Journal of Intelligent Management Decision
https://www.acadlore.com/journals/JIMD

Systematic Literature Review on Electric Vehicles and Multicriteria Decision Making: Trends, Rankings, and Future Perspectives

Maiquiel Schmidt de Oliveira[1*], Vilmar Steffen[2], Flávio Trojan[3]

[1] Academic Department of Physics, Statistics and Mathematics (DAFEM), Federal University of Technology - Parana (UTFPR), 85602-863 Francisco Beltrão, Brazil
[2] Academic Department of Engineering (DAENG), Federal University of Technology - Parana (UTFPR), 85602-863 Francisco Beltrão, Brazil
[3] Academic Department of Electronics (DAELE), Federal University of Technology - Parana (UTFPR), 85602-863 Francisco Beltrão, Brazil

[*] Correspondence: Maiquiel Schmidt de Oliveira (msoliveira@utfpr.edu.br)

Received: 01-03-2024 **Revised:** 02-07-2024 **Accepted:** 02-18-2024

Citation: M. S. de Oliveira, V. Steffen, and F. Trojan, "Systematic literature review on electric vehicles and multicriteria decision making: Trends, rankings, and future perspectives," *J. Intell Manag. Decis.*, vol. 3, no. 1, pp. 22–41, 2024. https://doi.org/10.56578/jimd030103.

© 2024 by the authors. Published by Acadlore Publishing Services Limited, Hong Kong. This article is available for free download and can be reused and cited, provided that the original published version is credited, under the CC BY 4.0 license.

Abstract: The paradigm shift towards sustainable transportation underscores the burgeoning focus on electric vehicles (EVs) as a viable alternative to combustion-powered counterparts. Concurrently, the corpus of scholarly publications exploring this domain has expanded, endeavoring to address multifaceted challenges across various disciplines. Among the methodologies enlisted, Multi-criteria Decision Analysis (MCDM) emerges as a pivotal tool for decision-makers, facilitating the resolution of complex problems characterized by multiple criteria and alternatives. This research employs a modified Systematic Literature Review (SLR) methodology, integrating the Analytical Hierarchical Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for article ranking. This novel approach not only enhances the precision of the ranking process but also earmarks the articles exerting substantial influence on the scholarly landscape. The exhaustive review culminates in a curated portfolio of 73 seminal articles, with a pronounced emphasis on Charging Stations applications, accounting for approximately 42.46% of the collective focus. This study's findings illuminate the prevailing trends within the nexus of EV research and MCDM, delineating a trajectory for future inquiries and applications. In doing so, it underscores the indispensable role of MCDM in navigating the complexities inherent in the transition to electrified mobility solutions. The meticulous application of the SLR methodology, augmented by AHP and TOPSIS, not only refines the academic discourse but also paves the way for a more structured and impactful exploration of EVs within the realm of sustainable transportation.

Keywords: Systematic Literature Review (SLR); Multi-criteria Decision Analysis (MCDM); Electric vehicles (EVs); Order of Preference by Similarity to Ideal Solution (TOPSIS); Analytical Hierarchical Process (AHP)

1 Introduction

There is a concern with themes that are of general interest, such as the issue of sustainability and environmental questions. Climate change and global warming are adversely affecting environmental quality, and transportation is a crucial factor for the environment [1]. Therefore, EVs have received attention around the world, mainly in relation to the reduction of gas emissions. In the last 200 years, mankind has begun to explore the world's resources, looking for non-renewable energy sources such as petroleum, coal, and natural gas, causing severe long-term environmental impacts [2], such as the high emission of carbon dioxide, which is linked to the rising global temperature [3]. With increasing demand for renewable energy sources and low environmental fuel consumption, vehicles powered by environmentally friendly sources are receiving government incentives, and the industry is growing significantly [4]. EVs are a possible alternative to help with sustainable development; they can decrease greenhouse gas emissions and the use of fossil fuels, and they are an optimal solution for transportation due to the zero emission of exhaust gas [5].

