
Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company

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ABSTRACT

Effective procurement and supplier selection processes are needed to create a low-cost and reliable supply chain. A power company is having difficulty determining a supplier of technical personnel because there was no scientific method used to weight and prioritize supplier assessment criteria. So far, decision-making has been done more subjectively, causing a mismatch between the result of supplier selection and the company's needs. This study uses a supplier selection model with the Fuzzy Analytical Hierarchy Process (FAHP) method to calculate the weight of each criterion and sub-criterion and determine the best supplier. The criteria used in this study include Financial Capability, Performance, Similar Experience, Expert Personnel, Office at Work Location, Similar Contracts, and Price, based on the company regulations. The result of this study shows the weight of each criterion that is: Financial Capability at 0.2007, Similar Experience at 0.1887, Performance at 0.1744, Price at 0.1545, Expert Personnel at 0.1518, Office at Work Location at 0.0877, and Similar Contracts at 0.042. Evaluation of three supplier alternatives indicates that supplier X obtained the highest preference value (0.9263), followed by supplier Y (0.8448) and supplier Z (0.8338). Sensitivity analysis on bid price changes demonstrates that supplier Z is more sensitive to price reductions than supplier Y, but supplier X remains the best alternative. Overall, FAHP effectively supports objective and comprehensive supplier selection decision-making. The proposed model can improve consistency, transparency, and procurement accountability.

Keywords: Supplier Selection, MCDM, Fuzzy AHP, Procurement.

INTRODUCTION

The business and industrial sectors are experiencing increasingly intense competition due to technological changes, market globalization, and growing demands for operational efficiency. Supply chain encompasses all parties and functions involved in fulfilling customer demand, as well as activities such as product development, marketing, operations, distribution, finance, and customer service [1]. The quality and sustainability of the company's business processes will be impacted by the procurement of goods, which typically involves several vendors [2]. Therefore, organizations are required to design competitive strategies in supplier management [3]. A good procurement process must ensure that the company obtains the right products, raw materials, and/or services at the agreed price, within the approved time, and in the appropriate quantity [4]. Excellence in procurement management is essential issue for achievement good project outcomes [5]. Suppliers capable of providing high-quality products and services at appropriate prices and with timely delivery can significantly influence the sustainability of company operations. Therefore, the supplier selection process has become an important part of supporting cost efficiency, improving service quality, and achieving overall company objectives.

The primary objective of supplier selection is to identify the supplier that best fits the company's requirements and provides the greatest value [6]. In supply chain management, companies implement procurement systems aimed at maintaining operational reliability, including the procurement of outsourced manpower. The reliability and continuity of electricity transmission systems heavily depend on technical personnel. These jobs require workers with

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

technical competence, an understanding of occupational safety, and robust operational capabilities. Choosing the correct technical personnel supplier is a crucial element in guaranteeing that business operations proceed efficiently and in accordance with predetermined benchmarks.

The company still encounters several challenges in the process of selecting technical personnel suppliers. A weighting system for criteria and sub-criteria in the procurement process is in place according to company guidelines, but universally accepted standards are not used to determine weightings for supplier evaluation. This condition causes the assessment process of remaining influenced by the subjectivity of decision-makers and potentially leads to inconsistencies in determining the best supplier. Supplier selection is a challenging issue because most input parameters are uncertain and cannot be precisely determined; therefore, deterministic supplier selection methods lose their effectiveness [7]. Supplier evaluation criteria are either based on qualitative and quantitative or based on competency, cleanliness, and communications [3]. Meanwhile, in an effort to build distinctive competitive advantages across companies, five criteria are considered influential in supplier selection: price, quality, delivery time, service, and production flexibility [8]. This complexity necessitates a decision-making method that can provide objective and systematic evaluation results.

Fuzzy AHP can be used to address these problems. The fuzzy approach is one of the common methods to deal with environmental uncertainty [9]. A fuzzy logic model is developed to determine the weights of the suppliers based on qualitative criteria [10]. Fuzzy set theory is a useful tool for representing the kind of subjectivity that exists in human decision-making [11]. This method is an extension of AHP that incorporates fuzzy logic concepts to reduce uncertainty and bias in subjective assessments. This method it is commonly used to create criterion weights based on pairwise comparisons of alternatives and criteria, calculate alternative relative significance values, determine their ranking, and choose the best alternative [6]. Using this method enables the supplier selection process to be conducted in a more structured manner, leading to more accurate and accountable decisions. This study applies the fuzzy AHP method to determine the weights of criteria and subcriteria for the selection of technical personnel suppliers. Several previous studies have also shown that FAHP can produce a better level of decision consistency and increase the validity of results in multi-criteria decision-making problems.

