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NUCLEAR POWER PLANT LIFE TIME IMPROVEMENT AND MANAGEMENT PROGRAM IN KOREA

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ABSTRACT

Korea Electric Power Research Institute(KEPRI) of Korea Electric Power Corporation(KEPCO) has performed a lifetime management of nuclear power plant program(LMNPP), "Nuclear Power Plant Lifetime Management(PLIM) (I)", since November 1993, which is a feasibility study of the Kori Unit 1 lifetime management including aging evaluation of the thirteen major components. The results of the PLIM(I) will provide information which is necessary for decision making of the Kori Unit 1 lifetime improvement. A plan of the work scope and schedule for the next phase, PLIM(II), will also be provided by this project.

This paper introduces KEPRI's basic strategy of LMNPP, PLIM organization, current status, some interim results of the PLIM(I), and other related programs in Korea. So far, we have done field data survey, systems/structures screening, components prioritization, lifetime evaluation methodology study, and fracture mechanics tests of the Kori Unit 1 reactor pressure vessel surveillance coupons. Currently life assessment of the major components and PLIM economic evaluation of Kori Unit 1 are under way.

1 INTRODUCTION.

Nuclear power plant(NPP) technology in Korea have been tremendously improved since commercial operation of Kori Unit 1 in 1978. In the early period of NPP management, Korea Electric Power Corporation(KEPCO) made efforts to accumulate technologies and experiences of plant construction, operation, and maintenance. Table 1 shows the status of operating and constructing NPP's in Korea. Figure 1 shows that KEPCO has done endeavors to enhance plant performance.[1]

As plants are getting old, plant aging and preventive maintenance became much concern of NPP management. Under these circumstances lifetime management of nuclear power plant(LMNPP) is a good way to address the concern because the plant lifetime management means to assess plant aging and to manage plant maintenance

with a vision of continuing plant operation beyond its design lifetime.

Korea Electric Power Research Institute(KEPRI) of KEPCO has performed LMNPP phase I since November 1993, "Nuclear Power Plant Lifetime Management(PLIM) (I)", which is a feasibility study of the Kori Unit 1 lifetime management. The results of the PLIM(I) will provide information which is necessary for decision making of the Kori Unit 1 lifetime improvement. A plan of the work scope and schedule for the next program PLIM Phase II(Detail Lifetime Evaluation and Engineering) will be established based on the Phase I results.

This paper introduces KEPCO's basic strategies for the NPP lifetime management, PLIM organization, current status, some interim results of the PLIM(I), and other related programs in Korea. So far, we have done field data survey, systems/structures screening, components prioritization, fracture mechanics test of the Kori Unit 1 reactor pressure vessel(RPV) surveillance coupons, component aging evaluation methodology study, and stress and fatigue analysis of pressurizer surge line nozzle. Lifetime evaluation of the major components, economic analysis, regulatory considerations, and key technology researches are scheduled to be performed by 1996.

2 LMNPP PROGRAM

2.1 Basic Strategy

The first goal of KEPCO LMNPP is to operate Koran NPP's safely and economically up to the plant specific design life. The second goal is to operate plants beyond the design life to the optimum life. In parallel with the LMNPP programs, key technologies needed to support the lifetime management are being developed by R&D.

To reach these goals, it is required to do a lot of work and to modify the current preventive maintenance practice by implementing state-of-the-art technologies. The specific LMNPP feasibility study evaluates each plant's optimum lifetime which is the target lifetime. If the optimum lifetime of the plant is longer than the design life, the required activities for the life improvement beyond the design life will be incorporated in the long term preventive/predictive maintenance program.

2.2 KEPCO LMNPP Program

As a part of the phase I, the feasibility study is under way for Kori Unit 1 which is selected as the pilot plant of the feasibility study. Detail work scope of the study consists of the 10 tasks as shown in Table 2. In addition to the Kori Unit 1 feasibility study, several key technology R&D's are on-going in the areas of radiation embitterment, corrosion and cracking, water chemistry management, non-destructive test & evaluation, and ageing of instrument and control(I&C), which are also shown in Table 2.

Phase AI program will perform detail lifetime evaluation and engineering for the critical components screened in Phase I. The LMNPP implementation plan for Phase III will be suggested by the result of Phase II. Overall schedule for the LMNPP programs are explained in Table 3 and general work flow of the Phase I program is

shown in Figure 2. This long term plan can be modified in accordance with the result of the PLIM(I) feasibility study.

3 CURRENT STATUS AND INTERIM RESULTS OF THE PLIM(I)

3.1 PLIM(I) Project Organization

Figure 3 shows the PLIM project organization which is composed of various bodies with their roles. Organizations currently related to the project are KEPRI, KOPEC(Korea Power Engineering Company), KAERI(Korea Atomic Energy Research Institute), and foreign consulting organizations. KEPCO plans and guides all the project processes. KOPEC and KAERI perform actual engineering works and key technology R&D's, respectively. Other organizations and institutes will join in LMNPP program as it proceeds.

3.2 Current Status

LMNPP is presently one of the important task in Korean nuclear industry as Kori Unit 1, the first commercial nuclear power plant, is getting old. The PLIM Phase I study has performed field data survey, screening and prioritization of systems, structures, and components(SSCs), and preliminary life evaluation of major components. Fracture mechanics test and evaluation of Kori Unit 1 RPV surveillance coupon is finished. In the remaining period of the PLIM project, major component aging and lifetime evaluation, review of regulatory aspects, economical evaluation of Kori Unit 1 LMNPP, key technology researches, and PLIM(II) planning will be continued.

3.3 Field Data Survey

To evaluate plant aging status, huge amount of design and field data of Kori Unit 1 accumulated since commercial operation should be surveyed and reviewed. Even though it is tedious and needs lots of man-power to re-produce useful data from the collected raw data, data survey is the most important job that has to be done in the early stage of the PLIM program. Figure 4 shows the process to evaluate operating transient data. Data required for the PLIM(I) project can be classified as follows.

- General methodology and technical procedures
- Operating transients and history
- Component specific design and manufacturing data
- Maintenance and in-service inspection data
- Economic evaluation data

3.4 Screening and Prioritization

Critical component identification for aging evaluation is important part of the PLIM Phase I efforts because we have to know why and which components are critical in LMNPP. These critical components were identified through applying the screening and prioritization criteria of Westinghouse owners group to the Kori Unit 1 SSCs.[2]

The screening process applies safety-related criteria which are based upon the U.S. NRC's license renewal(LR) and maintenance rule(MR) which are 10CFR54 and 10CFR50.65 respectively.[3],[4] The results of the screening process are presented in

Figure 5. 62 of the 71 Kori Unit 1 systems and structures met either the LR, MR, or PP criteria. 51 were identified important to LR, 55 important to MR, and 32 important to PP.

After screening of the Kori Unit 1 systems and structures, critical components and structures were identified and prioritized to determine their importance. Prioritization of Kori Unit 1 critical components is based upon ten attributes which were selected to assess the impact that either the replacement or refurbishment of these critical components would have on the decision to improve design life. These attributes are listed in Table 4. The result of the prioritization identified top-ranked critical components. The top-ten ranked SSCs from 47 prioritized components were compared to the prioritization results of the US nuclear plant experiences. Kori Unit 1 showed a similar result to the previous experiences as shown in Table 5. All major components selected in the Phase I evaluation are included in top twenties of the component prioritization ranking.[2],[5]

3.5 Major Components Life Evaluation

To accomplish life evaluation of the components, the stressors and the degradation sites and mechanisms in conjunction with the resulting failure modes and their operating history will be identified through the appropriate tests and technical evaluations. In consequence, the task will end up with quantitative evaluations of the plausible age-related degradation mechanisms and the consumed and residual life of the major components listed in Table 6. For life evaluation, KEPRI will refer to the technical papers collected by the literature survey and the generic technical procedures which were applied in the other previous studies. Table 7 shows a component life evaluation methodology with an example of RPV.

3.5.1 RPV Fracture Toughness Test

Special attention is paid to the RPV for its significant importance in LMNPP. Fracture toughness test results of the WOL specimens of the Kori Unit 1 surveillance capsule irradiated for 34 EFPY show that the fracture toughness properties of Kori Unit 1 beltline weld material are similar to those of other plants Linde 80 flux weld metals. Test results are compared to the U.S. NRC draft regulatory guide DG-1023 acceptance criteria as shown in Table 8. [6],[7],[8]

3.5.2 Fatigue Evaluation of Pressurizer Surge Line Nozzle

The PLIM(I) performed fatigue lifetime evaluation for Kori Unit 1 pressurizer surge line nozzle with the commercial finite element package, NISA, in oder to provide an evaluation procedure of stress and residual fatigue life. Calculated stress result of this study demonstrated good agreement with the vendor design stress report which did not show the detail calculation process. We could find out that the residual fatigue life of the nozzle operated for 15 years was sufficient to meet the first goal of Kori Unit 1 LMNPP, 40 years.[9]

3.6 LMNPP Regulation Review

Regulatory rules are necessary to guide the LMNPP in a proper way. As there are no LMNPP related rules in Korea, preliminary survey about overseas license renewal trend and rule development is needed to guide a domestic policy of rule making in the future. The government body, the Ministry of Science and Technology,

and its agency, Korea Institute of Nuclear Safety, are actually in charge of nuclear power plant licensing and other license-related issues in Korea. KEPRI is planning to provide regulatory bodies with information and interim results of the LMNPP study to help the rule making.