EVs play a very important role in decreasing pollution from fossil fuel consumption and are capable of making a paradigm shift in the entire transport sector, as transport contributes a lot to urban air pollution, and a reduction in pollution rates is the key need of the moment [6]. EVs have achieved great success, indicating that the automobile industry will soon be emission-free [7]. The electric car industry has developed in the last few years as they produce vehicles with high specifications that do not require the use of fossil fuels [6]. Therefore, the use of EVs is essential to controlling environmental challenges [8].

The growing search for the use of EVs also creates challenges for managers, considering that it will be necessary to increase production, search for charging spot locations, and replace batteries, in addition to battery reverse logistics, among other aspects. As a result, researchers in the area will need to carry out studies on different subjects linked to this topic, seeking solutions to the various problems that must be resolved with the growth in the search for EVs.

Due to the importance of the topic in recent years, several studies on EVs have been carried out in search of solutions, and consequently, literature reviews related to sustainability have been carried out, mainly due to the global demand for renewable energy sources [9–11]. Maybury et al. [12] carried out a SLR about research related to adhesion of EV use, based on the procedure of Kitchenham [11] and on the orientation presented by Weidt and Silva [13]. They analyzed 53 papers and concluded that most researchers apply the discrete choice model (DCM) and that the lack of successful businesses is a significant barrier to the adoption of EVs. Weidt and Silva [13] mapped a literature review on EV consumer behavior, analyzing 254 articles and verifying the existence of 4 clusters (environmental sustainability, transport infrastructure batteries, purchase ways, and battery use). Ding et al. [14] performed a literature review about EVs, addressing the operational processes of several EVs, battery technology, and super capacitors, aiming to increase the energy capacity of plug-in hybrid electric vehicles (PHEVs). Soares et al. [15] investigated EV supply chain management through a bibliometric and SLR using the PRISMA method.

The results of the systematic review showed that the most studied topics were related to risk management, while the bibliometric review showed the importance of associated costs as well as studies involving transparency and sustainability in the supply chain. Regarding the components, the battery was the most studied. Liao et al. [16] analyzed consumer preferences about EVs, comparing the economic and psychological approaches, followed by a conceptual framework of preferences. It was found that economic and technical aspects of EVs are generally significant, in addition to the density of charging stations, demonstrating the importance of charging infrastructure in the development of EVs. Other reviews about EV can be found in the literature, addressing aspects related to: commercial EV routing in urban logistics [17], locating charging infrastructure for shared autonomous EVs and for vehicle-to-grid strategies [18], characterizing the flexibility of EV charging strategies [19], consumer adoption of EVs [20], EV adoption [21], and sustainability assessment of EVs [22].

The MCDA methods can help researchers make decisions related to EV issues like the location of charging stations and the choice of EV and its components. Ecer [23] states that the techniques of MCDM are efficient tools for making the correct EV purchase decision. The selection of the most sustainable location for the EV charging station plays an important role in its life cycle. This process needs to consider some conflicting criteria and has a complex decision problem that can be modeled as a MCDM problem [24]. Pradhan et al. [25] cite that current research in the literature accepts that many MCDM techniques have been extensively used for various vehicle analyses.

SLR methods have advanced over time, with the creation of new methods or the adaptation or improvement of existing ones. Liberati et al. [26] proposed the PRISMA method for systematic reviews and meta-analyses. The PRISMA method was proposed in a meeting with several participants to analyze the QUOROM checklist and its flowchart [27]. Ensslin et al. [28] developed the ProKnow-C (Knowledge Development Process-Constructivist) method, which was organized into 4 blocks by Ensslin et al. [29]: bibliographic portfolio selection, bibliometric analysis, systematic analysis, and research question. These methods help researchers by guiding them in building a portfolio of articles. ProKnow-C and other SLR methods have spread throughout academia. The ProKnow-C method was adapted by Pagani et al. [30] for the creation of the Methodi Ordinatio.

