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Zero Emission Electric Vehicle Selection Using the MEREC-Based CoCoSo Method

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Abstract

Electric vehicles are a good alternative to traditional fossil fuel vehicles with their cheap maintenance costs, low consumption, and environmentally friendly technologies. Considering that three-quarters of today's greenhouse gas emissions originate from transportation, the increase in the use of electric vehicles will greatly contribute to the achievement of decreasing environmental issues. In this study, it is aimed to rank zero-emission SUV-type electric vehicles that all are available for sale in Turkey with MEREC-based CoCoSo. In the study, vehicles are considered to an evaluation in four different scenarios, where they are combined, urban and highway travel situations and performance oriented. In each scenario, the Scenarios were evaluated under two headings with and without the price criterion. When the results are examined, it has been determined that the vehicles that are thought to have economical prices are in the last place in the rankings made with the CoCoSo method by objective weights.

Keywords MEREC, CoCoSo, Full-Battery Electric Vehicle, Multi-Criteria Decision Making

Jel Codes C61, C72, G11

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1. Introduction

Various techniques are proposed for the analytical treatment of decision-making issues. In the literature, the most prevalent are multi-criteria decision-making techniques such as AHP, TOPSIS, ELECTRE, VIKOR, PROMETHEE, COPRAS, and WASPAS. In contrast, the applications of the mentioned methods involve a four-step procedure. In the initial phase, the collection of factors believed to influence the decision problem is determined. The second step involves calculating the weight values for these chosen criteria. In the third stage, the decision matrix is created by measuring the performance value under each alternative criterion; in the final stage, the alternatives are evaluated (ranked) based on these performance values.

To determine the criteria to be included in the problem, the decision maker may use the questionnaire method or other techniques such as brainstorming and focus group work. Because of the uniqueness of each problem, the decision-maker must determine the criteria. All relevant factors should be considered when setting the criteria. The more comprehensive the criteria, the more accurate the consideration of alternatives.

After identifying the criteria, the following step is to determine their weight values. Different weight values can be determined based on the distinct properties of identical issue subjects. According to the decision maker, these weights also indicate the order of priority of the problem's criteria. Because of this, it is expected that these weight values, which are believed to reflect the nature of the problem, will vary from problem to problem, even though the difficulties' subjects are identical. Numerous approaches, including AHP, DEA, SWARA, FUCOM, MEREC, and BWM, have been effectively utilized in the literature to calculate weight values from an analytical standpoint.

At the step of determining the performance measures for each alternative criterion, it is anticipated that there will be differences in measuring units. Therefore, the decision maker must normalize the decision matrix to avoid this effect. When the performance values of the alternatives in relation to the criteria are the unit of measurement, they can be utilized directly. In situations when the subjective judgments of the decision maker must be incorporated as a performance metric, however, approaches such as the Likert scale and fuzzy logic can be utilized.

With the aid of a literature analysis, this study aims to rank SUV-type electric vehicle choices by attempting to define the selection criteria for electric vehicles, which have begun to enter our lives with technological advancements in recent years. All vehicles are selected which are available for sale in Turkey. Using the MEREC technique, the criteria are weighted to reduce the subjectivity of the decision-maker. The alternatives were ranked using the CoCoSo method of consensus. No electric vehicle study employing both methodologies has been discovered in the literature. Our study is an original study that includes scenario-based evaluations. It is the first study in which evaluations involving many criteria and alternatives were evaluated in four different scenarios.

2. Literature Review

Population growth causes environmental problems caused by transportation's greenhouse gas emissions, which negatively affect air quality and, consequently, population health. Transportation is one of the largest contributors to global greenhouse gas emissions (Tie & Tan, 2013). According to data acquired from Our World in Data, as of 2018, three-quarters of the global transportation sector's total emissions are attributable to road travel. This rate is caused by 45.1% passenger cars and 29.4% cargo trucks. Road transport alone contributes to 15% of the world's total CO_2 emissions (Ritchie et al., 2023). Many city governments have already implemented policies to reduce the use of fossil fuels, such as limiting vehicle access to city centres, providing public transportation with zero-emission buses or subways, and encouraging individuals to use low-emission alternative vehicles (bikes, scooters, etc.) nearby. In this context, the demands for reducing pollutant emissions and fossil fuel consumption will accelerate the process of using electric vehicles for urban transportation with their environmentally friendly technologies and range values that will increase in tandem with the future development of battery technologies (Cheng et al., 2014). As the number of electric vehicles grows, so will their impact on the electrical grid's capacity. Therefore, the appropriate development of charging stations should be increased to encourage individuals to use these sorts of vehicles (Alahyari et al., 2014). In addition, government incentives that reduce the cost of obtaining and operating electric vehicles will contribute to the accomplishment of zero carbon targets on roadways.

Electric vehicles, the technologies of the future with their advantages, are essential for achieving the zero-emission goal in road transport, which accounts for over 15% of global emissions. As a result of the development of models that are affordable for all consumers, local environmental restrictions, and tax incentives, the sales of electric vehicles are increasing rapidly in response to the growing demand. According to data from the International Energy Agency, the rate of electric car sales in 2021 surpassed 6,6 million vehicles, which is nearly equivalent to 9% of total sales. Within the framework of zero-emission goals for 2050, the proportion of electric vehicles in total sales is anticipated to reach 60% in 2030. According to a report issued by the Turkish Electric and Hybrid Vehicles Association in July 2022, the number of electric cars sold in our nation during the first half of 2022 climbed by threefold to 2,413, while hybrid vehicle sales declined slightly to 9,731. In the coming years, it is evident that full-battery electric car models will dominate the market. As a result, several major automakers have declared their intention to attain an all-electric future shortly. By 2030, Toyota intends to sell 3.5 million electrified vehicles and offer 30 additional models. Volkswagen, on the other hand, plans to have at least 70% of its sales in Europe, at least 50% of its sales in China, and at least 100% of its sales from zero-emission electric vehicles by 2040. In contrast, Ford and BMW have established a goal that by 2030, 50% of their total sales will consist of electric vehicles (Paoli et al., 2022).

Land vehicles that consume fossil fuels, which have been in existence for more than a century in human life, are gradually being replaced by electric vehicles due to CO_2 and other polluting gas emissions (Işılak, 2020). When it comes to vehicles that use electric technology, they can be divided into two categories: full-battery electric vehicles and hybrid vehicles (İşen & Tarlak, 2018).

The term "hybrid" refers to a combination of two or more distinct entities. It can be used to describe numerous things, including plants, animals, and technologies. As a technical term, it is used to mean the coexistence of two different power supplies. Hybrid system vehicles refer to a category of cars equipped with both an electric motor and a fossil fuel-powered engine, and both systems contribute to the vehicle's traction. (Demir & Kaymaz, 2020). While the electric motor may be active until it exceeds a certain speed, it is disabled when the speed threshold is passed. While the advantages of this type of vehicle can be listed as fuel savings, low emission values, and energy recovery with the regenerative braking system, the disadvantages can be listed as being quiet, operating below the maximum power, high acquisition costs, and the complexity of the energy management system (Kerem, 2014). Hybrid electric vehicles are divided into two distinct categories: rechargeable and non-rechargeable (Özcan & Oral, 2018).

