Vendor Selection Analysis using Analytical Hierarchy Process (AHP) Method in Engineering, Procurement and Construction (EPC) Business
Pt. Rekadaya Elektrika

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Abstract:- Vendors have an important role in Supply Chain Management which will have an impact on company performance. One of method that can be used in vendor selection is the Analytical Hierarchy Process (AHP) method. This research was conducted at the company PT Rekadaya Elektrika which is engaged in the national electric power EPC. The sample of this research were all employees in the SCM Unit. The sampling technique used in this research is judgment sampling. Based on the results of this research, it was found that the most influential criteria in the selection of transmission tower material fabrication vendors were the priority I is lead time (0.390), priority II is quality (0.246), priority III is price (0.169), priority IV is quantity (0.111) and priority V is service (0.084). From the results of the assessment of alternative priority levels, priority I is Vendor D (0.386), priority II is Vendor E (0.230), priority III is Vendor C (0.195), priority IV is Vendor B (0.105) and priority V is Vendor A (0.066). Based on the results of the analysis, Vendor D is the vendor that has the highest overall value.

Keywords:- Vendor Selection, Analytical Hierarchy Process (AHP), Supply Chain Management, software expert choice.

I. INTRODUCTION

Vendors are important in Supply Chain Management which will have an impact on company performance. Therefore, the selection of vendors is an important part in sustaining the running of a project, with a supply of materials that are in accordance with demand, delivery schedules and affordable costs will result in maximum project profits. So companies need to conduct vendor assessments carefully and precisely.

Based on this, management is required to be able to select vendors carefully and precisely. In selecting vendors, the first step that must be done by the company is to determine the criteria as a reference for the assessment process. This is in accordance with the opinion of Pujawan and Mahendrawati (2017) who argue that the criteria used in the selection of suppliers are important things that can reflect the supply chain strategy and the characteristics of the goods to be supplied.

The next process is to determine the analytical tools to solve the problem. Some of the criteria that influence this vendor selection decision are qualitative and quantitative. Therefore, a method is needed to cover both. The Analytical Hierarchy Process (AHP) method can be used to solve problems in selecting the vendor (Mubarok, 2017). This method is used to solve complex problems by building a hierarchy of criteria, prospects and outcomes, using different considerations as weights or priorities (Mubarok, 2017).
II. RESEARCH METHOD

A. Research Design

![Research Flowchart](image_url)

**Fig. 1:** Research Flowchart

Source: Personal Processed Data, 2022

B. Research Instrument

Data used in this study include:

- Primary data, in the form of questionnaires and the results of forum group discussion for employees who provide an assessment of suppliers.
- Secondary data, in the form of data derived from historical data or vendor performance records and vendor lists as well as company tender documents.

C. Data Processing

In this study the method used is the Analytical Hierarchy Process (AHP) method. The calculation of the AHP method can be done using the help of expert choice software. Here are some steps that must be taken in the selection of vendors.

1. Develop a hierarchy of problems
   The hierarchical structure is formed based on the criteria and subcriteria that will be used in the selection of the transmission tower material fabrication vendor. The hierarchical structure in this study can be described as follows.
From the Figure 2.2, it can be seen that level one is the criteria that will be used including: Price, Quality, Service, Lead Time and Quantity. Level two is a subcriteria where there are eleven subcriteria used in this study. Next for level three are alternative vendors to be selected, including: Vendor A, Vendor B, Vendor C, Vendor D, and Vendor E.

2. Compile a pairwise comparison matrix that has accommodated the relative influence of each element on each criterion objective at the level above.

