**Transactions of the Korean Nuclear Society Spring Meeting**
**Korea, May 12 (Wen) ~ 14 (Fri), 2021**

# A Preliminary Study on Work Difficulty Factor of Decommissioning in Korean Nuclear Power Plants

**May. 13. 2021**

**Seung-Hyun Lee**

**Hanyang University**

**Korean Association for Radiation Application**

# Contents



# Introduction

Transactions of the Korean Nuclear Society Spring Meeting

# Ⅰ. Introduction

## Nuclear Facility Decommission

- **All activity that dismantles the facility and site or decontaminates after permanently shutdown the operation of a licensed nuclear facility**

## Nuclear Facility Decommission Strategy

- **Immediate Dismantling (U.S.A, German, French, Japan, etc.)**
- **Deferred Dismantling (England, Canada, Japan, etc.)**

## Pros. & Cons. according to Dismantling Type

| | Immediate Dismantling | Deferred Dismantling |
|---|---|---|
| Duration | • About 15 Years | • About 60 Years |
| Pros. | • Can Utilize Existing People<br>• Systematic Scheduling<br>• Reducing Cost<br>• Rapid Site Recycling | • Reduction of Radioactivity<br>• Reduction of Radio-waste<br>• Reduction of Exposure |
| Cons. | • Relative Higher Exposure<br>• Additional Shielding Need<br>• Remote Control Need | • Lack of Experienced People<br>• Increase Safety Cost<br>• Delayed Site Recycling |

## Decommission Cases (Yankee in U.S.A)

<Before Decommission>

<During Decommissioning>

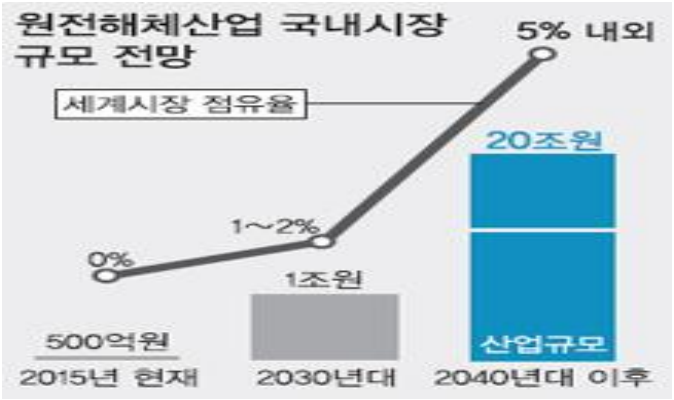
<After Decommission>

## Current Status of NPPs Decommission

- There are a total of 26 nuclear power plants in Korea, of which 24 are currently in operation, excluding Kori 1 and Wolseong 1, which are permanently stopped.
- If they are not operated continuously, a total of 12 nuclear power plants are expected to be dismantled by 2029.
- As of March 2020, there are 442 nuclear power plants in operation worldwide and 187 nuclear power plants with permanent shutdown, of which only 21 have been dismantled.

## Prospects for Domestic and Foreign NPPs Decommission

| | Domestic Decommission | Foreign Decommission |
|---|---|---|
| Before ’20 | • 2 NPPs | • 189 NPPs |
| ’21~’29 | • 10 NPPs | • 183 NPPs |
| ’31~’39 | • 4 NPPs | • 127 NPPs |
| After ’40 | • 14 NPPs | • 89 NPPs |
| Total | • 30 NPPs | • 588 NPPs |




<Domestic Market Size>


<Decommission Scale>

## Decommission Case in Domestic and Foreign

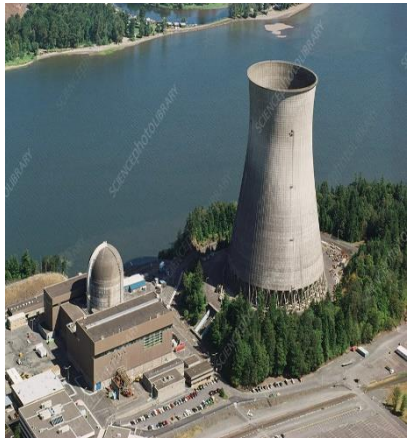
- A number of nuclear power plants are in operation overseas, and only four countries, such as the United States, Japan, Germany, and Switzerland have experience of dismantling nuclear power plants.
- In Korea, there is no experience in dismantling nuclear power plants, and only nuclear-related facilities such as Gongneung-dong and the research center uranium conversion facility exist.