The electric motor of an all-electric car is powered by the electrical energy stored in its batteries. These automobiles lack internal combustion engines that run on fossil fuels (İşen & Tarlak, 2018). These vehicles are known as zero-emission vehicles since they lack internal combustion engines. The batteries are charged by connecting the vehicle to the power grid or by the regenerative braking system (Demir & Kaymaz, 2020). The electric motor's motion is transferred to the wheels through the drivetrain. Since solely electric motors are used in these vehicles, they are silent and have lower fuel and maintenance expenses than traditional vehicles, but the expensive cost of their production also raises their selling prices, thereby reducing their market share (Kerem, 2014).

With the expansion of the market, electric vehicles, despite the high purchase prices and the limited number of charging stations; with low operating costs, government incentives, and environmentally friendly technologies, companies are placing a greater emphasis on incorporating them into their fleets. Increasing interest has resulted in a decision dilemma at the executive level, taking company preferences and individual preferences into consideration, and has found a place in academic literature.

Biswas & Das (2018a) select a hybrid vehicle based on car model price, EPA-estimated combined fuel economy, tank size, exhaust system emissions, and passenger capacity. As alternatives for ranking, the Ford C max hybrid plug-in, Honda Accord Hybrid, Honda CR-Z hybrid CVT, Infinity Q70 hybrid, Lexus city hybrid 200 H, Toyota Camry hybrid LE, Toyota Prius, Volkswagen Jetta hybrid, and Chevrolet Malibu hybrid were chosen from the passenger car category. In the study, criterion weights were determined using the entropy approach, and alternative hybrid vehicles were ranked using the MABAC method. According to the results of the investigation, the Toyota Prius ranked first and the Infinity Q70 hybrid ranked last (Biswas & Das, 2018a).

Biswas & Das (2018b) selected electric vehicles using Fuzzy AHP-MABAC techniques. BMW i3, Chevy Bolt, Chevy Spark, Fiat 500e, Ford Focus Electric, Mitsubishi i-MiEV, and Hyundai Ioniq Electric compared their brands using technical and operational parameters such as fuel economy, base model pricing, 0-100 km acceleration time, battery range, and top speed. Based on the given criteria, it has been determined that the Hyundai Ioniq electric vehicle performs better than other alternatives. The Mitsubishi i-MiEV is the last (Biswas & Das, 2018b).

Das et al. (2019) defined the selection criteria for electric vehicles as price, battery capacity, torque, charging time, total vehicle weight, seating capacity, driving distance, top speed, and acceleration. Using the fuzzy AHP method, the relevance weights of the criteria were determined. The EVAMIX method ranked twelve distinct electric vehicle brands based on these criteria. While the BYD E6 brand vehicle is at the top of the list, the BAIC E210 ranks last (Das et al., 2019).

Khan et al. (2020) provided a list of seven hybrid vehicle options based on ten sustainable hybrid vehicle selection criteria in Pakistan. In the study, the economic, environmental, and social aspects of vehicle cost, fuel economy, hybrid battery life, sales value, comfort, dependability, greenhouse gas emissions, safety features, status symbol, and employment opportunities are considered. Alternative hybrid vehicles consist of the Toyota Prius, Toyota Axio Hybrid, Toyota Aqua, Toyota C-HR, Honda Vezel, Honda Fit Hybrid, and Honda Grace. Using the fuzzy TOPSIS method, hybrid vehicles were ranked, and it was determined that the Toyota Aqua was the best and the Toyota C-HR was the worst (Khan et al., 2020).

Sonar & Kulkarni (2021) chose electric vehicles based on driving range, cost, charging capacity, charging time, seating capacity, and torque. Using the AHP method, the weights of these six criteria were determined. Using the MABAC method, they ranked the brands Hyundai Kona Electric, Mahindra e-Verito, Mahindra e20, MG ZS EV, Tata Tigor EV, and Tata Nexon EV. In terms of performance, the Hyundai Kona Electric is better than other alternatives. The Mahindra e-Verito has the worst results and is ranked last (Sonar & Kulkarni, 2021).

Using entropy and TOPSIS methods, Gavcar & Kara (2020) ranked eleven different electric vehicle models based on their battery, power, range, aerodynamic friction coefficient, and price. As a result of the analysis, it was determined that engine power is the most important criterion, and the friction coefficient is the least important criterion. Using the TOPSIS method to rank the alternatives, the Tesla Model X LR model ranked first.

Çoşkun (2022) listed five distinct electric vehicle alternatives based on price, horsepower, torque, maximum speed, acceleration, range, and DC charging time criteria. In the study, criterion weights were determined using the standard deviation method, while alternatives were ranked using the MultiMOORA method. The criterion with the highest weight, as determined by the standard deviation (SD) method, was torque with 0.157, while the criterion with the lowest weight was the maximum speed with 0.128. According to the results of the MultiMoora method's evaluation of the alternatives, the Hyundai Kona with 150KW of power is in the first place, and the Renault Zoe is in last.

Using the criteria of fast charging time, acceleration, full charge time, price, curb weight, energy consumption, battery capacity, range, maximum speed, maximum power, and permitted capacity (number of seats), Ecer (2021) ranked a total of 10 alternative electric vehicles. In the study, SECA, MARCOS, ARAS, CoCoSo, MAIRCA, COPRAS, Borda, and Copeland methods were utilized, and the vehicles Tesla Model S, Renault ZOE, and Hyundai Ioniq were ranked first, second, and third, respectively.

Bošković et al. (2023) listed four electric vehicle alternatives based on price, payload, width, battery capacity, and volume. The ranking of electric vehicle alternatives has been conducted using a new method called AROMAN. Rankings obtained from TOPSIS, EDAS, ARAS, WASPAS, and MARCOS methods have been compared with rankings obtained from the AROMAN method.

Tian et al. (2023), have identified eight criteria to choose between different electric vehicles. According to these criteria, they obtained the ranking of the eight alternative electric vehicles available in the country with the ORESTE method.

Golui et al. (2024) aimed to rank eight different electric vehicle alternatives using criteria such as range, smart features, performance, battery life, storage space, price, and charging time. In the study, alternatives have been ranked using the Fermatean Fuzzy TOPSIS (FF-TOPSIS) method.

3. Methods

In this study, the multi-criteria decision-making methods MEREC and COCOSO have been used. Weights of the criteria have been obtained using MEREC. Alternatives of electric vehicles have been ranked using the COCOSO method.

3.1. MEREC Objective Weighting Method

In order to incorporate the relative importance of the criteria into the evaluation process, the weights must be determined. Since the criteria can be considered as sources of information, they show that the importance weights are proportional to the amount of information each criterion contains (Diakoulaki et al., 1995). Therefore, the final evaluation results of multi-criteria decision-making methods are strongly influenced by the objectively determined weights of the criteria (Wang et al., 2009). When there are only a few criteria, the use of equal weights can lead to accurate results. However, as the number of criteria increases, the accuracy decreases due to the difficulty of evaluation (Ginevčius, 2011). In the broadest sense, the calculation of the weights of the criteria can be divided into three categories: subjective, objective and hybrid, depending on how closely they are related to the personal judgements and abilities of the decision-makers. (Yang et al., 2017). In subjective weighting methods, weights are derived from the subjective evaluations of decision-makers (Zardari et al., 2015). Objective weighting methods determine the weights by solving mathematical models without considering the decision maker's preferences (Ahn, 2011). The decision maker does not need to intervene (Aldian & Taylor, 2005). In determining criterion weights, subjective methods typically use a series of questions to elicit the decision maker's judgements, while objective methods use a calculation procedure based on the criterion performances for each alternative (decision matrix). Hybrid methods, on the other hand, use features of both types of weighting methods.

