	239.93	101.90	0	341.83
	C99	OTHERS	526	359	5.70	10.93	0	16.63
D S/G - SECONDARY SIDE	D01, D02	OPEN/CLOSE, HAND/EYE HOLE	1,596	885	0	87.28	0	87.28
	D03	Lancing	4,471	2,619	0.05	223.82	0	223.87
	D04	FOSAR (Foreign material removal)	1,737	944	0	124.96	0	124.96
	D05, D99	OTHERS	1,363	739	0.08	14.40	2.00	16.48
E : RHR & SI SYS		P/P, V/V, etc.	7,677	3,992	5.93	300.79	0.84	307.56

DOSE DISTRIBUTION VERSUS JOB TASK IN PWR

PWR JOB CODE		PWR TASK	WORKING HOUR (man-hr)	TOTAL ENTERANCE PERONNS)	COLLECTIVE DOSE (man-mSv)			
					NORMAL	O/H	UNPLANNED	TOTAL
F, H, J : CVCS & COOLANT, SEAL, WATER CLEAN-UP SYSTEM, SNUBBER		CHG P/P, CVCS	13,451	7,509	31.97	300.51	1.33	333.81
G : PZR		PZR	3,415	1,823	6.53	153.58	0.04	160.15
I : RCS PUMP		RCP	35,924	17,751	316.55	628.13	2.32	947.00
K : VALVE WORK		MOV, V/V etc.	20,738	11,769	43.88	465.82	2.12	511.82
L : ROUTINE INSPECTIONS		ROUTINE INSPECTIONS	84,147	70,909	83.26	216.14	5.90	305.30
M GENERAL WORK	M01, M09	In Service Inspection	14,449	7,798	0.45	568.71	0.58	569.74
	M11 M19	ILRT,LLRT	9,488	4,701	4.17	70.13	0.13	74.43
	M21	SYSTEM OPERATION	146,502	95,915	60.55	215.83	1.31	277.69
	M31, M32	Radiation Management, Decontamination, Laundary	379,499	187,929	186.26	556.66	35.46	778.38
	M33, M34	WASTE MANAGEMENT	117,656	58,662	412.69	127.51	0.49	540.69
	OTHERS	OTHERS	109,455	70,474	249.24	403.42	8.65	661.31
N : SCAFFOLDING		SCAFFOLDING	5	4	0	0	0	0
O : INSULATION		INSULATION	239	139	0.21	5.25	0	5.46
P : CONTROL ROD DRIVE		CONTROL ROD DRIVE	1,893	791	1.88	47.21	1.14	50.23
Q : UNSPECIFIED TASKS		UNSPECIFIED TASKS	39,734	24,082	43.43	235.61	1.75	280.79
R : SPECIAL LARGE TASK		RCP DACS & TVCS, RTD BYPASS LINE, S/G REPLACEMENT	413	263	1.12	0	0	1.12
TOTAL			1,103,802	623,234	1,781.69	7,680.77	232.84	9,695.30