This research aims to achieve the following:

1. Identify criteria and sub-criteria that can be used as a reference in determining the best technical personnel supplier.
2. Develop a supplier selection model or framework using the Fuzzy AHP method.
3. Determine the weighting of the criteria that can be used in selecting technical personnel suppliers.
4. Determine the best technical personnel supplier based on the weighting calculation.

There are many previous studies on supplier selection decision-making using the fuzzy AHP or other MCDM methods such as Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA), and Weighted Product (WP) to determine criteria weights and alternative priorities. However, in the context of outsourcing technical personnel in the electricity sector, there has been little scientific study. This study also uses criteria established in company regulations. Both of these factors differentiate this study from previous research.

METHODS

Supplier selection is a multi-criteria decision-making (MCDM) problem that enables suppliers to evaluate various qualitative and quantitative criteria that are often conflicting [12]. In the MCDM process, a set of alternatives or options is evaluated based on a set of criteria by multiple decision-makers (agents). Each agent has an attitude factor that influences the preference information provided [13]. The Analytic Hierarchy Process (AHP) is a concept of quantification through pairwise comparisons and depends on the judgements of experts to obtain priority scales [14]. The AHP is intended to help with the resolution of challenging multiple-criteria issues in a variety of application areas [8]. AHP is a structured decision-making methodology that systematically deconstructs complex decisions into a hierarchical structure [17]. The problem is revealed and deconstructed in depth during the development of the hierarchical structure, which is a significant advantage of this method [6]. In this study, AHP was applied to address the existing problems. This method is used to support decision-making processes that involve multiple criteria and are complex in nature. As a result, the evaluation outcomes are more structured, objective, and easier to analyze. Yurii

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

Salii proposed a broader type of structure known as L-relations, which were analyzed within the framework of abstract algebra [18]. Fuzzy relations themselves have wide applications in various fields, such as linguistics, decision-making, and clustering analysis.

The first step taken in fuzzy AHP is to fill out a paired comparison questionnaire for each criterion and sub-criterion by experts. It is used to obtain ratio levels from both discrete and continuous pairwise comparisons [15]. It is commonly used to create criterion weights based on pairwise comparisons of alternatives and criteria, calculate alternative relative significance values, determine their ranking, and choose the best alternative [6]. After that, the consistency ratio (CR) value is calculated. It is critical to evaluate if experts' responses were consistent for their opinions to be incorporated in the computation of global weights [16]. To ensure that the consistency index reaches a predefined threshold, namely 10%, the consistency ratio must be calculated for each number of criteria, the ratio between the consistency index and the random consistency index (RCI) [16]. The results of each expert's assessment are then converted into TFN form, and the geometric mean is calculated. A Triangular Fuzzy Number is defined by the parameters l , m , and u , which represent the lower bound, the peak value with the highest membership degree, and the upper bound, respectively, where l is less than or equal to m , and m is less than or equal to u [19]. Triangular fuzzy numbers are first used for pairwise comparison, and the synthetic extent value (S_i) is introduced by applying the extent analysis method, based on the principle of fuzzy numbers comparison [19]. Then the degree of possibility (V) is calculated to determine the level of possibility of a fuzzy number being greater than, equal to, or smaller than another fuzzy number. After that, the minimum degree of possibility (d) is obtained for each criterion against. This minimum degree of possibility is the initial weight vector (W'). This weight vector is normalized to produce the final weight (W) which represents the weight of each criterion and sub-criterion in the decision-making process. This weight vector is a non-fuzzy number.

Additionally, a sensitivity analysis was conducted to examine the effect of weight changes on supplier selection outcomes. In this scenario, adjustments were made to the values of the price bid sub-criteria, given the critical role of cost in decision-making. The bid prices were adjusted so that Suppliers X, Y, and Z received more competitive scores, with the goal of determining whether these changes would affect the resulting ranking order.

RESULTS

This chapter explains the data collection and processing methodology used in the study, which involves interviews, questionnaires distributed to experts, and secondary data. It further describes the data processing steps using the Fuzzy Analytic Hierarchy Process (FAHP) to determine the best technical outsourcing supplier. The discussion focuses on interpreting the weights of criteria and sub-criteria, evaluating the relative performance of each supplier, and testing decision stability through sensitivity analysis. This study offers an objective foundation for strategic decision-making by combining quantitative and qualitative data to identify partners that are financially robust, technically proficient, and compliant with operational regulations.

The respondents in this study are five experts selected based on their experience in procurement management or outsourcing contracts, particularly for technical outsourced personnel in the company. The respondents also hold responsibilities within teams or organizations involved in managing a technical outsourced workforce. All respondents have more than 10 to over 15 years of work experience, and are therefore considered to have sufficient competence and expertise in this field.

