Ha Van Nghi, 2025, 13:6
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science,
Engineering and Technology
An Open Access Journal

Integrating Entropy, MEREC and TOPSIS Methods in Solving Multi-Objective Optimization Problems: A Case Study in Electrical Wire Selection

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Abstract- Solving multi-objective optimization problems is a task that must frequently be performed across various fields, including economics, management, engineering, and other areas. Two important tasks in solving multi-objective optimization problems are calculating weights for the objectives and selecting a mathematical method to solve the optimization problem. The current research integrated three methods—Entropy, MEREC, and TOPSIS—to solve a multi-objective optimization problem in identifying the best type of copper-core electrical wire among 28 available types. Specifically, the Entropy and MEREC methods were used to calculate weights for the criteria, while the TOPSIS method was used to rank the types of copper-core electrical wires. The results showed that although the rankings of the copper-core electrical wires were inconsistent when the weights of the criteria were calculated using the two different methods (Entropy and MEREC), there were still several alternatives whose rankings remained consistent. The type of electrical wire corresponding to product code 20255114 was found to be the best among the 28 types considered in this study.

Keywords: weight, optimization, Entropy method, MEREC method, TOPSIS method.

I. INTRODUCTION

Calculating weights for objectives, also known as criteria, and selecting a Multi-Criteria Decision-Making (MCDM) method are two very important tasks in ranking alternatives to find the best option among many available ones [1-3]. To calculate weights for criteria, one can apply objective weighting methods, subjective weighting methods, and hybrid weighting methods, which combine both subjective and objective factors [4, 5]. Among these, many studies have indicated that using objective weighting methods provides users with more accurate and transparent decisions [6-8]. Many objective weighting methods have been widely used in various fields, such as the Entropy method [9], MEREC method [10], SPC method [11], LOPCOW method [12], CRITIC method [13], ITARA method [14], etc. The Entropy and MEREC methods have been confirmed to have high accuracy and are encouraged for use [15]. For this reason, these two methods have also been used in the current research.

There are currently hundreds of different MCDM methods, each built according to different philosophies [16]. Many famous methods have been extensively used over time, such as the TOPSIS method [17], SAW method [18], PIV method [19], VIKOR method [20], COCOSO method [21], MOORA method [22], COPRAS method [23], CODAS method [24], EDAS method [25], etc. Among them, TOPSIS is considered the most famous and most frequently used method [26]. This also explains why the TOPSIS method was used in this research.

Section 2 of this article presents the steps for applying the Entropy and MEREC methods to calculate weights for criteria and the steps for applying the TOPSIS method to rank alternatives. The integration of the three methods—Entropy, MEREC, and TOPSIS—to rank types of copper-core electrical wires is presented in Section 3. The conclusion regarding the best copper-core electrical wire found is the final content of this article.

II. METHODS USED

Entropy method

To calculate the weights for criteria using the Entropy method, the following sequence should be applied [27]:

Step 1: Construct the decision matrix with m rows and n columns, where m is the number of alternatives to be ranked (number of experiments), and n is the number of criteria to evaluate each alternative (number of criteria to evaluate the grinding process). Let xij be the value of criterion j for alternative i, with j = 1 ・ n, i = 1 ・ m.

Step 2: Determine the normalized values for the criteria according to formula (1).

$$n_{\mathrm{ij}} = \frac{x_{\mathrm{ij}}}{m + \sum_{i=1}^{m} x_{\mathrm{ij}}^2} \qquad (1)$$

Step 3: Calculate the Entropy measure value for each criterion according to formula (2).

$$e_j = \sum_{i=1}^{m} \left[n_{ij} \times \ln(n_{ij}) \right] - \left(1 - \sum_{i=1}^{m} n_{ij}\right) \times \ln\left(1 - \sum_{i=1}^{m} n_{ij}\right)$$

(2)

Step 4: Calculate the weight for each criterion according to formula (3).

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \qquad (3)$$

MEREC method

To calculate the weights for criteria using the MEREC method, the following sequence should be applied [28]:

Step 1: Similar to Step 1 of the Entropy method.

Step 2: Calculate the normalized values according to formulas (4) and (5).