4 MAINTENANCE AND COMPONENT REPLACEMENT

4.1 General Description[10]

In order to cope with component degradation, KEPCO applies state-of-the-art technologies to preventive maintenance. When the maintenance cost of fixing degraded components is not economical, the components are to be replaced with new ones manufactured by newly developed materials and subcomponents. Evaluation of economy of the replacement is always reviewed with the consideration of plant lifetime management.

Field refurbishment and replacement of the major components, such as reactor coolant pump motors, steam generators, low pressure turbine rotors, and CANDU pressure tubes are or will be done to maintain plant performance and operational safety up to the design life. Even though these activities are processed separately from the LMNPP program, positive effects are expected to the LMNPP from the viewpoint of economical aspect.

4.2 Steam Generators

Kori Unit 1 steam generators, Westinghouse model WH-51, Inconell 600MA tubes have experienced a lot of maintenance work such as plugging, sleeving, and chemical cleaning due to tube pitting, denting and primary water stress corrosion cracking. After detail economic evaluation, KEPCO decided to replace it with Inconell 690TT tubes and stainless steel broached support plate in 1998.

4.3 Low Pressure Turbine Rotors

In the field inspection of Kori Unit 1 low pressure turbine rotor discs, many cracks were found at disc, dowel hole, and disc head due to moisture induced intergranular stress corrosion cracking. After verifying safe operation of the turbine to the next outage by fracture mechanics analysis, temporary mitigation and maintenance schedule is prepared. This year KEPCO determined to replace the rotor and diaphragm of the low pressure turbines in the near future.

4.4 Others

Other projects which are closely related to LMNPP, such as process computer and I&C upgrade, plant updating, and probabilistic safety analysis, reliability centered maintenance are also considered by different programs with LMNPP. But LMNPP team always pay attention to the current status of the activities and try to put some result of them into use because these works are so closely related with the LMNPP. Figure 6 introduces KEPRI's tentative long term schedule for LMNPP related technology development.

5 SUMMARY

Nuclear LMNPP is currently one of the important tasks in Korean nuclear industry as Kori Unit 1 is getting old. This paper introduced KEPCO's basic strategy of the NPP lifetime management, LMNPP organization, current status, some interim results of the PLIM(I), and other related programs in Korea.

The feasibility study performed field data survey, screening, prioritization of the SSCs, major component life evaluation, fracture mechanics test of Kori Unit 1 reactor pressure vessel surveillance coupon. In the remaining period of PLIM(I) project, major component aging and lifetime evaluation, review of regulatory issues, evaluation of economy of Kori Unit 1 LMNPP, key technologies research, and PLIM(II) planning will be continued.

Field refurbishment and replacement of the major components are or will be done to maintain plant performance and operational safety up to the design life. Even though these activities are processed separately from LMNPP program, positive effects are expected to LMNPP from the viewpoint of the economical aspect. We expect that LMNPP will provide a good way of long term management of nuclear power plants in the cost-effective manner in Korea.

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Table 1 Status of Nuclear Power Plants in Korea

Plant	Capacity (MW)	Operat'n	Type	Supplier		Construction	Remark
				Reactor	T/G		
Kori #1	578	1978. 4	PWR	W	GEC	Turn Key	
Kori #2	650	1983. 7	PWR	W	GEC	〃	
Wolsong #1	700	1983. 4	PHWR	AECL	Parsons	〃	
Kori #3	950	1985. 9	PWR	W	GEC	Non-Turn Key	
Kori #4	950	1986. 4	PWR	W	GEC	〃	
Yonggwang #1	950	1986. 8	PWR	W	W	〃	
Yonggwang #2	950	1987. 6	PWR	W	W	〃	
Ulchin #1	950	1988. 9	PWR	Framatome	Alstome	〃	
Ulchin #2	950	1989. 9	PWR	〃	〃	〃	
Yonggwang #3	1000	1995. 3	PWR	KHIC/KAERI	KHIC/KAERI	Localized	Korean Standard
Yonggwang #4	1000	1996. 4	PWR	KHIC/KAERI	KHIC/KAERI	Localized	Korean Standard
Wolsong #2	700	1997. 6	PHWR	AECL	〃	〃	
Ulchin #3	1000	1998. 6	PWR	KHIC/KAERI	〃	〃	Korean Standard
Wolsong #3	700	1998. 6	PHWR	AECL	〃	〃	
Ulchin #4	1000	1999. 6	PWR	KHIC/KAERI	〃	〃	Korean Standard
Wolsong #4	700	1999. 6	PHWR	AECL	〃	〃	
New PWR #1	1000	2001. 6	PWR	Not Decided	Not Decided	Localized	Korean Standard
New PWR #2	1000	2002. 6	PWR	〃	〃	〃	Korean Standard
New PWR #3	1000	2003. 6	PWR	〃	〃	〃	Korean Standard
New PWR #4	1000	2004. 6	PWR	〃	〃	〃	Korean Standard
New PWR #5	1000	2005. 6	PWR	〃	〃	〃	Korean Standard
New PHWR#1	700	2006. 6	PHWR	〃	〃	〃	
New PWR #6	1000	2006. 6	PWR	〃	〃	〃	Korean Standard

(from MOTI Notice 93-96, 93.11.24)

Abbreviations

W: Westinghouse, GEC: General Electric Corp. (U.K), AECL: Atomic Energy Canadian Limited
KHIC: Korea Heavy Industry Co.(now HANJOONG), KAERI: Korea Atomic Energy Research Institute

under operation under construction under schedule

Table 2 Tasks and Research Activities of the Phase I

10 Tasks
○ PLIM project plan and design life review ○ Screening major SSCs ○ Data survey and review ○ Evaluation of reactor pressure vessel ○ Evaluation of major SSCs ○ Monitoring systems for LMNPP ○ Survey and review of LMNPP regulation ○ Economic evaluation ○ LMNPP technology development ○ Feasibility study reports
Research Activities
○ Utilization of Small or Reconstituted Specimens of RPV material ○ Pb Stress Corrosion Cracking of SG Tubes ○ Evaluation of Hideout Return and SG Crevice Condition ○ Natural Cracked Small Pipe Specimen and Defect Signal Analysis ○ Destructive Test of Thermal and Radiation Exposed Cable

Table 3 Three Phases of the LMNPP Program

Phases	Period	Contents
Phase I	1993 ~ 1996	Feasibility Study - Feasibility evaluation method and techniques - Kori Unit 1 LMNPP feasibility study - Phase II planning
Phase II	1997 ~ 1999	Detail Evaluation and Engineering - Kori Unit 1 detail inspection and residual life evaluation - Documentations for license renewal - Planning for life extension
Phase III	2000 ~ 2008	Refurbish, Replacement, and Maintenance - Implementation - Advanced technology development

Table 4 Ten Attributes for critical component prioritization

○ Cost to Replace or Refurbish	○ Replacement Precedent
○ Impact on Plant Availability	○ Generic Applicability
○ Radiation Dose	○ Mode of Failure
○ Regulatory Importance	○ Consequences of Failure on Plant Safety
○ Modifications Required	○ Consequences on Plant Operation

Table 5 Comparison of Prioritization results

Rank	Kori Unit 1	Other U.S. Plant 1	NRC	YNPS
1	Reactor Pressure Vessel	Reactor Pressure Vessel	Reactor Pressure Vessel	Reactor Pressure Vessel
2	Containment(Liner, Basemat, and Shield Bldg.)	Containment and Basemat	Containment and Basemat	Reactor Internals
3	Steam Generators	RPV Supports	Reactor Coolant Piping	Neutron Shield Tank
4	RCS Piping, Large Valves, Nozzles	RCS Piping(Cat. 1 and 2)	Steam Generators	HP Turbine
5	Reactor Coolant Pump Casing	Steam Generators	RCS Pump Bodies	LP Turbines
6	Pressurizer(Nozzles, Surge, Spray Piping)	Emergency Diesel Generators	Pressurizer	Generator
7	RPV Internals	RPV Internals(Upper and Lower)	CRDMs	Steam Generators
8	Cables(in Containment)	RCS Pump Body	Cables and Connectors	Pressurizer
9	CRDMs	Pressurizer	Emergency Diesel Generators	CRDMs
10	MS Piping(Stop, Control, Intercept Valves)	Neutron Shield Tank	RPV Internals	Condenser
11	HP & LP Turbine	CRDMs	RPV Supports & Biological Shield	Service Water System

