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EPC Contractor Selection Using Fuzzy AHP, TOPSIS, Partial Value Function, and Time Decay Correction Methods

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ABSTRACT

The selection of EPC contractors at PT XZ heavily relies on the lowest-bid method, which focuses on cost-effectiveness but may disregard the contractor's technical expertise, ability to implement projects, and previous track record. This study develops a model for contractor selection based on performance and objectivity by integrating some methods such as fuzzy AHP, TOPSIS, partial value function (PVF), and time decay correction (TDC). Fuzzy AHP is used to assign weight to criteria and TOPSIS is used to rank the contractors, PVF and TDC is used to evaluate the performance of previous projects more proportionally. The results show that Price Bid has the biggest weight at 0.362, with Technical Qualifications second at 0.279 and Previous Project Performance third at 0.234. This result shows that price remains a dominant factor in selecting EPC contractors. However, the price is still combined with technical criteria, project execution capability, project experience, and the contractor's past performance, so the model provides a more balanced evaluation, where cost efficiency is considered without ignoring the risks of project delays, additional work, lower work quality, and failure to achieve the project target. Based on the TOPSIS results, Contractor E (0.8837) is the most suitable contractor for Project XYZ. However, the difference in preference scores should also be considered as an early signal of project risk, particularly for lower-ranked contractors (A, B, C, and D). PT XZ should therefore set a minimum preference score before awarding the contract. This would help ensure that the selected contractor is not only competitive in price, but also strong in technical capability and past performance. The sensitivity analysis confirms that the ranking is stable, making the model useful for transparent and risk-based contractor selection.

Keywords: EPC Contractors Selection, Fuzzy AHP, TOPSIS, Partial Value Function, Time Decay Correction.

INTRODUCTION

PT XZ plays a strategic role in electricity supply. Based on the electricity network development plan, electricity demand is projected to grow at an average rate of 5.3% per year. To meet this increasing of electricity demand, PT XZ must build a massive power infrastructure, such as transmission lines and substations.

Transmission and substation projects at PT XZ are commonly tendered using Engineering, Procurement, and Construction (EPC) scheme. However, the contractor selection process at PT XZ still depend on the lowest bid approach. Although this approach may assist in terms of cost effectiveness, it would not always give a true representation of the overall capability of a contractor, especially when viewed in the aspects of technical quality/capabilities, managerial strength and experience/past performance. As a result, the contractor offering the lowest price may not always be the most capable of completing the project on time and in line with PT XZ's quality guidelines.

Delays in several ongoing transmission and substation projects show that contractor capability remains an important concern for PT XZ. Some projects are already behind schedule (based on ongoing project data), while others still carry a similar risk. Therefore, contractor selection in PT XZ should not rely mainly on the lowest bid price but also consider measurable performance indicators and past project records (delays and termination contract).

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Contractor selection in EPC transmission and substation projects involves multiple criteria beyond bid price, including technical capability, financial capacity, project management readiness, and past performance. MCDM methods are therefore useful for supporting a more structured and objective evaluation process. Previous studies have applied methods such as AHP [1], [2], ANP [3], PROMETHEE [4], BWM [5], and SWARA-CoCoSo [6] to determine criteria weights and compare alternatives across different decision contexts. In addition, fuzzy-based MCDM approaches have been introduced to handle uncertainty in expert judgment and contractor assessment. Several hybrid models, including Fuzzy BWM–Fuzzy TOPSIS [5], Light GBM–TOPSIS [7], and Fuzzy AHP–Fuzzy TOPSIS [8], show that combining weighting and ranking methods can improve the quality of contractor selection decisions.

This study proposes a contractor selection model for transmission and substation EPC projects by combining fuzzy AHP (criteria weighting), TOPSIS (ranking), partial value function (performance scoring), and time decay correction (historical performance assessment). The proposed model is expected to help PT XZ evaluate contractors more comprehensively by considering both price and nonprice factors, including contractors' historical performance. The study's findings are expected to support a more transparent, accountable, and data-driven EPC procurement process, thereby reducing project delay risks and enabling the achievement of commercial operation date targets.

