Nuclear Power Plant Competitiveness from Exporter and Importer Perspective.

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1. Introduction

There is a lasting consensus in Central and Eastern European countries regarding the need to develop nuclear power. Neither the failure in Fukushima nor the German energy transformation policy (Energiewende) changed it. For all countries, energy security considerations and EU climate policy are the key motivations for developing nuclear capacity. However, in the implementation of new nuclear projects, political and business spheres are closely linked. The scope of this research is to compare expectations of the importing country which is Poland and the offer of the exporting country-Korea.

2. NPP Competitiveness

Currently, only six countries are considered to have the capability to export nuclear power plants: Korea, Japan, China, Russia, the United States and France. Reactor technologies available to export are presented in Table 1. Each of plant models are 3rd generation NPP which demonstrate safety, modernity and the highest standards, therefore, additional economic packages or diplomatic cooperation may be the decisive factor. The key criteria determining the choice of nuclear technology from the exporter's perspective were previously described[1], while the importer's point of view was not yet presented.

Country	Developer	Type of reactor	Number of projects
USA	Westinghouse	AP1000	8
South Korea	Kepco/KHNP	APR1400	1
China	CNNC & CGN	HPR1000	2
Japan	AREVA & Mitsubishi	ATMEA-1	1
Russia	OKB Gidropress	VVER-1200	11
France	Areva-EDF	EPR	4

Table 1. Current export-import of NPP.

3. Methods

To accurately compare the perspectives of both countries, Delphi method and literature review were used as references.

3.1 Delphi method

Delphi method was implemented by conducting surveys among seven Polish experts in nuclear technology. Academic professors and government officials with more than 10 years of experience, answered questions based on the Table 2 with classification of import competitiveness of nuclear power create by Korean researchers[1] and based on the IAEA report[2]. The main categories are: Nuclear Technology, Nuclear Fuel Cycle, Export Country Support, Commercial Capability and Technology Transfer. All of these aspects are divided into groups, which more detailed are checking import /export competitiveness of nuclear power. These factors are presented in Table 2[1]. By comparison of the statements and checking by scale of importance (1-9), collected data are then analyzed by AHP (The Analytic Hierarchy Process) method.

3.2 AHP method

AHP method is used to solve decision problems that contain more than one criterion. It was used to analyze collected data because of direct comparison measurable and non-measurable elements determined by expert's knowledge. In addition, this method allows to present the result in a simple way, using graphs.

After pairwise comparison by experts, their answers are presented in matrixes. The reverse of grades is very important in the AHP method. This means that if, as result of comparing variant A with variant B, we get the value x, then it should be assumed that the result of comparing B with A will be the value 1/x. The reliability of the result is checked by calculating the consistency ratio (CR), from formula:

$$CR = \frac{CI}{RI} \cdot 100\% \quad (1)$$

RI-random index, depend in degree of matrix n

$$CI = \frac{\lambda_{max} - n}{(n-1)} \quad (2)$$

λ_{max}-matrix eigenvalue, n-degree of matrix

If its value does not exceed 10%, it means that the assessments are consistent[3].

1.Nuclear Technology	1.1 Plant Design Technology	1.1.1 Original Technology
		1.1.2 Demonstration of reference reactors
		1.1.3 Nuclear Safety and Design certification
	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. Export Country Support	3.1 Political support	3.1.1 Nuclear industry promotion by government
		3.1.2 Power of government org. for nuclear export
		3.1.3 Nuclear R&D support by government
		3.1.4 Sustainability of domestic nuclear industry
	3.2 Financial support	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 org. 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

Table 2. Classification of competitiveness factors for import/export of nuclear technology.

4. Results

Firstly Polish experts were asked about main NPP import competitiveness factors. The weight factor calculation by AHP method, on each criterion compared with responses of Korean experts are presented in Fig.1. From importer's perspective, the most important is Export Country Support. Poland is a developed country with fast economic development in recent years. Nuclear Power Plant is a long term and very expensive venture so both of countries should take advantage from it and cooperate in other fields too. Not only Export Country Support but Nuclear Technology is significant factor in decision-making process. Poland in a member of European Union which is connected with many restrictions. Required certificates and security standards are key elements for the proposal to be accepted for both, Polish and EU authorities.

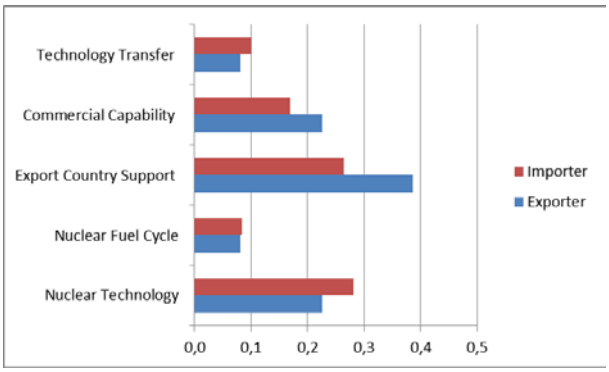

Fig. 1. Weighted values for main NPP import and exporter competitiveness factors .

5. Discussion

The responses of Korean and Polish experts are mostly similar which shows, that presented factors are established well. In case of trainings of personnel and Bilateral R&D cooperation, newcomer country evaluate it as more important factor than for export country. Because of lack of university nuclear engineering courses and professional training facilities, personnel of NPP needs competent knowledge and abilities. Sustainability of domestic nuclear industry is important for both of the countries. Many Polish companies are producing components for European NPPs so it is priority to involve them in Polish nuclear project. Not only this but also, from importer point of view, support of final waste disposal is much more important than for exporter country. For Poland, building special facilities for reprocessing or temporary storage for spent fuel is additional expense. Moreover, to build this kind of facilities, it is needed to create special law. Finally, Demonstration of reference reactors is more significant for export country than for import country. South Korea has many nuclear reactors and is building new ones. All of APR1400 reactors are still under construction , so importers are not fully convinced that this reactors will be reliable It makes this criterion's weight low for them. For newcomers in nuclear energy, still financing and governmental support, total cost and presence of special certificates will be the most important factors.

6. Conclusions

Comparison of Poland and Korea perspectives are helpful to implement Korean nuclear technology in another countries. This research is also presenting requirements of potential import country which can be discuss in negotiation processes and create a plan of implementing nuclear technology in Poland.

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