The Status of Decommissioning Engineering for Kori 1

May 8, 2018

Jung-Moo YU

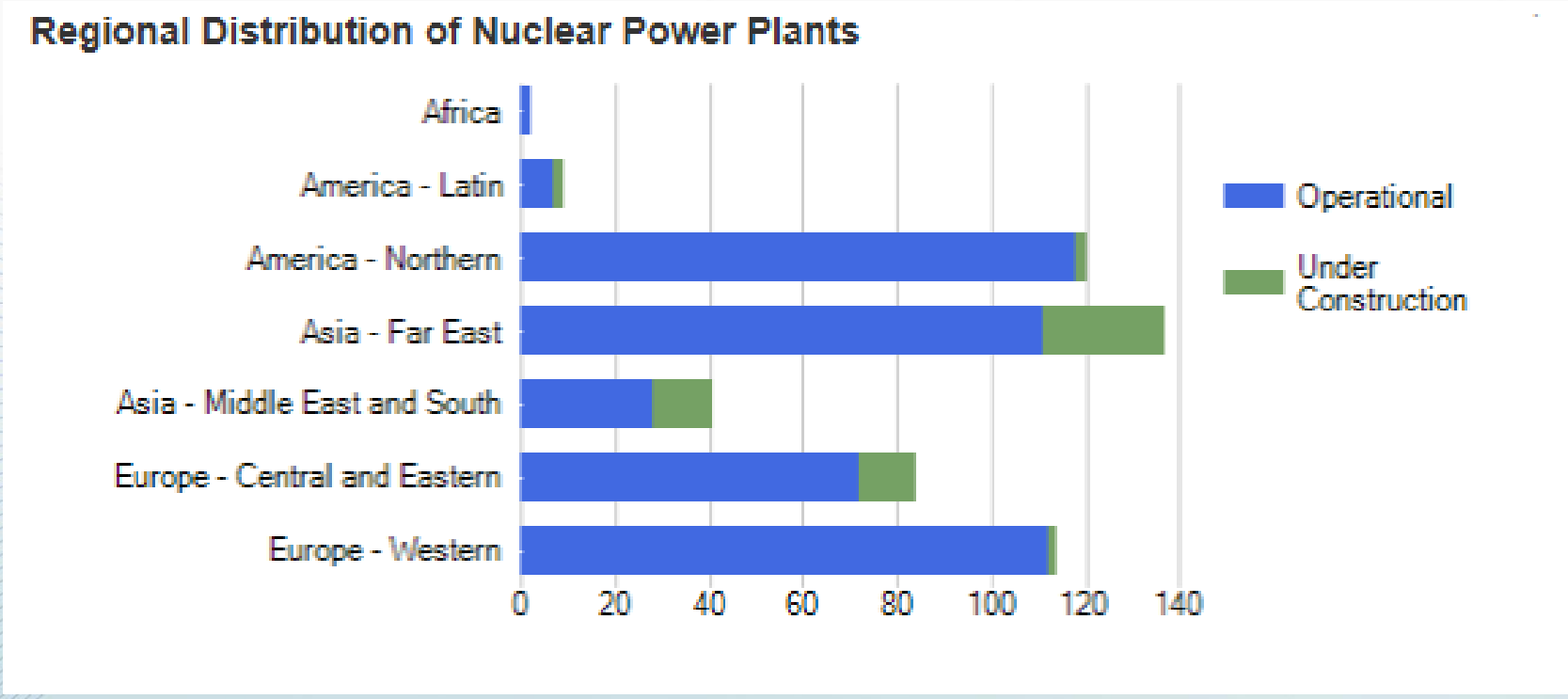
jmyu@kepco-enc.com

Contents

Introduction

Status of Worldwide Nuclear Power Plants*

- Operating Units : 450 units (* as of April 2018, IAEA PRIS)
- Permanent Shutdown : 166 units
  (Decommissioned/Under Decommissioning : 131 units)
- Construction Units : 57 units