METHODS

The study's EPC contractor selection process employs a multi-method evaluation approach to provide a more thorough assessment of contractors, considering both cost and non-cost factors, including contractors' past performance, via techniques such as fuzzy AHP, TOPSIS, partial value function, and time decay correction.

The fuzzy analytical hierarchy process (Fuzzy AHP) method is used to determine the weights of criteria and subcriteria in the selection of transmission and substation EPC contractors. Fuzzy set theory was first introduced by Lotfi Zadeh in 1965 [9]. Fuzzy sets are intended to model uncertainty, imprecision, incomplete information, and partial truth in decision-making processes [10]. Fuzzy AHP is applied because contractor evaluation cannot always be expressed precisely, especially when it involves subjective and linguistic judgments from experts [11]. With the Triangular Fuzzy Number approach, judgments such as "more important," "very important," or "absolutely more important" can be converted into fuzzy numbers. This makes the weighting process easier and more realistic, capturing the uncertainty in human opinions [12]. As a result, Fuzzy AHP produces weights that better reflect the complexity of real decision-making [13].

Once the criteria weights are determined, the Partial Value Function (PVF) is used to turn the contractors past performance into scores that reflect their actual achievements more fairly [14]. This method allows each performance indicator to be evaluated according to its level of achievement, enabling differences in contractor performance to be represented more fairly and objectively. Furthermore, time decay correction (TDC) is implemented to adjust historical performance values based on time relevance. More recent project performance is given greater influence than older projects, as it is considered to better reflect the contractor's current capability [15].

In the final stage, the TOPSIS method is used to determine contractor rankings based on the final values of all calculated criteria. TOPSIS evaluates each contractor alternative by comparing its distance to the positive and negative ideal solutions [16]. The contractor with the closest proximity to the positive ideal solution and the furthest distance from the negative ideal solution is considered the best alternative [17]. The research framework of this study is presented as follows:

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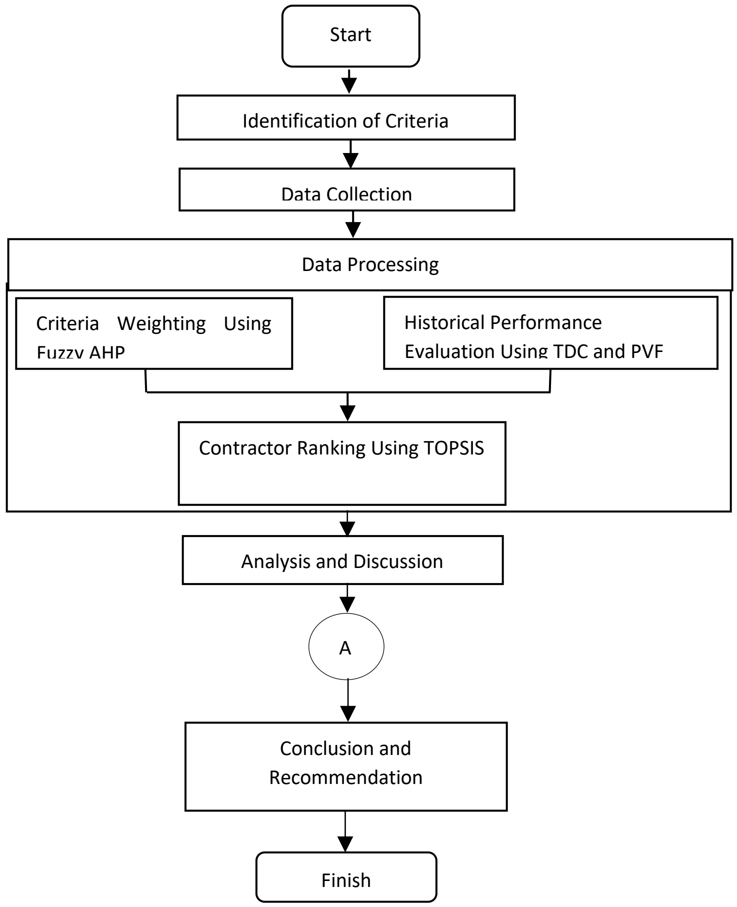

