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SUPPLIER SELECTION WITH AHP- TOPSIS COMBINATION IN NATURAL GAS COMBINED CYCLE POWER PLANT

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ABSTRACT
Today, energy is one of the most important problems that need to be solved and be agreed on worldwide due to increasing population, urbanization and industrialization phenomena and technological developments. At the same time, natural gas combined cycle power plants (NGCCPP) have advantages such as high thermal efficiency, high installed capacity, operational simplicity, and low greenhouse gas emissions compared to other fossil fuels. Therefore, the widespread use of these power plants in electricity generation also continues in the whole world as well as in Turkey regardless of the resource availability. One of the important steps to utilize the advantages of these plants is maintenance management, and supplier management constitutes a significant pillar of the maintenance management in these power generation facilities. In this context in this study, supplier selection problem with a multiple criteria structure is handled for gas turbine rotor which is the most critical equipment for a big scale NGCCPP in Turkey for the first time in the literature. In order to select the most suitable supplier among the 6 potential ones, 3 criteria are determined by NGCCPP specialists are used in the problem. Consequently, priority ranking of the potential suppliers is obtained by using TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) algorithm which uses the relevant criteria weights calculated by AHP (Analytic Hierarchy Process).
Keywords: Natural Gas Combined Cycle Power Plant (NGCCPP), Supplier Selection, AHP, TOPSIS, Multi-Criteria Decision Making

1. INTRODUCTION
The most commonly used form of energy is electricity, and coal is the most used resource in electricity generation and it is followed by natural gas. About 24% of the world energy demand is covered by natural gas and it is predicted that the amount of electricity generated from natural gas will increase by 2,7% per annum until 2040 [1]. Natural gas combined cycle power plants (NGCCPP) that generate electricity from natural gas have advantages such as high thermal efficiency, high installed capacity, quick commissioning, operational simplicity, and low greenhouse gas emissions compared to other fossil fuels. These advantages explain why natural gas is ranked at the top among the resources used for electricity generation. This situation is not different from the world for Turkey. 36,2% of Turkey's total electricity generation is met from natural gas between January 2017 and April

2018 [2]. As it is seen from this statistic, NGCCPs have critical importance in terms of Turkey's energy supply security. One of the most important requirements of these plants to serve at high levels to the Turkey's energy supply security is maintenance, and supplier management constitutes a significant pillar of the maintenance management in these power generation facilities.

The problem of supplier selection, which has been studied in many areas from healthcare [3] to the automotive sector [4], from textile industry [5] to electrical resistance production [6], has also been addressed for nuclear [7] and hydroelectric power plants [8] in the literature. However, no study has been conducted on supplier selection for critical components in NGCCPPs in the literature. In addition to this, by considering the supplier effects on the NGCCPPs described in detail below in this study, supplier selection problem is handled for gas turbine (most critical equipment for NGCCPP) rotor blade parts in a big scale NGCCPP in Turkey for the first time in the literature.

2. SUPPLIER EFFECTS ON THE NGCCPPs

Supplier selection is the process of determining from which supplier and how much the materials must be taken. Working with the most suitable supplier offers advantages such as cost, efficiency, customer satisfaction and competitiveness [4,6]. In addition to this, NGCCPPs are the continuous production facilities as in all power generation plants and the main purpose of these plants in the large-scale infrastructure investment group, is to realize the sustainable electricity generation. As is known, the components of sustainability in NGCCPPs are uninterrupted, efficient, economic and environmentally friendly generation, and maintenance has critical importance to achieving this comprehensive objective. Furthermore, supplier quality level in terms of delivery of materials on time and on the desired specifications directly affects the maintenance. Because, comprehensive maintenance processes are carried out in NGCCPPs and a significant amount of material change takes place in these processes for reasons such as high voltage, temperature, pressure, metal fatigue etc. From this point of view, determining the most suitable supplier set for all critical equipment, spare parts and consumables is a critical process to realize the sustainable power generation in NGCCPPs. However, this problem is not studied by researchers in the literature for NGCCPPs. In this context in this study, supplier selection problem is handled for gas turbine rotor blade parts (these are critical spare parts and must be renewed every 25.000 hours) in a big scale NGCCPP in Turkey.

3. METHODS

Supplier selection is influenced by many conflicting/related quantitative and qualitative parameters. In fact, these parameters are criteria and therefore it is obligation to take these criteria into account when selecting suppliers in terms of analytic evaluation. Multi-criteria decision making (MCDM) approaches, which consider the multiple and usually conflicting/related objectives/criteria in the decision-making process, are also one of the most popular methods used in the supplier selection problem because of their advantages. There are so many improved MCDM methods such as AHP, ANP (Analytic Network Process), TOPSIS, ELECTRE (Elimination and Choice Expressing Reality) and PROMETHEE (The Preference Ranking Organization Method for Enrichment of Evaluations) in the literature, and they have relative advantages and disadvantages according to their applicability in different situations. AHP uses the pairwise comparisons and this allows to weight criteria or coefficients and compare alternatives. It is scalable and can easily adjust in size to accommodate decision-making problems due to its hierarchical structure. TOPSIS is the other MCDM method used in this study, has more simple process than the other outranking algorithms such as ELECTRE and PROMETHEE. Furthermore, in this method the alternative which is the nearest to the ideal solution and the farthest to the negative ideal solution is chosen [9]. When considering the advantages of AHP and TOPSIS, in this study, the combination of these methods is used for supplier selection problem in NGCCPP. Application steps of the methods are shown in Figure 1.