Introduction

Status of Nuclear Power Plants in Korea

- Permanent shutdown : 1 unit
- Operation : 24 units
- Under construction : 5 units

Name	Type	Status	Electricity Gross(Mwe)	Commercial Operation	Exp' Date of Design Life	Remark
Kori 1	PWR	Permanent Shutdown	603	1977-06-17	2017-06-17	
Kori 2	PWR	Operation	675	1983-07-25	2023-07-25	
Kori 3	PWR	Operation	1,035	1985-09-30	2025-09-30	
Kori 4	PWR	Operation	1,035	1986-04-29	2026-04-29	
Hanul 1	PWR	Operation	985	1988-09-10	2028-09-10	
Hanul 2	PWR	Operation	984	1989-09-30	2029-09-30	
Hanul 3	PWR	Operation	1,047	1998-08-11	2038-08-11	
Hanul 4	PWR	Operation	1,045	1999-12-31	2039-12-31	
Hanul 5	PWR	Operation	1,048	2004-07-29	2044-07-29	
Hanul 6	PWR	Operation	1,048	2005-04-22	2045-04-22	
Wolsong 1	PHWR	Operation	622	1983-04-22	2023-04-22	
Wolsong 2	PHWR	Operation	740	1997-07-01	2027-07-01	
Wolsong 3	PHWR	Operation	729	1998-07-01	2028-06-30	
Wolsong 4	PHWR	Operation	730	1999-10-01	2029-09-30	
Hanbit 1	PWR	Operation	985	1986-08-25	2026-08-25	
Hanbit 2	PWR	Operation	978	1987-06-10	2027-06-10	
Hanbit 3	PWR	Operation	1,039	1995-03-31	2035-03-31	
Hanbit 4	PWR	Operation	1,039	1996-01-01	2036-01-01	
Hanbit 5	PWR	Operation	1,046	2002-05-21	2042-05-21	
Hanbit 6	PWR	Operation	1,050	2002-12-24	2042-12-24	
Shin-Kori 1	PWR	Operation	1,053	2011-02-28	2051-02-28	
Shin-Kori 2	PWR	Operation	1,053	2012-07-20	2052-07-20	
Shin-Wolsong 1	PWR	Operation	1,053	2012-07-31	2052-07-31	
Shin-Wolsong 2	PWR	Operation	1,053	2015-07-24	2055-07-24	
Shin-Kori 3	PWR	Operation	1,455	2016-12-20	2076-12-20	
Shin-Kori 4	PWR	Under Construction	1,455	2018-09-30	2078-09-30	99.58%
Shin-Hanul 1	PWR	Under Construction	1,455	2019-10-31	2079-10-31	97.18%
Shin-Hanul 2	PWR	Under Construction	1,455	2019-10-31	2079-10-31	
Shin-Kori 5	PWR	Under Construction	1,455	2022-03-31	2082-03-31	32.54%
Shin-Kori 6	PWR	Under Construction	1,455	2023-03-31	2083-03-31	