Table 6 Selected Major Components in LMNPP(I)

- ○ Reactor pressure vessel
- ○ Reactor vessel internals
- ○ Control rod drive mechanisms
- ○ Reactor coolant system piping
- ○ Reactor coolant system charging and safety injection nozzles
- ○ Pressurizer
- ○ Pressurizer surge and spray lines nozzles
- ○ Reactor coolant pump
- ○ Reactor pressure vessel supports
- ○ Turbine
- ○ Generator
- ○ Containment
- ○ Cables

Table 7 Summary of Evaluation Procedure for Reactor Pressure Vessel

Sub Components	Specific ISI	Degradation Evaluation	Recommendations
Beltline Region	o No crack found o Pressure Vessel : SA508 Cl.2 low alloy steel o Weld Material: Linde 80 flux Mn-Mo-Ni filler wire o Beltline Welding : B&W WF-233 (Cu 0.29 wt%)	Radiation Embrittlement o Verify with Surveillance Coupon Test Result : 2 Criteria - Revise P-T Limit Curve with the Test Result o RT_{NDT} Transition - RT_{NDT} = initial RT_{NDT} + ΔRT_{NDT} + Margin - below 300°F during plant operation o Upper Shelf Energy(USE) - Unless satisfy 50 ft-lb, perform low fracture toughness test o Low fracture toughness test & elastic/pastic analysis - Verified safety up to 34EFPY Fatigue: simple method o Analyze cumulative usage factor(CUF) using S_{ALT}, N_f, design transient n_i of design stress report(DSR) & actual operating transient counts n_k	o If $RT_{PTS} \geq 300°F$ during lifetime, Plant Specific PTS o Rescreen PTS with revised PTS rule & additional surveill. test result o Additional surveill. test plan o Flux reduction o Archive material test plan이용방안 o Reconstitution and small specimen o RPV thermal annealing trend o Environmental fatigue analysis trend o Under clad cracking review
Outlet/Inlet Nozzle	o PSI found a crack at welding point at Outlet Nozzle to Shell o Verified it as no significant indication by the 2nd & 5th ISI o Confirm it as geometric by the 8th ISI	Fatigue: simple method o $\frac{\text{Actual transient count no}}{\text{Design transient no}} \times U_{c,design} = U_{c,new} \leq 1.0$ $\frac{U_{c,new}}{U_{c,design}} \times 40$ = Expected fatigue life o Analyze CUF using S_{ALT}, N_f, design transient n_i of DSR & actual operating transient counts n_k	o For the point where $U_{c,new} \geq 0.67$, detail fatigue analysis o Fatigue transient monitoring o Advanced ultrasonic technique
Instrumentation Nozzles and CRDM Housing Nozzles	o No crack found	Fatigue: Negligible CUF of 0.02 & 0.00 in DSR, no fatigue analysis requied PWSCC: No PWSCC reported yet	o Detail inspection & analysis for life improvement
Flange Closure Studs	o No crack found	Fatigue: Analyze CUF using S_{ALT}, N_f, design transient n_i of DSR & actual operating transient counts n_k	o High design CUF o Replace for life improvement

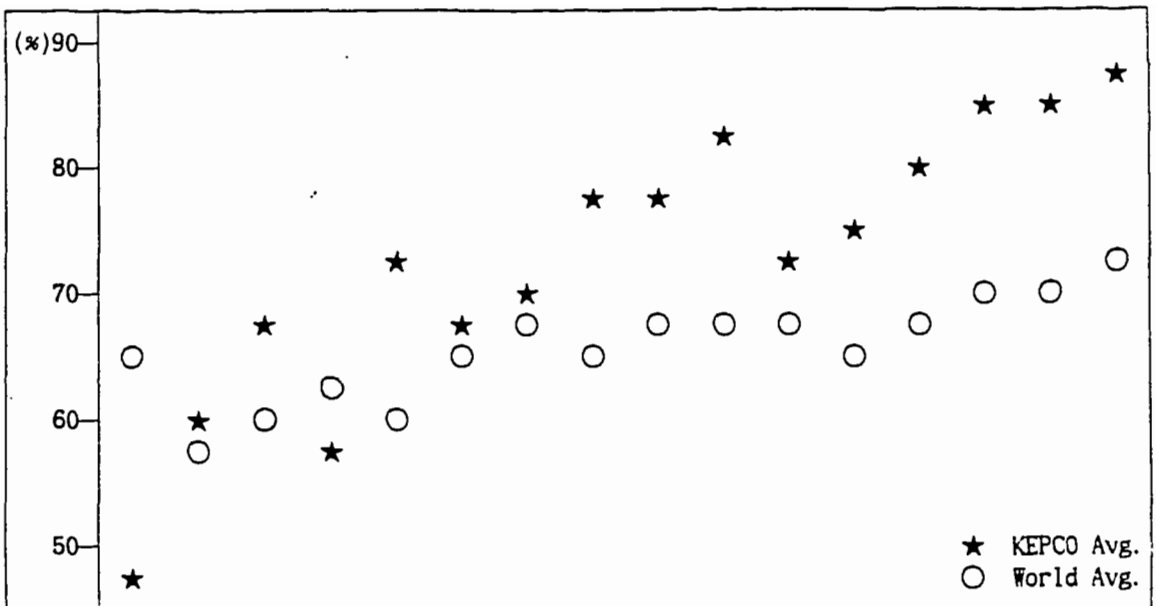
Table 8 Analysis results for low upper-shelf toughness issue of Kori Unit 1 RPV

(a) Level A/B service loads

J-R Curve	J_{app} lb/in (SF=1.15)	J_{app} lb/in (SF=1.25)	$J_{0.1}$ lb/in	SM (P_{crit}/P_a)	Criteria
Lower Bounding	93	110	416	2.65	Satisfying

(b) Level C/D service loads

Transient	J_{app} lb/in (max. value)	$J_{0.1}$ lb/in	Criteria
Level C	289	416 (lower bounding)	All satisfy the Criteria Conservatively. $J_{app} < J_{0.1}$ with lower bounding J-R curve.
Level D	367	642 (mean value)	



Year	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
KEPCO	46.3	61.3	67.4	56.3	73.5	66.6	70.1	78.7	78.1	81.5	73.0	76.2	79.3	84.4	84.5	87.2
World	65.4	58.4	59.7	63.2	61.6	64.2	67.0	65.4	66.9	66.7	65.9	64.8	65.7	67.8	67.3	69.4