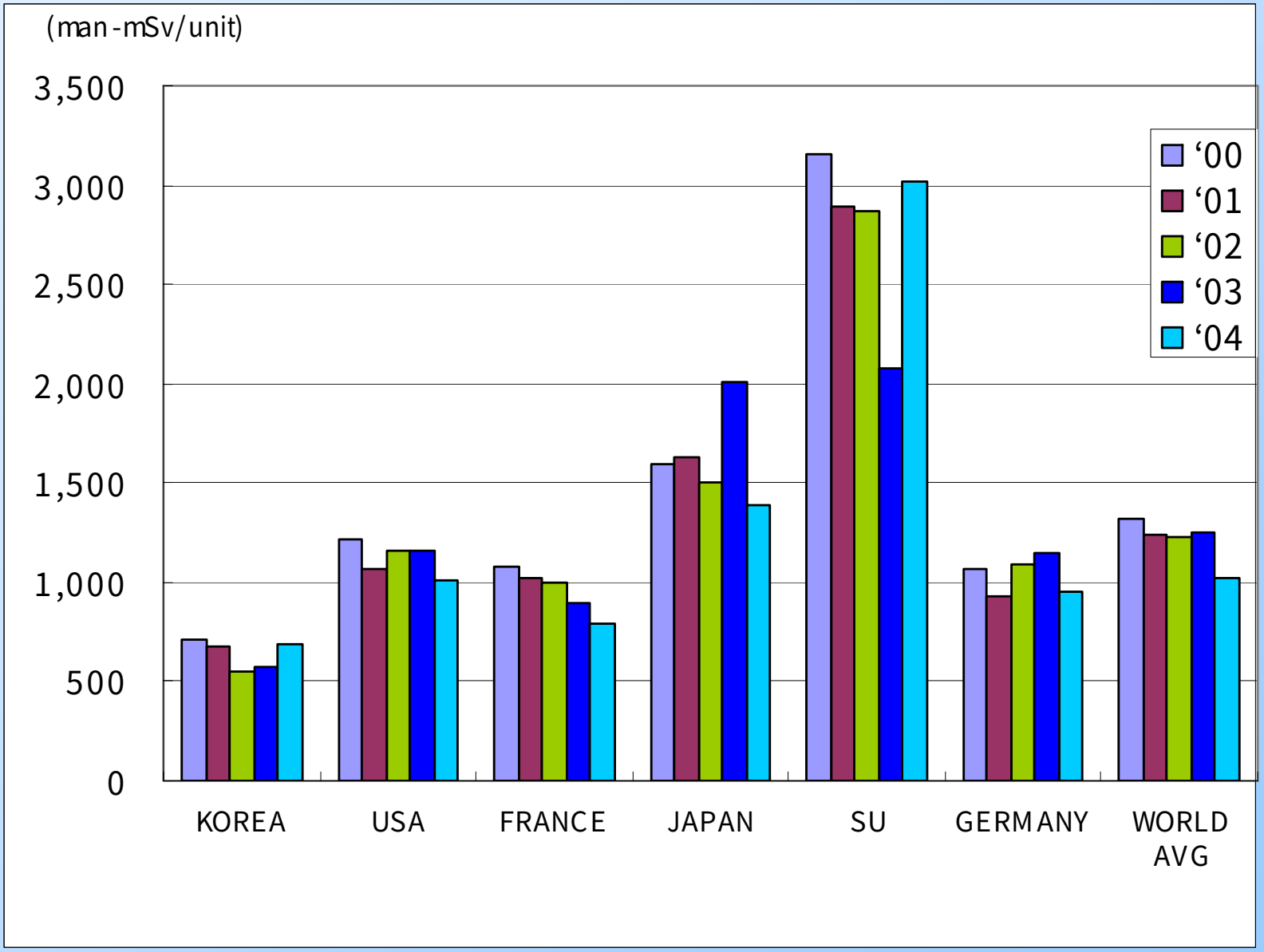
DOSE DISTRIBUTION VERSUS JOB TASK IN CANDU TYPE

CANDU JOB CODE		CANDU TASK	WORKING HOUR (man-hr)	TOTAL ENTERANCE (MAN)	COLLECTIVE DOSE (man-mSv)			
					NORMAL	O/H	UN-PLANNED	TOTAL
A : REFUELLING	A11 A13	REFUELLING	11,475	6,774	121.17	130.81	0	251.98
	OTHERS	OTHERS	15,722	8,426	89.75	15.74	0	105.49
B : REACTOR VESSEL OR INTERNAL	B01	PRESSURIZER (CIGAR)	2,661	1,477	14.86	76.99	0	91.85
	B02	SLARETTE	66	42	0	0	0	0
	B03	SCRAPE SAMPLING	119	52	0	0	0	0
	B04	END FITTING LAPPING	159	95	0.27	40.42	0	40.69
	OTHERS	OTHERS	1,446	825	10.11	10.05	0	20.16
C, D S/G - PRIMARY & 2ry SIDE	C01	Man-way OPEN/CLOSE	1,148	561	1.59	134.31	0	135.9
	C11,C21	ECT	2,034	1,368	0	144.22	0	144.22
	D11	LANCING	0	0	0	0	0	0
	OTHERS	S/G OTHERS (S/G 1 ry TUBE CLEAN)	2,800	1,361	0.23	266.04	0	266.27
H : REACTOR WATER CLEAN-UP SYSTEM	H01 H04 J01 J03	WATER CLEAN-UP AUXILIARY SYSTEM	637	426	11.78	8.67	0	20.45
	H11 H13	RCS AUXILIARY SYSTEM	794	450	2.79	16.10	0	18.89

DOSE DISTRIBUTION VERSUS JOB TASK IN CANDU TYPE

CANDU JOB CODE		CANDU TASK	WORKING HOUR (man-hr)	TOTAL ENTERANCE (MAN)	COLLECTIVE DOSE (man-mSv)			
					NORMAL	O/H	UN-PLANNED	TOTAL
I : RCS PUMP	I01 I03	RCS PUMP, MOTOR, SEAL	321	182	2.95	23.46	4.88	31.29
	I11 I13	PHT PUMP, MOTOR, SEAL	2,025	1,174	16.26	38.60	0	54.86
L : ROUTINE INSPECTIONS	L01 L02	ISI, FEEDER THICKNESS CHECK	1,857	943	0.03	116.01	0	116.04
	L03 04	ILRT,LLRT	1,616	1,079	0.68	45.68	0	46.36
	L14 L16	INSPECTION, AUDIT, QA	1,105	925	3.86	4.71	0	8.57
M : GENERAL WORK	M01, M02	DN TUBE & COIL ASSEMBLY	3,154	1,796	8.78	535.01	134.74	678.53
	M03 M05	H3 SYSTEM	9,199	2,198	10.78	0	0	10.78
	M11 M12	ROUTINE INSPECTIONS BY OPERATORS	28,421	19,657	53.95	27.44	0	81.39
	M13 M17	MISCELLANEOUS INSPECTION, Call-up WORK	32,245	42,610	151.71	62.62	0	214.33
	M21	RADIATION MANAGEMENT	75,928	46,488	82.67	126.51	8.72	217.9
	M22 M23	HOT & COLD SURVEY	254	212	7.27	3.51	9.94	20.72
	M24	Decontamination, Laundry	11,830	5,371	0.99	4.07	0	5.06
	M25 28	WASTE MANAGEMENT	18,432	13,379	28.26	7.20	0	35.46
	M35	P/P (INSULATOR)	176	116	0.53	0	0	0.53
	M36 M39	Air, HVAC, ION EXCHANGE, LAC	5,844	3,103	9.25	118.49	14.50	142.24
N : SCAFFOLDING		SCAFFOLDING	78	45	0.12	33.37	0	33.49
Q: UNSPECIFIED TASKS		UNSPECIFIED TASKS	49,452	37,070	214.83	312.54	9.29	536.66
R: LARGE TASK		SPECIAL TASK	0	0	0	0	0	0
TOTAL			280,998	198,205	845.47	2302.57	182.07	3330.12

