Effects of One-sided Weights on Multi-criteria Decision Making for Promising Nuclear Fuel Cycle Options in Korea

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1. Introduction

Most countries adopting the nuclear energy have cast a doubt on the nuclear sustainability and postponed making the decision on policies aimed at managing spent fuel. One reason is that, the nuclear sustainability is significantly interconnected with the multiple controversial issues. In this point, the integrated evaluation method, such as multi-criteria decision making (MCDM) methods, can help decision makers to assess the nuclear fuel cycle (NFC) options quantitatively and systematically.

2. Nuclear Fuel Cycle Evaluation

Based on the current situation in Korea, two NFC options are promising; once-through (OT) cycle, and pyroprocessing and sodium-cooled fast reactor (pyro-SFR) cycle. To evaluate them, five evaluation criteria related with key issues were selected; natural U requirement, waste management, NFC cost, proliferation resistance, technical readiness. And the waste management were further divided into three sub-criteria; disposal area for the high level waste (HLW), disposal area for the low and intermediate level waste (LILW), storage area for Cs/Sr.

The first three criteria were quantified based on the dynamic mass flow calculated from the NFC model [1] and an assumed growth scenario of nuclear electricity demand. The scenario follows the 7th Basic Plan on Electricity Demand and Supply until 2029, and then fixes the power capacity at 2029 from 2030 to 2100. The mass flow was converted to the disposal and storage area, and the NFC cost through additional analysis. The proliferation resistance was quantified based on the previous KAERI report [2]. And the technical readiness was quantified based on the engineering sense. As a result, pyro-SFR has higher scores for the natural U requirement and waste management, and OT has higher scores for the rest.

3. Multi-criteria Decision Making

For fair evaluation of the NFC options, two different MCDM methods were used; technique for order of preference by similarity to ideal solution (TOPSIS) and preference ranking organization method for enrichment evaluation (PROMETHEE) [3]. A prior step for the integrated evaluation using MCDM is determining the weights for the criteria. In this study, various decision making groups were assumed to see the effect of their biased characteristics. And the characteristics were reflected in the weights. For example, a group against nuclear weapons might give a higher (doubled) weight on the proliferation resistance than others. Like this way, 6 groups were assumed; G1) neutral, G2) conservationist, G3) local resident, G4) economic realist, G5) anti-nuclear, G6) technician. Table 1 shows the weights for all groups. Weights for sub-criteria are same for all groups. The weight of the HLW disposal area is two times higher than that of the Cs/Sr storage area and four times higher than that of the LILW disposal area.

Table 1. Weights for the different decision making groups

Criteria	G1	G2	G3	G4	G5	G6
Natural U requirement	1/5	1/3	1/6	1/6	1/6	1/6
Waste Management	1/5	1/6	1/3	1/6	1/6	1/6
NFC cost	1/5	1/6	1/6	1/3	1/6	1/6
Proliferation Resistance	1/5	1/6	1/6	1/6	1/3	1/6
Technical Readiness	1/5	1/6	1/6	1/6	1/6	1/3

4. Results and Discussions

Fig. 1 ~ 6 show evaluation results from TOPSIS and PROMETHEE with same weights in Table 1. TOPSIS gives a higher priority on pyro-SFR except on G6 (Fig. 6). PROMETHEE gives a higher priority on OT except on G3 (Fig. 3).

TOPSIS is based on the multidimensional distance (root of squares) from the best and worst options [3] so that the priority is largely dominated by the highest score among all criteria. For G1~G5, pyro-SFR gets a higher priority because its score for the waste management is dominant regardless of their weights. In case of G6, however, the dominant score moves to the technical readiness of OT so that the priorities are reversed.

On the other hand, PROMETHEE is based on the degree of outranking for one option over another [3], which is usually estimated by using linear or stepwise functions. For the groups except on G3, OT having more outranking criteria than pyro-SFR gets a higher priority regardless of their weights. But in case of G3, the degree of outranking of the waste management of pyro-SFR becomes higher than the sum of others of OT. Therefore, the priorities are changed.