The MEREC method (Method Based on the Removal Effects of Criteria) is one of the objective ways that have been suggested in recent years to figure out the weights of criteria. The method is based on the idea of causality, and it is different from other objective methods in that it looks at how taking criteria out of the process affects performance. As a result, it can assist the decision-maker in eliminating criteria from the process. The steps of how the method works are listed below (Keshavarz-Ghorabaee et al., 2021).

Step 1: *Construct the decision matrix.*

In this step, the elements of the decision matrix X are made up of the performance value of each alternative based on the criteria for the multi-criteria decision problem. x_{ij}, where i is the index of related alternatives and j is the index of related criteria, shows the performance value of the i^{th} alternative and j^{th} criteria ($i = 1, 2, ..., m$ and $j = 1, 2, ...n$). And the decision matrix can be written as follows for m alternatives and n criteria:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \tag{1}$$

If the elements of the decision matrix X have negative values, they must be transformed so that their values are between 0 and $+\infty$ ($x_{ij} \geq 0$).

Step 2: *Normalization.*

In the normalization step, different equations are used depending on whether the criteria are benefit or cost oriented. n_{ij}^{x} is the normalized performance value of the i^{th} alternative and j^{th} criteria, which is calculated with the following Eq. 2:

$$n_{ij}^{x} = \begin{cases} \dfrac{\min_k x_{kj}}{x_{ij}} & \text{if } j \in \mathbb{B} \\ \dfrac{x_{ij}}{\max_k x_{kj}} & \text{if } j \in \mathbb{H} \end{cases} \tag{2}$$

Within the previous equations, $\mathbb{B}$ represents the set of benefit-oriented criteria, while $\mathbb{H}$ represents the set of cost-oriented criteria. When normalizing a column vector in a set of benefit-oriented criteria, the element with the smallest value is identified, then divided by each column element in turn, and the relevant value is normalized. When normalizing a column vector in the cost-oriented criteria set, the highest-valued element is identified, and then this value is divided by each column value in turn, and the resulting value is normalized. The values of a normalized decision matrix range between 0 and 1.

Step 3: *Determining the overall performance values of the alternatives (S_i).*

Using the logarithmic function and equal criterion weights, the overall performance values of the alternatives are calculated. This step is another instance where the method is flexible. The researcher is not limited to the logarithmic performance function shown in the following Eq. 3:

$$S_i = \ln\left(1 + \left(\frac{1}{m}\sum_j \left|\ln\left(n_{ij}^{x}\right)\right|\right)\right) \tag{3}$$

According to the equation given above, it can be seen that the alternative with the lower n_{ij}^{x} value will have a higher S_i value. The other functions that could be used for evaluating the overall performance should have the same attribute.

Step 4: *Calculating the performance of the alternatives by removing each criterion individually.*

In this step, the overall performance values resulting from the elimination of each criterion are calculated. In this manner, it is intended to measure the impact of excluding the relevant criterion from the process. With the aid of the following equation, the S'_{ij}) that is the general performance of the i^{th} alternative when the j^{th} criterion is removed is computed.

$$S'_{ij} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} |\ln(n_{ik}^{x})|\right)\right) \tag{4}$$

Step 5: *Calculation of the total absolute deviation.*

This value could be calculated by adding up the absolute differences between the values in step 3 and step 4. The E_j value gives the magnitude of the effect resulting from the exclusion of the j^{th} criterion from the process. A large E_j value means that the effect of removing the criterion is also large. To calculate E_j, the equation is presented below would be as follow.

$$E_j = \sum_i |S'_{ij} - S_i| \tag{5}$$

Step 6: *Finding the final weights for the set of criteria.*

Where $\sum_k E_k$, is the total of all E_j values, the related weight of w_j could be calculated by taking ratios of those two values. The formula is given below:

$$w_j = \frac{E_j}{\sum_k E_k} \tag{6}$$

3.2. CoCoSo Method

In practice, since decision problems are often characterized by unmeasurable and conflicting criteria, a compromise solution can help decision-makers reach a final decision (Büyüközkan & Görener, 2015). Compromise means an agreement established by mutual concessions, and the compromise solution is a viable solution that is closest to the ideal (Opricovic & Tzeng, 2004). CoCoSo (Combined Compromise Solution) method is one of the newly proposed compromise methods for solving a decision problem in which there are conflicting criteria identified by researchers in the literature. This method is based on the simple sum weighting (SAW) and the exponential weighting product (EWP) models (Topal, 2021). The superiority of this method lies in combining perspectives that ultimately reconcile conflicting evaluation criteria (Popović, 2021). By using different sum and aggregation operators in CoCoSo, utility scores are calculated for the alternatives, and a compromise solution is provided by combining them (Altıntaş, 2021). The CoCoSo method proposed by Yazdani et al. (2019) is applied with the help of the following steps after the alternatives and criteria of the problem are determined (Yazdani et al., 2019). The steps for the CoCoSo are listed below.

Step 1: *Constructing Decision Matrix.*

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}, i = 1, 2, ..., m; j = 1, 2, ..., n \tag{7}$$

x_{ij} is the element of the decision matrix that the decision makers construct, and it is also the same MEREC's decision matrix with m alternatives and n criteria.

Step 2: *Compromise Normalization for Decision Matrix.*

A normalization procedure must be applied to the decision matrix to eliminate unit measure differences. Using the following equations and considering the difference in benefit or cost criteria, the best value of the normalization process would be 1 or 100%.

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{for benefit criteria} \tag{8}$$

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}; \text{for cost criteria} \tag{9}$$

Step 3: *The Implementation of Saw and EWP methods.*

The value of S_i that corresponds to related criteria is equal to the sum of multiplying criteria weights by normalized values. The value of S_i that corresponds to related criteria is equal to the sum of multiplying criteria weights by normalized values. On the other hand, P_i is equal to the sum of terms, which are calculated with the related criteria weight power of the normalized values. The equations for those values are given below.

$$S_i = \sum_{j=1}^{n} w_j r_{ij} \tag{10}$$

$$P_i = \sum_{j=1}^{n} \left(r_{ij}\right)^{w_j} \tag{11}$$

The higher the values of P_i and S_i, the better they are. If P_i and S_i have higher values, the criterion can be said to be better than others whose P_i and S_i values are not higher.