For the larger-the-better criteria.

$$n_{ij} = \frac{\min x_{ij}}{x_{ij}} \qquad (4)$$

For the smaller-the-better criteria.

$$n_{ij} = \frac{x_{ij}}{\max x_{ij}} \qquad (5)$$

Step 3: Calculate the overall performance of the alternatives according to formula (6).

$$S_i = Ln\left[1 + \left(\frac{1}{n} \sum_{j}^{n} \left| ln(n_{ij}) \right| \right)\right] \qquad (6)$$

Step 4: Calculate the performance of the alternatives according to formula (7).

$$S'_{ij} = Ln\left[1 + \left(\frac{1}{n} \sum_{k,k \neq j}^{n} \left| ln(n_{ij}) \right| \right)\right] \quad (7)$$

Step 5: Calculate the absolute value of the deviations according to formula (8).

$$E_j = \sum_{i}^{m} \left| S'_{ij} - S_i \right| \qquad (8)$$

Step 6: Calculate the weights for the criteria according to formula (9).

$$w_j = \frac{E_j}{\sum_{k}^{n} E_k} \qquad (9)$$

TOPSIS method

To rank the alternatives using the TOPSIS method, the following sequence should be applied [29]:

Step 1: Similar to Step 1 of the Entropy method.

Step 2: Determine the normalized values according to formula (10).

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \qquad (10)$$

Step 3: Calculate the weighted normalized values according to formula (11).

$$y_{ij} = w_j . n_{ij} \quad (11)$$

Step 4: Determine the best solution A^+ and the worst solution A^- for the criteria according to formulas (12) and (13).

$$A^+ = \left\{ y_1^+, y_2^+, \dots, y_j^+, \dots, y_n^+ \right\} \qquad (12)$$

$$A^- = \left\{ y_1^-, y_2^-, \dots, y_j^-, \dots, y_n^- \right\} \qquad (13)$$

In which: yj+ and yj- are respectively the best value and the worst value of the normalized value yij of criterion j.

Step 5: Determine the values Si+ and Si- according to formulas (14) and (15).

$$\boldsymbol{S_i^+} = \sqrt{\sum_{j=1}^{n} \left(\boldsymbol{y_{ij}} - \boldsymbol{y_j^+}\right)^2} \quad i=1,2,\dots,m \quad (14)$$

$$\boldsymbol{S_i^-} = \sqrt{\sum_{j=1}^{n} \left(\boldsymbol{y_{ij}} - \boldsymbol{y_j^-}\right)^2} \quad i=1,2,\dots,m \quad (15)$$

Step 6: Determine the values Ci according to formula (16).

$C_i = \frac{S_i^-}{S_i^+ + S_i^-}$i=1,2,...,m; 〖0≤C〗 _i^(*)≤1 (16)

Step 7: Rank the alternatives according to the principle that the alternative with the largest Ci is the best alternative.

III. RESULTS AND DISCUSSION

Table 1 summarizes the data for 28 types of copper-core electrical wires introduced by a supplier, denoted from A1 to A28, with corresponding product codes as shown in column 2 of Table 1 [30]. Nine criteria used to describe each alternative are denoted from C1 to C9, where C9 is a smaller-the-better criterion, and the remaining eight criteria are all larger-the-better.

C1: Nominal cross-section (mm2);
C2: Number of strands;
C3: Diameter of copper strand (mm);
C4: Insulation thickness between copper strands (mm);
C5: Sheath thickness (mm);
C6: Overall diameter (mm);
C7: Maximum DC resistance of conductor at 20°C (Ohm/km);
C8: Weight (kg/m);
C9: Price (VNDT/m, VNDT = Vietnam dong thousand).

Table 1. Types of copper-core electrical wires [30]