COMPARISON OF AVERAGED DOSE TREND



Current Status in KOREAN NPPs

- **Using the ISOEDAT for annual report**
  - **ISOE system: effective tool for decision-making process**
  - **annual RPM meeting to collect Korean data**
- **Web type KISOE will be completed in 2005**
  - **3 year project since 2003 (browser type)**
  - **Data-Mart: professional analysis**
  - **Use for Emergency Response System if necessary**

RADIATION EXPOSURE STATUS: KHNP

Dose Limit: 50mSv/y→40mSv/y(1996)→ ICRP-60 (2001)

- ◆no workers exceeding 20 mSv/yr since 1999
- ◆ decline trend on average annual individual dose

Year	`96	`97	`98	`99	`00	`01	02	03	04
Number of Worker exceeding 20mSv/yr	12	7	10	0	0	0	0	0	0
Individual Average Dose (mSv)	1.84	1.23	1.57	1.44	1.51	1.41	1.29	1.18	1.32

DOSE REDUCTION STRATEGY: KHNP

Improvement of Operation and Administration System

- Improvement of internal dose evaluation system to comply with ICRP-60
- Upgraded ALARA review at the design and construction stage
- Enactment of radiation safety award

Korean Model Study: Alpha value by the use of CEPN Model

$$\alpha_{ref}(x) = \alpha_{base} \qquad \text{for } x < x_o$$

$$\alpha_{ref}(x) = \alpha_{base} \times \left(\frac{x}{x_o}\right)^a \qquad \text{for } x \geq x_o$$