Step 4: *Calculation of relative weight values.*

Overall ranking can be constructed by three distinct relative weights summation strategies. those relative weights are given below.

$$\mathfrak{k}_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m} P_i + S_i} \tag{12}$$

$$\mathfrak{k}_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i} \tag{13}$$

$$\mathfrak{k}_{ic} = \frac{\lambda S_i + (1-\lambda) P_i}{\lambda \max_i S_i + (1-\lambda) \max_i P_i}; 0 \leq \lambda \leq 1 \tag{14}$$

$\mathfrak{k}_{ia}$ represents the relative value of the eleventh alternative that corresponds to the sum of P_i and S_i. $\mathfrak{k}_{ib}$ returns the ratio of the eleventh alternative's values to the minimum P_i and S_i values. $\mathfrak{k}_{ic}$ provides the i^{th} alternative's weighted success criterion based on P_i and S_i values. If the λ that is given in the Eq. 14 is 1, the criterion is the simple additive weight; otherwise, it is the exponential multiplicative weight criterion. Using λ, this equation approaches an additive or multiplicative optimality criterion, that is, the value that most accurately reflects the actual situation. If no predetermined value exists, λ is determined to be 0.5 (Yazdani et al., 2019).

Step 5: *Ranking of the Alternatives.*

Relative weights that are given in the previous step for being used to be included in this step to gain the last ranking.$\mathfrak{k}_i$ value of the i^{th} alternative consists of two parts. the first part is the geometric mean of the relative weights that are given in Step 4, and the second part is the arithmetic mean of the relative weights, which are given in Step 4. The equation of $\mathfrak{k}_i$ is given as below.

$$\mathfrak{k}_i = (\mathfrak{k}_{ia} \cdot \mathfrak{k}_{ib} \cdot \mathfrak{k}_{ic})^{\frac{1}{3}} + \frac{1}{3}(\mathfrak{k}_{ia} + \mathfrak{k}_{ib} + \mathfrak{k}_{ic}) \tag{15}$$

4. Applications of Ranking the SUV Zero-Emission Vehicles

In recent years, the demand for zero-emission electric vehicles has increased in parallel with the demands and expectations, especially in developed markets. In this context, the question of which vehicle has gained importance is in parallel with the technological developments of full-battery electric vehicles with zero emissions. All-electric vehicles, which have a higher acquisition cost compared to vehicles using fossil fuels, come to the fore with their environmental friendliness and low maintenance costs. In the study, 17 vehicles from 11 different brands were selected to rank the SUV and Cross body style full-battery electric vehicles, which are among the top preferences of individual users in Türkiye. The weights of the criteria were determined by the MEREC objective weighting method. Alternatives were evaluated using the CoCoSo method under scenarios by using different criteria sets. In the literature, it is seen that criteria such as battery power, electric motor power, electric motor torque value, vehicle weight, consumption, vehicle luggage volume, price, and the number of seats are frequently used.

Table 1. Selected Criteria for Scenario

Criteria	Min Max	Code	Scenario							
			1-a	1-b	2-a	2-b	3-a	3-b	4-a	4-b
Combined Cold Weather Range (km)	Max	c1	✓	✓	-	-	-	-	-	-
Combined Mild Weather Range (km)	Max	c2	✓	✓	-	-	-	-	-	-
City Cold Weather Range (km)	Max	c3	-	-	✓	✓	-	-	-	-
City Mild Weather Range (km)	Max	c4	-	-	✓	✓	-	-	-	-
Highway Cold Weather Range (km)	Max	c5	-	-	-	-	✓	✓	-	-
Highway Mild Weather Range (km)	Max	c6	-	-	-	-	✓	✓	-	-
Acceleration (0-100 km/h - sec)	Min	c7	✓	✓	✓	✓	✓	✓	✓	✓
Total Engine Power (kw)	Max	c8	✓	✓	✓	✓	✓	✓	✓	✓
Maximum Torque (Nm)	Max	c9	✓	✓	✓	✓	✓	✓	✓	✓
Useable Battery Capacity (kwh)	Max	c10	✓	✓	✓	✓	✓	✓	✓	✓
Maximum Fast Charge Power - DC (kw)	Max	c11	✓	✓	✓	✓	✓	✓	✓	✓
300 kw DC Charge Duration	Min	c12	✓	✓	✓	✓	✓	✓	✓	✓
Comb. Cold Weather Consumption (kwh/100km)	Min	c13	✓	✓	-	-	-	-	-	-
Combined Mild Weather Consumption (kwh/100km)	Min	c14	✓	✓	-	-	-	-	-	-
City Cold Weather Consumption (kwh/100km)	Min	c15	-	-	✓	✓	-	-	-	-
City Mild weather Consumption (kwh/100km)	Min	c16	-	-	✓	✓	-	-	-	-
Highway Cold Weather Consumption (kwh/100km)	Min	c17	-	-	-	-	✓	✓	-	-
Highway Mild Weather Consumption (kwh/100km)	Min	c18	-	-	-	-	✓	✓	-	-
Curb Weight (kg)	Min	c19	✓	✓	✓	✓	✓	✓	-	-
Trunk Volume (liters)	Max	c20	✓	✓	✓	✓	✓	✓	-	-
Sale Price (Turkish Liras)	Min	c21	-	✓	-	✓	-	✓	-	✓
Maximum Speed (km/s)	Max	c22	-	-	-	-	-	-	✓	✓

Criteria	Min Max	Code	Scenario							
			1-a	1-b	2-a	2-b	3-a	3-b	4-a	4-b
Total Vehicles Evaluated			17	13	17	13	17	13	17	13

Literature and expert opinion were used to identify the parameters associated with the vehicles in the study. In the study, vehicles were listed using four distinct management scenarios. In the first scenario, consumption, and range values for combined travel (mixed values for urban and highway use) are provided, but in the second and third scenarios, range and consumption data for urban and highway travel are used, respectively. In the fourth scenario, alternatives were attempted to be ranked using solely performance indicator-related data. Scenarios are carried out for two distinct sets of alternatives, one of which includes pricing information and the other does not. Table 1 provides details on the many criteria that have been incorporated into the various scenarios. Scenario number a describes a scenario in which pricing information is not provided, whereas scenario number b describes a situation in which price information is included. The alternatives that are going to be utilized in the study were found online at the site ev-database.org. These alternatives are going to be used for SUV cars that are marketed by various companies in Türkiye. The following is a summarized explanation of the criteria that were utilized below.

4.1. Zero-Emission Vehicles Selection Criteria

The range of an electric vehicle indicates how far it can travel on a single charge. This value is dependent on numerous variables, including the car's battery capacity, engine power, driver and air conditions, and vehicle weight. The usage of heating and cooling systems in extremely cold and extremely hot weather will accelerate battery consumption and reduce the vehicle's range. The range is also affected by the variation in transit between urban areas and highways. Traffic on the highway usually flows easily and traffic jams are not uncommon. This has a negative impact on energy recovery systems. For example, on the highway, energy recovery will be less since the regenerative braking system will be activated less. In order to comprehend the consequences of weather conditions and road types, the study utilized data from two distinct scenarios. According to statistics from ev-database.org, mildly cold weather is −10°C and the worst for heating usage; warm air is optimal compared to 23°C with no air conditioning. On the highway, the vehicle's speed is assumed to be constant at 110 km/h. Consumption and range are the first characteristics a customer considers when purchasing a car. Consequently, customers prefer vehicles with low fuel consumption and a long range; customers will want to travel further on a single charge.

