A Study on Nuclear Power Plant Export Competitiveness by AHP Analysis

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1. Introduction

In spite of Fukushima accident in 2011, worldwide demand for nuclear power plants (NPP) is still increasing, notably by Czech Republic, the United Kingdom, and Saudi Arabia. Since these countries have no necessary technology, funds, and human resources to construct new NPP, they have to import NPP from qualified supplier countries. Currently, only six countries – Korea, France, Japan, China, Russia, and United States – are considered as having necessary capability to export NPPs. These countries possess their own respective advantages and they exported around 55 units of NPPs to 14 different countries for past decade.

However, despite these successful NPP exports, it is difficult to figure out official factors that affect the NPP contract due to the secretive nature of NPP export contracts [1]. Therefore, it is difficult to understand current state of global NPP market precisely for both buyer countries and supplier countries. To evaluate the capability of NPP supplier countries, a model should be developed to compare the export competitiveness of aforementioned six countries.

In this study, quantitative comparison model for NPP export competitiveness was developed. The model 1) categorizes various criteria important to nuclear power plant export and 2) determine the weight factors on each criterion based on an AHP analysis to 3) compare the competitiveness of six major NPP supplier countries. Then, the advantages and disadvantages of six supplier countries were evaluated base on the weighted criteria.

2. Literature Review

Overall process of NPPs export is very complex. Export of NPPs requires technology expertise on plant design, construction, and maintenance and furthermore factors – capability of nuclear industry, professionals, and even indirect competitiveness of economy, finance, nuclear policy, and foreign affairs of the supplier country [2]. IAEA guideline about management of the first NPP defined the major factors of NPP export competitiveness as nuclear technology, nuclear fuel cycle, finance, commercial capability and technology transfer [3]. However, model from IAEA fails to reflect the changed trend on NPP export after Korea's export to UAE in 2009 [1]. Recent NPP export requires not only the traditional competitiveness, such as technology expertise, economic feasibility of NPP, financial support, and commercial capability but also governmental supports including policy of the domestic nuclear promotion and package deals. These powerful support of government emerged as a decisive factor in case of Korea and Russia. The detail studies of Korea's NPP export competitiveness were conducted by Kim&Chang [4] and Park&Yong [5].

However, these studies did not suggest the weighted factor of each criterion. Without the quantitative importance of evaluation criteria, only the advantage and disadvantage of supplier countries can be evaluated qualitatively but overall competitiveness cannot be evaluated. Therefore, a model that quantitatively assess export competitiveness of the supplier countries was developed by analytic hierarchy process (AHP) in this study.

3. Model Development

3.1 Evaluation Model Hierarchy

The main framework of evaluation model was established based on bid invitation specifications suggested by IAEA [3]. It is based on five criteria – technology, nuclear fuel, finance, commercial capability, and technology transfer – as evaluation criteria. Furthermore, we simplified the lower level of evaluation criteria and included new criteria to reflect current NPP export trend. The modified evaluation model hierarchy is shown in Table 1. Nuclear fuel category was expanded into nuclear fuel cycle and includes the back-end nuclear fuel cycle. Also, a new assessment criterion of governmental support was added to evaluate government policy support and package deals offered to the importing country to reflect Russia's recent export cases. Previous literature and Delphi method were used as reference [6]. The discussion was conducted by seven professionals with over 20 years of experience on nuclear research, export, finance, and other related fields.

Table I: Evaluation Hierarchy Model of NPP Export Competitiveness

1. Nuclear Technology
- 1.1 Plant design technology
  - 1.1.1 Original technology
  - 1.1.2 Demonstration of reference reactors
  - 1.1.3 Design certification (Licensability)
- 1.2 Plant construction technology
  - 1.2.1 Designed construction period
  - 1.2.2 Punctuality of construction schedule
  - 1.2.3 Quality assurance and control
- 1.3 Plant operation technology
  - 1.3.1 History of plant availability
  - 1.3.2 Plant maintenance

2. Nuclear Fuel Cycle
- 2.1 Front-end fuel cycle service
  - 2.1.1 Capability of uranium procurement
  - 2.1.2 Capability of uranium enrichment
  - 2.1.3 Fuel fabrication and supply
- 2.2 Back-end fuel cycle service
  - 2.2.1 Availability of reprocessing service
  - 2.2.2 Support of final waste disposal
  - 2.2.3 Availability of leaseback option

3. Governmental Supports
- 3.1 Political supports
  - 3.1.1 Nuclear industry promotion by government
  - 3.1.2 Power of Gov. organization for nuclear export
  - 3.1.3 Nuclear R&D supports by government
  - 3.1.4 Sustainability of domestic nuclear industry
- 3.2 Financial supports
  - 3.2.1 Scale of available ECAs
  - 3.2.2 Financing package
- 3.3 Diplomatic negotiation power
  - 3.3.1 Economic package
  - 3.3.2 Military package