3. Perform calculations weight or priority on each criterion variable. The following are the steps in calculating the weights for each criterion.
   a. For each criterion, make of pairwise comparisons
   b. Performing the average calculation of the respondents' assessment results using the geometric mean. Averaging these values is mandatory because AHP only knows one answer for the comparison matrix. Mathematically the geometric mean theory can be written with the following formula.
   \[
   a_{ij} = \left( Z_1, Z_2, Z_3, \ldots , Z_n \right)^{1/n}
   \]
   Description :
   \(a_{ij} \): The average value of pairwise comparisons, criteria \(Ai\) with \(Aj\) for \(n\) respondents  
   \(Z_1\) : The comparison value between \(Ai\) and \(Aj\) for respondent \(I\), with \(i = 1, 2, 3, \ldots, n\)  
   \(N\) : Number of respondents  
   c. The results obtained from pairwise comparisons are then displayed in the form of a pairwise comparison matrix or pairwise comparison  
   d. Divide each element in a certain column by the value of the number of that column  
   e. The results in step (d) are then normalized to obtain the eigenvector matrix by averaging the number of rows with the criteria used. The calculation above shows the eigenvector which is the priority weight of the criteria used against the goal.  
   The Formula is :
   \[ A.w = \lambda.w \]
   Description :
   \(w\) : eigenvector  
   \(\lambda\) : eigenvalue  
   \(A\) : square matrix  
   f. Perform the calculation of the consistency ratio as follows:
   i. Multiply the value of the initial comparison matrix by the weight  
   ii. Multiply the number of rows by the weight  
   iii. Calculate max by adding up the product above divided by \(n\).  
   \[ \lambda_{max} = \left( \sum \lambda \right)/n \]  
   iv. Calculating the consistency index can be measured through CI which is formulated:
   \[ CI = \frac{\left( \lambda_{max} - n \right)}{(n - 1)} \]
   Description :
   \(CI\) : consistency index  
   \(\lambda_{max}\) : maximum eigenvalue  
   \(n\) : matrix order  
   v. Calculate the consistency ratio with the following formula:
   \[ CR = \frac{CI}{RI} \]
4. Calculating of weight or priority on each subcriteria that has been determined with the same stages in point 3 above. Next, determine the global priority by multiplying the local priority for each subcriteria against the priority criteria.

5. Calculating of weight or priority for each alternative vendor that has been determined with the same stages in point 3 above.

6. Determine the vendor to be selected by adding up the whole of the multiplication of vendor weights with subcriteria weights. The overall value of each vendor is what will determine which the best vendor, it is the vendor with the highest value.

D. Operational Variables

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>DIMENSIONS</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>Price feasibility versus quality (P1)</td>
<td>Bidding Document</td>
</tr>
<tr>
<td></td>
<td>Ability to provide discounted prices (P2)</td>
<td>Percentage of Discount</td>
</tr>
<tr>
<td>Service</td>
<td>Communication (S1)</td>
<td>Response and Feedback</td>
</tr>
<tr>
<td></td>
<td>Responsiveness to consumer requests (S2)</td>
<td>Response and Feedback</td>
</tr>
<tr>
<td></td>
<td>Ability to solve problems (S3)</td>
<td>Response and Feedback</td>
</tr>
<tr>
<td></td>
<td>Ability to provide routine fabrication progress (S4)</td>
<td>Progress Report</td>
</tr>
<tr>
<td>Quality</td>
<td>Production of materials without defects (Q1)</td>
<td>Inspection Report</td>
</tr>
<tr>
<td></td>
<td>Material conformity with approved specifications (Q2)</td>
<td>Drawing and Specification</td>
</tr>
<tr>
<td>Lead Time</td>
<td>Speed of supply raw material (L1)</td>
<td>Material Schedule</td>
</tr>
<tr>
<td></td>
<td>Ability to complete fabrication in accordance with the agreement (L2)</td>
<td>Contractual Documents</td>
</tr>
<tr>
<td>Quantity</td>
<td>Conformity with order quantity (J1)</td>
<td>Order Quantity / Packing list</td>
</tr>
</tbody>
</table>

Table 1: Table of Operational Variables

Source: Personal Processed Data, 2022

III. RESULTS AND DISCUSSION

A. Priority of Criteria

![Vendor Selection Based on Priority of Criteria](image)

Selection of the transmission tower material fabrication vendor from all the criteria used result is, the first priority criteria used is lead time with a weight of 0.390, then the second priority is quality with a weight of 0.246, the third priority is the price with a weight of 0.169, the fourth priority is the quantity with a weight of 0.111 and the last or fifth priority is the service with a weight of 0.084.
B. Vendor Selection Based on Criteria

Vendor Selection Based on Price Criteria

In the price criteria, the first priority is Vendor D with a weight of 0.462, the second priority is Vendor E with a weight of 0.206, the third priority is Vendor C with a weight of 0.169, the fourth priority is Vendor B with a weight of 0.090 and the fifth priority is Vendor A with a weight of 0.073.