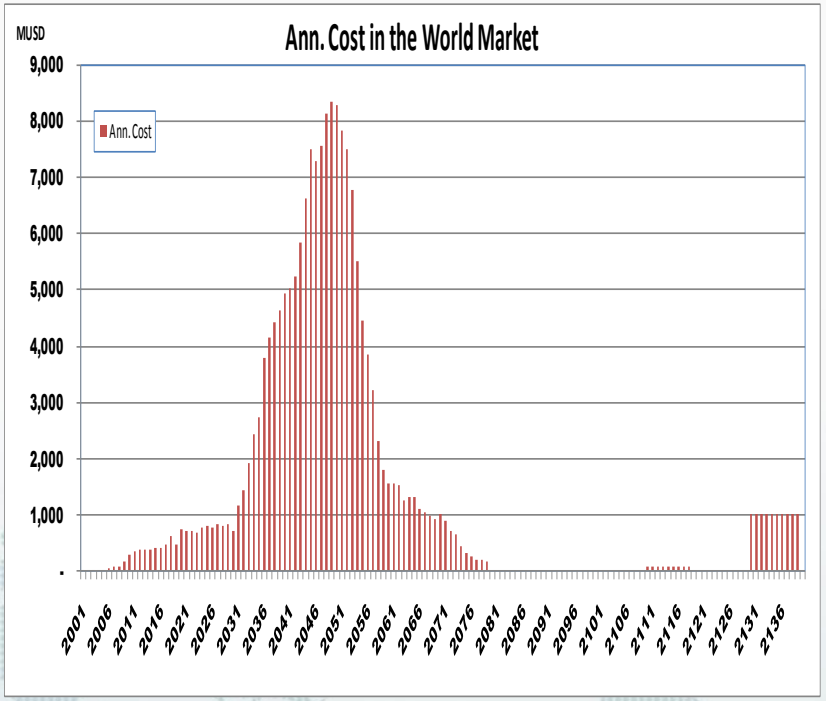
Status of Decommissioning Market

Worldwide Decommissioning Market

Assumptions

- Expected permanent shutdown date for each country
- Fixed decommissioning cost as of 2002
- Cost for each country, reactor type, decommissioning option(immediate/deferred)
- Average cost applied for no cost data country (USD/KWe)
  - ✓ PWR: 320, VVER: 330, BWR: 420, PHWR: 360, GCR: 2,658, etc: 685
- Operating Unit : immediate decom after 20 years continuous operation
- Decommissioning period : 10 years
- Exclude units under construction

Reference: OECE/NEA, Decommissioning Nuclear Power Plants - Policies, Strategies and Costs, 2003



Summary

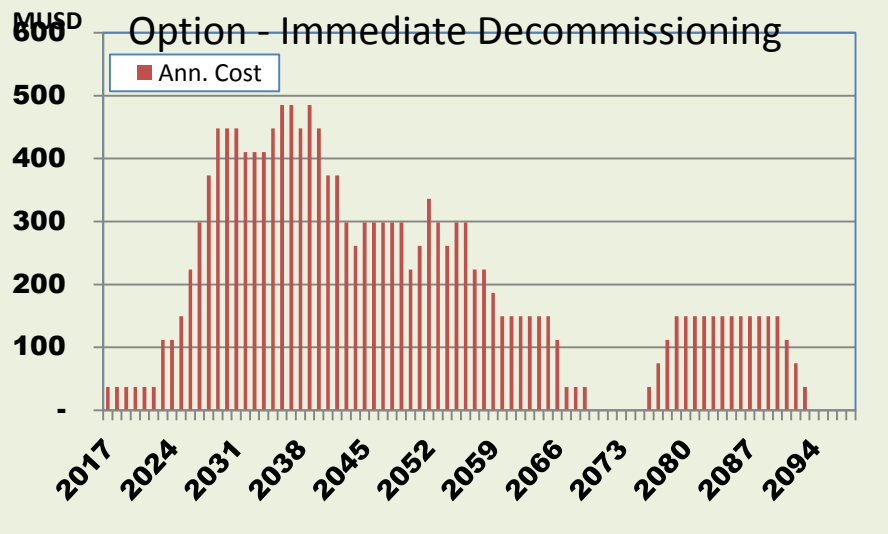
- Total worldwide decommissioning market is expected by 19billion USD by 2002 fixed price (2017 current price is estimated by 1.687 times when applied to annual interest rate of 3.55% from 2002)
- Annual market of 1bUSD from 2030 and increased to 4bUSD
- Annual market of 7bUSD during 2045 to 2055
- Peak annual market of 8.5bUSD in 2050 and decreased sharply to 2060
- Market in 2130 is caused by 100-year deferred decommissioning of Magnox NPPs in UK