White Paper of Korean Nuclear Power Plants, 1994

Figure 1 Trend of Korean Nuclear Power Plants Capacity Factor

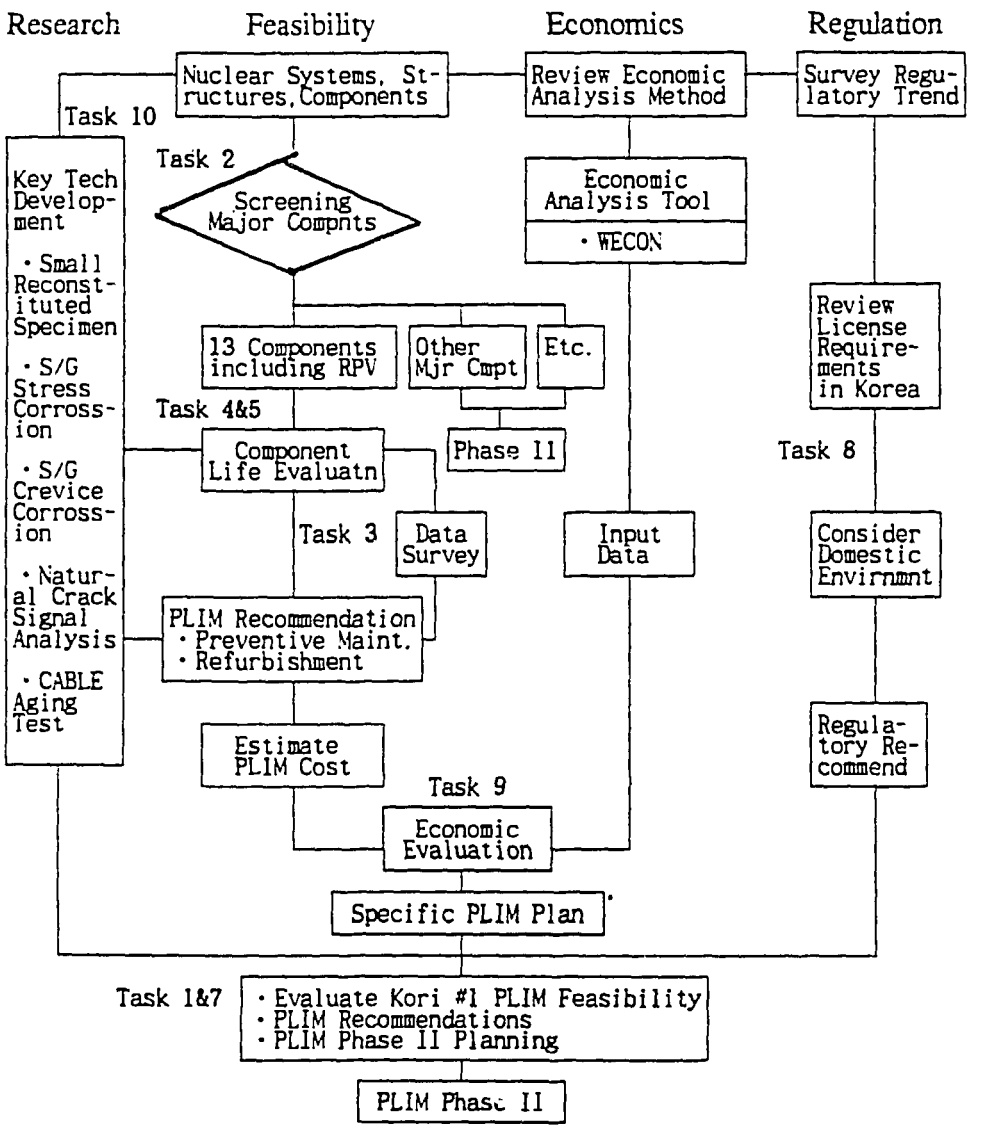
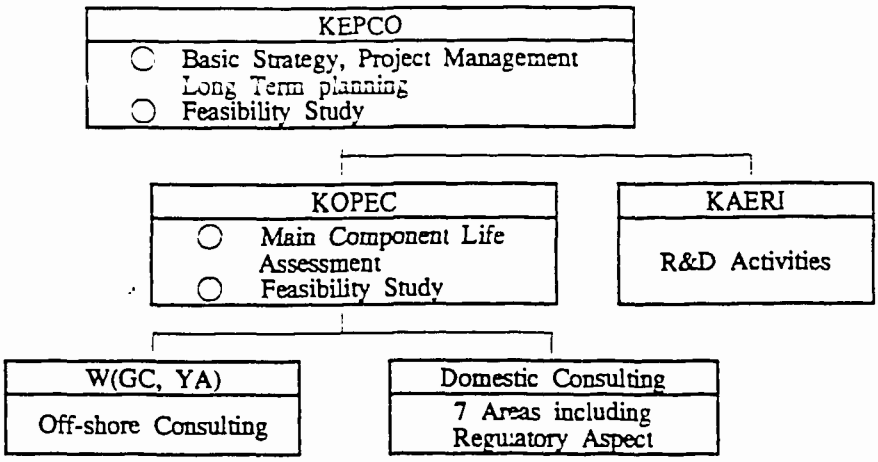