Top Speed and torque are the most significant characteristics that define a vehicle's performance. The torque of an electric motor is a measure of its rotational force and is directly related to the vehicle's acceleration values. High engine power also indicates that the vehicle has a higher top speed and can accelerate more rapidly, resulting in greater torque. In today's technology, the fact that a vehicle has a powerful engine also increases its price. High engine and torque power can be appealing to drivers who seek electric vehicle performance. However, high speed and torque values can increase accident risk by making it difficult for the driver to maintain vehicle control. To protect the safety of the driver and passengers, manufacturers also may limit these values of vehicles.

The most important factor impacting the vehicle's range is its battery capacity. The range of the car would also be high due to the large battery capacity. There is a significant statistical relationship between a vehicle's price and battery capacity as well as the price rises as battery capacity increases, those parameters must be optimized for customers' benefit. Additionally, because they take longer to charge, high-capacity batteries will make these vehicles less convenient to operate. It can be noted that the study's vehicles' battery capacities range from 80 kWh to 39.2 kWh. The engine power of the cars likewise increases as battery capacity values do. Additionally, because of the limited technology, battery cost is high, but it can be expected to get decreased soon.

The weight of an electric vehicle depends on its size and design. In general, electrical vehicles tend to be heavier than comparable fossil fuel-powered vehicles because they have a heavy battery pack. The weight of the car is inversely proportional to the consumption and range criteria. Therefore, in terms of consumption and range, customers are expected to prefer vehicles with low weight. However, weight is ignored in vehicle preference, with the expectation that high weight has a positive effect on safety. As a result, the weight of an electric vehicle alone is not an absolute good indicator of its performance. In the study, the weight value refers to the curb weight of the vehicle with only the driver (75kg) is in. Unladen vehicle weight is the weight of the vehicle excluding its load in a stationary and ready-to-go condition. The weight values of the vehicles vary between 1598 kg and 2495 kg.

Another important factor for customers is the size of the trunk. The trunk size of a vehicle is a measure of how much space it has inside for carrying luggage or other things. Many customers, especially families with kids, like this feature because it makes a car easier to use every day and better able to handle longer trips. When a vehicle has a large cargo volume, it is simple to transport such as food, suitcases, and other things. But a vehicle with little room for packs might not be the best for daily driving or long trips. Due to the trunk influencing the size of the car, it is expected that the trunk volume of the car will be directly related to the weight of the car.

Table 2. The Value of The Decision Matrix for Electric Vehicles

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	Av.
C1	305	325	230	210	320	340	315	295	285	315	310	280	215	215	275	300	285	283.5
C2	405	440	305	290	435	460	420	400	380	420	315	370	290	290	380	405	380	375.6
C3	350	385	275	245	375	395	365	345	330	370	370	330	255	255	320	360	340	333.2
C4	515	560	405	380	565	580	535	510	485	530	550	485	385	385	490	520	500	492.9
C5	260	275	190	175	270	285	265	250	240	270	255	230	180	180	235	255	235	238.2
C6	330	350	240	230	345	370	335	320	305	340	325	295	230	230	305	320	300	304.1
C7	6.1	6.8	8.9	9.9	7.8	5.2	3.5	6	6.2	5.1	8.4	4.9	9.2	8.5	7.4	6.9	7.4	7
C8	204	210	120	100	150	239	430	215	215	300	115	212	100	100	160	160	170	188.2
C9	630	400	300	395	255	605	740	520	520	760	280	665	260	260	300	336	330	444.5
C10	71	74	52	39.2	64.8	74	74	66.5	66.5	80	68.3	65	45	45	55	71.4	67	63.5
C11	148	155	56	44	80	233	233	112	112	112	94	94	101	101	129	150	136	122.9
C12	31	31	46	47	41	16	16	29	29	35	37	35	26	26	28	32	26	31.2
C13	23.3	22.8	22.6	18.7	20.3	21.8	23.5	22.5	23.3	25.4	22	23.2	20.9	20.9	20	23.8	23.5	22.3
C14	17.5	16.8	17	13.5	14.9	16.1	17.6	16.6	17.5	19	16.5	17.6	15.5	25.5	14.5	17.6	17.6	17.1
C15	20.3	19.2	18.9	16	17.3	18.7	20.3	19.3	20.2	21.6	18.5	19.7	17.6	17.6	17.2	19.8	19.7	18.9
C16	13.8	13.2	12.8	10.3	11.5	12.8	13.8	13	13.7	15.1	12.4	13.4	11.7	11.7	11.2	13.7	13.4	12.8
C17	27.3	26.9	27.4	22.4	24	26	27.9	26.6	27.7	29.6	26.8	28.3	25	25	23.4	28	28.5	26.5

A1: BMW iX xDrive40, A2: BMW iX3 eDrive30, A3: DFSK Seres 3, A4: Hyundai Kona Electric, A5: Kia Niro EV, A6: Kia EV6 GT- 325 PS, A7: Kia EV6 GT- 585 PS, A8: Mercedes EQA 350, A9: Mercedes EQB 350, A10: Mercedes EQC 400, A11: MG ZS EV Long Range, A12: MG Marvel R Perf., A13: Opel Mokka-e, A14: Peugeot e-2008 SUV, A15: Renault Megane E-Tech, A16: Subaru Solterra AWD, A17: Volvo XC40 Recharge, Av.: Average

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	Av.
C18	21.5	21.1	21.7	17	18.8	20	22.1	20.8	21.8	23.5	21	22	19.6	19.6	18	22.3	22.3	20.8
C19	2440	2260	1650	1610	1757	2090	2200	2105	2175	2495	1695	1995	1598	1623	1711	2110	2023	1972.8
C20	500	510	526	332	475	480	480	340	495	500	448	357	310	434	440	441	419	440.4
C21	3414	2870	920	-	1550	2280	2580	1938	1974	2635	950	-	-	900	-	1652	1729	-
C22	200	180	155	155	167	185	260	160	160	180	175	200	150	150	160	160	160	200

A1: BMW iX xDrive40, A2: BMW iX3 eDrive30, A3: DFSK Seres 3, A4: Hyundai Kona Electric, A5: Kia Niro EV, A6: Kia EV6 GT- 325 PS, A7: Kia EV6 GT- 585 PS, A8: Mercedes EQA 350, A9: Mercedes EQB 350, A10: Mercedes EQC 400, A11: MG ZS EV Long Range, A12: MG Marvel R Perf., A13: Opel Mokka-e, A14: Peugeot e-2008 SUV, A15: Renault Megane E-Tech, A16: Subaru Solterra AWD, A17: Volvo XC40 Recharge, Av.: Average

The first feature to consider with battery-powered electric vehicles is DC charging. because, compared to conventional AC charging techniques, it enables quicker charging times. The range disadvantage of electric vehicles in comparison to fossil fuel vehicles will be eliminated through a large network of charging stations and quick charging periods. In addition to lowering overall running expenses, DC charging can increase the battery life of battery-powered electric vehicles. DC charging is a better choice for EV drivers because it is typically more accessible at public charging stations. The study considers the vehicles' DC fast charging duration at a 300kW charging station, and the charging duration of the cars is given according to it.