Status of Decommissioning Market

Korean Decommissioning Market

Assumptions

- 560 MUSD for one unit decommissioning cost as of 2017
- No life extension for 28 NPPs except Kori unit 1 which was already permanently shutdown after 10-year life extension
- Decommissioning period : 10 years
- Immediate decommissioning option
- Spent fuel Cooling time of 5 years
- Market period of one NPP is arisen 15 years constantly after permanent shutdown



Summary

- Korean decommissioning market is estimated total 15.6 bUSD from 2017 to 2093
- 37 MUSD market starts in 2017 and continues to 2021
- 410~485 MUSD market of 10 NPPs in 4 sites in 2029 to 2040
- 149 MUSD market in 2079 to 2090 due to the 60 years of life-time for APR-1400 NPPs
- No market of 6 years is expected in 2070 to 2075

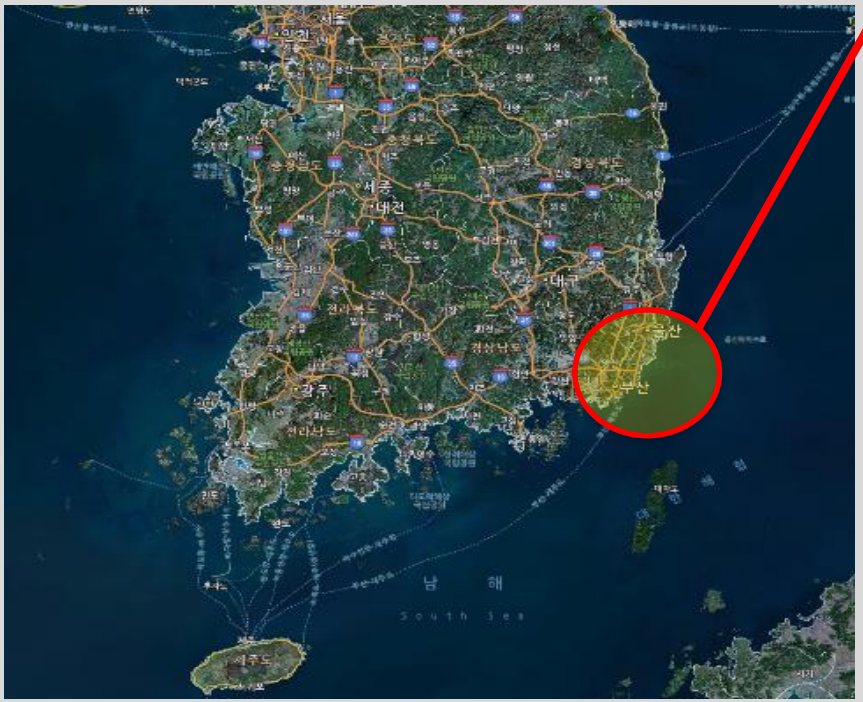
Considerations

- Korean decommissioning market could be flexible according to the national nuclear policy such as life extension of nuclear power plant
- Peak market in 2030's could be leveled by partially delayed decommissioning options for some units

Status of Decommissioning Engineering of Kori 1

❑ Kori Unit 1

- **Location** : Jangan-eup Gijang-gun Busan-si
- Type & Capacity : PWR / 587MWe



Status of Decommissioning Engineering of Kori 1

❑ Schedule for Kori 1 Decommissioning Project

Key Milestone	Date(based on completion)
Permanent Shutdown	2017. 06. 18
Decommissioning Engineering Contract	2018. 02. 13
FDP Submit for Approval (Goal)	2020. 06. 30
Acquisition of Decommissioning Approval (Goal)	2022. 06. 30
Completion of Service	2030. 06. 30
Site Restoration Start	2031. 01. 01
Completion of Decommissioning (Operating License Termination)	2032. 12. 31