In this study, the criteria for technical outsourcing suppliers are determined based on applicable company regulations, while the sub-criteria are obtained through literature review and expert interviews. The supplier selection criteria for technical workforces in this study comprise seven key aspects: financial capability, experience in analogous projects, performance records on similar work, possession of a local office at the work site, availability of certified specialists, ongoing similar project contracts, and cost. These criteria and sub-criteria are compared with each other (pairwise comparison) and included in a questionnaire, then assessed by experts. The results of each expert's pairwise comparison assessment were subjected to a consistency test until a consistency ratio (CR) value ≤ 0.1 was obtained. The results of the pairwise comparison and consistency test are as shown in Table 1. The responses were then converted into Triangular Fuzzy Numbers (TFN) to accommodate uncertainty and subjectivity in the assessments. The fuzzy data were processed using the geometric mean to obtain combined values for each pairwise comparison of criteria. These results were used to construct a pairwise comparison matrix in TFN form, consisting of seven main

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

criteria with (l, m, u) values representing the relative importance between criteria. This matrix serves as the input for the subsequent fuzzy analysis stage to determine the final priority weights.

Table 1. The Results of The Pairwise Comparison and Consistency Test

Criteria	Pairwise Comparison Matrix							Normalized Matrix							Eigen Value	Consistency
	Financial Capability	Experience in Similar Projects	Performance	Office at Work Location	Expert Personnel	Similar Contracts	Price	Financial Capability	Experience in Similar Projects	Performance	Office at Work Location	Expert Personnel	Similar Contracts	Price		
RESPONDEN 1																
Financial Capability	1,00	2,00	2,00	3,00	4,00	5,00	0,50	0,21	0,27	0,21	0,21	0,26	0,24	0,17	1,07	0,035
Experience in Similar Projects	0,50	1,00	2,00	3,00	3,00	3,00	0,33	0,10	0,13	0,21	0,21	0,19	0,14	0,12	1,19	
Performance	0,50	0,50	1,00	2,00	2,00	3,00	0,33	0,10	0,07	0,11	0,14	0,13	0,14	0,12	1,07	
Office at Work Location	0,33	0,33	0,50	1,00	1,00	2,00	0,25	0,07	0,04	0,05	0,07	0,06	0,10	0,09	1,00	
Expert Personnel	0,25	0,33	0,50	1,00	1,00	2,00	0,25	0,05	0,04	0,05	0,07	0,06	0,10	0,09	1,03	0,027
Similar Contracts	0,20	0,33	0,33	0,50	0,50	1,00	0,20	0,04	0,04	0,04	0,03	0,03	0,05	0,07	0,92	
Price	2,00	3,00	3,00	4,00	4,00	5,00	1,00	0,42	0,40	0,32	0,28	0,26	0,24	0,35	0,93	
Total	4,78	7,50	9,33	14,50	15,50	21,00	2,87	1,00	1,00	1,00	1,00	1,00	1,00	1,00	7,21	
RESPONDEN 2																
Financial Capability	1,00	0,33	0,25	2,00	0,33	2,00	0,33	0,07	0,04	0,05	0,13	0,11	0,12	0,03	1,16	0,127
Experience in Similar Projects	3,00	1,00	0,33	3,00	0,33	3,00	2,00	0,20	0,12	0,06	0,19	0,11	0,18	0,20	1,28	
Performance	4,00	3,00	1,00	3,00	0,33	4,00	3,00	0,27	0,35	0,18	0,19	0,11	0,24	0,30	1,29	
Office at Work Location	0,50	0,33	0,33	1,00	0,33	2,00	0,33	0,03	0,04	0,06	0,06	0,11	0,12	0,03	1,02	
Expert Personnel	3,00	3,00	3,00	3,00	1,00	3,00	3,00	0,20	0,35	0,55	0,19	0,33	0,18	0,30	0,90	0,096
Similar Contracts	0,50	0,33	0,25	0,50	0,33	1,00	0,50	0,03	0,04	0,05	0,03	0,11	0,06	0,05	0,90	
Price	3,00	0,50	0,33	3,00	0,33	2,00	1,00	0,20	0,06	0,06	0,19	0,11	0,12	0,10	1,22	
Total	15,00	8,50	5,50	15,50	3,00	17,00	10,17	1,00	1,00	1,00	1,00	1,00	1,00	1,00	7,76	