4.2. Weighting the Criteria

In the literature, both objective and subjective weighting techniques have been used in the criteria weighting procedure. In this study, the MEREC method, which was developed in recent years, was used to determine the weights of the selected criteria for SUV-type electric vehicles without the influence of the decision maker's opinions. A total of 17 vehicles were included in the analysis (the number was reduced to 13 when the price criteria were included). The vehicle decision matrix values are shown in Table 2. Different criterion weights were generated for four distinct scenarios. In Table 3, the weights that were determined by the MEREC methods according to the scenarios were shown. Depending on whether the criteria are benefit-oriented or cost-oriented, they are put into the MEREC weight calculation.

Table 3. Objective Weights Calculated with MEREC

Max Min	Code	Scenario							
		1-a	1-b	2-a	2-b	3-a	3-b	4-a	4-b
Max	K1	0.057546	0.057582	-	-	-	-	-	-
Max	K2	0.048596	0.052387	-	-	-	-	-	-
Max	K3	-	-	0.062148	0.058902	-	-	-	-
Max	K4	-	-	0.052371	0.053835	-	-	-	-
Max	K5	-	-	-	-	0.062599	0.061389	-	-
Max	K6	-	-	-	-	0.056274	0.060489	-	-
Min	K7	0.075651	0.056947	0.079342	0.059866	0.080215	0.059939	0.109165	0.076665
Max	K8	0.108152	0.115552	0.113601	0.121518	0.114777	0.121737	0.156662	0.15788
Max	K9	0.095488	0.093256	0.100331	0.098111	0.101363	0.098188	0.138384	0.126389
Max	K10	0.093282	0.072968	0.097736	0.076593	0.098934	0.076842	0.137886	0.100664
Max	K11	0.193498	0.147622	0.202599	0.154765	0.205072	0.155239	0.287951	0.203013
Min	K12	0.090021	0.084074	0.094158	0.088016	0.095312	0.088306	0.131936	0.114319

Max Min	Code	Scenario							
		1-a	1-b	2-a	2-b	3-a	3-b	4-a	4-b
Min	K13	0.028942	0.021435	-	-	-	-	-	-
Min	K14	0.085467	0.070401	-	-	-	-	-	-
Min	K15	-	-	0.030368	0.022558	-	-	-	-
Min	K16	-	-	0.038446	0.028342	-	-	-	-
Min	K17	-	-	-	-	0.02574	0.01833	-	-
Min	K18	-	-	-	-	0.028959	0.020311	-	-
Min	K19	0.05397	0.040603	0.056311	0.042277	0.05723	0.042618	-	-
Max	K20	0.069387	0.058359	0.072589	0.06112	0.073525	0.061396	-	-
Min	K21	-	0.128814	-	0.134096	-	0.135216	-	0.184
Max	K22	-	-	-	-	-	-	0.038014	0.036606

Examining the weights reveals that the DC maximum fast charging power (kW) criterion has the highest weight for the combined travel condition criterion set, excluding the price criterion, with 0.192. It is then followed by total motor power (kW) at 0.108, maximum torque (Nm) at 0.095, net battery capacity (kwh) at 0.093, and DC charging time (300 kW) at 0.90. When the price is included as one of the criteria, DC maximum charging power (kW) ranks top with 0.148, followed by Price with 0.129 and total motor power (kW) in third with 0.116.

For urban travel, the highest weight is 0.203 and belongs to the DC maximum fast charging power (kW) criterion. Total engine power (kW) is in second place with 0.114, and maximum torque (Nm) is in third place with 0.100. Net battery capacity (kwh) is in fourth place with 0.098 and DC (300kw) charging time is in fifth place with 0.094. When the price criterion is included in the process, DC maximum fast charging power (kW) takes the first place with 0.155, followed by price with 0.134 and total motor power (kW) with 0.122.

The criterion weights calculated in the case of highway travel similarly gave the same ranking as the results of the other two cases. DC maximum fast charging power (kW) is in first place with 0.205, total motor power (kW) is in second place with 0.115 and maximum torque (Nm) is in third place with 0.101. In the fourth and fifth rows, there is a net battery capacity (kwh) of 0.099 and a DC charging time of 0.953 to 300kw. When the price criterion is included in the scenario, DC maximum fast charging power (kW) is in first place with 0.155, price is in second place with 0.135 and total motor power (kW) is in third place with 0.122.

Considering the weights calculated by considering only the performance criteria, the highest value of 0.288, when the price is not included, belongs to the DC maximum fast charging power (kW) criterion. In second place is the total engine power with 0.157. In the weight ranking recalculated by including the price criterion, DC maximum fast charging power (kW) is in first place with 0.20, price is in second place with 0.184, and it is followed by the total motor power (kW) with 0.159, which is in the third place.

4.3. Ranking the Alternatives

In the study, the alternatives were ranked by the CoCoSo method. CoCoSo is a newly proposed compromise method based on simple sum weighting (SAW) and exponential weighting product (EWP) models. Using the aggregation procedure, the CoCoSo method produced three different relative weights to rank the alternatives. By summing the geometric and arithmetic means of the values represented by $\varkappa_{ia}$, $\varkappa_{ib}$ and $\varkappa_{ic}$, it was possible to calculate the final weights of the alternatives. The final weight values derived by the CoCoSo method are listed in Table 4. When applying the CoCoSo there are two basic situations taken into account. Is the price included or not? When the price is taken as a member of the criteria set, there were 13 vehicles taken as alternatives. On the other hand, if the price is put out outside of the criteria set, there were 17 vehicles that get to be ranked by CoCoSo. The result of the CoCoSo implementation with criteria set without price was shown in Table 4.

Table 4. CoCoSo Ranking of Vehicles Without Price Criteria

Model	Scenario							
	Combined 1-a		City 2-a		Highway 3-a		Performance 4-a	
	$\varkappa_i$	Rank	$\varkappa_i$	Rank	$\varkappa_i$	Rank	$\varkappa_i$	Rank
BMW iX xDrive40	2.786421	4	3.006132	4	3.165777	3	7.311334	4
BMW iX3 eDrive30	2.799982	3	3.049392	3	3.161391	4	6.748209	5
DFSK Seres 3	2.043791	14	2.11732	15	2.103836	14	2.64665	16
Hyundai Kona Electric 39 kWh	1.081384	17	1.077926	17	1.077704	17	0.944232	17
Kia Niro EV	2.342064	13	2.502692	13	2.563379	13	3.773355	13
Kia EV6 GT- 325 PS	3.259151	2	3.615668	2	3.795159	2	9.403268	2
Kia EV6 GT - 585 PS	3.38645	1	3.781437	1	3.974697	1	11.10923	1
Mercedes EQA 350 4MATIC	2.606319	6	2.788615	7	2.891871	6	6.363422	7
Mercedes EQB 350 4MATIC	2.661534	5	2.850195	5	2.968782	5	6.330954	8
Mercedes EQC 400 4MATIC	2.573328	9	2.686437	11	2.841051	8	7.770174	3
MG ZS EV Long Range	2.347666	12	2.592717	12	2.604989	12	4.291465	12
MG Marvel R Performance	2.575806	8	2.772536	8	2.830677	9	6.48503	6
Opel Mokka-e	1.709334	15	1.898182	16	1.78927	16	3.160236	15
Peugeot e-2008 SUV	1.664156	16	2.16396	14	2.06682	15	3.289079	14
Renault Megane E-Tech EV60 220hp	2.56156	10	2.730366	10	2.827251	10	5.177277	11
Subaru Solterra AWD	2.603139	7	2.81125	6	2.889276	7	6.042218	9
Volvo XC40 Recharge Pure Electric	2.549554	11	2.749719	9	2.790344	11	5.890962	10