- α base value : 13 US$/man-mSv

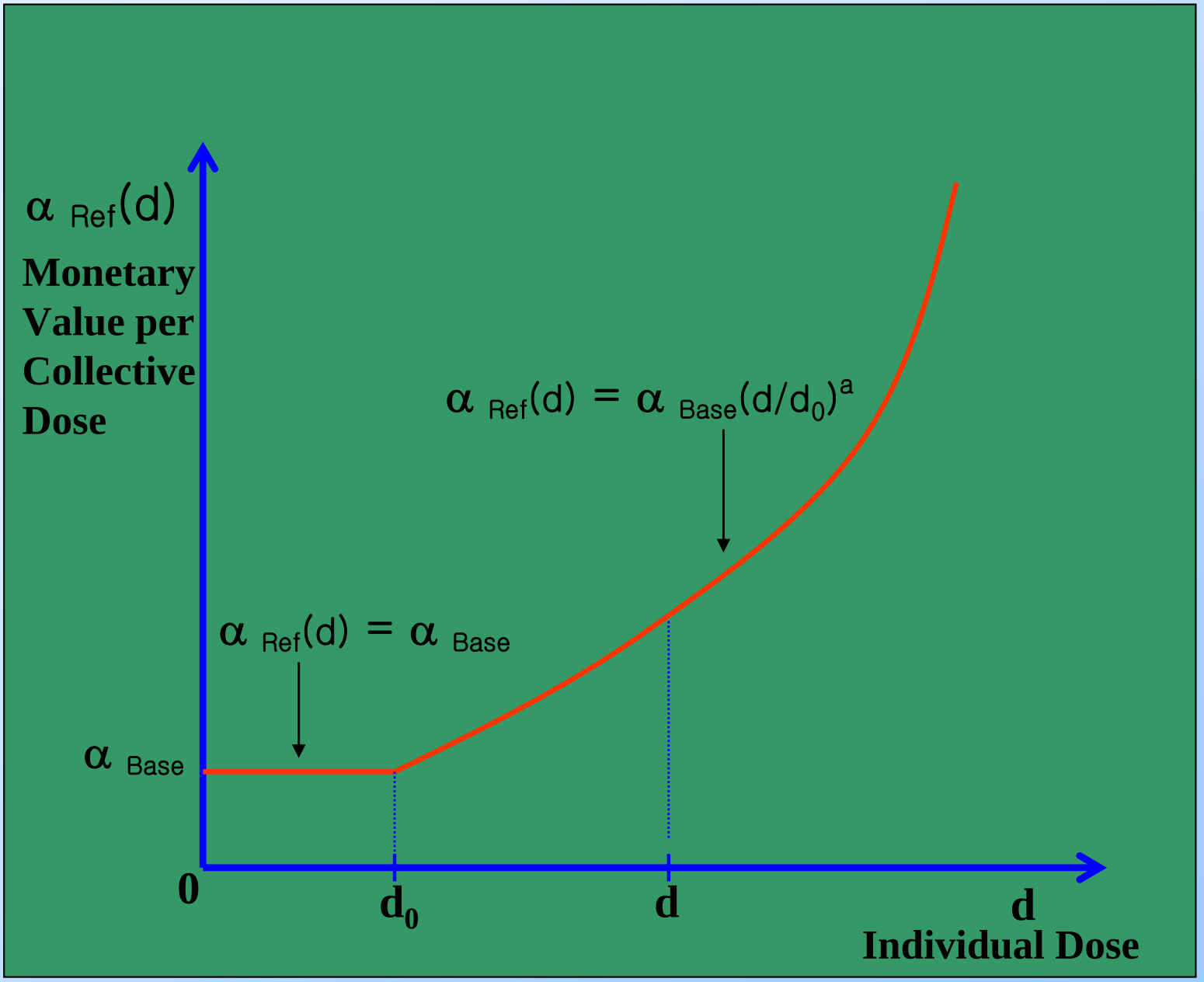
GDP/capita (2002) : 14,504 US$/man

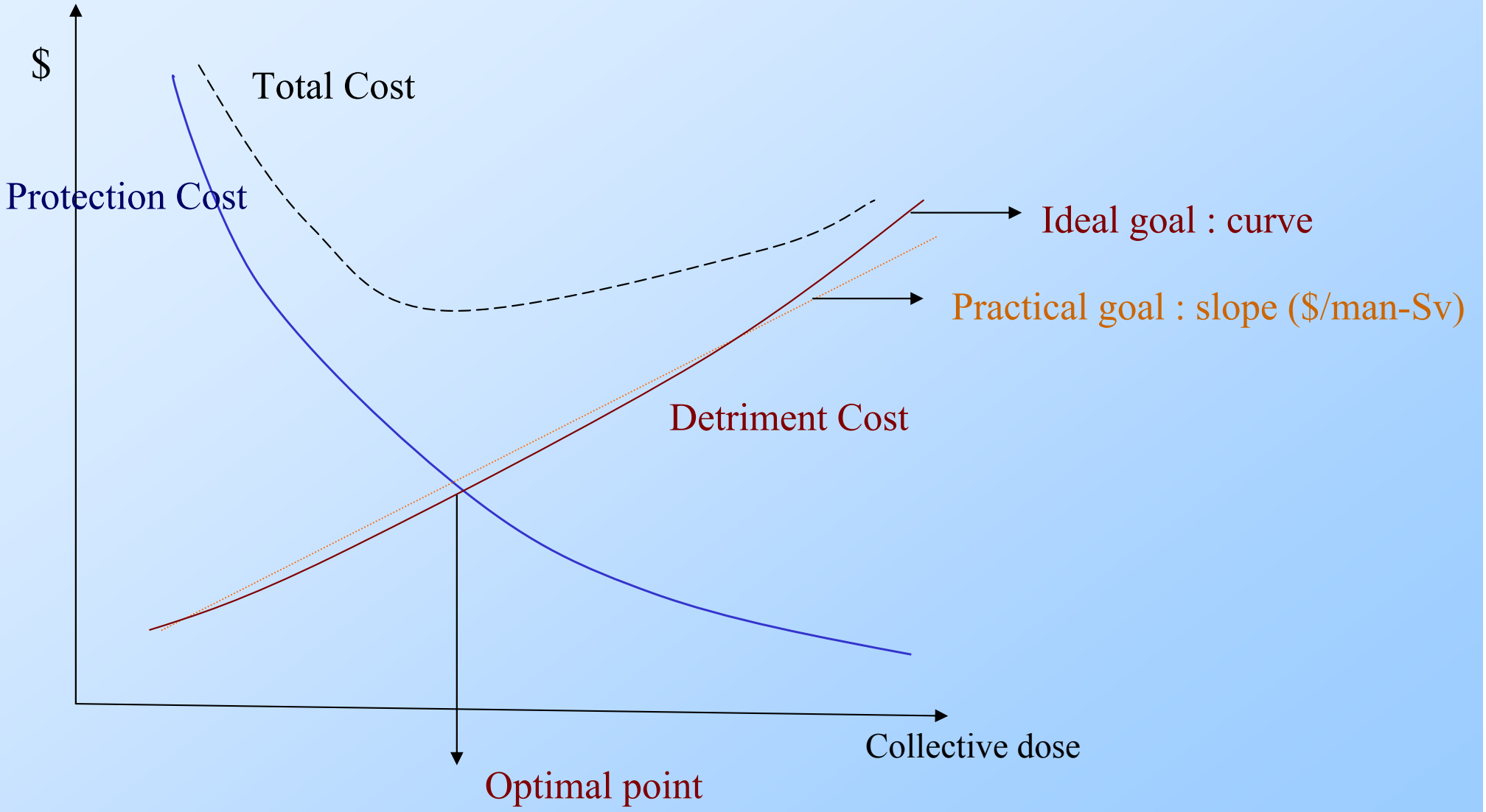
Loss of life expectancy caused by radiation : 16 years
Monetary value influenced by personal health : 232,057 US$