Alt.	CODE	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	20225103	1.00	20	0.18	0.6	0.8	5.4	39.00	0.0489	7.201
A2	20225106	1.50	30	0.18	0.6	0.8	6.3	26.00	0.0587	11.533
A3	20225107	2.00	40	0.18	0.6	0.8	6.6	19.50	0.0688	18.346
A4	20225108	2.00	32	0.20	0.6	0.8	6.6	19.50	0.0686	26.607
A5	20225110	3.00	48	0.20	0.7	0.8	7.6	13.20	0.0935	42.857
A6	20225111	3.00	30	0.25	0.7	0.8	7.6	13.30	0.0930	24.388
A7	20225114	5.00	50	0.25	0.8	1	9.3	7.98	0.1405	38.284
A8	20235103	1.50	20	0.18	0.6	0.8	6.2	39.00	0.0573	57.225
A9	20235106	2.25	30	0.18	0.6	0.8	6.7	26.00	0.0709	23.670
A10	20235107	3.00	40	0.18	0.6	0.8	7	19.50	0.0833	38.418
A11	20235108	3.00	32	0.20	0.6	0.8	7	19.50	0.0830	58.843
A12	20235110	4.50	48	0.20	0.7	0.9	8.3	13.30	0.1187	38.699
A13	20235111	4.50	30	0.25	0.7	0.9	8.3	13.30	0.1172	24.412
A14	20235114	7.50	50	0.25	0.8	1.1	10.1	7.98	0.1782	35.212
A15	20245103	2.00	20	0.18	0.6	0.8	6.7	39.00	0.0706	26.117
A16	20245106	3.00	30	0.18	0.6	0.8	7.2	26.00	0.0869	36.484
A17	20245107	4.00	40	0.18	0.6	0.9	7.9	19.50	0.1074	54.228
A18	20245108	4.00	32	0.20	0.6	0.9	7.9	19.50	0.1071	26.685
A19	20245110	6.00	48	0.20	0.7	1	9.3	13.30	0.1517	48.426
A20	20245111	6.00	30	0.25	0.7	1	9.3	13.30	0.1507	48.426
A21	20245114	10.00	50	0.25	0.8	1.1	10.9	7.98	0.2200	66.126
A22	20255103	2.50	20	0.18	0.6	0.9	7.7	39.00	0.0830	26.123
A23	20255106	3.75	30	0.18	0.6	0.9	8.2	26.00	0.1075	33.170
A24	20255107	5.00	40	0.18	0.6	0.9	8.9	19.50	0.1294	34.208
A25	20255108	5.00	32	0.20	0.6	0.9	8.9	19.50	0.1298	37.816
A26	20255110	7.50	48	0.20	0.7	1.1	9.7	13.30	0.1871	44.126
A27	20255111	7.50	30	0.25	0.7	1.1	9.7	13.30	0.1858	54.212
A28	20255114	12.50	50	0.25	0.8	1.2	11	13.30	0.2724	65.746

The objective is to identify the best type of electrical wire in Table 1. However, according to the data in this table, it is observed that C1 is largest at A28, C2 is largest at alternatives A14, A21, and A28, C3 is largest at alternatives A13, A14, and A28, C4 is largest at alternatives A14 and A21, C5 is largest at A28, C6 is also largest at A28, C7 is largest at A22, C8 is largest at A28, while C9 is smallest at A1. This means that no single alternative exists where all parameters are optimal; rather, one can only find an alternative where all criteria are considered "best" collectively. Naturally, to achieve this, it is necessary to solve a multi-objective optimization problem. In this study, the TOPSIS method was used to perform this task.

To apply the TOPSIS method in solving the multi-objective optimization problem, it is crucial to calculate the weights for the criteria. Applying formulas (1) to (3), the weights for criteria C1 to C9 calculated by the Entropy method are 0.1089, 0.0759, 0.1183, 0.1675, 0.1739, 0.1008, 0.0804, 0.0994, and 0.0749, respectively. Applying formulas (4) to (9), the weights for criteria C1 to C9 calculated by the MEREC method are 0.2710, 0.1089, 0.0240, 0.0162, 0.0223, 0.0773, 0.1781, 0.1572, and 0.1450, respectively. It Is noted that the value of each criterion weight differs significantly when calculated by the two different methods. This is explained by the fact that the approaches of the Entropy and MEREC methods are very different. However, this also provides an opportunity for the selection of the best electrical wire to be achieved in the most objective manner.
Using the weight values of the criteria calculated by the Entropy and MEREC methods and applying formulas (10) to (16) to calculate the Ci scores for each alternative, the results are summarized in Table 2. Based on these scores, the rankings of the alternatives were also established and summarized in this table.

Table 2. Scores and rankings of electrical wire types

Alt.	Entropy weight		MEREC weight	
	C_i	Rank	C_i	Rank
A1	0.3233	16	0.3267	13
A2	0.2815	20	0.2755	19
A3	0.2652	23	0.2512	24
A4	0.2333	27	0.2234	27
A5	0.2585	25	0.2240	26
A6	0.2853	19	0.2515	23
A7	0.4126	8	0.3523	10
A8	0.2595	24	0.2745	20
A9	0.2695	21	0.2685	22
A10	0.2470	26	0.2417	25
A11	0.1996	28	0.2021	28
A12	0.3459	12	0.3211	16
A13	0.3601	11	0.3345	12
A14	0.5454	3	0.5073	4
A15	0.3139	17	0.3224	14
A16	0.2691	22	0.2735	21
A17	0.2857	18	0.2793	18
A18	0.3265	15	0.3191	17
A19	0.4338	6	0.4108	6
A20	0.4240	7	0.4010	7
A21	0.6061	2	0.5962	2
A22	0.3384	13	0.3395	11
A23	0.3267	14	0.3221	15
A24	0.3804	9	0.3754	8
A25	0.3688	10	0.3658	9
A26	0.5391	4	0.5179	3
A27	0.5160	5	0.4971	5
A28	0.6969	1	0.6962	1