Steffen et al. [31] proposed a SLR method that considers a raking index for ordering the publications in order of importance. There are 14 steps in the method that use normalized scientific indicators in the index calculation.

In this work, a SLR was carried out to create the ranking of articles based on the method proposed by Steffen et al. [31], with a modification in the ranking index calculation to make the method less subject and more robust. The index is obtained using the same normalized input data but in a weighted sum, in which the weights used for deciding the relevance of the papers are calculated using the AHP method. Furthermore, for generating the papers, ranking is made by using the arithmetic mean of the method TOPSIS.

Studies focused on sustainable issues are proving to be increasingly important. In this context, the main motivations of this study are:

Realize a SLR involving EVs and MCDM methods;

Propose a new way for ranking papers in a research field using MCDM methods in SLR techniques;

- Visualize methods more applied, main authors, among other aspects.

- Provide potential possibilities for future studies, presenting gaps in the literature.

To carry out this study, searches were carried out in two databases (Web of Science and Scopus), considering articles that fit the keywords chosen from exploratory searches.

This study is organized into four sections. Section 2 presents the methodologies adopted, pointing to the SLR method adopted and the MCDM and Cluster Analysis (CA) methods used. Section 3 discusses the results of the SLR. Finally, Section 4 presents a discussion around the results, directions for future studies, and limitations of the study.

2 Methodology

2.1 Systematic Literature Review

SLR is a very useful tool that can make the review process more robust and efficient, resulting in a number of articles about a specific subject. From the final set of articles (normally named portfolios), various characteristics about the subject being reviewed can be easily determined. There are several SLR methods in the literature that are composed of many rigorous steps because they are not only a way to group existing papers but also a way to support the development of knowledge in many research fields [32].

Among the several SLRs available in the literature, there are some that provide an equation used to calculate an index that is the basis for ranking the papers in the final portfolio (FP). This ranking index is one of the SLR features that has improved in the last few years, as can be seen in the works of Pagani et al. [30], Pagani et al. [33], and Steffen et al. [31]. In this study, an adaptation of the SLR methodology proposed by Steffen et al. [31] is presented, and 14 steps are presented in Figure 1. The steps are divided into search, filtering, and ranking the papers; our aim was to improve the ranking procedure (more details about all steps can be found in the work of Steffen et al. [31]). This method incorporated MCDA methods for the generation of the criteria weights, aiming to generate the way of calculating the rank index used for the ordering of the FP. This new methodology was applied in the search for articles with the theme "MCDM methods involving EVs."