Figure 1. Research Flow Diagram

Based on the research flow presented above, the steps carried out in this research are as follows:

1) Identifying the criteria and sub-criteria used for evaluating EPC contractors
2) Collecting relevant research data, including expert judgments and historical contractor performance data
3) Processing the collected data to ensure completeness, consistency, and suitability for the proposed decision-making model.
4) Determining the weights of criteria and sub-criteria using the fuzzy AHP method
5) Applying partial value function and time decay correction to calculate contractor evaluation scores based on historical performance.
6) Calculating the final scores and ranking contractors using the TOPSIS method
7) Conducting analysis and discussion of the ranking results.
8) Drawing conclusions and formulating recommendations based on the research findings.

RESULT AND DISCUSSION

Selection of Criteria and Subcriteria

The criteria and subcriteria used as the basis for evaluation in this study were agreed upon by expert respondents, as presented in the following table:

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Table 1. List of Criteria and Subcriteria

Criteria	Code	Subcriteria	Code
Administrative Qualification	K1	Regulatory Compliance	K11
		Project Organization	K12
Technical Qualification	K2	Technical Specifications	K21
		Type and Capacity of Equipment	K22
		Project Execution Method	K23
		Project Schedule	K24
Company Qualification	K3	Financial Capability	K31
		Key Personnel	K32
		Occupational Health and Safety Management	K33
Past Project Performance	K4	Number of Similar Projects	K41
		Termination in Pas Contract	K42
		Delay in Pas Contract	K43
Price Offer	K5	Lowest Bid Price	K51
		Local Content	K52

Consistency Ratio

Based on the completed questionnaires from the expert respondents, namely, Respondents 1, 2, 3, 4, and 5, a consistency assessment was conducted to evaluate the reliability of each respondent's pairwise comparison judgments. The assessment was conducted using the consistency ratio, where a value below 0.1 indicates that the judgment is acceptable and consistent [1]. The results of the consistency measurement for each respondent are presented as follows:

Table 2. Consistency Level Measurement of Each Respondent

Consistency Test Object	Consistency Level				
	R1	R2	R3	R4	R5
Criteria	0.06	0.02	0.02	0.05	0.07
Administrative Qualification Subcriteria	0.00	0.00	0.00	0.00	0.00
Technical Qualification Subcriteria	0.02	0.04	0.04	0.02	0.02
Company Qualification Subcriteria	0.05	0.00	0.00	0.00	0.02
Historical Project Performance Subcriteria	0.01	0.01	0.00	0.01	0.03
Price Offer Subcriteria	0.00	0.00	0.00	0.00	0.00

The consistency ratio results presented in Table 2 show that all questionnaire assessments provided by the respondents have values below 0.1, indicating that the judgments are acceptable and consistent. Therefore, the questionnaire data can be used for the weighting calculation process using the fuzzy AHP method.

Criteria and Subcriteria Weights

Following the confirmation of consistent results from the respondents' evaluation questionnaires, the questionnaire data were further processed using the Fuzzy AHP method to derive the weights for the criteria and subcriteria in contractor evaluation. The following are the results of the criteria subcriteria weighting calculations using the fuzzy AHP method:

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Table 3. Weights of Criteria

Criteria	Code	Weight
Administrative Qualification	K1	0.067
Technical Qualification	K2	0.279
Company Qualification	K3	0.057
Past Project Performance	K4	0.234
Price Offer	K5	0.362

The Fuzzy AHP weighting results showed that the Price Offer criterion (K5) was the most dominant factor in EPC contractor selection, with a weight of 0.362, followed by Technical Qualification (K2) with a weight of 0.279 and Historical Project Performance (K4) with a weight of 0.234. Administrative Qualification (K1) and Company Qualification (K3) received lower weights of 0.067 and 0.057, respectively. The evaluation process continues to prioritize price considerations, while also taking into account technical capability and contractor track record as key factors in reducing project execution risks.

The results of the subcriteria weighting calculations, as determined by the fuzzy AHP method, are as follows.