Detriment Probability : 0.056 /Sv
Monetary Value for Sv : 12,995 US$/Sv

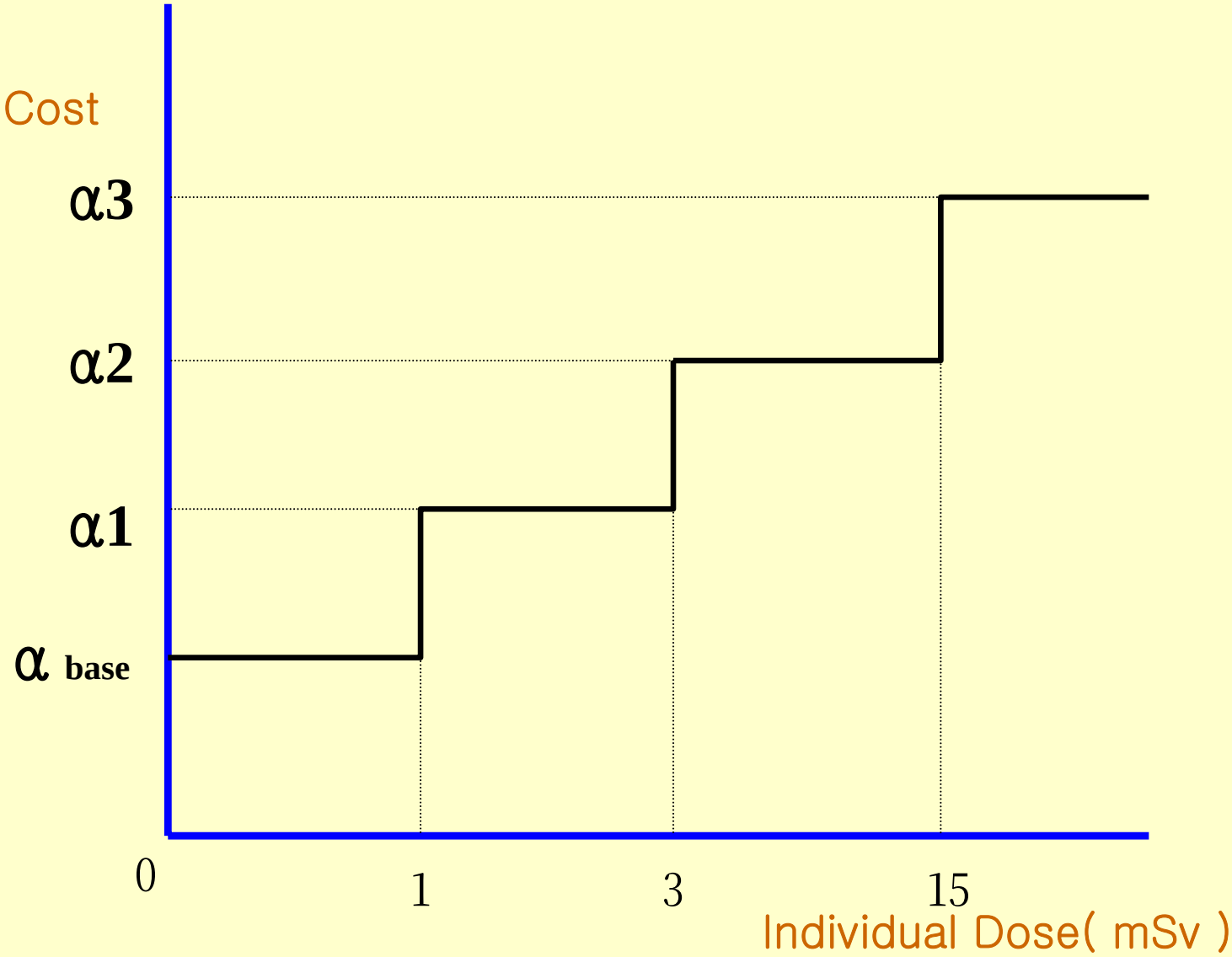
Alpha base value → 13 US$/man-mSv

CEPN Model for Alpha Value




$
Total Cost
Protection Cost
Ideal goal : curve
Practical goal : slope ($/man-Sv)
Detriment Cost
Collective dose
Optimal point

Proposed Alpha Value Model for Korea



Draft Alpha Value in Korea

- $\alpha_{ref}(x) = \alpha_{base}$, if $x \leq 1$

  $= \alpha_1$, if $1 < x \leq 5$

  $= \alpha_2$, if $5 < x \leq 10$

  $= \alpha_3$, if $10 < x$

- α_{base} : **13 US$/man-mSv**

  = GDP/capita × expected life × health detriment cost × Prob.

- α_1 : **63.1 US$/man-mSv** (shown slide 10)

- α_2 : **220.6 US$/man-mSv**

- α_3 : **582.1 US$/man-Sv**

Applied in Other Country

1) Corporate or plant alpha values for occupational exposure: set of values

Country	Corporate or NPP	Monetary Value of Man-mSv ($)	Adoption year
Belgium	CEN SCK Mol	0-1 mSv : 23 1-2 mSv : 58 2-5 mSv : 232 5-10 mSv : 620 10-20 mSv : 1,158 20-50 mSv : 4,635	1995
France	EDF	0-1 mSv : 14 1-5 mSv : 57 5-15 mSv : 328 15-30 mSv : 955 30-50 mSv : 2,138	1993
Germany	VGB proposal agreed on by all utilities for testing	0-1 mSv : no value 1-10 mSv : 143 10-20 mSv : ~1,434	1997
Netherlands	Borssele NPP	0-10 mSv : 467 10< mSv : 935	2002