4. Commercial Capability
- 4.1 Costs
  - 4.1.1 TCIC(Total Capital Investment Costs)
  - 4.1.2 Nuclear fuel cycle costs
  - 4.1.3 O&M costs
- 4.2 Organization of consortium
  - 4.2.1 Leadership on the organization of domestic nuclear industry
  - 4.2.2 International partnership
- 4.3 Supply chain
  - 4.3.1 Supplier country's component industry
  - 4.3.2 Supplier country's construction industry
  - 4.3.3 Supplier country's nuclear fuel industry
  - 4.3.4 Supply chain localization in buyer's country

5. Technology Transfer
- 5.1 Knowledge sharing
  - 5.1.1 Quality of knowledge
  - 5.1.2 Supplier country's initiative to share technology
- 5.2 Training of personnel
  - 5.2.1 Training of operation professionals
  - 5.2.2 Training of technical professionals
- 5.3 Bilateral R&D cooperation
  - 5.3.1 Scale of bilateral R&D funding
  - 5.3.2 Scale of involved researchers

3.2 Weight Factor Analysis

An AHP analysis was used to evaluate the competitiveness evaluation criteria quantitatively. The AHP analysis is well-known decision-making methodology first developed by T.L. Saaty [7]. The AHP methodology have great advantage to consider multiple subjective factors, which are difficult to quantify, simultaneously. The weight factor result by AHP analysis was shown in figure 1. With the result of weight factor analysis, evaluation model of overall NPP export competitiveness was developed.

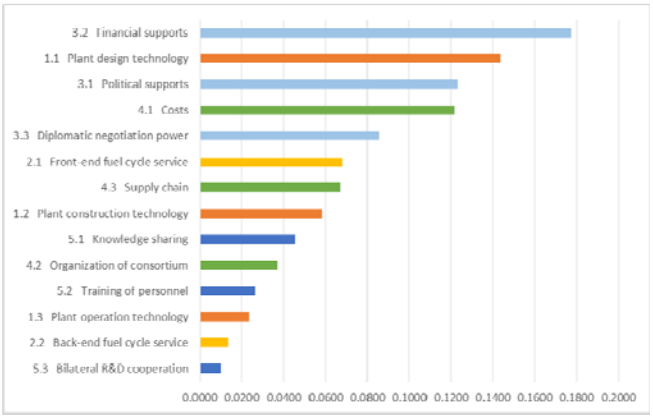

Fig. 1. Weight factor of evaluation criteria

4. Comparison of NPP Export Competitiveness

The developed model was applied to the six NPP supplier countries to evaluate their export competitiveness. The Delphi method was used to calculate the competitiveness for the comparison. The comparison result of main 5 evaluation criteria is shown in figure 2.

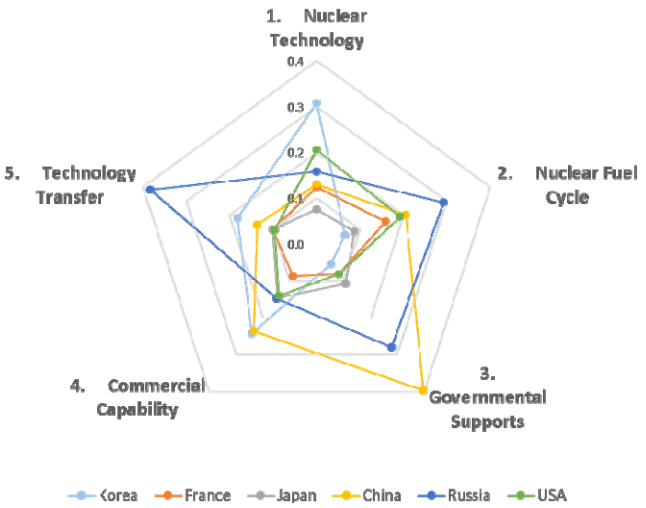

Fig. 2. Field-wise comparison of six NPP supplier countries

Figure 2 shows that Korea has advantages on nuclear technology and commercial capability. On the other hands, Korea has great weakness on governmental supports. This shows Korea might suffer difficulty due to insufficient support from government unlike the past case of UAE. Russia has advantage on nuclear fuel cycle and technology transfer. Russia has no constraints on fuel supply and back-end fuel cycle, and open at technology transfer by well-trained professionals. Moreover, China has advantage on governmental supports and commercial capability based on large domestic nuclear industry. By integrating weight factor and field-wise comparison results, China was evaluated as the prospective country to export NPP and Russia have comparable competitiveness. In addition, Korea has third position on NPP export market among six countries.

5. Conclusion

The results in this study indicate that Korea requires huge amount of effort and investment to win the NPP contract after UAE. Between Korea and China (or Russia), there is remarkable gap of competitiveness. Therefore, Korea cannot succeed in exporting additional NPPs without proper strategies.

First, target countries interested in NPP import with strong leadership. The strong political decision marking of the buyer country is a game-changing factor as the UAE case indicates. Second, a consumer oriented export package must be developed. Third, target countries uninterested in Korea's weakness or cooperate with the complementary supplier countries. Fourth, emphasize and improve Korea's on-time and on-budget performance. Lastly, target countries that refrain from adopting Chinese or Russian NPPs due to a close relationship with the United States.

Future NPP market will be taken by Korea, China and Russia. If Korea improve the competitiveness with high weight factor and follow the suggested export strategies, Korea can succeed in tough competition of NPP exportation.

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