Status of Decommissioning Engineering of Kori 1

❑ Project Purpose

- Implement safe and economic decommissioning of Kori 1 nuclear power plant according to the national policy
- Prepare for overseas decommissioning market and enhance decommissioning industrial competitiveness through early decommissioning technology development
- Securing new growth engines such as business diversification and domestic supply chain development

Status of Decommissioning Engineering of Kori 1

❑ Design Goal

❍ Basic Requirements

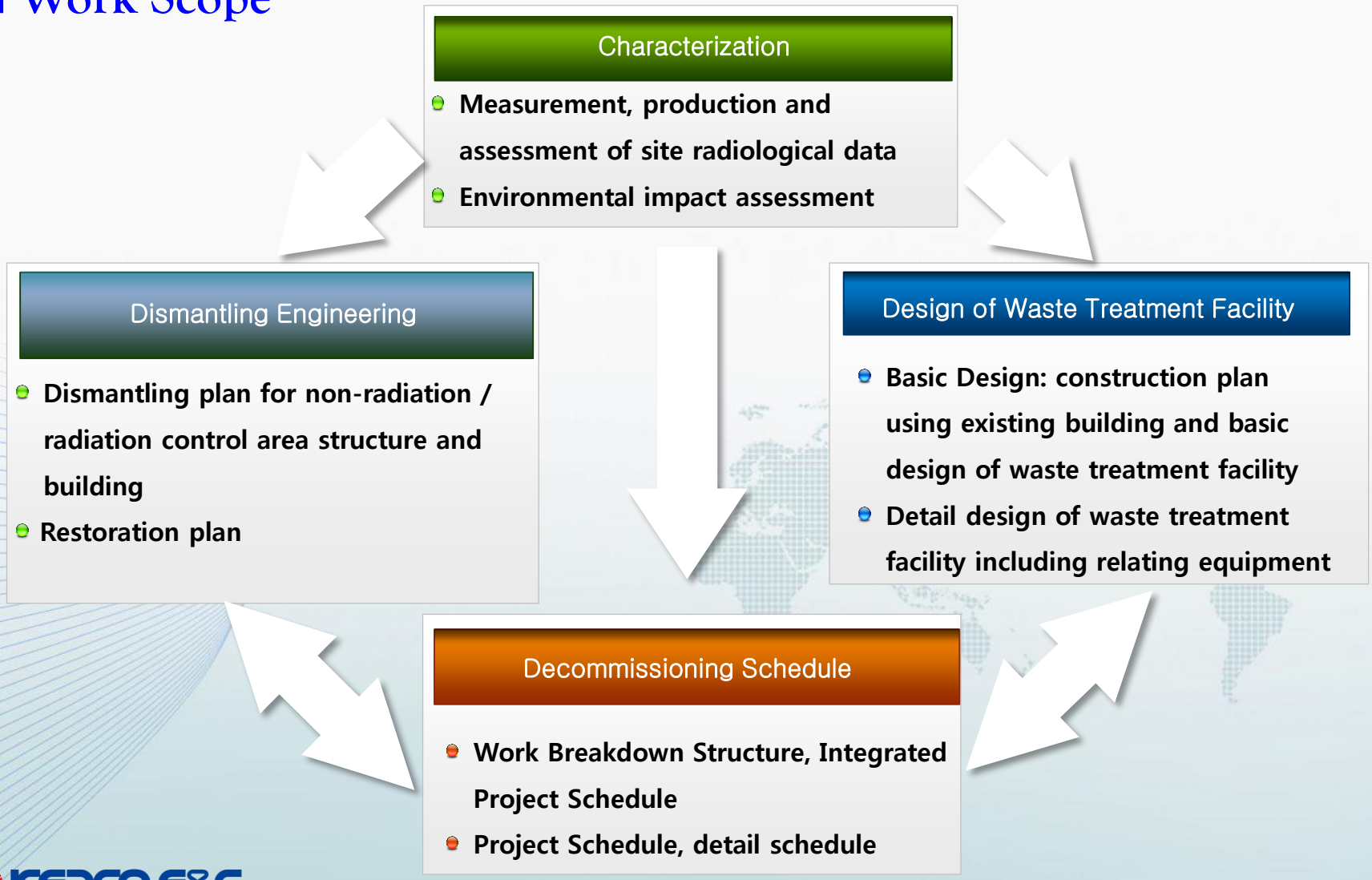
- Reasonable and economical decommissioning with "Safety First" principle
- Reflecting laws, guidelines and standards related to decommissioning including environmental requirements for local residents
- Preventing harmful influence on neighboring NPP(Kori unit 2)