Table 4. Weights of the Subcriteria

Subcriteria	Code	Weight
Regulatory Compliance	K11	0.950
Project Organization	K12	0.050
Technical Specifications	K21	0.541
Type and Capacity of Equipment	K22	0.159
Project Execution Method	K23	0.048
Project Schedule	K24	0.252
Financial Capability	K31	0.809
Key Personnel	K32	0.072
Occupational Health and Safety Management	K33	0.119
Number of Similar Projects	K41	0.022
Termination in Pas Contract	K42	0.748
Delay in Pas Contract	K43	0.229
Local Content	K51	0.949
Lowest Bid Price	K52	0.051

Based on the subcriteria weighting results in Table 5, Regulatory Compliance (K11) received the highest weight under Administrative Qualification (K1). This indicates that compliance with regulations and administrative requirements is the main consideration before contractors participate in EPC projects. Technical Specifications (K21) surpassed Project Schedule (K24) to become the leading subcriterion under Technical Qualification (K2). Assessing contractors' technical capability hinges on their technical suitability and ability to meet project timelines. Financial Capability (K31) received the highest weight for Company Qualification (K3). The discovery implies that financial stability is crucial to guarantee that contractors can finish EPC projects efficiently. Termination in Past Contract (K42) became the most influential subcriterion within Past Project Performance (K4). Previous contract termination is seen as an important indicator of a contractor's reliability. Under the Price Offer criterion (K5), the Lowest Bid Price (K51) carried the highest weight compared to Local Content (K52). This shows that offering the lowest price is still considered more important than local content requirements.

Prozima : Vol. 10, No. 1, June 2026, 51-60
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The final weights were calculated by multiplying each criterion's weight with its corresponding subcriterion weight. The resulting values, which show the overall importance of each subcriterion, are presented in Table 5.

Table 5. Final Weights of Criteria and Subcriteria

Criteria	Code	Weight	Subcriteria	Code	Weight	Final Weight
Administrative Qualification	K1	0.067	Regulatory Compliance	K11	0.950	0.064
			Project Organization	K12	0.050	0.003
Technical Qualification	K2	0.279	Technical Specifications	K21	0.541	0.151
			Type and capacity of the equipment	K22	0.159	0.044
			Project Execution Method	K23	0.048	0.013
			Project Schedule	K24	0.252	0.070
Company Qualification	K3	0.057	Financial Capability	K31	0.809	0.046
			Key Personnel	K32	0.072	0.004
			Occupational Health and Safety Management	K33	0.119	0.007
Past Project Performance	K4	0.234	Number of Similar Projects	K41	0.022	0.005
			Termination in the Pas Contract	K42	0.748	0.175
			Delay in Pas Contract	K43	0.229	0.054
Price Offer	K5	0.362	Lowest Bid Price	K51	0.949	0.344
			Local Content	K52	0.051	0.018

At the final weight calculation, the highest weight was assigned to the lowest bid price (K51) with a value of 0.344, followed by previous contract termination (K42) at 0.175, Technical Specifications (K21) at 0.151, and project execution method (K23) at 0.113. These findings indicate that, in addition to price considerations, the risks associated with contractors' historical performance and their technical readiness are important factors in selecting transmission and substation EPC contractors.

Calculation of Contractors' Historical Performance

To evaluate contractors' historical performance, this study applied a time correction approach using the time decay function [14]. The criteria assessed using the time decay correction (TDC) and partial value function methods include previous contract termination (tWSj) and delays in previous contracts (dWSj). The calculation was conducted on Tender XYZ, which involved five contractor alternatives, namely, Contractors A, Contractor B, Contractor C, Contractor D, and Contractor E. The results of the historical performance calculation for each contractor are presented as follows:

Table 6. Scores of Terminations and Delays in Past Contracts

Contractor	tWSj	dWSj
Contractor A	0.319	0.531
Contractor B	0.827	0.321
Contractor C	0.823	0.999
Contractor D	0.823	0.584
Contractor E	1.000	0.979

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E. ISSN. 2541-5115
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The calculation results were then used in the contractor ranking process using the TOPSIS method, particularly for the criteria of previous contract termination and delays in previous contracts.