Figure 2 Work Flow Chart of the LMNPP Phase I



W:Westinghouse, GC:Gilbert/Commonwealth, YA:Yankee Atomic

Figure 3 Block diagram of Korean LMNPP organization

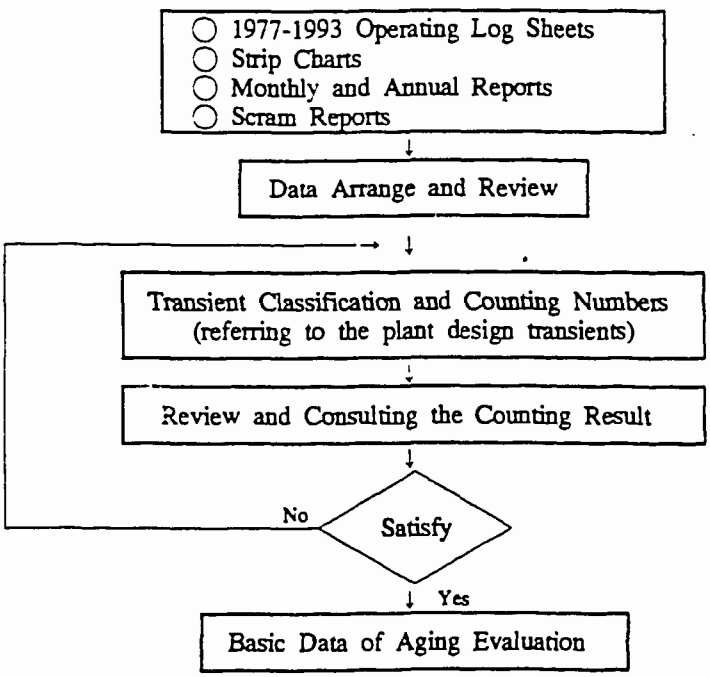


Figure 4 Flow Chart of Transient Data Evaluation

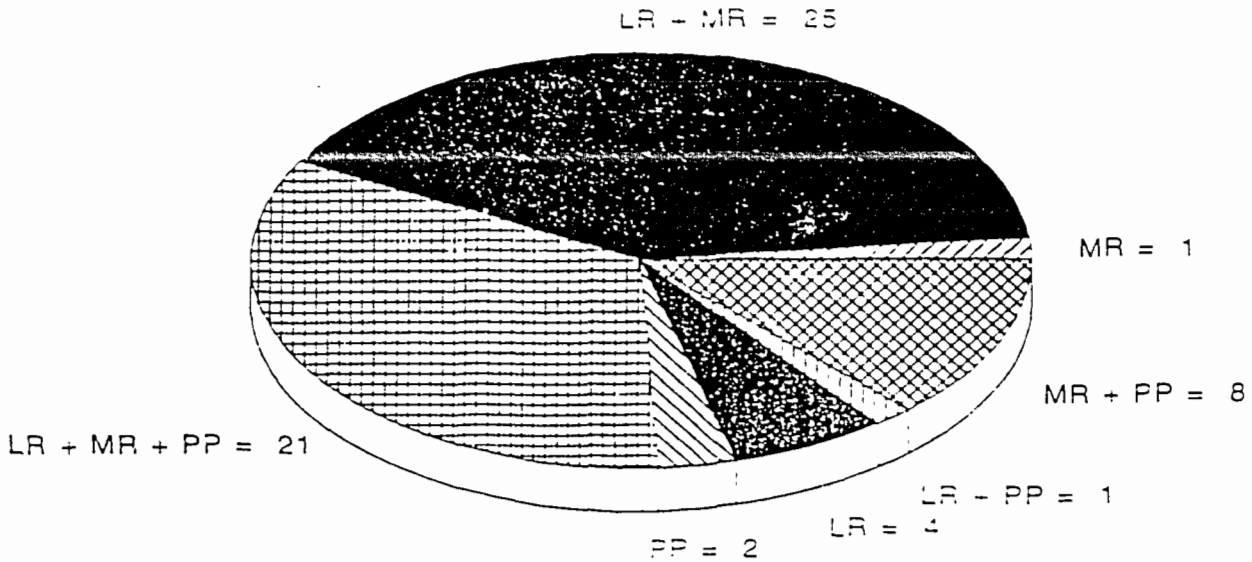


Figure 5 Screening of the Kori Unit 1 Systems and Structures

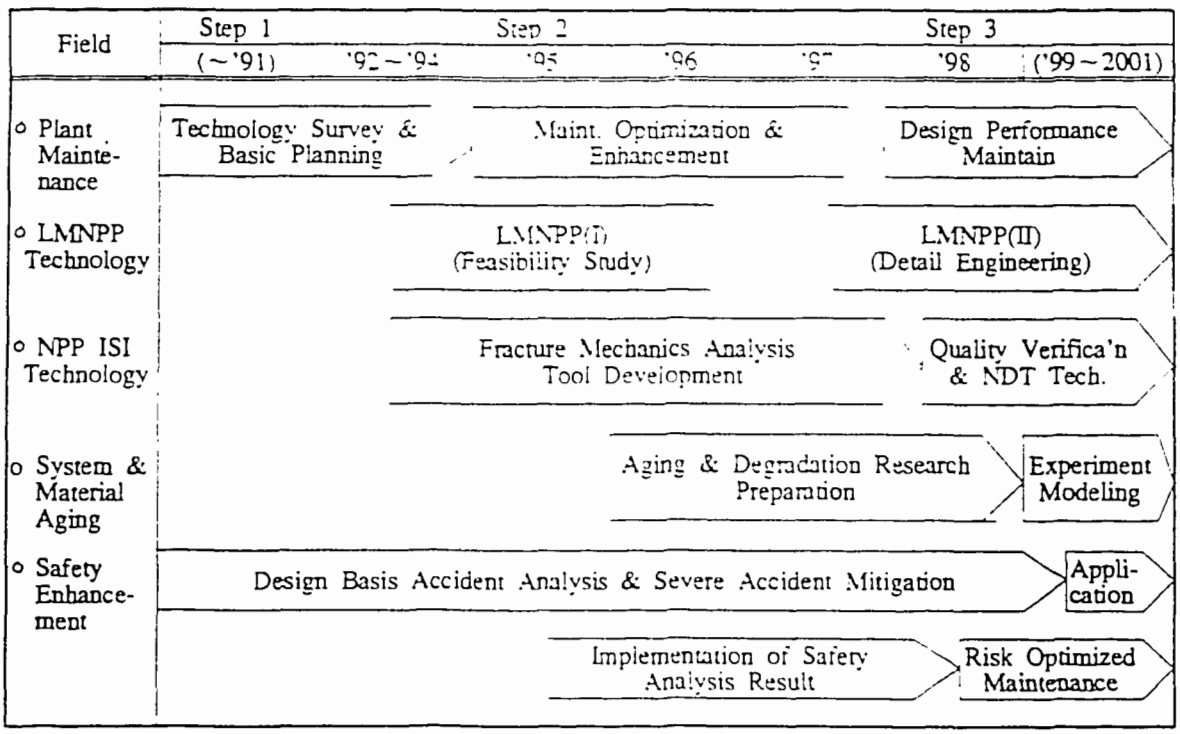


Figure 6 Tentative Long Term Plan of PLIM Related Works

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Presented by
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○ RESEARCH and ENGINEERING ACTIVITIES for LMNPP

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○ SUMMARY

Nuclear Power Plants in Korea

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Yonggwang #2	950	1987. 6	PWR	W	W	"	
Ulchin #1	950	1988. 9	PWR	Framatome	Alstome	"	
Ulchin #2	950	1989. 9	PWR	"	"	"	
Yonggwang #3	1000	1995. 3	PWR	KHIC/KAERI	KHIC/KAERI	Localized	Korean Standard
Yonggwang #4	1000	1996. 4	PWR	KHIC/KAERI	KHIC/KAERI	Localized	Korean Standard
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Ulchin #3	1000	1998. 6	PWR	KHIC/KAERI	"	"	Korean Standard
Wolsong #3	700	1998. 6	PHWR	AECL	"	"	
Ulchin #4	1000	1999. 6	PWR	KHIC/KAERI	"	"	Korean Standard
Wolsong #4	700	1999. 6	PHWR	AECL	"	"	
New PWR #1	1000	2001. 6	PWR	Not Decided	Not Decided	Localized	Korean Standard
New PWR #2	1000	2002. 6	PWR	"	"	"	Korean Standard
New PWR #3	1000	2003. 6	PWR	"	"	"	Korean Standard
New PWR #4	1000	2004. 6	PWR	"	"	"	Korean Standard
New PWR #5	1000	2005. 6	PWR	"	"	"	Korean Standard
New PHWR#1	700	2006. 6	PHWR	"	"	"	
New PWR #6	1000	2006. 6	PWR	"	"	"	Korean Standard

(from MOTI Notice 93-96, 93.11.24)

10 operation

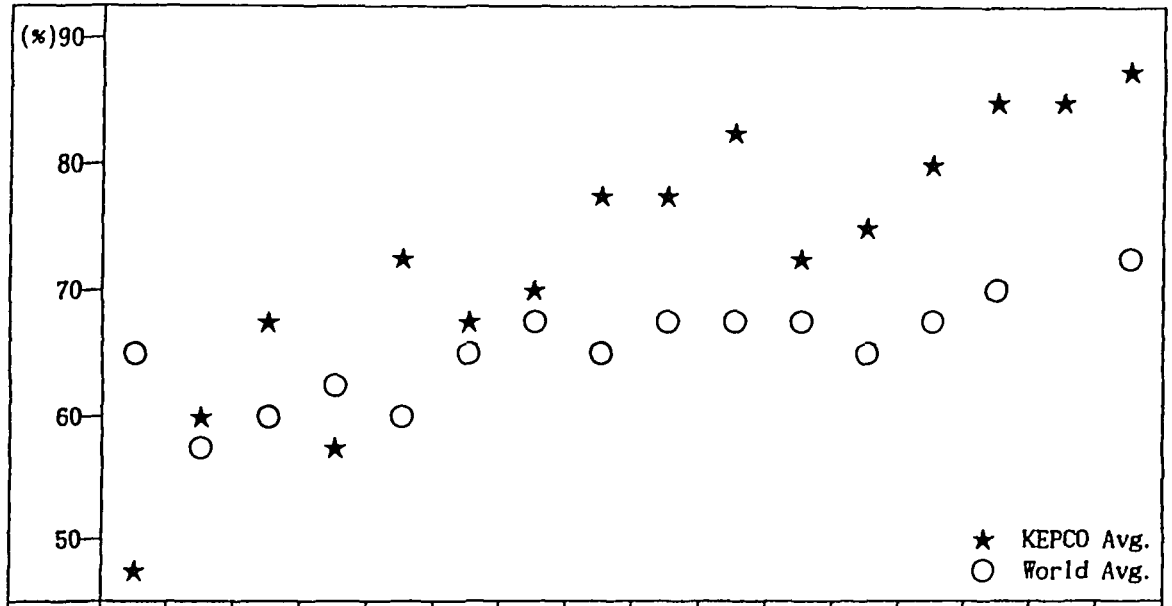
6 construction

11 planned

Abbreviations

W: Westinghouse, GEC: General Electric Corp. (U.K), AECL: Atomic Energy Canadian Limited
KHIC: Korea Heavy Industry Co.(now HANJOONG), KAERI: Korea Atomic Energy Research Institute

under operation under construction under schedule



Year	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
KEPCO	46.3	61.3	67.4	56.3	73.5	66.6	70.1	78.7	78.1	81.5	73.0	76.2	79.3	84.4	84.5	87.2
World	65.4	58.4	59.7	63.2	61.6	64.2	67.0	65.4	66.9	66.7	65.9	64.8	65.7	67.8	67.3	69.4

White Paper of Korean Nuclear Power Plants, 1994

Trend of Korean Nuclear Power Plants Capacity Factor

INTRODUCTION

○ 17 YEARS OPERATION OF KORI UNIT 1 SINCE 1978

○ NEED LIFETIME MANAGEMENT NUCLEAR POWER PLANT(LMNPP) PROGRAM

○ 3 PHASES LMNPP PROGRAM

○ FEASIBILITY STUDY OF KORI UNIT 1 LMNPP
- Nuclear Power Plant Lifetime Improvement and Management(PLIM) (I)
- 1993. 11 - 1996. 11(3Years)

○ CURRENT STATUS AND INTERIM RESULTS OF THE PLIM(I)

KEPCO LMNPP PROGRAM

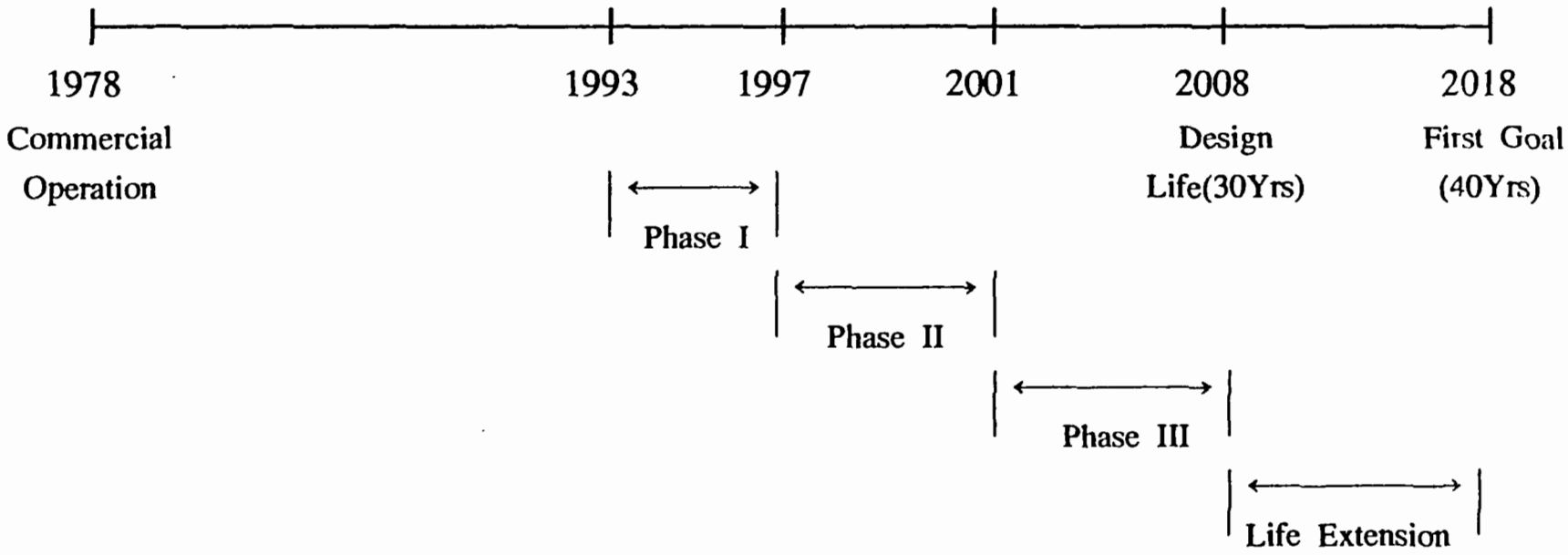
○ BASIC STRATEGY

- To Operate a Plant Safely and Economically
  - · Up to the Design Life (the First Goal)
  - · Up to the Optimum Life Beyond the Design Life (the Second Goal)