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

RESPONDEN 3																
Financial Capability	1,00	1,00	3,00	1,00	3,00	3,00	1,00	0,20	0,20	0,25	0,21	0,25	0,20	0,13	1,03	CI
Experience in Similar Projects	1,00	1,00	3,00	1,00	2,00	4,00	1,00	0,20	0,20	0,25	0,21	0,17	0,27	0,13	1,04	0,031
Performance	0,33	0,33	1,00	0,50	1,00	1,00	1,00	0,07	0,07	0,08	0,11	0,08	0,07	0,13	1,04	
Office at Work Location	1,00	1,00	2,00	1,00	3,00	3,00	2,00	0,20	0,20	0,17	0,21	0,25	0,20	0,27	1,00	
Expert Personnel	0,33	0,50	1,00	0,33	1,00	1,00	1,00	0,07	0,10	0,08	0,07	0,08	0,07	0,13	1,03	CR
Similar Contracts	0,33	0,25	1,00	0,33	1,00	1,00	0,50	0,07	0,05	0,08	0,07	0,08	0,07	0,07	1,04	
Price	1,00	1,00	1,00	0,50	1,00	2,00	1,00	0,20	0,20	0,08	0,11	0,08	0,13	0,13	1,00	
Total	5,00	5,08	12,00	4,67	12,00	15,00	7,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	7,19	
RESPONDEN 4																
Financial Capability	1,00	2,00	2,00	1,00	1,00	2,00	1,00	0,18	0,27	0,24	0,10	0,11	0,18	0,22	1,02	CI
Experience in Similar Projects	0,50	1,00	2,00	2,00	1,00	2,00	0,50	0,09	0,13	0,24	0,20	0,11	0,18	0,11	1,14	0,061
Performance	0,50	0,50	1,00	2,00	2,00	2,00	0,50	0,09	0,07	0,12	0,20	0,22	0,18	0,11	1,20	
Office at Work Location	1,00	0,50	0,50	1,00	1,00	1,00	0,50	0,18	0,07	0,06	0,10	0,11	0,09	0,11	1,03	
Expert Personnel	1,00	1,00	0,50	1,00	1,00	1,00	0,50	0,18	0,13	0,06	0,10	0,11	0,09	0,11	1,01	CR
Similar Contracts	0,50	0,50	0,50	1,00	1,00	1,00	0,50	0,09	0,07	0,06	0,10	0,11	0,09	0,11	0,99	
Price	1,00	2,00	2,00	2,00	2,00	2,00	1,00	0,18	0,27	0,24	0,20	0,22	0,18	0,22	0,97	
Total	5,50	7,50	8,50	10,00	9,00	11,00	4,50	1,00	1,00	1,00	1,00	1,00	1,00	1,00	7,36	
RESPONDEN 5																
Financial Capability	1,00	1,00	1,00	4,00	0,33	3,00	3,00	0,14	0,09	0,13	0,24	0,12	0,28	0,14	1,15	CI
Experience in Similar Projects	1,00	1,00	0,33	2,00	0,25	1,00	4,00	0,14	0,09	0,04	0,12	0,09	0,09	0,19	1,19	0,130
Performance	1,00	3,00	1,00	3,00	0,25	2,00	4,00	0,14	0,28	0,13	0,18	0,09	0,19	0,19	1,28	
Office at Work Location	0,25	0,50	0,33	1,00	0,33	0,33	3,00	0,04	0,05	0,04	0,06	0,12	0,03	0,14	1,12	
Expert Personnel	3,00	4,00	4,00	3,00	1,00	3,00	3,00	0,43	0,37	0,54	0,18	0,35	0,28	0,14	0,93	CR
Similar Contracts	0,33	1,00	0,50	3,00	0,33	1,00	3,00	0,05	0,09	0,07	0,18	0,12	0,09	0,14	1,14	
Price	0,33	0,25	0,25	0,33	0,33	0,33	1,00	0,05	0,02	0,03	0,02	0,12	0,03	0,05	0,97	
Total	6,92	10,75	7,42	16,33	2,83	10,67	21,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	7,78	

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

Table 2. Total Fuzzy Numbers for Each Row of Criteria

Criteria	<i>Ml</i>	<i>Mm</i>	<i>Mu</i>
Financial Capability	7,8903	12,5689	17,9421
Experience in Similar Projects	7,1409	11,3815	15,9987
Performance	5,9931	10,0564	14,6546
Office at Work Location	3,6092	5,1087	7,5061
Expert Personnel	6,7528	9,2183	10,5254
Similar Contracts	2,6811	3,3463	5,3146
Price	5,4991	8,6406	12,3228
Total (Σ)	39,5665	60,3207	84,2642

The total fuzzy value for each row of the pairwise comparison matrix is then calculated by separately summing the lower (*Ml*), middle (*Mm*), and upper (*Mu*) values, in accordance with the rules for triangular fuzzy number operations. The result is a total fuzzy value for each criterion, representing its overall level of importance. These values are then presented in Table 2 and Table 3 and followed by the calculation of the over and sub-criteria all sum (Σ) for each component *Ml*, *Mm*, and *Mu*. Then, the synthetic extent (*Si*) value is calculated for each criterion and sub-criterion. This synthetic extent value is obtained by normalising the total fuzzy value of each row against the overall sum of fuzzy values, so that it represents the relative importance of each criterion and sub-criterion, as shown in Table 4. The fuzzy degree of possibility for each criterion and sub-criterion is calculated to determine their relative priority levels.

