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Development of the Manpower Demand Forecast Model of Nuclear Industry Using the System Dynamics Method – Operation Sector

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1. Introduction

Recently, the resource management of nuclear engineering manpower has become an important issue in Korean nuclear industry. The government's plan for increasing the number of domestic nuclear power plants and the recent success of nuclear power plant export to UAE (United Arab Emirates) will increase demand for nuclear engineers in Korea. Accordingly, the Korean government decided to supplement 2,246 engineers in the public sector of nuclear industry in the year 2010 [1] to resolve the manpower shortage problem in the short term. However, the experienced engineers which are essentially important in the nuclear industry cannot be supplied in the short term. Therefore, development of the long term manpower demand forecast model of nuclear industry is needed.

The system dynamics (SD) is useful method for forecasting nuclear manpower demand. It is because the time-delays which is important in constructing plants and in recruiting and training of engineers, and the feedback effect including the qualitative factor can be effectively considered in the SD method. Especially, the qualitative factor like "Productivity" is very important concept in Human Resource Management (HRM) but it cannot be easily considered in the other methods.

In this paper, the concepts of the nuclear manpower demand forecast model using the SD method are presented and the some simulation results are being discussed especially for the "Operation Sector"[1].

2. Manpower Demand Forecast – SD Method

2.1 Qualitative Assessment – Casual Loop Diagram

The qualitative assessment by using the Casual Loop Diagram(CLD) has been performed before doing the quantitative simulation. It is needed to develop the logical structure of model and find the feedback loops. The CLD presented in Figure 1 shows the positive (reinforced) and negative (balancing) feedback loops.

The example of positive feedback loop is as follows ;

Increasing the domestic number of plants can result in increasing "the learning effect", therefore result in <u>*increase*</u> *of "Productivity".*

On the other hand, the example of negative feedback loop is as follows ;

Increasing the domestic number of plants can result in increasing the "number of unskilled (Beginning Level) engineers", therefore result in <u>*decrease*</u> *of "Productivity".*

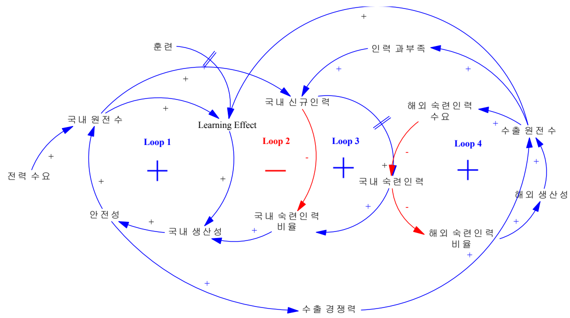

Figure 1. Casual Loop Diagram for Nuclear Manpower Demand

2.2 Quantitative Assessment – Stock and Flow Diagram

After making the CLD to develop the logical structure of the model, quantitative model which is named Stock and Flow Diagram (SFD) has been developed. The example of SFD for "Operation Sector" is presented in Figure 2. In the figure 2, the left box means domestic manpower demand by age and the right box means international project (e.g. UAE project) manpower demand by age. The main assumption is ;

- The government's plan for electricity demand and supply have been used for the estimating number of domestic nuclear power plants(left box in Figure 1). The recent success of nuclear power plant export to UAE has been considered in international project (right box in Figure 2).
- The manpower demand in the "Operation Sector" was assumed to be nearly proportional to number of power plants.
- The manpower loading curve presented in IAEA report[2] has been used. It includes not only

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[1] There are various sectors in nuclear industry : Operation, Maintenance, Design, Manufacturing, Construction, R&D, Fuel Processing, Regulation, etc. In this paper, the results are being discussed only for "Operation Sector".

manpower for commercial operation but for construction management and commissioning.

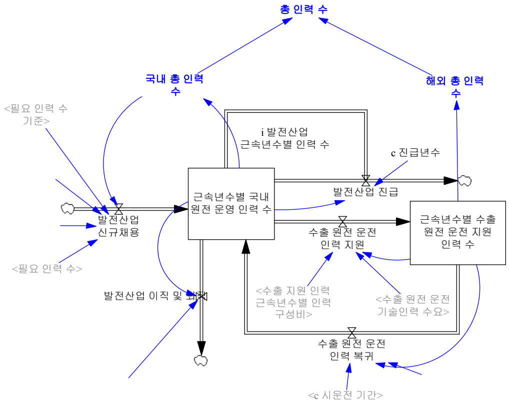

Figure 2. Stock and Flow Diagram for Nuclear Manpower Demand – Operation Sector

Moreover, the following assumptions have been made in this paper to consider the effect of the "Productivity".