- Key Technology R&D's in Parallel with LMNPP

KEPCO LMNPP PROGRAM (Continued)

○ LMNPP PROGRAMS



LMNPP Schedule of Kori Unit 1

Three Phases of LMNPP Program

Phases	Period	Contents
Phase I	1993～1996	Feasibility Study - Feasibility evaluation method and techniques - Kori Unit 1 LMNPP feasibility study - Phase II planning
Phase II	1997～2000	Detail Evaluation and Engineering - Kori Unit 1 detail inspection and residual life evaluation - Documentations for license renewal - Planning for life extension
Phase III	2001～2008	Refurbish, Replacement, and Maintenance - Implementation - Advanced technology development

KEPCO LMNPP PROGRAM (Continued)

○ TASKS OF THE PHASE I

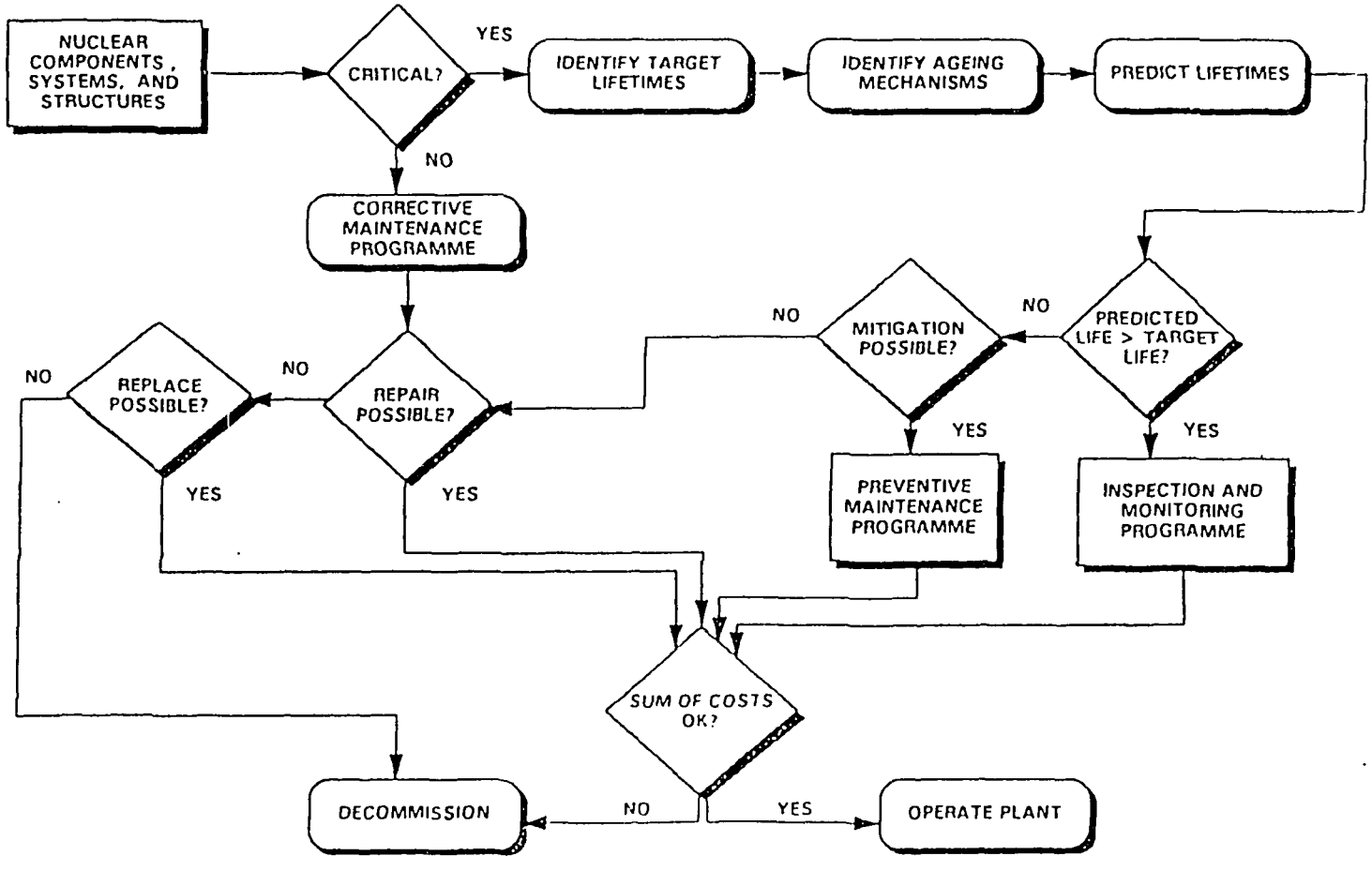
Task 1: PLIM Project Planning and Design Life Review
Task 2: Major SSC's Screening of Kori Unit 1
Task 3: Data Survey and Review
Task 4: Reactor Pressure Vessel Evaluation
Task 5: Major Components Evaluation
Task 6: Monitoring Systems Evaluation
Task 7: Feasibility Study Final Report
Task 8: Regulatory Status Review
Task 9: Economical Evaluation
Task10: PLIM Advanced Technology Development

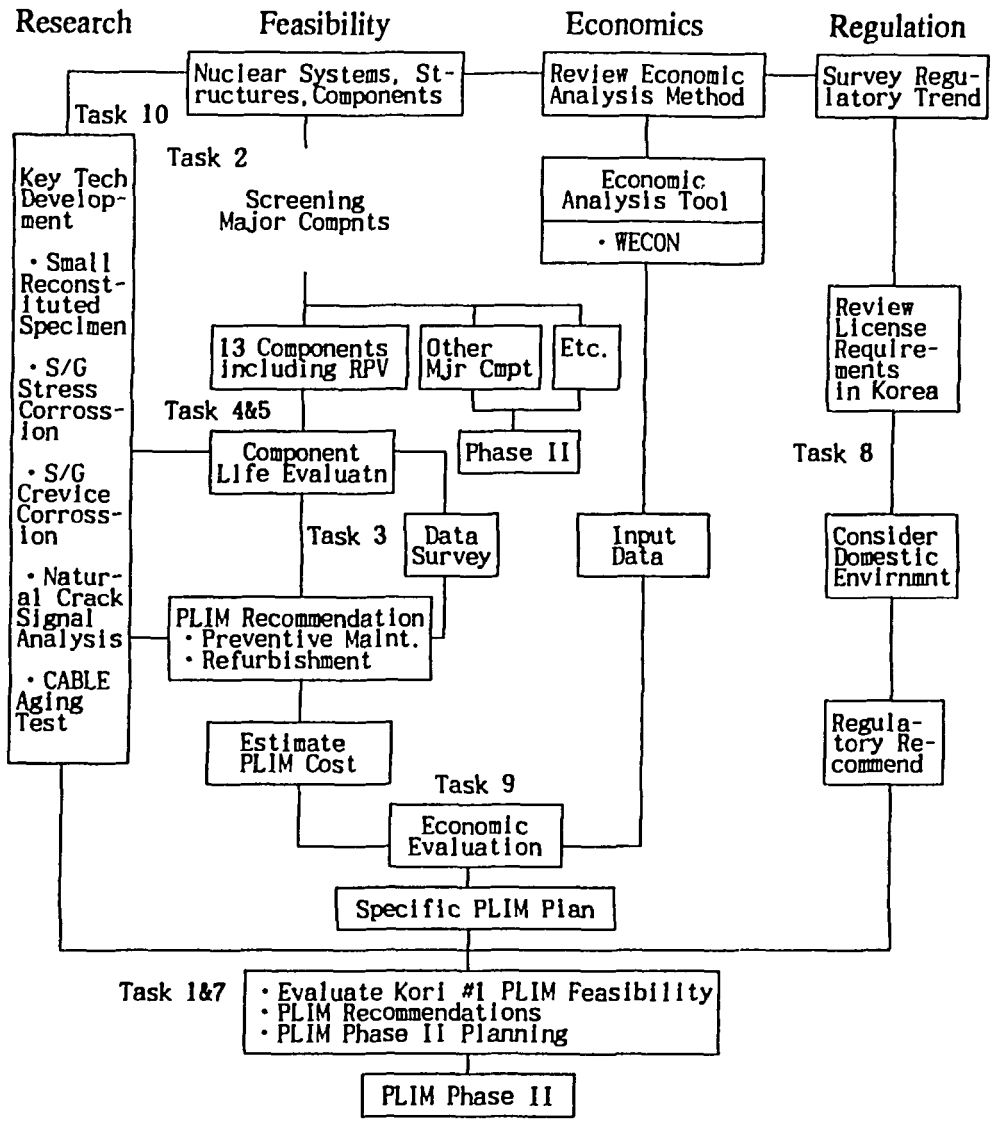
KEPCO LMNPP PROGRAM (Continued)