C. Vendor Selection Based on Service Criteria

In the service criteria, the first priority is Vendor D with a weight of 0.394, the second priority is Vendor E with a weight of 0.247, the third priority is Vendor C with a weight of 0.192, the fourth priority is Vendor B with a weight of 0.115 and the fifth priority is Vendor A with a weight of 0.052.
D. Vendor Selection Based on Quality Criteria

![Synthesis: Summary](image)

Combined instance - Synthesis with respect to: Kualitas (Quality)
(Goal: Pemilihan Vendor Fa > Kualitas (Quality) (L1,2))
Overall Inconsistency = 0.02

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.379</td>
</tr>
<tr>
<td>C</td>
<td>0.230</td>
</tr>
<tr>
<td>E</td>
<td>0.223</td>
</tr>
<tr>
<td>B</td>
<td>0.106</td>
</tr>
<tr>
<td>A</td>
<td>0.063</td>
</tr>
</tbody>
</table>

Fig. 6: Vendor Selection Based on Quality Criteria
Source: AHP Processing Result, 2022

In the quality criteria, the first priority is Vendor D with a weight of 0.379, the second priority is Vendor C with a weight of 0.230, the third priority is Vendor E with a weight of 0.223, the fourth priority is Vendor B with a weight of 0.106 and the fifth priority is Vendor A with a weight of 0.063.

E. Vendor Selection Based on Lead Time Criteria

![Synthesis: Summary](image)

Combined instance - Synthesis with respect to: Waktu Tunggu Pekerjaan (Lead Time)
(Goal: Pemilihan Vendor Fa > Waktu Tunggu Pekerjaan (L))
Overall Inconsistency = 0.02

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.396</td>
</tr>
<tr>
<td>C</td>
<td>0.235</td>
</tr>
<tr>
<td>E</td>
<td>0.211</td>
</tr>
<tr>
<td>B</td>
<td>0.099</td>
</tr>
<tr>
<td>A</td>
<td>0.058</td>
</tr>
</tbody>
</table>

Fig. 7: Vendor Selection Based on Lead Time Criteria
Source: AHP Processing Result, 2022

In the lead time criteria, the first priority is Vendor D with a weight of 0.396, the second priority is Vendor C with a weight of 0.235, the third priority is Vendor E with a weight of 0.211, the fourth priority is Vendor B with a weight of 0.099 and the fifth priority is Vendor A with a weight of 0.058.
F. Selection of Vendors Based on Quantity Criteria

In the quantity criteria, the first priority is Vendor E with a weight of 0.314, the second priority is Vendor D with a weight of 0.285, the third priority is Vendor C with a weight of 0.177, the fourth priority is Vendor B with a weight of 0.131, and the fifth priority is Vendor A with a weight of 0.093.

G. Consistency

<table>
<thead>
<tr>
<th>Pairwise Comparison</th>
<th>CR</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between criteria</td>
<td>0.03</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between price subcriteria</td>
<td>0.00</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between servicesubcriteria</td>
<td>0.01</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between qualitysubcriteria</td>
<td>0.00</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between lead timesubcriteria</td>
<td>0.00</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaP1</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaP2</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaS1</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaS2</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaS3</td>
<td>0.04</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaS4</td>
<td>0.03</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaQ1</td>
<td>0.01</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaQ2</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaL1</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to subcriteriaL2</td>
<td>0.02</td>
<td>Consistent</td>
</tr>
<tr>
<td>Between alternatives to criteria quantity</td>
<td>0.03</td>
<td>Consistent</td>
</tr>
</tbody>
</table>

Table 3.1 Consistency Ratio of Respondents' Assessment

Source : AHP Processing Result, 2022

From Table 3.1 can be seen that there is no CR value that exceeds 0.1 so that all respondents' assessments can be declared consistent and can be used.
**H. Discussion**

<table>
<thead>
<tr>
<th>Subcriteria</th>
<th>Priority</th>
</tr>
</thead>
</table>
| Price Subcriteria | 1. Ability to provide discounted prices (P2) (0,762)  
| | 2. Price feasibility versus quality (P1) (0,238) |
| Service Subcriteria | 1. Ability to provide routine fabrication progress (S4) (0,465)  
| | 2. Ability to solve problems (S3) (0,275)  
| | 3. Communication (S1) (0,161)  
| | 4. Responsiveness to consumer requests (S2) (0,098) |
| Quality Subcriteria | 1. Material conformity with approved specifications (Q2) (0,751)  
| | 2. Production of materials without defects (Q1) (0,249) |
| Lead Time Subcriteria | 1. Ability to complete fabrication in accordance with the agreement (L2) (0,813)  
| | 2. Speed of supply raw material (L1) (0,187) |