❍ Design Requirements (Essential considerations)

- Immediate Dismantling, Non-radiation zone first dismantling
- Contaminated equipment/building demolition after spent fuel withdrawal
- Ensure worker safety
- Restoration to industrial site level (Brown Field) and reuse
- Minimization of radioactive decommissioning waste generation
- Provide measures to prevent radioactive waste leakage to environment
- Compliance with domestic regulations and licensing requirements

Status of Decommissioning Engineering of Kori 1

❑ Work Scope



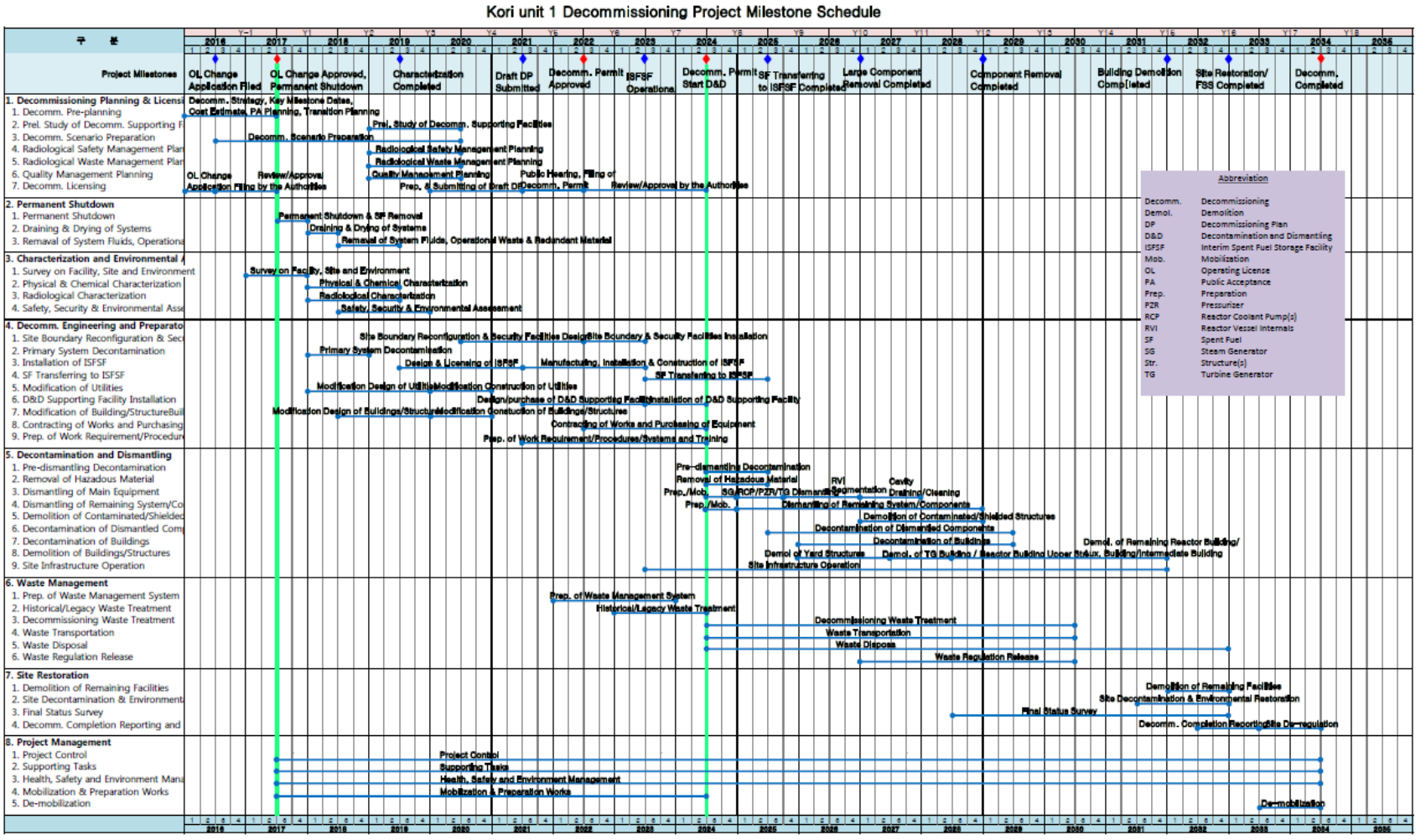
Status of Decommissioning Engineering of Kori 1