○ SPECIAL RESEARCH ITEMS OF THE PHASE I

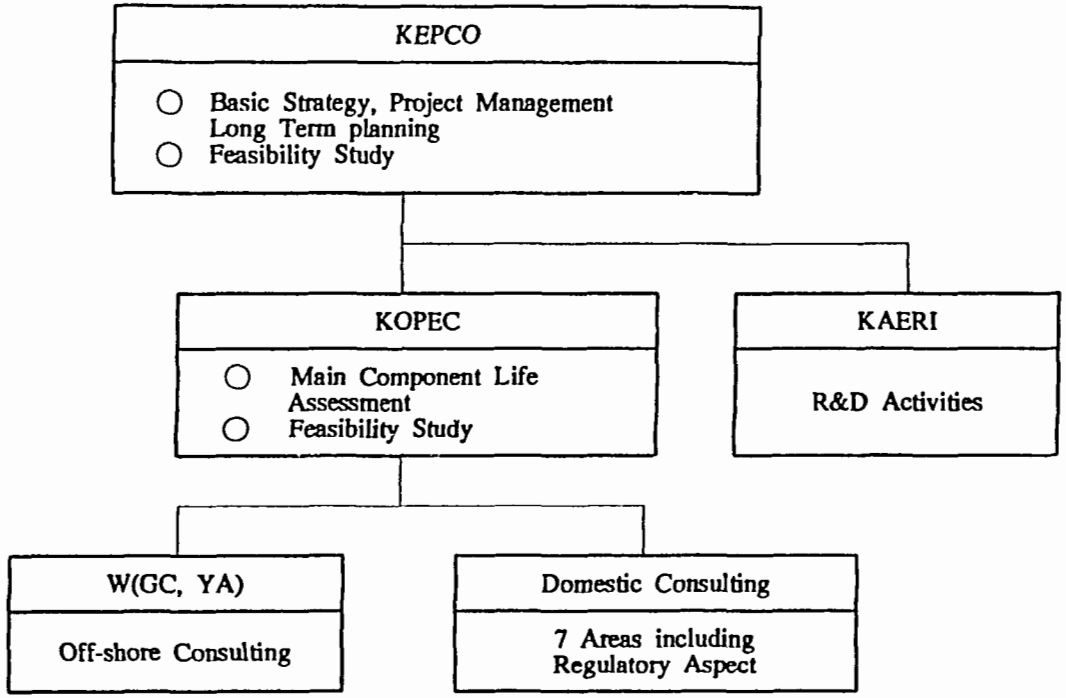
- Utilization of Small or Reconstituted Specimens of RPV material
- Pb Stress Corrosion Cracking of SG Tubes
- Evaluation of Hideout Return and SG Crevice Condition
- Natural Cracked Small Pipe Specimen and Defect Signal Analysis
- Destructive Test of Thermal and Radiation Exposed Cable

PLANT LIFE MANAGEMENT





Work Flow Chart of the LMNPP Phase I



W:Westinghouse, GC:Gilbert/Commonwealth, YA:Yankee Atomic

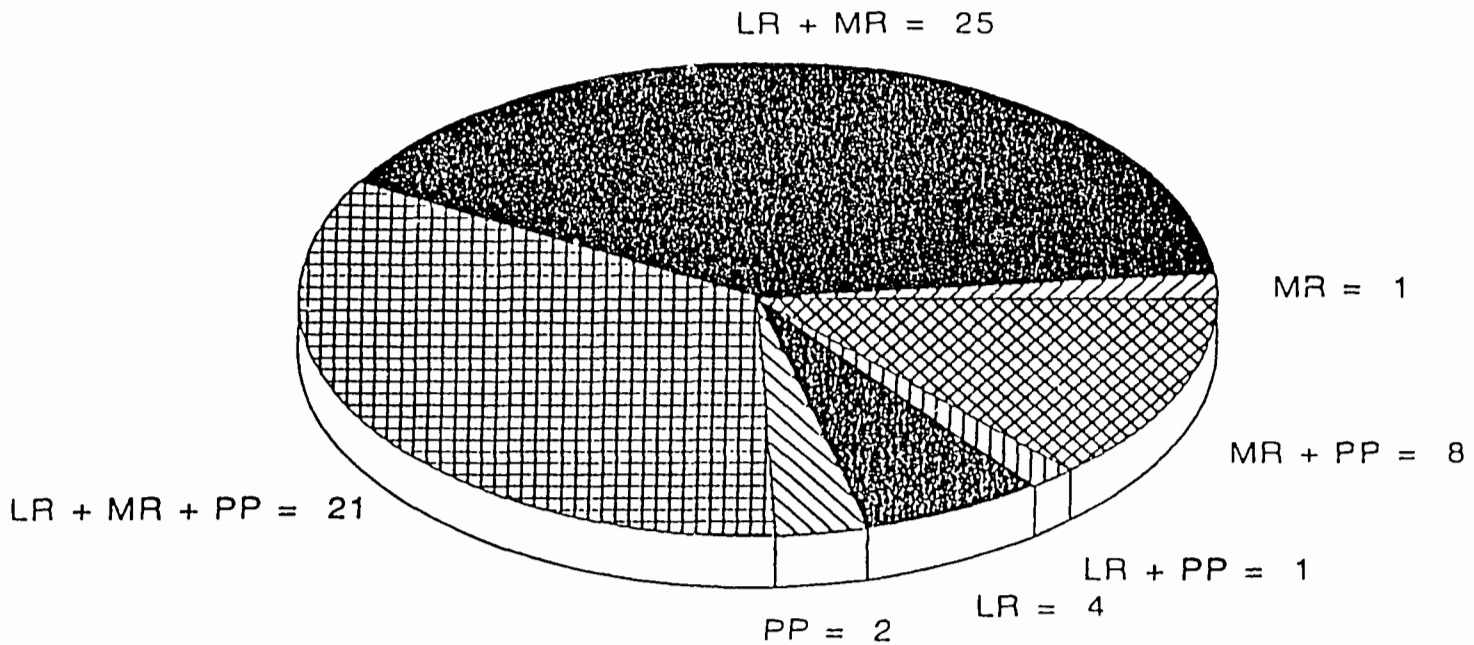
LMNPP Phase I Project Organization

RESEARCH and ENGINEERING ACTIVITIES(Continued)

○ SCREENING AND PRIORITIZATION OF SSCs

Screening

- To Identify SSC's Importances to LMNPP
- Westinghous Owners Group Methodology
- Criteria
  - License renewal rule (10CFR54)
  - Maintenance rule (10CFR50.56)
  - Power production



Screening of the Kori Unit 1 System and Structures

RESEARCH and Engineering ACTIVITIES(Continued)

Priorotization

- To Ensure the Proper Focus of the Phase I Efforts
- 3 Categories for Critical Components and Structures (CS's)
  - Category 1 : non-limiting plant life but justification required
  - Category 2 : long life, high impact on plant life
  - Category 3 : long life, nominal impact on plant life