<table>
<thead>
<tr>
<th>Criteria Priority</th>
</tr>
</thead>
</table>
| 1. Lead Time (0,390)  
| 2. Quality (0,246)  
| 3. Price (0,169)  
| 4. Quantity (0,111)  
| 5. Services (0,084) |

<table>
<thead>
<tr>
<th>Alternative Priority</th>
</tr>
</thead>
</table>
| 1. Vendor D (0,386)  
| 2. Vendor E (0,230)  
| 3. Vendor C (0,195)  
| 4. Vendor B (0,105)  
| 5. Vendor A (0,066) |

Table 3.2: Executive Summary AHP Processing

Source: Personal Processed Data, 2022

Based on the results of the AHP processing above, it can be seen that the most influential criteria in the selection of transmission tower material fabrication vendors are lead time criteria with a weight of 0.390, the next criteria is the quality criteria on the second priority with a weight of 0.246, the third priority is the price with a weight of 0.169, the fourth priority is the quantity with a weight of 0.111 and the last priority is the service with a weight of 0.084.

The lead time criteria in this research include 2 (two) sub criteria, the speed of supply of raw materials (L1) and the ability to complete the fabrication in accordance with the agreement (L2). Of the two subcriteria, the subcriteria for the ability to complete the fabrication in accordance with the agreement (L2) occupies the first priority with a weight of 0.813 and the second priority is occupied by the sub criteria for the speed of supply raw materials (L1) with a weight of 0.187.

The most influential of the priority lead time and sub-criteria Ability to complete the fabrication in accordance with the agreement (L2) in the selection of the transmission tower material fabrication vendor. It can be seen that PT. RekadaYa Elektrika prioritizes punctuality in the fabrication of transmission tower materials. This is not without reason because the delay in the transmission tower material fabrication schedule, take effect in a delay the material on site schedule, thus disrupting field activities. The delay of material on site schedule will affect the overall project schedule and the biggest impact is the project cost (overhead cost) which is still running even though the work on the main material has not yet started. Not to mention if it results in a delay in the project completion schedule so that PT RekadaYa Elektrika has the potential to get a liquidated damages from the owner.

Overall result in the selection of transmission material fabrication vendors, Vendor D has the first priority with a weight of 0.386, the second priority is occupied by Vendor E with a weight of 0.230, the third priority is Vendor C with a weight of 0.195, the fourth priority is Vendor B with a weight of 0.105 and the last or fifth priority, occupied by Vendor A with a weight of 0.066. Vendor D wins absolutely for the 4 (four) criteria, it is the criteria for price, service, quality and lead time. However, for the quantity criteria of Vendor D is only able to occupy the second priority, where for the first priority is occupied by Vendor E.
IV. CONCLUSION AND RECOMMENDATION

A. Conclusion
Based on discussion and results of the research, it can be concluded several things including the following:

• The most influential criteria in the selection of the transmission tower material fabrication vendor is lead time criteria with a weight of 0.390 as the first priority, then the second priority is quality with a weight of 0.246, the third priority is price with a weight of 0.169, the fourth priority is the quantity with a weight of 0.111 and the last or fifth priority is service with a weight of 0.084.

• Based on the criteria and subcriteria used in the selection of the transmission tower material fabrication vendor, it can be concluded that Vendor D is the best vendor in the transmission tower material fabrication with a weight of 0.386, then for the second priority is occupied by Vendor E with a weight of 0.230, the third priority is Vendor C with a weight of 0.195, the fourth priority is Vendor B with a weight of 0.105 and the last or fifth priority is occupied by Vendor A with a weight of 0.066.

B. Recommendation
Based on the results and conclusions of this study, the authors provide suggestions regarding several things to the company:

• In the bidder list selection process, it is expected that the bidder list has been filtered on the financial capabilities of the bidders and weighted the criteria for determining the bidder list. So it is hoped that the selection process will produce the best vendor according to the company's needs.

• If at another time there are new criteria that are more in line with the vendor selection process, it is expected to be able to re-weight each criteria to be used so that the results of determining the criteria are not more subjective.

REFERENCES