Table 3. Total Fuzzy Numbers for Each Row of Sub Criteria

Financial Capability Sub Criteria	<i>Ml</i>	<i>Mm</i>	<i>Mu</i>
Bank Statement	1,9923	2,1883	2,7248
Financial Report	2,6776	3,4547	4,0112
Rating Assessment	3,2826	3,9460	4,6169
Total (Σ)	7,9526	9,5890	11,3529
Experience in Similar Projects Sub Criteria	<i>Ml</i>	<i>Mm</i>	<i>Mu</i>
Number of Contracts	3,2891	4,2083	5,3217
Contract Value	1,8022	2,0700	2,7630
Project Owner	2,7056	4,1696	5,8455
Total (Σ)	7,7970	10,4479	13,9302
Performance Sub Criteria	<i>Ml</i>	<i>Mm</i>	<i>Mu</i>
Wage Compliance	3,4243	5,1748	6,9627
Penalty	1,4399	1,5914	1,9843
Zero Accident	3,7955	5,6073	7,6993
Good Performance	2,8870	4,5239	6,9355
Total (Σ)	11,5467	16,8974	23,5819

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

Office at Work Location Sub Criteria	MI	Mm	Mu
Office Status	1,6656	2,3088	3,4534
Office Location	2,4270	3,5281	5,6394
Supporting Facilities	2,4270	3,5281	5,6394
Total (Σ)	6,5196	9,3651	14,7323
Expert Personnel Sub Criteria	MI	Mm	Mu
Expert Certification	2,2457	3,6673	4,8762
Expert Experience	1,2580	1,3749	1,8027
Total (Σ)	3,5037	5,0422	6,6789
Similar Contracts Sub Criteria	MI	Mm	Mu
Collective Labor Agreement (CLA)	2,2457	3,1411	3,8094
Number of Workers	1,3560	1,4670	1,8027
Total (Σ)	3,6017	4,6082	5,6121

Table 4. Synthetic Extent Value

Synthetic Extent (<i>S_i</i>)	<i>l</i>	<i>m</i>	<i>u</i>
Financial Capability	0,0936	0,2084	0,4535
Bank Statement	0,1755	0,2282	0,3426
Financial Report	0,2359	0,3603	0,5044
Rating Assessment	0,2891	0,4115	0,5806
Similar Experience	0,0847	0,1887	0,4043
Number of Contracts	0,2361	0,4028	0,6825
Contract Value	0,1294	0,1981	0,3544
Project Owner	0,1942	0,3991	0,7497
Performance	0,0711	0,1667	0,3704
Wage Compliance	0,1452	0,3063	0,6030
Penalty	0,0611	0,0942	0,1719
Zero Accident	0,1610	0,3318	0,6668
Good Performance	0,1224	0,2677	0,6006
Office at Work Location	0,0428	0,0847	0,1897
Office Status	0,1131	0,2465	0,5297
Office Location	0,1647	0,3767	0,8650
Supporting Facilities	0,1647	0,3767	0,8650
Expert Personnel	0,0801	0,1528	0,2660
Expert Certification	0,3362	0,7273	1,3917
Expert Experience	0,1884	0,2727	0,5145
Similar Contracts	0,0318	0,0555	0,1343
Collective Labor Agreement (CLA)	0,4002	0,6816	1,0577
Number of Workers	0,2416	0,3184	0,5005
Price	0,0653	0,1432	0,3114

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

At the next stage, the weight of each criterion is determined by identifying the minimum degree of possibility to form the fuzzy weight vector, followed by normalization to obtain the final non-fuzzy weights. The results indicate the relative importance of each criterion, where Experience in Similar Projects has the highest weight, while Similar Contracts has the lowest weight. Table 5 presents the weight of each criterion and sub-criterion.