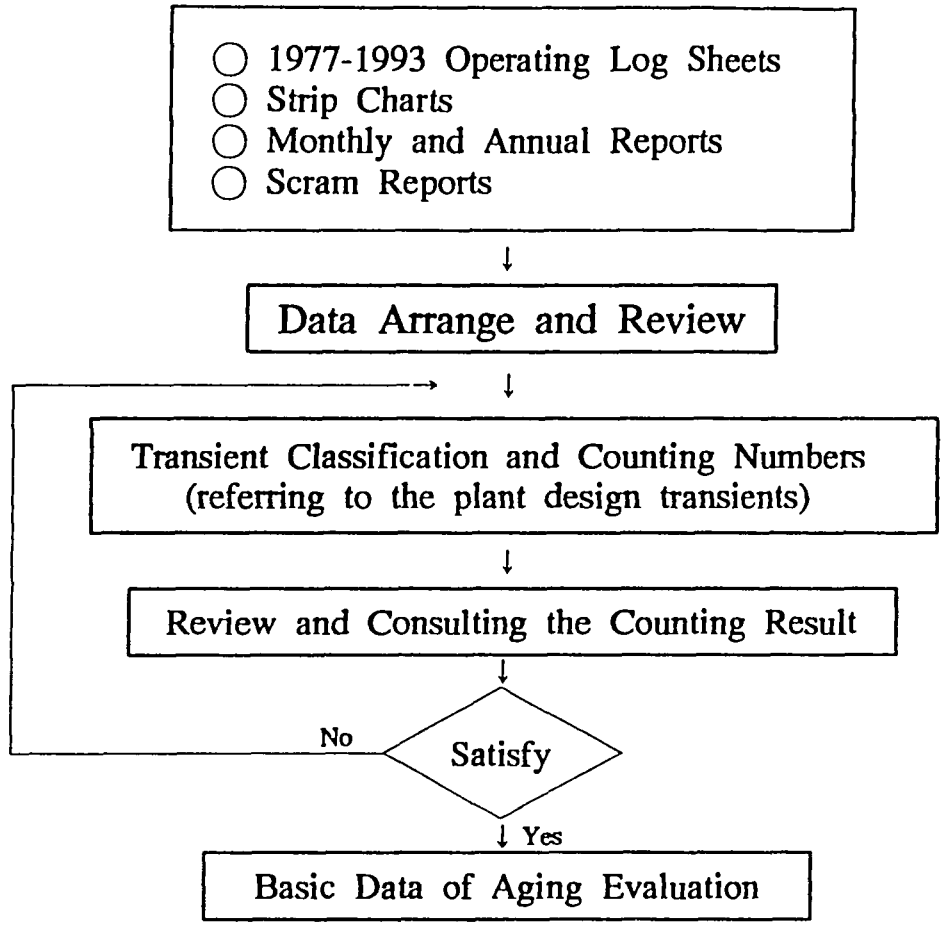
RESEARCH and ENGINEERING ACTIVITIES(Continued)

- 10 Prioritization Attributes to Assess the Impact of the Critical Components
  - Cost to replace or refurbish
  - Impact on plant availability
  - Radiation dose
  - Regulatory importance
  - Modifications required
  - Replacement precedent
  - Generic applicability
  - Mode of failure
  - Consequences of failure on plant safety
  - Consequences on plant operations

RESEARCH and ENGINEERING ACTIVITIES

○ DATA SURVEY

- Data Requied for PLIM(I)
  - General methodology and procedures
  - Operating transient history data
  - Component specific technical data
  - Maintenance and in-service inspection data
  - Economical evaluation input data



Flow Chart of Transient Data Evaluation

RESEARCH and ENGINEERING ACTIVITIES(Continued)

○ REACTOR PRESSURE VESSEL EVALUATION

- Fracture Touhness Test
  - · WOL specimens from surveillance capsule R irradiated for 34 EFPY
  - · Fracture toughness testing temperature 550°F
- Evaluation
  - · U.S. NRC draf regulatory guide DG-1023 and ASME Sec. XI Appendix K
  - · Evaluate the test results at the normal and abnormal conditions
  - · Satisfy USE criterion up to 34 EFPY
  - · On-going PTS evaluation

PTS · 27 EFPY

Analysis results for low upper-shelf toughness issue of Kori Unit 1 RPV

(a) Level A/B service loads

J-R Curve	J_{app} lb/in (SF=1.15)	J_{app} lb/in (SF=1.25)	$J_{0.1}$ lb/in	SM (P_{crit}/P_d)	Criteria
Lower Bounding	93	110	416	2.65	Satisfying

(b) Level C/D service loads

Transient	J_{app} lb/in (max. value)	$J_{0.1}$ lb/in	Criteria
Level C	289	416 (lower bounding)	All satisfy the Criteria Conservatively. $J_{app} < J_{0.1}$ with lower bounding J-R curve.
Level D	367	642 (mean value)	

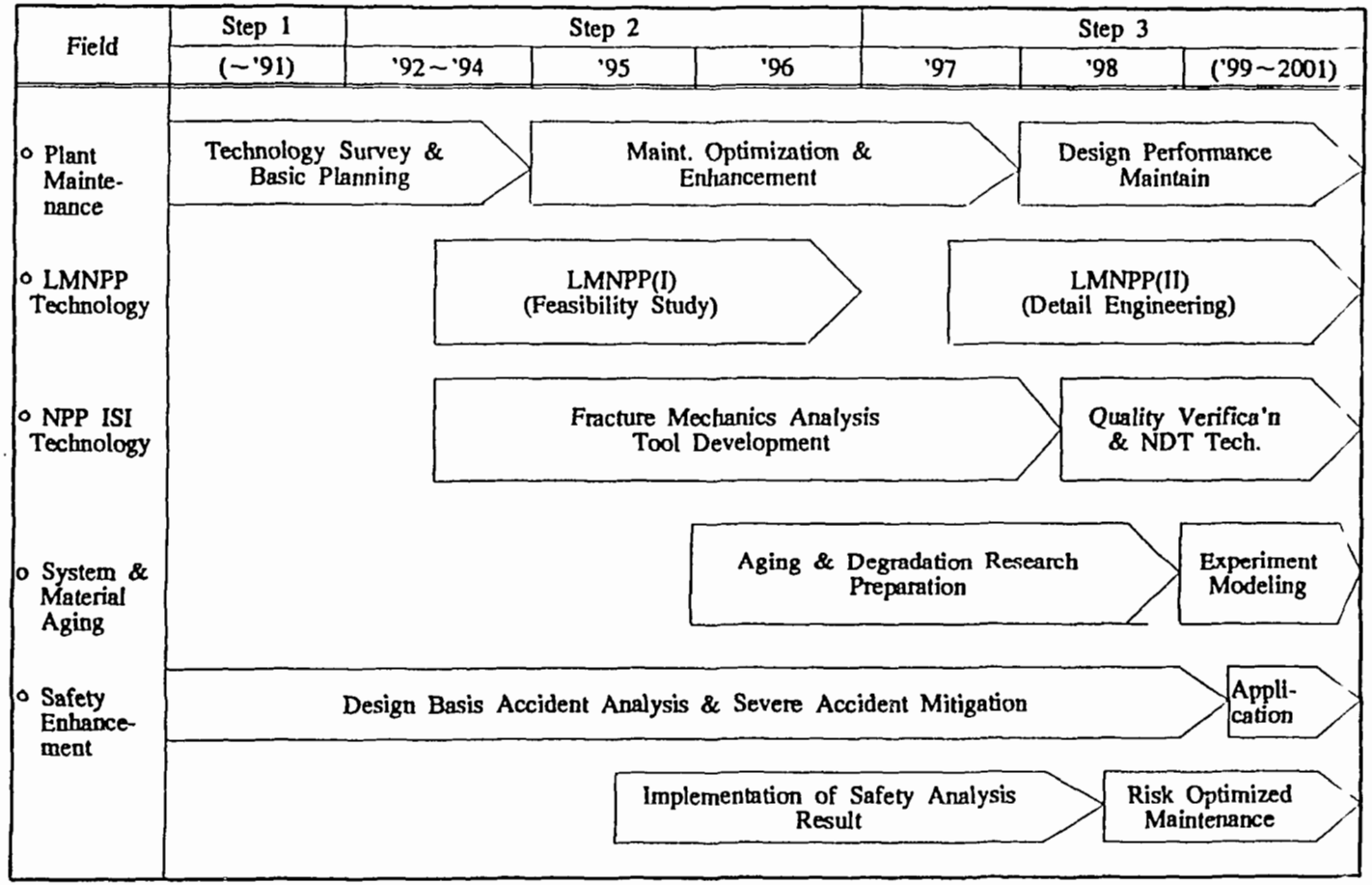
MAINTENCE and COMPONENT REPLACEMENT

- ○ FOR PLANT SAFE OPERATION UNTIL DESIGN LIFE
- ○ POSITIVE EFFECT TO PLANT LIFE EXTENSION
- ○ MAJOR COMPONENT REPLACEMENT
  - RCP Motors Replacement — planned in 1994, with Inconel 690 from Inconel 600
  - Steam Generator Replacement — planned in 1998, with Inconel 690 from Inconel 600
  - LP Turbine Rotor Replacement — planned in 1997 (1/7), GE

MAINTENCE and COMPONENT REPLACEMENT (Continued)

○ WORKS RELATED TO THE LMNPP

- Plant Process Computer and I&C Upgrade
- Plant Uprating
- Probabilistic Safety Analysis



Tentative Long Term Plan of LMNPP Related Works

SUMMARY

○ REVIEWED KEPCO LMNPP PROGRAM

○ CURRENT STATUS OF KORI UNIT 1 FEASIBILITY STUDY

○ ON-GOING WORKS

- Lifetime Evaluation of Major Components
- Regulatory Status Review
- Economical Evaluation
- PLIM Phase II Planning