Draft Alpha Value in Korea (Regulatory Authority)

- 0~1m Sv : 13 $/man-mSv
- 1~5mSV : 63 $/man-mSv
- 5~10mSv : 221 $/man-mSv
- >10mSv : 582 $/man-mSv

2) Alpha values of Regulatory bodies

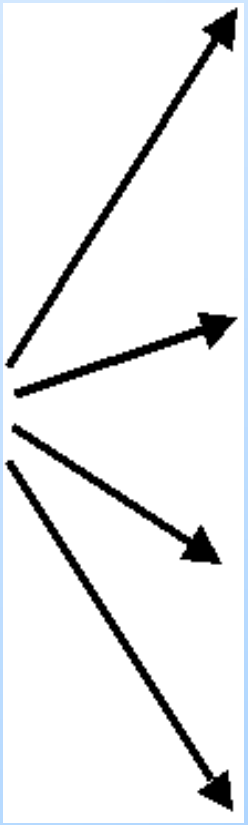
Country	PPP GNI($) 2002	Monetary Value of Man-mSv ($) (Exchange rate of Mar. 27, 2003)	Adoption year
Korea	16,960	13 ~ 582	2006 ?
Canada	28,390	70.3	1997
Czech Republic	14,920	16.8~84.1	2002
Finland	26,160	100	1991
Netherlands	28,350	486	1995
Romania	6,490	220	~2002
Sweden	25,820	13.5~277.8	~2002
Switzerland	31,840	2172	1994
United Kingdom	26,580	15.7~157.2	1998
USA	36,110	200	1995

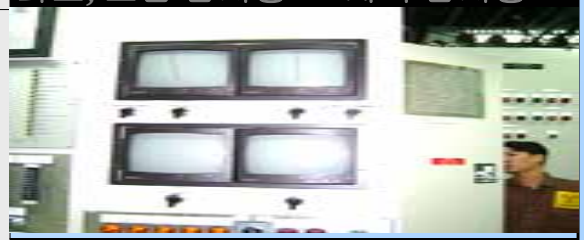
* CEPN, 2003

* PPP GNI : Purchasing Power Parity Gross National Income
It reflects the real value of currency and objective-economic situation.