According to the data in Table 2, it is observed that the rankings of the alternatives differ significantly when the weights of the criteria are calculated by the two different methods. This is entirely understandable because the weight values of the criteria calculated by the Entropy and MEREC methods are relatively different, as discussed above. Nevertheless, there are still alternatives with consistent rankings regardless of which weighting method was used. Specifically, A19 always ranks 6th, A20 always ranks 7th, A21 always ranks 2nd, A27 always ranks 5th, and especially A28 always ranks 1st. Thus, we conclude that A28 is the best alternative among the options, or in other words, the electrical wire with product code 20255114 is the best type among the 28 evaluated types.

IV. CONCLUSION

In this study, three methods Entropy, MEREC, and TOPSIS were integrated to solve an optimization problem, specifically identifying the best type of electrical wire among 28 types available from a supplier. The electrical wire with product code 20255114 was identified as the best type, with parameter values as follows: nominal cross-sectional area of 12.50 (mm^2); 50 strands; copper strand diameter of 0.25 (mm); insulation thickness between copper strands of 0.8 (mm); sheath thickness of 1.2 (mm); overall diameter of 11 (mm); maximum DC resistance of the conductor at 20°C of 13.30 (Ohm/km); weight of 0.2724 (kg/m); and a price of 65.746 (Vietnam dong thousand/m).

REFERENCES

1. X. Li, Z. Tang, C. Chen, L. Wang, Y. Zhang, D. Wang, An optimization method of grinding wheel profile for complex large shaft curve grinding, Journal of Advanced Manufacturing Science and Technology, 5(2), Art. no. 2025008, 2025.
2. N.–T. Nguyen, D. D. Trung, Combination of taguchi method, MOORA and COPRAS techniques in multi-objective optimization of surface grinding process, Journal of Applied Engineering Science, 19(2) 390 – 398, 2021.
3. D. D. Trung, A combination method for multi-criteria decision making problem in turning process, Manufacturing review, vol. 8, Art. no. 26, 2021.
4. T. V. Dua, PSI-SAW and PSI-MARCOS Hybrid MCDM Methods, Engineering, Technology & Applied Science Research, 14(4) 15963-15968, 2024.
5. T. V. Dua, D. V. Duc, N. C. Bao, D. D. Trung, Integration of objective weighting methods for criteria and MCDM methods: application in material selection, EUREKA: Physics and Engineering, 2024(2), 131–148, 2024.
6. D. T. Do, Assessing the Impact of Criterion Weights on the Ranking of the Top Ten Universities in Vietnam, Engineering, Technology & Applied Science Research, 14(4), 14899-14903, 2024.
7. R. N. Wardany, Zahedi, A study comparative of PSI, PSI-TOPSIS, and
8. PSI-MABAC methods in analyzing the financial performance of state-owned enterprises companies listed on the INDONESIA stock exchange, Yugoslav Journal of Operations Research, 2024.
9. D. D. Trung, B. Dudić, D. V. Duc, N. Hoai Son, Aleksandar Ašonja, Comparison of MCDM methods effectiveness in the selection of plastic injection molding machines, Teknomekanik, 7(1), 1-19, 2024.
10. Y. Zhu, D. Tian, F. Yan, Effectiveness of Entropy Weight Method in Decision-Making, Mathematical Problems in Engineering, 2020.
11. M. Keshavarz-Ghorabaee, M. Amiri, E. K. Zavadskas, Z. Turskis, J. Antucheviciene, Determination of Objective Weights Using a New Method Based on the Removal Effects of Criteria (MEREC), Symmetry, 13(525), 2021.
12. Z. Gligoric, M. Gligoric, I. Miljanovic, S. Lutovac, A. Milutinovic, Assessing Criteria Weights by the Symmetry Point of Criterion (Novel SPC Method)–Application in the Efciency Evaluation of the Mineral Deposit Multi-Criteria Partitioning Algorithm, Computer modeling in Engineering & Sciences, 136(1), 955-979, 2023.
13. F. Ecer, D. Pamucar, A novel LOPCOW-DOBI multi-criteria sustainability performance assessment methodology: An application in developing country banking sector, Omega, 112, Art. no. 102690, 2022.
14. E. A. Adal, A. T. Isık, Critic and Maut Methods for the Contract Manufacturer Selection Problem, European Journal of Multidisciplinary Studies, 2(5), 88-96, 2017.
15. Ulutas, D. Karabasevic, G. Popovic, D. Stanujkic, P. T. Nguyen, C. Karakoy, Development of a Novel Integrated CCSD-ITARA-MARCOS Decision-Making Approach for Stackers Selection in a Logistics System, Mathematics, 8(1672), 2020.
16. D. D. Trung, H. X. Thinh, A multi-criteria decision-making in turning process using the MAIRCA, EAMR, MARCOS and TOPSIS methods: A comparative study, Advances in Production Engineering & Management, 16(4), 443–456, 2021.
17. D. D. Trung, B. Dudić, N.-T. Nguyen, A. Ašonja, Data Normalization for Root Assessment Methodology, International Journal of Industrial
18. Engineering and Management, 15(2), 156 – 168, 2024.
19. S. Opricovic, T. Gwo-Hshiung, Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS, European Journal of Operational Research, 156(2), 445-455, 2004.
20. Z. Stevic, E. Durmic, M. Gajic, D. Pamucar, A. Puska, A Novel Multi-Criteria Decision-Making Model: Interval Rough SAW Method for Sustainable Supplier Selection, Information, 10(292), 1-21, 2019.