- The grade of engineer has been divided into 4 categories by experience as presented in Table 1 (1^{st}, 2^{nd}, 3^{rd} row).
- The "Productivity Index" has been defined based on the nuclear engineering labor cost of Korea Engineering & Consulting Association[3] as presented in Table 1 (4^{th}, 5^{th} row).
- The "Average Productivity" is defined in this paper as follows to show the average productivity of nuclear industry;

$$\text{Average Productivity} = \Sigma_i P_i * N_i$$

i = Grade in table 1 (1, 2, 3, 4)

P_i = "Productivity Index" of grade i

N_i = Total number of engineers of grade i

Table 1. The Definition of Productivity Index Used in This Study – Operation Sector

Grade	Description	Experience (Years)	Labor Cost (Won)	Productivity Index
1	Top Level Engineer	12~35	339,500 (A)	1 (=A/A)
2	High Level Engineer	9~11	283,311 (B)	0.83 (=B/A)
3	Middle Level Engineer	6~8	233,700 (C)	0.69 (=C/A)
4	Beginning Level Engineer	0~5	179,608 (D)	0.53 (=D/A)

2.3 Simulation Results

The simulation result for the future demand of nuclear engineers is presented in Figure 3. "Total Number of Engineers" (blue line) in the "Operation Sector" will expected to be more than 9,000 persons by year 2030. One of the important finding in Figure 3 is that the "Number of Beginning Level Engineers" (red line) will be significantly increased by year 2020. As explained in section 2.1 in this paper, the significant increase of "Number of Beginning Level Engineers" can cause the decrease "Average Productivity" by negative feedback. The result is presented in Figure 4 in this paper.

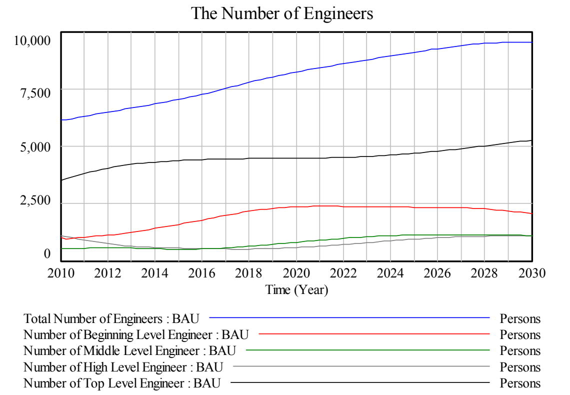

Figure 3. The Simulation Result for Future Demand of Nuclear Engineers – Operation Sector

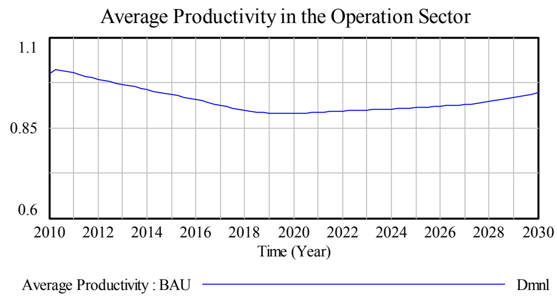

Figure 4. The Simulation Result for Average Productivity – Operation Sector

4. Conclusion and Future Work

The manpower demand forecast model of "Operation Sector" has been developed in this study. The model of other sectors (Maintenance, Design, Manufacturing, Construction, R&D, Fuel Processing, Regulation, etc) will also be developed in the future work.

In the simulation result for the "Operation Sector", it was found that the "Average Productivity" can be decreased by the significant increase in the "Number of Beginning Level Engineers" in the future. Therefore, it would be important to improve the productivity especially for "Beginning Level Engineers". The study will be performed to find best ways for improving the productivity of "Beginning Level Engineers" in the future work.

REFERENCES

[1] Ministry of Knowledge Economy & Ministry of Strategy and Finance, News Report, 2010. 4. 16

[2] IAEA, "Manpower Development for Nuclear Power", Technical Reports Series No. 200, 1980

[3] KENCA, "Labor Cost Standard – Nuclear Engineering", 2009