I. RWB CRANE RENOVATION

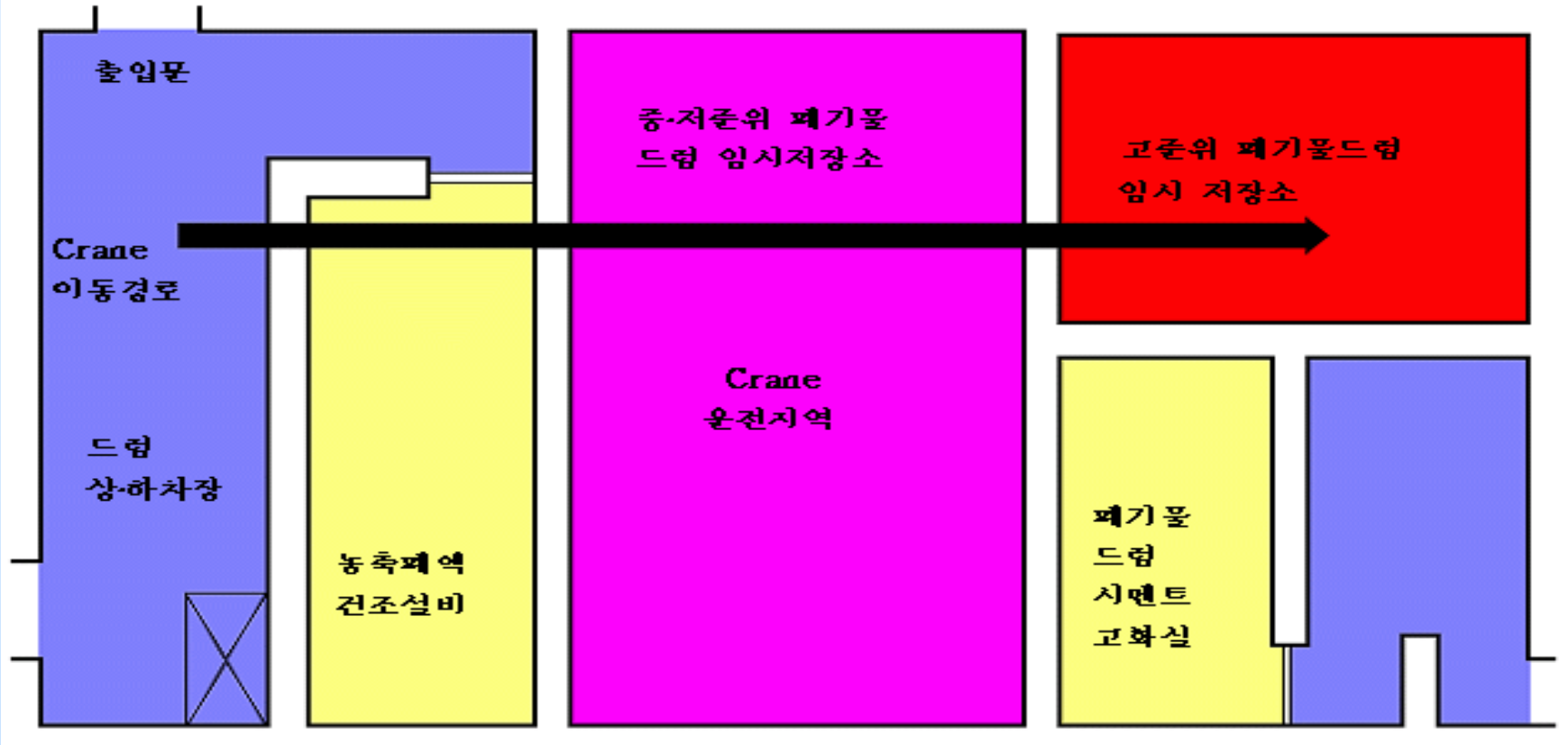
Crane Body



Camera	 2대(Grab,Grid) 좌표, 드럼 감시용	 2대(Survellence) 지역 감시용
Monitor		
Cable		
Control Pannel		

Ⅱ. RWB CRANE LOCATION

2. RWB Crane System in Use



※ Drum storage capacity

- LLRW : 949 drums
- HLRW : 583 drum

III. WASTE PRODUCTION & RWB CRANE OPERATION

○ **OPERATION TIME : 1,200hr/Y**

◆ No. of Drums Produced in Wooljin-2 ◆					
Year	**2000**	**2001**	**2002**	**2003**	**AVERAGE**
DRUMS	383	360	403	376	380

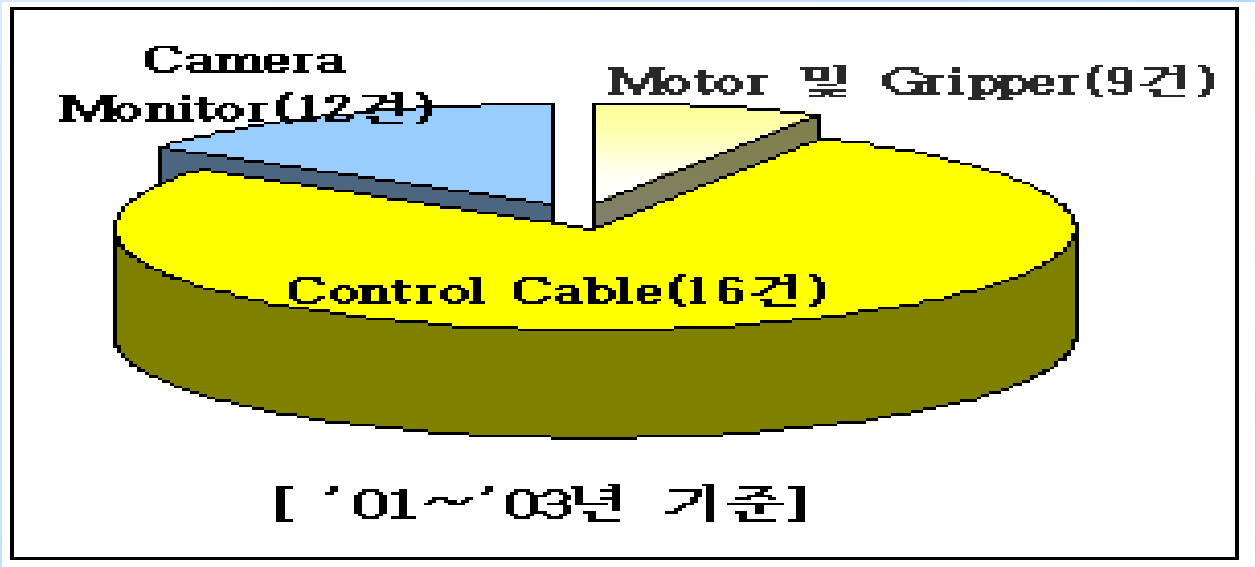
IV. REPLACEMENT & ENHANCEMENT

ITEMS	TASKS	OUTCOMES
Control Cable	○ Cable Replacement (current 75 fibers➪ 100) ○ clothing change (current 2PNCT ➪ 3PNCT) ○ Cable Wheel (25mm ➪ 35mm)	• Dose Saving • Fire Protection • Time & Cost Saving
Camera & Monitor	○ Radiation Registrant Camera →Normal Camera ○ Enlarging Monitor Size (8':B/W ➪ 14':Colour)	• Dose & Cost Saving • Improved Work Environment • In-house Production Equipment
Video Lines	○ Co-axial Cable ➪ Wireless	• Dose Saving • Operational Cost Saving

V. Intercepted Events & Causes

YEAR	INTERSEPTIONS	COMMENTS
'01	8	-
'02	13	-
'03	16	-

Causes of Crane System



VI. Dose Received by the Intercepted Events during Last 3 Years

- Number of Interception : 37
- Related Total Dose : 29.4 man-mSv
- Dose per Interception : about 0.7 man-mSv
- Accumulated Dose per Year : 9.8 man-mSv/Y
- ※ Relate Dose is increasing