21. D. D. T., The combination of TAGUCHI – ENTROPY – WASPAS - PIV methods for multi-criteria decision making when external cylindrical grinding OF 65G steel, Journal of Machine Engineering, 21(4), 90–105, 2021.
22. D. Siregar, H. Nurdiyanto, S. Sriadhi, D. Suita, U. Khair, R. Rahim, D. Napitupulu, A. Fauzi, A. Hasibuan, M. Mesran, A. P. U. Siahaan, Multi-Attribute Decision Making with VIKOR Method for Any Purpose Decision, IOP Conf. Series: Journal of Physics: Conf. Series, 1019(012034), 1-7, 2019.
23. M. Yazdani, P. Zaraté, E. K. Zavadskas, Z. Turskis. A Combined Compromise Solution (CoCoSo) method for multi-criteria decision-making problems, Management Decision, Emerald, 57(9), 2501-2519, 2019.
24. L. Pérez-Domínguez, K. Y. Sánchez Mojica, L. C. O. Pabón, M. C. C. Díaz, Application of the MOORA method for the evaluation of the industrial maintenance system, IOP Conf. Series: Journal of Physics: Conf. Series, 1126 (012018), 1-6, 2018.
25. S. B. Patil, Tushar A. Patole, Rasika S. Jadhav, Shruti S. Suryawanshi, Sunil J. Raykar, Complex Proportional Assessment (COPRAS) based Multiple-Criteria Decision Making (MCDM) paradigm for hard turning process parameters, Materialstoday: Procedings, 59(1), 835-840, 2022.
26. D. D. Trung, Expanding data normalization method to CODAS method for multi-criteria decision making, Applied Engineering Letters, 7(2), 54-66, 2022.
27. E. Torkayesh, M. Deveci, S. Karagoz, J. Antucheviciene, A state-of-the-art survey of evaluation based on distance from average solution (EDAS): Developments and applications, Expert Systems with Applications, 221(119724), 2023.
28. D. D.Trung, Application of TOPSIS and PIV methods for multi-criteria decision making in hard turning process, Journal of Machine Engineering, 21(4), 57–71, 2021.
29. S. A. I. Hussain1and, U. K. Mandal, Entropy based MCDM approach for Selection of material, National Level Conference on Engineering Problems and Application of mathematics, 2016.
30. Puška, D. Božanić, Z. Mastilo, D. Pamučar, A model based on MEREC-CRADIS objective decision-making methods and the application of double normalization: A case study of the selection of electric cars, Research Square, 1-19, 2023.
31. D. D. Trung, Application of EDAS, MARCOS, TOPSIS, MOORA and PIV methods for multi-criteria decision making in milling process, Strojnícky časopis – Journal of MECHANICAL ENGINEERING, 71(2), 69 – 84, 2021.
32. H. X. Thinh, D. V. Duc, N. C. Bao, The Effect of CoCoSo Method on the Ranks of Alternatives: A Case Study of Copper Electrical Wire Selection, Engineering, Technology & Applied Science Research, vol. 14, no. 6, pp. 18307-18315, 2024.