❑ Task of Decommissioning Schedule

Item	Deliverables	Due Date
Project Schedule	• Project Milestone Schedule (Level Ⅰ)	2018.04
	• Project Summary Schedule (Level Ⅱ)	2018.05
	• Integrated Project Schedule (Level Ⅲ)	2018.08
	• Detail Schedule (Level IV)	2018.11
Project Control Procedure	• Work Breakdown Structure (WBS) & Project Numbering System (PNS) Procedure	2018.05
	• Decom. Project Control Schedule Procedure	2018.10
	• Decom. Project Information Control Procedure	2018.11
	• Project Progress Management System	2018.11

Status of Decommissioning Engineering of Kori 1

❑ Schedule of Kori 1 Decommissioning Project

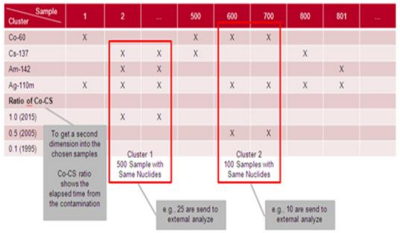


Status of Decommissioning Engineering of Kori 1

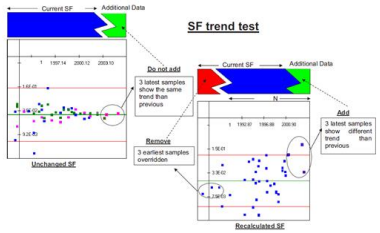
❑ Task of Characterization

- ❑ Development of Characterization Procedure
- ❑ Historical Site Assessment (HSA)
- ❑ Scoping Survey
- ❑ Detail Characterization Survey
- ❑ Environmental Impact Assessment (Radiological/non-radiological)

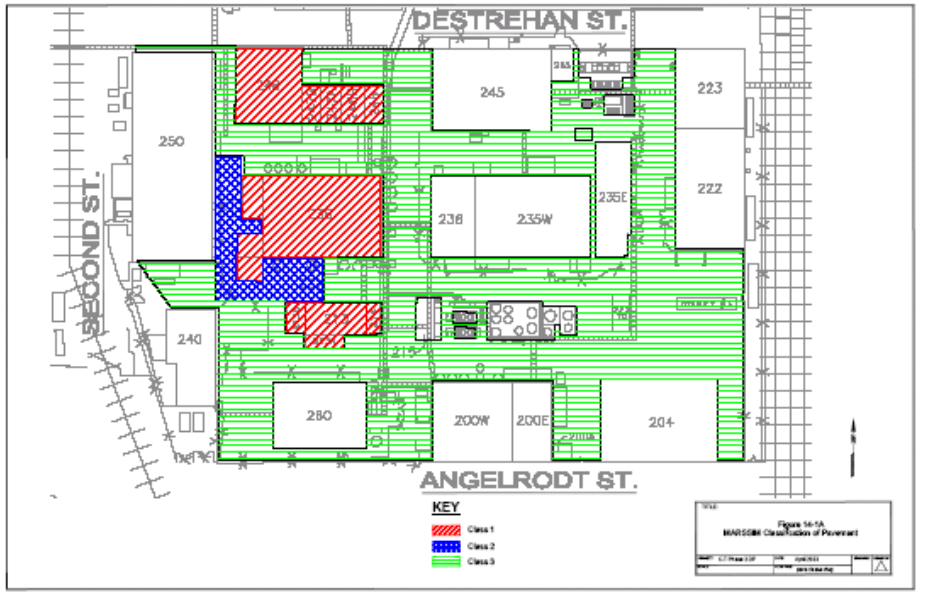
[시료채취 및 분석 절차 예시]