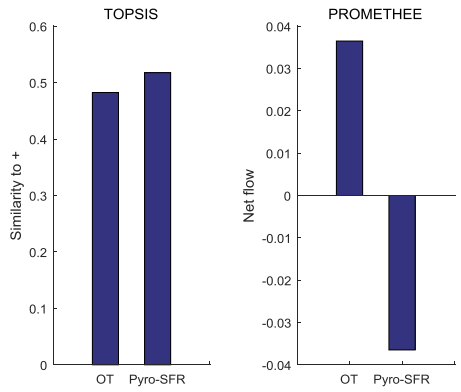

Fig. 1. Integrated evaluation results for G1.

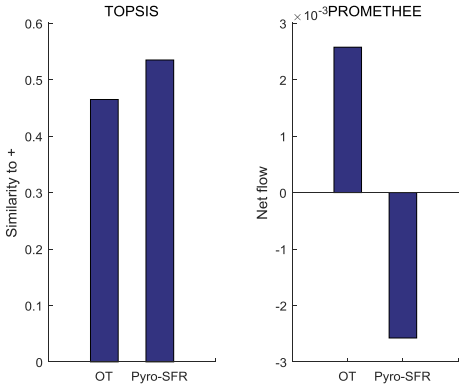

Fig. 2. Integrated evaluation results for G2.

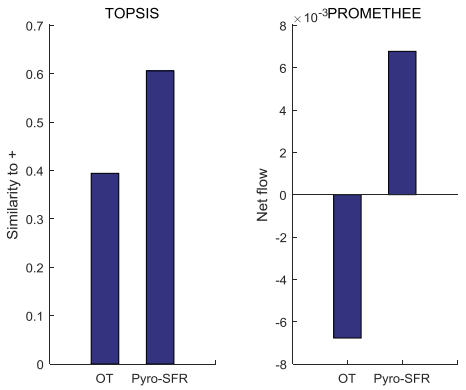

Fig. 3. Integrated evaluation results for G3.

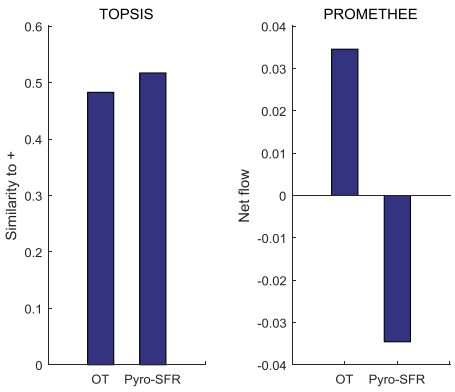

Fig. 4. Integrated evaluation results for G4.

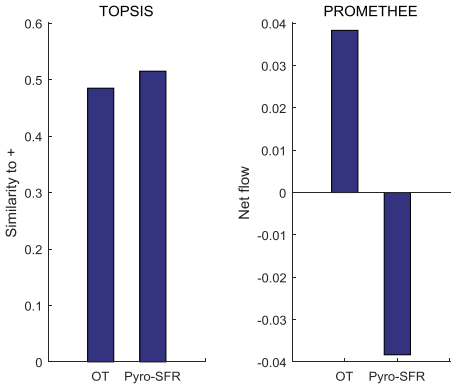

Fig. 5. Integrated evaluation results for G5.

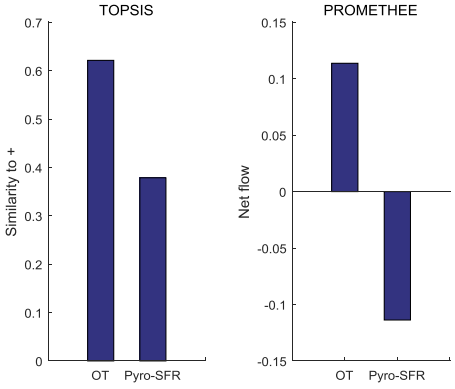

Fig. 6. Integrated evaluation results for G6.

5. Conclusions

Based on the evaluation results for two NFC options considered in Korea, one-sided weights (doubled weight) for TOPSIS and PROMETHEE seems not to affect their priorities significantly. TOPSIS can be recommended for decision makers who want to give higher priorities to the option getting a few but dominant scores among the criteria. And PROMETHEE can be recommended for decision makers who want to give higher priorities to the option having many favorable criteria.

In the future, the sensitivity analysis for the degree of bias of weights will be performed.

REFERENCES

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