Table 4's ultimate weights indicate that Kia EV6 GT 325PS and Kia EV6 GT 585PS models are ranked first and second in every scenario. Among the situations, however, the third position is shared by multiple vehicles. While the BMW iX3 eDrive30 ranked third in the combined and urban travel scenarios, the BMW iX xDrive40 ranked third in the highway travel scenario. In addition to struggling for the top positions, the competition for the remaining positions is minimal. In all situations, the Hyundai Kona Electric held the last row (39kWh). The Peugeot e-2008 SUV ranks sixteenth in the combined travel scenario, while the Opel Mokka-e ranks sixteenth in the urban and highway travel scenario. According to the performance-based scenario outcomes, the first two ranks are similar to the other situations. In this scenario, the Kia EV6 GT 325PS and EV6 GT 585PS models are placed first and second, respectively. In addition to being positioned in the average of the other scenarios, the Mercedes EQC 400 4MATIC is ranked third in terms of performance.

Table 5. Sorting Vehicles by CoCoSo Method When Price Criteria is Included

Model	Scenario							
	Combined 1-a		City 2-a		Highway 3-a		Performance 4-a	
	k_i	Rank	k_i	Rank	k_i	Rank	k_i	Rank
BMW iX xDrive40	1.973256	7	1.866511	8	1.929532	7	2.0649	9
BMW iX3 eDrive30	2.109855	3	2.014059	3	2.053219	3	2.1621	8
DFSK Seres 3	1.491845	12	1.407468	12	1.398746	12	1.2156	13
Kia Niro EV	1.894393	11	1.798948	10	1.82305	11	1.6776	11
Kia EV6 GT- 325 PS	2.445106	2	2.357066	2	2.42549	2	2.7636	2
Kia EV6 GT - 585 PS	2.513022	1	2.431137	1	2.502484	1	3.075	1
Mercedes EQA 350 4MATIC	1.959253	8	1.859194	9	1.901778	9	2.2588	4
Mercedes EQB 350 4MATIC	2.095666	4	1.986515	4	2.036423	4	2.247	5
Mercedes EQC 400 4MATIC	1.957346	9	1.767988	11	1.832247	10	2.4363	3
MG ZS EV Long Range	1.943093	10	1.907231	7	1.907647	8	1.9417	10
Peugeot e-2008 SUV	1.250152	13	1.370127	13	1.380016	13	1.3806	12
Subaru Solterra AWD	2.06878	5	1.976729	5	2.006357	5	2.2025	6

In Table 5, thirteen vehicles' (only those with sales price data) respective CoCoSo evaluation results for four distinct scenarios are displayed. Regardless of the sale prices of the vehicles used in the evaluation, any change does not occur at the top of the list. So, the first and second places are taken by two Kia EV6 models. Third place among the combined urban and highway travel scenarios is taken by the BMW iX3 eDrive30. Finally, when the vehicles are evaluated based on performance indicators, both of Kia EV6 models come in first and second, with the Mercedes-Benz EQC400 4MATIC coming in third. The Peugeot e-2008 SUV, on the other hand, ranks last in the combined urban and highway travel scenarios. DFSK Seres 3 is ranked 13th in terms of performance criteria.

5. Conclusion

This study aims to rank electric vehicles within the scope of scenarios created under different criteria sets. The criteria weights were determined objectively using the MEREC method. Alternatives were ranked by the CoCoSo method using these weight values.

In consideration to evaluate electric vehicles when the selling price is added to the criteria set, it is seen that it has the second highest weight. Because the sales price of the vehicle is a combination of all other performance, consumption, range, and brand value. Also, the higher the level of technology used, the higher the price will be. In addition, it should not be ignored that criteria, such as design, comfort, and material quality, which were not included in the study, are positively related to the sales price. Generally, considering that the sales price criterion of the vehicle is in the first place in the purchasing behaviors of the consumer, it is expected that the weight of the objectively determined price criterion is in the first two ranks.

The vehicles that are more affordable in terms of sale pricing are placed in the final position in the rankings of the vehicles that were evaluated using CoCoSo. Although the price has the second highest weight among the criteria, the fact that it does not have a significant value gap when compared to the other criteria did not produce a significant shift in the vehicle rankings when the price was the primary concern.

The fact that the vehicle's DC maximum charging power has the highest weight in the evaluations made by subtracting the sale price from the criteria also would show a situation in line with consumer expectations. This result shows that customer expectations would be met by short charge time which is supplied with max DC charging time. As a result, despite the use of objective weighting methods, it is acceptable in terms of market realities that this criterion, which can reduce the stated period, is first. In contrast, the development of the present fast-charging network is a more significant factor affecting vehicle preference in the actual market. A widespread charging network would direct market behaviours to electric vehicles. By the zero-emission goal, If the wide charge network does not be supported, customers will hesitate to buy a new car which is a full-battery electric vehicle.

According to the evaluation based only on performance, the fact that the automobiles with the highest engine power are at the top indicates that their weights represent their technological ability. It is also projected that budget-friendly vehicles would slip to the bottom of the list based on this criterion, as customers will favour fuel-efficient vehicles that are priced competitively.

Electric vehicles' range and energy consumption are highly dependent on their usage conditions and environmental factors. As a result of regenerative braking technologies, electric vehicles have a high urban range and low consumption values. On the highway, range values decrease while consumption values increase. In consideration of the conditions under which electric vehicles are being evaluated, a scenario-based evaluation methodology was chosen for this study. Scenario-based evaluation makes the study unique and provides useful information to the literature. Considering the results of this study it was discovered that the vehicle rankings derived from this strategy varied. In future studies, instruments can be selected using subjective weighting methods to incorporate the decision-makers judgements. Since the performance of the vehicles varies depending on the conditions, the scenario-based ranking should be preferred.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

References

Ahn, B. S. (2011). Compatible weighting method with rank order centroid: Maximum entropy ordered weighted averaging approach. *European Journal of Operational Research*, *212*(3), 552–559. https://doi.org/10.1016/j.ejor.2011.02.017

Alahyari, A., Fotuhi-Firuzabad, M., & Rastegar, M. (2014). Incorporating Customer Reliability Cost in PEV Charge Scheduling Schemes Considering Vehicle to Home Capability. *IEEE Transactions on Vehicular Technology*, 1–2. https://doi.org/10.1109/tvt.2014.2352413

Aldian, A., & Taylor, M. A. P. (2005). A consistent method to determine flexible criteria weights for multicriteria transport project evaluation in developing countries. *Eastern Asia Society for Transportation Studies*, *6*, 3948–3963. https://doi.org/10.11175/easts.6.3948

Altıntaş, F. F. (2021). G7 ülkelerinin bilgi performanslarının analizi: COCOSO yöntemi ile bir uygulama. *Journal of Life Economics*, *8*(3), 337–347. https://doi.org/10.15637/jlecon.8.3.06