Contractor Ranking Using the TOPSIS Method

The positive and negative ideal solution values were calculated based on the contractor evaluation questionnaires completed by the respondents. The positive ideal solution was determined by selecting the highest value for criteria with benefit attributes and the lowest value for criteria with cost attributes. The positive ideal solution is represented as A+. The results of the positive ideal solution calculation are given below.

Table 7. Positive Ideal Solution

Criteria	Attribute	Contractor					A+
		A	B	C	D	E	
K11	Benefit	0.0276	0.0292	0.0276	0.0292	0.0292	0.0292
K12	Benefit	0.0015	0.0016	0.0015	0.0015	0.0016	0.0016
K21	Benefit	0.0677	0.0639	0.0639	0.0708	0.0708	0.0708
K22	Benefit	0.0202	0.0193	0.0193	0.0202	0.0202	0.0202
K23	Benefit	0.0055	0.0058	0.0064	0.0061	0.0061	0.0064
K24	Benefit	0.0290	0.0304	0.0336	0.0336	0.0304	0.0336
K31	Benefit	0.0153	0.0191	0.0199	0.0256	0.0221	0.0256
K32	Benefit	0.0017	0.0018	0.0020	0.0019	0.0018	0.0020
K33	Benefit	0.0030	0.0030	0.0030	0.0031	0.0030	0.0031
K41	Benefit	0.0022	0.0022	0.0024	0.0025	0.0024	0.0025
K42	Benefit	0.0316	0.0818	0.0815	0.0815	0.0990	0.0990
K43	Benefit	0.0174	0.0105	0.0328	0.0192	0.0321	0.0328
K51	Cost	0.1619	0.1457	0.1548	0.1518	0.1538	0.1457
K52	Benefit	0.0080	0.0081	0.0084	0.0088	0.0081	0.0088

The negative ideal solution is determined in the opposite manner to the positive ideal solution by selecting the highest value for criteria with cost attributes and the lowest value for criteria with benefit attributes. The negative ideal solution is represented by A−, and its results are provided below:

Table 8. Negative Ideal Solution

Criteria	Attribute	Contractor					A-
		A	B	C	D	E	
K11	Benefit	0.0276	0.0292	0.0276	0.0292	0.0292	0.0276
K12	Benefit	0.0015	0.0016	0.0015	0.0015	0.0016	0.0015
K21	Benefit	0.0677	0.0639	0.0639	0.0708	0.0708	0.0639
K22	Benefit	0.0202	0.0193	0.0193	0.0202	0.0202	0.0193
K23	Benefit	0.0055	0.0058	0.0064	0.0061	0.0061	0.0055
K24	Benefit	0.0290	0.0304	0.0336	0.0336	0.0304	0.0290
K31	Benefit	0.0153	0.0191	0.0199	0.0256	0.0221	0.0153
K32	Benefit	0.0017	0.0018	0.0020	0.0019	0.0018	0.0017
K33	Benefit	0.0030	0.0030	0.0030	0.0031	0.0030	0.0030
K41	Benefit	0.0022	0.0022	0.0024	0.0025	0.0024	0.0022
K42	Benefit	0.0316	0.0818	0.0815	0.0815	0.0990	0.0316
K43	Benefit	0.0174	0.0105	0.0328	0.0192	0.0321	0.0105
K51	Cost	0.1619	0.1457	0.1548	0.1518	0.1538	0.1619
K52	Benefit	0.0080	0.0081	0.0084	0.0088	0.0081	0.0080

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After determining the value of positive and negative ideal solution, along with the distances to ideal solutions were calculated for each contractor alternative. The results of the positive ideal distance calculation for each contractor alternative are presented as follows:

Table 9. Positive Ideal Solution Distance

Positive Ideal Distance	Contractor	Value
D_{1+}	A	0.0720
D_{2+}	B	0.0298
D_{3+}	C	0.0217
D_{4+}	D	0.0230
D_{5+}	E	0.0095

The following are the negative ideal solution distance values for each contractor alternative:

Table 10. Negative Ideal Solution Distance

Negative Ideal Distance	Contractor	Value
D_{1-}	A	0.0079
D_{2-}	B	0.0530
D_{3-}	C	0.0555
D_{4-}	D	0.0533
D_{5-}	E	0.0719