Table 5. Weights of Criterion and Sub-Criterion

No.	Criterion and Sub-Criterion	Weight		
		Initial	Normalization	Final
1	Financial Capability	1,0000	0,2007	0,2007
	Bank Statement	0,2259	0,1111	0,0223
	Financial Report	0,8077	0,3972	0,0797
	Rating Assessment	1,0000	0,4917	0,0987
2	Similar Experience	0,9404	0,1887	0,1887
	Number of Contracts	1,0000	0,4105	0,0800
	Contract Value	0,4435	0,1820	0,0293
	Project Owner	0,9928	0,4075	0,0794
3	Performance	0,8692	0,1744	0,1744
	Wage Compliance	0,9453	0,3303	0,0576
	Penalty	0,0439	0,0153	0,0027
	Zero Accident	1,0000	0,3494	0,0609
	Good Performance	0,8727	0,3050	0,0532
4	Office at Work Location	0,4372	0,0877	0,0877
	Office Status	0,7370	0,2693	0,0236
	Office Location	1,0000	0,3654	0,0321
	Supporting Facilities	1,0000	0,3654	0,0321
5	Expert Personnel	0,7563	0,1518	0,1518
	Expert Certification	1,0000	0,7802	0,1184
	Expert Experience	0,2817	0,2198	0,0334
6	Similar Contracts	0,2102	0,0422	0,0422
	Collective Labor Agreement (CLA)	1,0000	0,8220	0,0347
	Number of Workers	0,2165	0,1780	0,0075
7	Price	0,7698	0,1545	0,1545

The next step is to select the most suitable technical outsourcing supplier from three options: Supplier X, Supplier Y, and Supplier Z, by evaluating each based on weighted criteria and sub-criteria, and then ranking them objectively according to their performance. The final results are presented in Table 6.

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

Table 6. Evaluation Results of Supplier Alternatives

No	Criterion/Sub-Criterion	Weight	Supplier		
			X	Y	Z
1	Financial Capability	0,2007			
	Bank Statement	0,0223	0,0223	0,0223	0,0223
	Financial Report	0,0797	0,0797	0,0000	0,0000
	Rating Assessment	0,0987	0,0987	0,0987	0,0987
2	Similar Experience	0,1887			
	Number of Contracts	0,0800	0,0800	0,0800	0,0800
	Contract Value	0,0293	0,0293	0,0293	0,0293
	Project Owner	0,0794	0,0794	0,0794	0,0794
3	Performance	0,1744			
	Wage Compliance	0,0576	0,0576	0,0576	0,0576
	Penalty	0,0027	0,0027	0,0027	0,0027
	Zero Accident	0,0609	0,0609	0,0609	0,0609
	Good Performance	0,0532	0,0532	0,0532	0,0532
4	Office at Work Location	0,0877			
	Office Status	0,0236	0,0236	0,0236	0,0236
	Office Location	0,0321	0,0321	0,0321	0,0321
	Supporting Facilities	0,0321	0,0321	0,0321	0,0321
5	Expert Personnel	0,1518			
	Expert Certification	0,1184	0,1184	0,1184	0,1184
	Expert Experience	0,0334	0,0334	0,0000	0,0334
6	Similar Contracts	0,0422			
	Collective Labor Agreement (CLA)	0,0347	0,0000	0,0000	0,0000
	Number of Workers	0,0075	0,0000	0,0000	0,0000
7	Price	0,1545	0,1229	0,1545	0,1102
	Total		0,9263	0,8448	0,8338
	Score		92,63	84,48	83,38
Rank			1	2	3

Based on Table 6, Supplier X achieved the highest score of 0.9263, followed by Supplier Y with 0.8448, and Supplier Z with 0.8338. These results indicate that Supplier X has a more balanced competitive advantage across the key criteria. The synthetic extent value is calculated by normalising the total fuzzy value of each row against the overall

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

sum of fuzzy values, thereby representing the relative importance of each criterion and sub-criterion, as illustrated in Table 4. This reflects that in multi-criteria decision-making models, consistency across various aspects is more influential than excellence in a single factor, such as price. In contrast, although Supplier Y excels in price, it loses points in the expert personnel aspect, resulting in a lower overall score. Meanwhile, Supplier Z shows performance relatively similar to Supplier X but lacks additional advantages in financial and contract-related aspects, placing it in the lowest rank. Several criteria showed identical scores across the three suppliers. For example, in the Similar Experience criterion, all suppliers received full points, indicating that in this criterion all suppliers were able to meet the supplier assessment aspects. The same situation also occurred in the Performance and Office at Work Location criteria. In future research, it is necessary to add other sub-criteria so that they can be differentiators in the value of supplier selection. A different situation occurred in the Similar Contracts criterion, where none of the three suppliers received a score on this criterion. This may occur because the suppliers do not have ongoing similar contracts with other electricity company entities.