Biswas, T. K., & Das, M. C. (2018b). Selection of Commercially Available Electric Vehicle using Fuzzy AHP-MABAC. *Journal of the Institution of Engineers (India): Series C*, *100*(3), 531–537. https://doi.org/10.1007/s40032-018-0481-3

Biswas, T. K., & Das, M. C. (2018a). Selection of hybrid vehicle for green environment using multi-attributive border approximation area comparison method. *Management Science Letters*, 121–130. https://doi.org/10.5267/j.msl.2017.11.004

Bošković, S., Švadlenka, L., Jovčić, S., Dobrodolac, M., Simić, V., & Bacanin, N. (2023). An Alternative Ranking Order Method Accounting for Two-Step Normalization (AROMAN)–A Case Study of the Electric Vehicle Selection Problem. *IEEE Access*, *11*, 39496–39507. https://doi.org/10.1109/access.2023.3265818

Büyüközkan, G., & Görener, A. (2015). Evaluation of product development partners using an integrated AHP-VIKOR model. *Kybernetes*, 44(2), 220–237. https://doi.org/10.1108/k-01-2014-0019

Cheng, L., Chang, Y., Wu, Q., Lin, W., & Singh, C. (2014). Evaluating Charging Service Reliability for Plug-In EVs From the Distribution Network Aspect. *IEEE Transactions on Sustainable Energy*, *5*(4), 1287–1296. https://doi.org/10.1109/tste.2014.2348575

Das, M. C., Pandey, A., Mahato, A. K., & Singh, R. K. (2019). Comparative performance of electric vehicles using evaluation of mixed data. *OPSEARCH*, *56*(3), 1067–1090. https://doi.org/10.1007/s12597-019-00398-9

Demir, M. F., & Kaymaz, H. (2020). Elektrikli Otomobiller için Çekiş Motor Tip Seçimi. *Marmara University*, *2*(1), 35–41. https://doi.org/10.35333/porta.2020.211

Diakoulaki, D., Mavrotas, G., & Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: The critic method. *Computers & Operations Research*, *22*(7), 763–770. https://doi.org/10.1016/0305-0548(94)00059-h

Ecer, F. (2021). A consolidated MCDM framework for performance assessment of battery electric vehicles based on ranking strategies. *Renewable and Sustainable Energy Reviews*, *143*, 110916–110917. https://doi.org/10.1016/j.rser.2021.110916

Gavcar, E., & Kara, N. (2020). Elektrikli Otomobil Seçiminde Entropi ve TOPSIS Yöntemlerinin Uygulanması. *İş Ve İnsan Dergisi*, *7*(2), 351–359. https://doi.org/10.18394/iid.695702

Ginevčius, R. (2011). A new determining method for the criteria weights in multicriteria evaluation. *International Journal of Information Technology & Decision Making*, *10*(6), 1067–1095. https://doi.org/10.1142/s0219622011004713

Golui, S., Mahapatra, B. S., & Mahapatra, G. S. (2024). A new correlation-based measure on Fermatean fuzzy applied on multi-criteria decision making for electric vehicle selection. *Expert Systems with Applications*, *237*, 121605–121606. https://doi.org/10.1016/j.eswa.2023.121605

Işılak, C. (2020). Elektrikli araçların konvansiyonel araçlara göre gövde, şasi ve iç trim açısından tasarım farklılıkları. *Uluslararası Bilim, Teknoloji Ve Tasarım Dergisi*, *1*(1), 46–58.

İşen, E., & Tarlak, H. (2018). Elektrikli Araçlar ve Akü Şarj Sistemleri. *Kırklareli Üniversitesi Mühendislik Ve Fen Bilimleri Dergisi*, *4*(1), 124–141.

Kerem, A. (2014). Elektrikli Araç Teknolojisinin Gelişimi ve Gelecek Beklentileri. *Mehmet Akif Ersoy Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *5*(1), 1–13.

Khan, F., Ali, Y., & Khan, A. U. (2020). Sustainable hybrid electric vehicle selection in the context of a developing country. *Air Quality, Atmosphere & Health*, *13*(4), 489–499. https://doi.org/10.1007/s11869-020-00812-y

Opricovic, S., & Tzeng, G.-H. (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research*, *156*(2), 445–455. https://doi.org/10.1016/s0377-2217(03)00020-1

Paoli, L., Dasgupta, A., & McBain, S. (2022). Electric Vehicles. *International Energy Agency: IEA*.

Popović, M. (2021). An MCDM approach for personnel selection using the CoCoSo method. *Journal of Process Management. New Technologies*, *9*(3–4), 78–88. https://doi.org/10.5937/jouproman2103078p

Ritchie, H., Rosado, P., & Roser, M. (2023). Energy. *Our World in Data*.

Sonar, H. C., & Kulkarni, S. D. (2021). An Integrated AHP-MABAC Approach for Electric Vehicle Selection. *Research in Transportation Business & Management*, *41*, 100665–100666. https://doi.org/10.1016/j.rtbm.2021.100665

Tian, Z.-p., Liang, H.-m., Nie, R.-x., Wang, X.-k., & Wang, J.-q. (2023). Data-driven multi-criteria decision support method for electric vehicle selection. *Computers & Industrial Engineering*, *177*, 109061–109062. https://doi.org/10.1016/j.cie.2023.109061

Tie, S. F., & Tan, C. W. (2013). A review of energy sources and energy management system in electric vehicles. *Renewable and Sustainable Energy Reviews*, *20*, 82–102. https://doi.org/10.1016/j.rser.2012.11.077

Topal, A. (2021). Çok kriterli karar verme analizi ile elektrik üretim şirketlerinin finansal performans analizi: Entropi tabanlı Cocoso yöntemi. *Business & Management Studies: An International Journal*, *9*(2), 532–546. https://doi.org/10.15295/bmij.v9i2.1794

Wang, J.-J., Jing, Y.-Y., Zhang, C.-F., & Zhao, J.-H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renewable and Sustainable Energy Reviews*, *13*(9), 2263–2278. https://doi.org/10.1016/j.rser.2009.06.021

Yang, G.-l., Yang, J.-B., Xu, D.-L., & Khoveyni, M. (2017). A three-stage hybrid approach for weight assignment in MADM. *Omega*, *71*, 93–105. https://doi.org/10.1016/j.omega.2016.09.011

Yazdani, M., Zarate, P., Kazimieras Zavadskas, E., & Turskis, Z. (2019). A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems. *Management Decision*, *57*(9), 2501–2519. https://doi.org/10.1108/md-05-2017-0458

Zardari, N. H., Ahmed, K., Shirazi, S. M., & Yusop, Z. B. (2015). *Weighting Methods and their Effects on Multi-Criteria Decision Making Model Outcomes in Water Resources Management*. Springer International Publishing. https://doi.org/10.1007/978-3-319-12586-2

Çoşkun, İ. T. (2022). Çok Kriterli Karar Verme Teknikleri İle Elektrikli Otomobil Seçimi: SD-MULTIMOORA Yaklaşımı. *3. Sektör Sosyal Ekonomi Dergisi*. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.22.01.1735

Özcan, M., & Oral, B. (2018). Elektrikli Araç Mimarileri ve Batarya Teknolojilerinin Değerlendirilmesi. *Proceedings of the International Eurasian Conference on Science, Engineering and Technology*, 1015–1023.