[척도인자 평가를 위한 분석 시료 선정 예시]



[척도인자 경향분석 예시]



Status of Decommissioning Engineering of Kori 1

❑ Task of Dismantling Engineering

❑ Common Work

- Preparation of dismantling plan for each unit
- Preparation of dismantling inventory for the design of dismantling work
- Preparation of decommissioning cost statement

❑ Common Work of Dismantling Plan for Each Unit

- Preparation of dismantling and decontamination (D&D) technology for equipment and structure
- Preparation of location drawing and list of dismantling equipment
- Extraction of optimal dismantling sequence for D&D of equipment and structure
- Preparation of holding method of D&D equipment

❑ Preparation of Dismantling Plan for Non-Radiation Control Area/YARD

- Design change of existing building
- Dismantling plan including dismantling work specification

Status of Decommissioning Engineering of Kori 1

❑ Task of Dismantling Engineering

- ❑ **Preparation of Dismantling Plan for Radiation Control Area**
  - Dismantling plan for each unit including reactor vessel internals (RVI) and reactor vessel (RV) including dismantling work specification
  - Method and Guarantee of Credibility for on-going measurement of radioactivity
  - Method of in-situ measurement of radioactivity and in-situ decontamination
- ❑ **Preparation of Dismantling Plan for Building and Structure**
  - Dismantling plan for building and structure
  - Dismantling plan for underground structure, buried structure, and plan for site restoration
- ❑ **Preparation of Integrated Plan for Use of Site and Building for Decommissioning**
- ❑ **Preparation of Supply Plan for Utilities including design change**

Status of Decommissioning Engineering of Kori 1

❑ Design of Waste Treatment Facility

❑ Development of facility construction plan

- Optimal facility layout plan selection
- Conceptual design

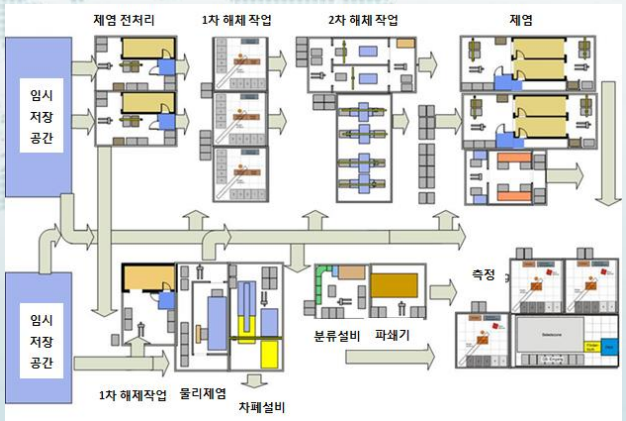
❑ Basic design of waste treatment facility

- Estimate rough construction cost and milestone
- Preliminary design

❑ Detail design of waste treatment facility

- detail design
- Design standard, Purchase specification
- Quality assurance plan, Quality control procedure
- Performance verification and Pre-op/Startup Test Procedure Guideline etc.

❑ Licensing Support



Thank you !