A sensitivity analysis was conducted to determine how price changes could affect the final total weight and ranking position of each supplier in the decision-making process. Supplier Y and Supplier Z's bid prices were gradually lowered until each was ranked first. Based on procurement data, Supplier Z had the highest bid price of Rp15,188,799,889.00, while Supplier X had Rp13,616,669,886.00, and Supplier Y had Rp10,836,073,746.00. The sensitivity analysis is presented in tabular form in Table 7.

Table 7. Sensitivity Analysis of The Price Bid Sub-Criteria

Supplier Y			Supplier X		Supplier Z	
% Price	Bid Price	Score	Bid Price	Score	Bid Price	Score
100%	10.836.073.746	0,8448	13.616.669.886	0,9263	15.188.799.889	0,8338
99%	10.727.713.009	0,8448	13.616.669.886	0,9250	15.188.799.889	0,8327
98%	10.619.352.271	0,8448	13.616.669.886	0,9238	15.188.799.889	0,8316
97%	10.510.991.534	0,8448	13.616.669.886	0,9226	15.188.799.889	0,8305
...
35%	3.792.625.811	0,8448	13.616.669.886	0,8464	15.188.799.889	0,7622
34%	3.684.265.074	0,8448	13.616.669.886	0,8451	15.188.799.889	0,7611
33%	3.575.904.336	0,8448	13.616.669.886	0,8439	15.188.799.889	0,7600
32%	3.467.543.599	0,8448	13.616.669.886	0,8427	15.188.799.889	0,7589
31%	3.359.182.861	0,8448	13.616.669.886	0,8414	15.188.799.889	0,7578
30%	3.250.822.124	0,8448	13.616.669.886	0,8402	15.188.799.889	0,7567
Supplier Z			Supplier X		Supplier Y	
% Price	Bid Price	Score	Bid Price	Score	Bid Price	Score
100%	15.188.799.889	0,8338	13.616.669.886	0,9263	10.836.073.746	0,8448
99%	15.036.911.890	0,8350	13.616.669.886	0,9263	10.836.073.746	0,8448
98%	14.885.023.891	0,8361	13.616.669.886	0,9263	10.836.073.746	0,8448
97%	14.733.135.892	0,8373	13.616.669.886	0,9263	10.836.073.746	0,8448
...
45%	6.834.959.950	0,8781	13.616.669.886	0,8809	10.836.073.746	0,7877
44%	6.683.071.951	0,8781	13.616.669.886	0,8792	10.836.073.746	0,7856
43%	6.531.183.952	0,8781	13.616.669.886	0,8774	10.836.073.746	0,7834
42%	6.379.295.953	0,8781	13.616.669.886	0,8757	10.836.073.746	0,7812
41%	6.227.407.954	0,8781	13.616.669.886	0,8740	10.836.073.746	0,7791
40%	6.075.519.956	0,8781	13.616.669.886	0,8723	10.836.073.746	0,7769

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

DISCUSSION

Analysis of Criteria Weights

The weighting of criteria is a crucial stage in this decision-making model. The use of the Fuzzy Analytic Hierarchy Process (FAHP) allows uncertainty in decision-makers' preferences to be accommodated through the degree of possibility values. In Table 5, the weight of each criterion is obtained. Financial Capability has the highest weight of 0.2007, followed by Similar Experience of 0.1887, and Performance of 0.1744 in second and third place. Price and Expert Personnel received nearly equal weightings of 0.1545 and 0.1518. Office at Work Location has 0.0877, and Similar Contracts have the lowest weight of 0.0422. From these results, it is known that Financial Capability has the highest level of importance compared to other criteria. It implies that supplier financial stability is the critical factor in project sustainability. Besides that, the supplier's capabilities and track record of experience are also more important than the supplier's offer price. The criteria for Similar Contracts and Office Location at the Workplace have the lowest weighting compared to other criteria, indicating that these administrative criteria are less influential than the others. This is in line with previous FAHP-based supplier selection studies that prioritized financial and technical capabilities and supplier performance as the primary criteria in supplier selection. However, the Price criterion differs. This study found that financial capabilities and supplier experience were more important than price. This may be due to the electricity utility sector prioritizing operational feasibility, project reliability, and service continuity over cost. Failure by supplier personnel to maintain the continuity of the power system can result in greater losses.

