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Performance-Based Selection of Diesel Generator Using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

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Abstract The selection of diesel generators is a critical decision in environments requiring reliable and uninterrupted power supply. This study presents a structured multi-criteria decision-making (MCDM) approach for evaluating and selecting the most suitable diesel generator using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Four key performance criteria, fuel consumption, lifespan, estimated maintenance time, and mean time between failures (MTBF)were considered. Criteria weights were determined using the Analytic Hierarchy Process (AHP), ensuring consistency and objectivity. A case study involving four 75 kVA diesel generator alternatives was conducted. The results indicate that Alternative C achieved the highest closeness coefficient (0.970), making it the most preferred option due to its superior reliability, longer lifespan, and lower maintenance requirements. The study demonstrates the effectiveness of integrating AHP and TOPSIS for rational and data-driven decision-making in equipment selection.

Keywords: *Diesel generator, TOPSIS, AHP, multi-criteria decision-making, MTBF, performance evaluation*

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1. Introduction

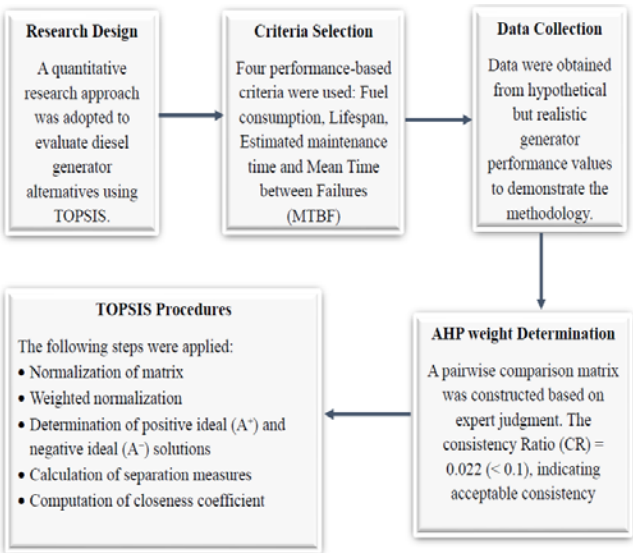
Reliable power supply is fundamental to industrial, commercial, and residential operations. However, persistent instability in national power grids, particularly in developing regions, necessitates the use of backup power systems such as diesel generators [1,2,3]. Diesel generators are widely preferred due to their durability, cost-effectiveness, and fuel availability [4,5].

Selecting an appropriate diesel generator constitutes a complex decision-making problem involving multiple, often conflicting criteria, including fuel consumption, lifespan, estimated maintenance time, and mean time between failures (MTBF) [6,7,8]. Traditional selection approaches based solely on cost or brand are inadequate and may result in suboptimal long-term performance [3,9].

To overcome this limitation, this study applies a multi-criteria decision-making (MCDM) approach using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). This method facilitates the systematic evaluation of alternatives based on their relative proximity to ideal and negative-ideal solutions, thereby ensuring a robust and objective selection process [10,11,12].

2. Methodology

The analysis of the alternatives was conducted using the following approach [13,14,15].



2.1. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was developed by Hwang and Yoon in 1981 to address decision-making problems involving multiple, often conflicting criteria [16]. The method was applied in this study through the following steps:

- Normalized Decision Matrix (R):

The decision matrix was normalized using vector normalization

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}}$$

- Weighted Normalized Decision Matrix:

Each normalized value was multiplied by its corresponding weight (obtained from AHP)

$$v_{ij} = w_j r_{ij}$$

- Determination of Ideal Solutions:

The positive ideal solution (A^+) and negative ideal solution (A^-) were determined by maximizing benefit criteria (lifespan and MTBF) and minimizing cost criteria (fuel consumption and maintenance time).

- Separation Measures:

The distances from the ideal and negative-ideal solutions were computed as

$$S_i^+ = \sqrt{\sum_{j=1}^n \left(v_{ij} - v_j^+\right)^2}, S_i^- = \sqrt{\sum_{j=1}^n \left(v_{ij} - v_j^-\right)^2}$$

- ClosenessCoefficient:

The relative closeness to the ideal solution was calculated as

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

3. Result

Table 1. Surveyed Data

Alternatives	Fuel Consumption (Liter per day)	Lifespan (Years)	Estimated maintenance (Hours)	MTBF (in every 10000 hours)
A	112	7	5	2500
B	110	6	7	2000
C	114	10	3	3500
D	100	8	6	1500

Table 2. Description of Criteria

Criteria	Type	Description
Fuel Consumption	Cost	Lower values are preferred
Lifespan	Benefit	Higher values indicate longer service life
Estimated Maintenance time	Cost	Lower values indicate less frequent servicing
Mean Time Between Failures (MTBF)	Benefit	Higher values indicate greater reliability

Table 3. Saaty scale (1-9)

Importance Level	Meaning
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
Reciprocals(1/3, 1/5…,)	Opposite comparison

3.1. Criteria Weighting Justification

The criteria-weighting order obtained from the AHP reflects the relative importance of each criterion based on pairwise comparisons and the decision objective. In this study, MTBF received the highest weight due to its critical role in ensuring system reliability and minimizing downtime. Lifespan was ranked second as it represents long-term durability, while maintenance and fuel consumption were assigned lower weights as they primarily influence operational cost rather than system performance. This weighting structure highlights the prioritization of reliability and sustainability over short-term cost considerations.