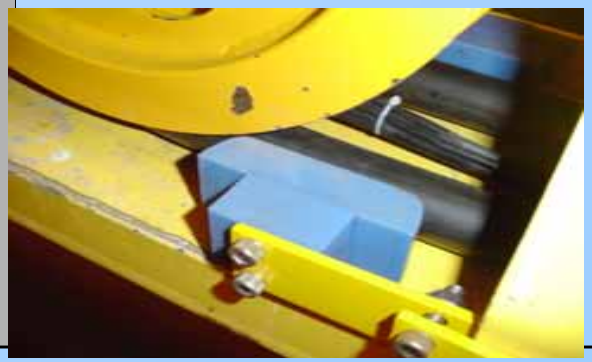
>10mSv : 582 $/man-mSv

VII. Dose History

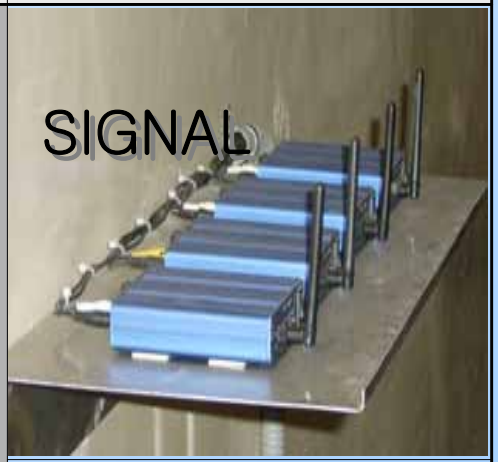
YEAR	No. of Work	Caused Dose (man-mSv)	Scaffolding (man-mSv)	TOTAL (man-mSv)
'01	8	2.4	4.8	7.2
'02	13	3.8	5.9	9.7
'03	16	5.2	7.3	12.5
TOTAL	37	11.4	18	29.4

Scaffolding

VIII. Crane System Before & After

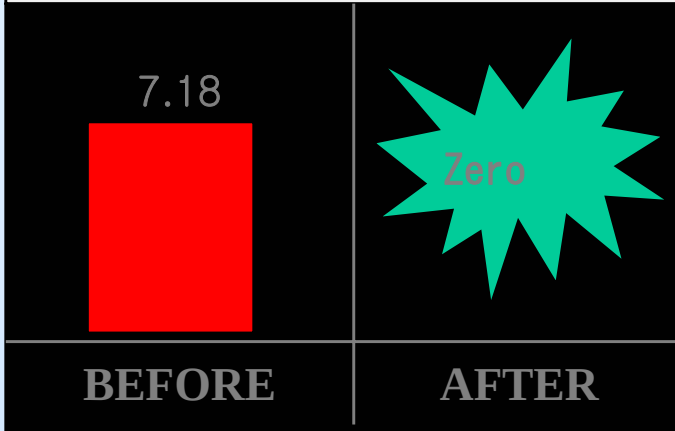
BEFORE	IMPROVED ITEMS	AFTER
	- BACKUP LINES - CLOTHING (2PNCT ⇨ 3PNCT)	
	- Protection of Cable Cut - Replacement of Cable Wheel (25mm ⇨ 35mm)	
	- Cable Derail - Guide Rail	

IX. Crane System Improvement before and after

BEFORE		AFTER
	Cable ⇨ Wireless	 
Rail & Cable		

X. Improvement Analysis before and after in 2004

Dose Saving (man-mSv)	Results



	Dose Saving (man-mSv)	Interceptions
Before	7.18	9
After	0	0

COST Saving in US$

■ **Cost of Parts: 5000/each * Interceptions/year**

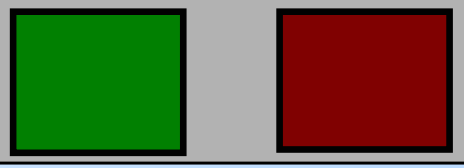
▷ 5000 * 4/Y = 20,000 US$

▷ Wireless Function Cost : 250/ea * 4ea = 1000

■ **Enhancement of Safety**

XI. Achieved Cost Saving

Cost Saving : about 0.3 Million US$

Products	BEFORE	AFTER
• IN-HOUSE PRODUCTS • PURCHASE AND REPAIRING TIME SAVING (18 Month to Obtain Imported Parts versus 1 month)	316,000 $ 18 Month 	21,400 $ 1 Month 

Calculation (´01~´03 basis)

ITEMS	IMPORTED PARTS US$	IN-HOUSE PRODUCTS $	COST SAVING (① - ②) $
Camera	28,000/ea × 4 ea = 112,000 $	2000/ea × 4 ea = 8000	104,000
Monitor	1000/ea × 4 ea = 4000	100/1 ea × 4 ea = 400	3600
Cable	200,000	13,000	187,000
TOTAL	① 316,000	② 21,400	294,600

XII. Achievements

◯ Average Dose Saving : 10 man-mSv/Y

OUTCOMES	BEFORE	AFTER
DOSE SAVING	29.4 man-mSv	0 man-mSv
Time Saving	18 Month	1 Month
Cost Saving	316,000 $	21,400 $

>10mSv : 582 $/man-mSv

◯ Recurrences in (′01~′03)

TASK	No. of EVENTS	DOSE SAVING (man-mSv)
Control Cable Replacement	16	12.7
Camera & Monitor Replacement	12	9.52
Diversion into Wireless Equipment	9	7.18

Any Questions ?