Analysis of Alternative Evaluation Results

Three potential suppliers (X, Y, and Z) were systematically assessed and compared based on established criteria to identify the most suitable option for the company after the weights of each evaluation criterion had been determined. The results indicate that the FAHP method is able to generate different weights for each supplier selection criterion and sub-criteria. Supplier X has superior financial capabilities compared to other suppliers and therefore received the highest weighting on this criterion. In the Similar Experience, Performance, and Workplace Location criteria, all suppliers received full marks. In the Expert Personnel criterion, Suppliers X and Z received full marks, while Supplier Y received no marks on the Expert Experience sub-criterion. This indicates that this criterion significantly determines the final outcome in supplier selection. In the Similar Contracts criterion, no suppliers received any marks. This occurred because it was very difficult to find suppliers with technical personnel contracts at other electric utilities. This criterion may be less relevant for use in selecting technical personnel suppliers. In the Price criterion, Supplier Y offered the most competitive price compared to other suppliers and received the highest score on this criterion. However, it was still not enough for Supplier Y to surpass Supplier X's overall score and become the best supplier. Some criteria have low discriminating ability because all suppliers receive the same score. This is also true in previous FAHP-based supplier selection studies, where high supplier qualification standards were unable to differentiate between alternatives. While these criteria remain important from a compliance perspective, their contribution to differentiating supplier rankings is limited. Therefore, future research should consider adding indicators that are more sensitive to operational performance, such as responsiveness, technological capability, or innovation capacity, to enhance the evaluation model's discriminating ability. The results indicate that emphasizing financial transparency, technical certification, and supplier capabilities can improve procurement quality and reduce operational risk in electric utility projects.

Sensitivity Analysis of Price

Based on Table 7, Supplier Y can exceed the total weight of the other two suppliers only if Supplier Y lowers its price to equal or lower than 33% of the initial price offer, which is at Rp3,575,904,336.00. This shows that changes in the price sub-criteria of Supplier Y's offer do not have a significant effect on increasing its final preference value in the model used. On the other hand, the total weight values of Supplier X and Supplier Z experience a gradual decrease along with changes in the percentage of offers, even though the price values of both do not change. This finding demonstrates that Supplier X's superiority is relatively robust because a very substantial reduction in Supplier Y's bid price was required before the ranking changed. Similarly, it can be seen that Supplier Z can exceed the total

Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

weight of the other two suppliers if it lowers its price to the same or lower than 43% of the initial price offer, which is Rp6,379,295,953.00. On the other hand, even though the prices offered by Supplier X and Supplier Y remain constant, the total weight value of both tends to decrease gradually along with changes in the percentage of offers made in the test scenario. These results suggest that Supplier X's ranking remains stable under moderate price fluctuations and only changes under extreme reductions in competing suppliers' bid prices. This sensitivity analysis indicates that price is not a significant factor in supplier selection, but should also be supported by other factors such as financial capacity, experience, and performance. Although in the scenario where Supplier Y and Supplier Z could ultimately outperform Supplier X, such a scenario is likely unrealistic, as an excessively low bid price could impact the supplier's performance, financial sustainability, and service quality during the contract execution. From a practical perspective, this analysis also suggests that procurement decisions focused solely on the lowest price do not always result in the selection of the most reliable supplier, particularly in industries requiring high levels of operational reliability and technical competence.

CONCLUSION

This study aimed to develop a Fuzzy Analytic Hierarchy Process (FAHP) model for selecting technical personnel suppliers in the electricity utility sector. The results show that the FAHP method can effectively handle uncertainty and subjectivity in procurement decision-making by combining quantitative and qualitative criteria in a structured way. The study answers the main research problem by showing how companies can select the most suitable supplier based not only on price, but also on strategic capability factors. This indicates that operational reliability, financial stability, experience, and technical capability are considered more important than bid price. Therefore, the FAHP approach can help companies make more objective supplier selection decisions. The results of this study indicate that a low price is not sufficient for a supplier to achieve the highest overall score, as financial capability, experience, and performance have a greater influence on the final outcome. Furthermore, a sensitivity analysis shows that the FAHP model is relatively robust to price changes. Ranking changes only occur during extreme price decreases, confirming that supplier selection decisions do not depend on the lowest bid price.

This study can be used by companies to more comprehensively assess suppliers and reduce operational risks in technical personnel procurement. However, this study has several limitations. The number of expert respondents involved in determining the criteria weights is relatively small, and it would be beneficial to conduct it with more respondents. Furthermore, the research object is also limited to one organizational unit, and it would be better if it were expanded to other units to obtain more diverse information. Supplier identities are also anonymized to maintain confidentiality, thus limiting external verification in the study. The FAHP method can be combined with other multi-criteria decision-making methods such as TOPSIS, VIKOR, or PROMETHEE to provide more comprehensive supplier evaluation results. Adding more operational performance criteria, such as innovation capability and responsiveness, may also improve the model's ability to differentiate suppliers more effectively.

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Supplier Selection For Technical Labor Procurement Using Fuzzy Analytical Hierarchy Process Approach In The Power Company / Hari Asman, Niniet Indah Arvitrida, Suparno

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