Table 4. Comparison Matrix

Criteria	Fuel	Lifespan	Maintenance	MTBF
Fuel	1	1/3	1/2	1/4
Lifespan	3	1	2	1/2
Maintenance	2	1/2	1	1/3
MTBF	4	2	3	1

Table 5. Each Column Summation

Column	Sum
Fuel	10
Lifespan	3.833
Maintenance	6.5
MTBF	2.083

Table 6. Normalized Matrix

Criteria	Fuel	Lifespan	Maintenance	MTBF
Fuel	0.10	0.087	0.077	0.120
Lifespan	0.30	0.261	0.308	0.240
Maintenance	0.20	0.130	0.154	0.160
MTBF	0.40	0.522	0.462	0.480

Each element in Table 4 was divided by the sum of its respective columns in Table 5.

3.2. Final Analytic Hierarchy Process (AHP) Weighting

The AHP weights were obtained by averaging each row of the normalized matrix. For example, the weight for Fuel is calculated as:

(0.10 + 0.087 + 0.077 + 0.120)/4 = 0.095

Lifespan = 0.284, Maintenance = 0.170, MTBF = 0.451 respectively.

Table 7. Normalized Decision Matrix

Alternative	Fuel	Lifespan	Maintenance Time	MTBF
A	0.5131	0.4436	0.4583	0.5025
B	0.5040	0.3802	0.6416	0.4020
C	0.5223	0.6337	0.2750	0.7035
D	0.4581	0.5070	0.5500	0.3015

Table 8. Weighted Normalized Decision Matrix

Alternative	Fuel (0.095)	Lifespan (0.284)	Maint. (0.170)	MTBF (0.451)
A	0.0487	0.1260	0.0779	0.2266
B	0.0479	0.1080	0.1091	0.1813
C	0.0496	0.1800	0.0468	0.3173
D	0.0435	0.1440	0.0935	0.1359

Table 9. Separation Measures

Alternatives	S^+ (Distance to Ideal)	S^- (Distance to NIS)
A	0.1195	0.0930
B	0.1804	0.0450
C	0.0070	0.2230
D	0.2030	0.0200

Table 10. Closeness Coefficient and Final Ranking

Alternative	S^+	S^-	Closeness (C_i)	Rank
A	0.1195	0.0930	0.437	2nd
B	0.1804	0.0450	0.200	3rd
C	0.0070	0.2230	0.970	1st
D	0.2030	0.0200	0.090	4th

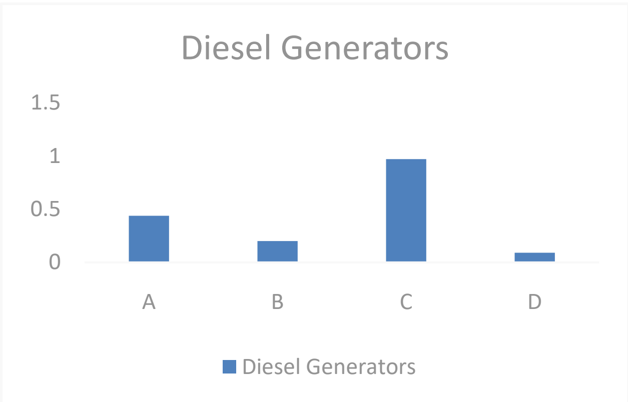


Figure 1. Graphical Representation of the Result

The results displayed on Figure 1 shows Alternative C is the most preferred diesel generator. This is primarily due to:

- Highest MTBF (3500 hours), indicating superior reliability.
- Longest lifespan (10 years).
- Lowest maintenance requirement (3 hours).

Although Alternative C has the highest fuel consumption, its advantages in reliability and durability outweigh this drawback. This highlights the importance of using a multi-criteria approach rather than relying on a single factor such as cost.

The integration of AHP and TOPSIS proved effective in balancing conflicting criteria and providing a rational basis for decision-making.

4. Conclusion and Recommendations

4.1. Conclusion

This study demonstrates the applicability of the TOPSIS method in selecting the most suitable diesel generator based on multiple performance criteria. By incorporating AHP-derived weights, the approach ensures consistency and objectivity in evaluation.

The findings confirm that Alternative C is the optimal choice, offering the best trade-off among fuel consumption, lifespan, maintenance, and reliability. The proposed methodology provides a robust framework for decision-makers in engineering and procurement.

4.2. Recommendations

- Organizations should adopt MCDM methods such as TOPSIS for equipment selection.
- Future studies should include additional criteria such as emissions, noise levels, and acquisition cost.
- Sensitivity analysis should be conducted to evaluate the impact of weight variations.

Real-world data should be incorporated to validate the model further.

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