Based on the calculation results of the positive and negative ideal solution distances, the preference values for each contractor alternative were calculated to determine the contractor rankings. The results of the preference value calculations for each contractor alternative are presented as follows:

Table 11. Results of Preference Value Calculation Based on the Closeness to Positive and Negative Ideal Solutions

Closeness to the Positive and Negative Ideal Solutions	Contractor	Preference Value
V_1	A	0.0992
V_2	B	0.6396
V_3	C	0.7189
V_4	D	0.6989
V_5	E	0.8837

The preference values obtained above represent the final scores of each contractor alternative. A higher value indicates better performance; therefore, the ranking results of the contractor alternatives are presented in Table 12 as follows:

Table 12. Contractor Ranking Using the TOPSIS Method

Contractor	Evaluation Score	Rank
A	0.0992	5
B	0.6396	4
C	0.7189	2
D	0.6989	3
E	0.8837	1

Prozima : Vol. 10, No. 1, June 2026, 51-60
E. ISSN. 2541-5115
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Based on the TOPSIS calculation results, Contractor E achieved the highest ranking with the highest preference score of 0.8837. The result shows that Contractor E has the strongest overall position among the evaluated contractors. Its TOPSIS score indicates a better balance between price, technical capability, and past project performance (delays and termination contract) compared with the other alternatives.

Contractor C ranked second (0.7189), followed by Contractor D (0.6989) and Contractor B (0.6396). Their close scores show that these contractors have similar strengths, mainly in technical capability and past project performance (delays and termination contract). Even though they were not the top choice, they still demonstrate solid and competitive capabilities.

Contractor A came in last with a score of 0.0992, showing a large gap compared to the other contractors. This indicates that Contractor A's performance is far from the ideal standard.

CONCLUSION

Based on the weighting results using the Fuzzy AHP method, the Price Offer criterion (K5) was identified as the most influential factor in contractor selection with a weight of 0.362. Technical Qualification (K2) and Historical Project Performance (K4) also showed significant influence, particularly in terms of technical specifications, project execution methods, and previous project records. This result shows that price remains a dominant factor in selecting EPC contractors. However, the high weight of price does not mean that the evaluation goes back to the lowest-bid approach. In the proposed model, price is still combined with technical criteria, project execution capability, project experience, and the contractor's past performance. Therefore, the model provides a more balanced evaluation, where cost efficiency is considered without ignoring the risks of project delays, additional work, lower work quality, and failure to achieve the project target.

Using the Time Decay Correction (TDC) and Partial Value Function (PVF) methods is important for evaluating past project performance. The historical performance was integrated by applying a time decay correction to the contractor's past performance data. More recent performance was given a higher influence than older performance, so the evaluation could better reflect the contractor's current capability. The corrected score was then included in the TOPSIS decision matrix together with the other criteria. The final ranking was therefore based not only on bid price, but also on each contractor's technical capability, price competitiveness, and project track record (delays and termination in past contract).

The contractor E received the highest preference value (0.8837) and thus became the most preferred alternative of all contractors by the TOPSIS analysis method. The lowest value was recorded for the contractor A (0.0992), while contractors C (0.7189), D (0.6989), and B (0.6396) were ranked quite close. In such an arrangement, it becomes evident that the gap between the preference values of other contractors is to be viewed as a risk indicator for management purposes. The low preference score can point out possible problems related to technical competence, bid price, project implementation ability, and project performance. Thus, contractors that have low preference scores may pose more threat to the timely and successful completion of projects. Hence, the TOPSIS analysis cannot only serve for prioritization of contractors but also help manage risks.

PT XZ should establish a certain cut-off point for the minimum preference score to be awarded. Such a score will allow PT XZ to evaluate whether the contractors chosen to have adequate technical competence (based on tender requirement) and project experience aside from providing competitive prices. Those who do not meet the cut-off score should be re-evaluated or disqualified from the bidding process altogether. This step can help PT XZ reduce the risk of choosing contractors that may cause delays or other problems during project implementation.

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