## Major Decommission Reactors in U.S.A

Marine Yankee in U.S.A

Connecticut Yankee in U.S.A

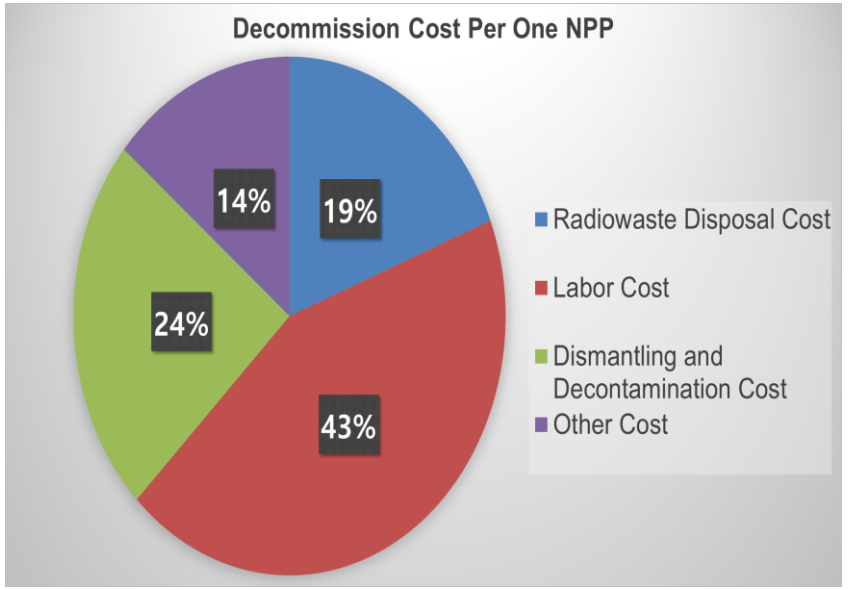
Shoreham in U.S.A



Trojan in U.S.A

## NPP Decommission Cost

- Because the decommissioning process has a number of unclear assumptions and the standards for decommissioning costs vary, the uncertainty in decommissioning data and costs is high.
- Also, decommissioning costs may increase even more as decommissioning research advances.
- Therefore, it is necessary to classify the demolition work according to the characteristics of the dismantling facility and object, applying an economical and reasonable method of calculating engineering costs.





## Unit Cost Factor

- The UCF method is widely used in cost estimating to simplify the estimation for a large number of plant inventory items.
- UCF is developed in terms of hours of the mixed labor crew to perform an activity (such as removal) per unit of measure (such as each, ton, $m^2$, etc.).

  → Labor Cost, Equipment Cost, Material Cost, Contingency Cost.

## Work Difficulty Factor

- The work difficulty factor refers to a factor that causes work delay due to factors that cannot be avoided other than the average time required to perform a certain dismantling work and is expressed as a percentage of work time increase when calculating costs.

## Cost Estimating Process

1. Review and Select Decommissioning Alternatives
2. Tour the Plant Site
3. Develop List of Assumptions
4. Develop Decommissioning Work Activities
5. Inventory Plant Equipment and Structures
6. Develop Unit Factors
7. Calculate Equipment and Structure Decontamination and Removal Costs
8. Determine Crew Work Force
9. Calculate Waste Disposal Costs
10. Develop Decommissioning Schedule
11. Develop Decommissioning Staff
12. Calculate Activity-dependent Costs
13. Calculate Collateral and Special Item Costs
14. Calculate Period-dependent Costs
15. Calculate Total Costs

## Objective of This Study

- Certain countries which are leading the nuclear industry have already had a number of decommissioning experiences, and the decommissioning cost was evaluated by establishing a systematically defined WDF in advance. Also, the WDF was verified through a number of decommissioning cases.
- However, Korea has no experience in decommissioning, and a WDF suitable for domestic situations has not been established.
- The determination of the WDF is urgently required to estimate the cost for the decommissioning of Kori Unit 1, which will soon be decommissioning.

**In this study, to calculate decommission cost of the Korean NPP, the WDF in labor costs is suggested that meet domestic situations.**



# Methods and Results

## Work Difficulty Factors recommended in AIF/NESP-036 Report

- The AIF/NESP-036 report, which is widely cited in many countries abroad, presents the following five factors, which are highly recommended by the IAEA.
  - ✓ Height Factor : Dismantling Activities According to Height and Complexity
  - ✓ Respiratory Protection Factor : Dismantling Activities by Wearing or not Wearing Protective Equipment
  - ✓ Radiation/ALARA Factor : Dismantling Activities according to the degree of radiographic contamination
  - ✓ Protective Clothing Factor : Dismantling Activities by Wearing or not Wearing Protective Clothing
  - ✓ Work Break Factor : Work Difficulty Factor According to Worker Break
- Total Working Times $= Net\ Working\ Times \times (1 + A + B + C) \times (1 + D) \times (1 + E)$

## Work Difficulty Factor in AIF/NESP-036 Report

| Classification | Factors | Additional Rates |
|---|---|---|
| A | Height Factor | • 10~20% |
| B | Respiratory Protection Factor | • 25~50% |
| C | Radiation/ALARA Factor | • 10~40% |
| D | Protective Clothing Factor | • 15~30% |
| E | Work Break Factor | • 8.33% |

- Example
  - ✓ $T = t \times (1 + 0.15 + 0.40 + 0.25) \times (1 + 0.25) \times (1 + 0.0833) = 2.437 \times t$
  - ✓ where, $t = Net\ Working\ Times$