4. APPLICATION

When considering the advantages of NGCCPP's, it is one of the most preferred power plants for electricity generation in Turkey similar to the world, despite the unavailability of local natural gas resource. More than one-third of Turkey's total electricity generation is realized in the NGCCPPs in the period between January 2017-April 2018 [2]. This statistic proves that the NGCCPPs are indispensable for Turkey's energy supply security. Sustainable energy supply directly affects the

energy supply security and can be defined as realizing the uninterrupted, reliable, efficient, economic and environmentally friendly electricity generation in the power plants. Carrying out the required maintenance processes on time has critical importance in terms of prolonging the effective operational lifetime of power plants and thus improving the sustainable power generation of the system [9]. Especially, in terms of quality and delivery date supplying processes directly affect the maintenance processes that are so important. Therefore, determining the suitable suppliers is a critical process to realize the sustainable power generation in NGCCPPs. Because, materials that are not delivered on time and on desired quality level will disturb the maintenance processes, and this will cause in deviations from uninterrupted, reliable, environmentally friendly and efficient generation. By considering these facts together with the gaps in the literature, in this study, supplier selection problem is handled in a big scale NGCCPP in Turkey. 3 criteria (casting, machining and coating) which directly affect the material quality are determined by the power plant specialists by considering 9 parameters (given in Figure 2) for supplier selection problem for gas turbine rotor blade parts in NGCCPP. According to these criteria, 6 potential suppliers are evaluated with the AHP-TOPSIS combination and the most suitable supplier is obtained. Application steps are given in Figure 1.

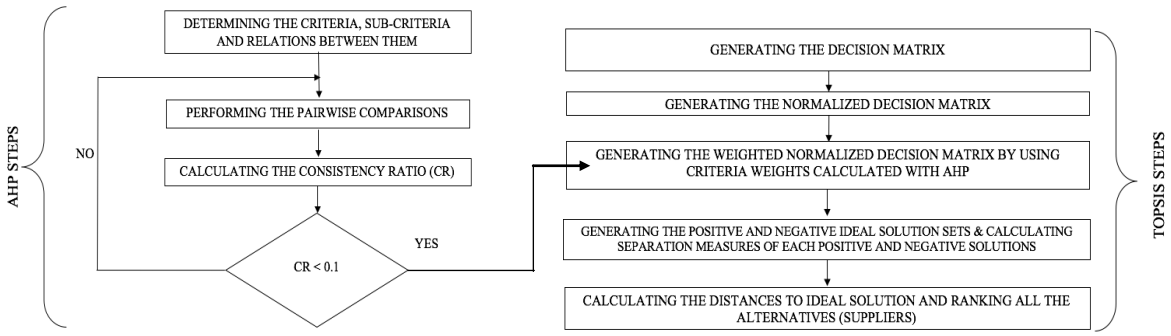

Figure 1. Application steps [10,11]

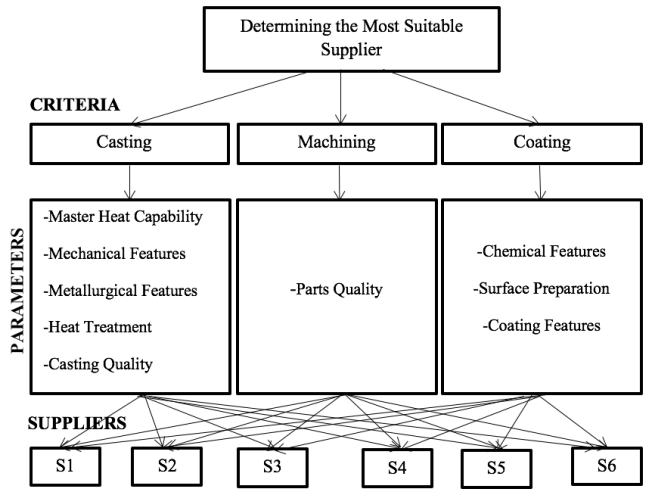

Figure 2. Hierarchical structure

Table 1. Criteria weights

Criteria	*w*
Casting	0,778
Machining	0,111
Coating	0,111

Table 2. Decision matrix

10	2	10
6	10	5
9	4	5
10	2	3
6	2	3
4	1	2

As mentioned in the above sections, on-time delivery is an important criterion affecting supplier performance. However, this criterion was not taken into account due to all suppliers have the same delivery dates. Criteria weights calculated with AHP by following the steps given in Figure 1 are given in Table 1.

After the calculation of the criterion weights, calculation of alternative supplier priorities is started with TOPSIS methodology by following the steps given in Figure 1. The decision matrix is constructed with power plant and procurement specialists and given in Table 2.
As can be seen in Figure 1, weighted normalized matrix was constructed by using the normalized decision matrix obtained as a result of the normalization of the decision matrix and the criteria

weights calculated with AHP. Then ideal and negative ideal solution sets are prepared, and the distances to the ideal and negative ideal solutions, in other words, alternative suppliers priorities (Table 3) are obtained by calculating the separation measures from these sets.

Table 3. Supplier priorities

Suppliers	Score	Ranking	Suppliers	Score	Ranking
S1	*0,729*	*1*	S4	0,664	2
S2	0,412	4	S5	0,131	5
S3	0,603	3	S6	0,034	6

5. RESULTS AND DISCUSSION

In this study, supplier selection problem is handled for the first time in the literature for NGCCPPs, and supplier effects on the NGCCPPs and energy supply security are specified by considering the operational realities of the power plants and sectoral framework. The most suitable supplier for gas turbine rotor blade parts which is the most critical equipment spare part of a big scale NGCCPP in Turkey is obtained by using a combined AHP-TOPSIS methodology. In this study, it is aimed not to negatively affect the maintenance processes from the material quality level. It is foreseen that this goal will be achieved when considering the criteria set by the experts and the advantages of the application methods.

The use of mathematical programming methods such as goal programming and the comparison of the results can be suggested for the future studies.

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