    $T = Total\ Working\ Times$

# Ⅱ. Methods and Results

## Standard Cost Estimates

- Definitions
  - ✓ General Criteria for Calculating the Appropriate Estimated Cost for Construction Implemented by Public Institutions
  - ✓ A Standard that Expresses Numerical Values such as Materials, Labor, and Equipment usage Time per Unit Work based on Representative and Generalized Public and Engineering Methods
  - ✓ Cost Estimates Published by the Government-designated 『Standard Cost Estimates Management Agency』 to Professionally Perform Cost Estimates related Management Tasks such as Development, Interpretation, and Distribution of Cost Estimates
- Purpose
  - ✓ Suggesting General Standards for Calculating an Appropriate Projected Cost for Construction, Making Budget Planning and Cost Calculation Efficiency, Securing Basic Performance and Quality in the Public Construction

## Standard Cost Estimates in Korea

| Classification | Standard Cost Estimates Management Agency | Activities |
|---|---|---|
| Construction | • Korea Institute of Civil Engineering and Building Technology | • Maintenance<br>• Evaluation Analysis<br>• Safety Review<br>• Business Management<br>• Feasibility Study<br>• Design, Purchase, Procurement<br>• Etc. |
| Information and Communication | • Korea Information & Communication Technology Industry Association | |
| Electricity | • Korea Electric Association | |
| Fire Fighting | • Korea Fire Facility Association | |

# Ⅱ. Methods and Results

## Additional Allowance for Working Time

| No. | Factors | Additional Rates |
|---|---|---|
| 1 | Work Efficiency Factor | 0~20% |
| 2 | Work in Mountain Area Factor | 0~50% |
| 3 | Factor by Train Frequency | 3~37% |
| 4 | Night Work Factor | 0~25% |
| 5 | Small Size Work Factor | 0~50% |
| 6 | Work Factor by Geography | 0~50% |
| 7 | Work Factor by Terrain | 0~50% |
| 8 | Risk Work Factor | 10~80% |
| 9 | Work Factor by Building Floors | 1~7% |
| 10 | Work Factor by Hazard | 10~30% |
| 11 | Special Work Factor | 5~10% |
| 12 | Work Time Limit Factor | 0~35% |
| 13 | Etc. Work Factor | 0~50% |
| 14 | Factor by Move Inconvenient | 0~50% |
| 15 | Factor for NPP Construction | No Decided* |

- In the case of processes in which the quality and safety inspection for each work stage is strictly applied in nuclear power plant construction, a work premium is added separately for each process.

# Ⅲ. Conclusion



## Necessity of Establishing Work Difficulty Factor

- ✓ It is necessary to set an appropriate work difficulty factor so that the decommissioning cost can be calculated in consideration of the NPP situation in Korea.
- ✓ However, in the domestic, standard cost estimates are not specified for the nuclear industry, and the work difficulty factor has not been established, so it is arbitrarily set by referring to overseas decommissioning cases.
- ✓ Therefore, it is necessary to introduce an appropriate additional allowance for working time or work difficulty factor in order to set the work difficulty factor for estimating the unit cost factor in the domestic nuclear field, which has not yet been systematically established.
- ✓ It can have a socio-economic advantage, and it is possible to estimate the labor cost more accurately and reliably by setting the Korean work difficulty factor suitable for the domestic decommissioning situation.

## Additional Allowance for Working Time

| No. | Work Difficulty Factors | Additional Allowance for Working Time Factors |
|---|---|---|
| 1 | Height Factor | Risk Work Factor |
| 2 | Respiratory Protection Factor | Etc. Work Factor |
| 3 | Protective Clothing Factor | |
| 4 | ALARA Factor | Work Factor by Hazard |
| 5 | - | Work Time Limit Factor |
| 6 | Work Break Factor | - |
| 7 | - | Special Work Factor |

- Since it is a work adjustment factor in the process of constructing a nuclear power plant, it is not applicable during the decommissioning process, so the factor for NPP construction was excluded from the list..
- The respiratory protection factor and protective clothing factor were integrated into Etc. work factor because they are overlapped with each other.
- The special work factor about work that must be accompanied by a supervisor for work with special work conditions is not considered in the WDF recommended by IAEA, so it was contained in the list.

# Conclusions

# Ⅲ. Conclusion



## Conclusions and Future Works

- ✓ In this study, the additional allowance for working time of Korea similar to the work difficulty factor recommended by AIF was analyzed, and applicable factors were derived in the decommissioning process of Korean nuclear power plants.
- ✓ The results were analyzed that it would be more appropriate to consider the risk work additional allowance, etc. work additional allowance, additional allowance work factor by hazard, and special work additional allowance as work difficulty factors.
- ✓ In the future, a conformity evaluation for the proposed Korean work difficulty factor and its additional allowance for working time will be performed.

# Thank you