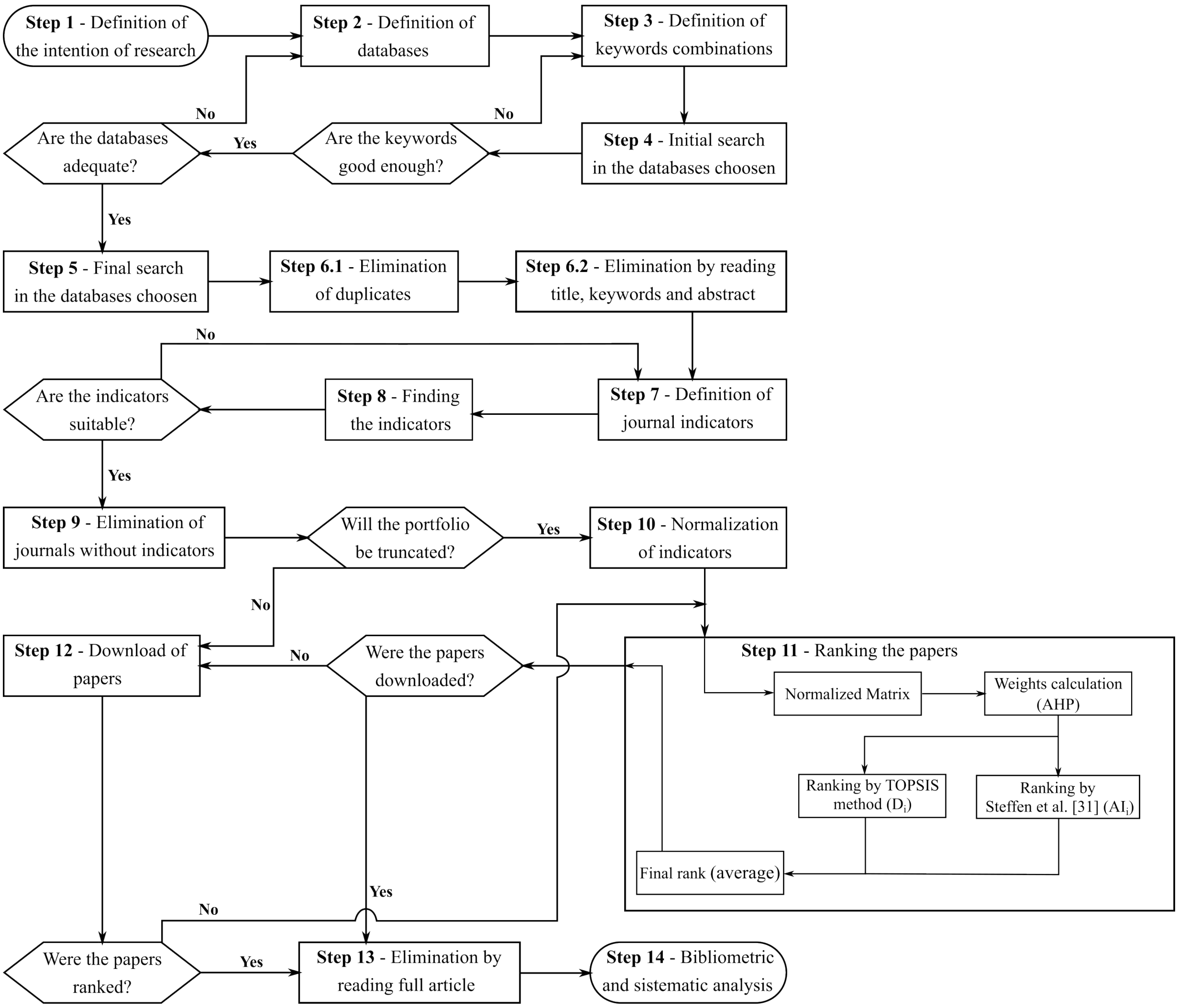

Figure 1. Flowchart of the SLR adaptation of SLR proposed by Steffen et al. [31]

The method proposed by Steffen et al. [31] consists of 14 steps, as does the modification proposed in this study. In Steffen et al. [31], the ranking obtained in Step 11 is calculated using Eq. (5), where researchers attribute the weights according to the importance they consider for each criterion. In this case, it is suggested that the weights must be calculated using a method widespread in the literature (AHP) and that the ranking is also an average between the calculation with the original method and using the TOPSIS method, providing greater robustness to the results.

Steps 1-5: In these initial steps, the authors must define research intentions, the databases that will be considered, and carry out exploratory searches to define keywords.

Steps 6.1-6.2: Usually some papers appear more than once in the search, so it is necessary to eliminate the duplicates (Step 6.1). This elimination can be carried out aided by software (like Endnote, Mendeley, JabRef, etc.) or manually. The next filtering procedure (Step 6.2) is the elimination by reading the title, keywords, and abstract, which help us analyze if the paper is really about the subject we want to review.

Steps 7-9: The definition of the journal indicators is realized in step 7. After this, searches are carried out for the indicators of each article (Step 8), and articles without indicators are eliminated (Step 9). In the journal indicators definition, all papers without citations published more than five years ago or in journals without an impact factor were excluded.

Steps 10-11: In step 10, the normalization (Eqs. (1)-(2)) of the decision matrix (composed by articles and your respective indicators, which in this case are considered criteria) is realized. The adaptation in the methods is related to step 11, as presented in Figure 1, which was split into many sub-steps. In addition to calculating the original index of the study proposed by Steffen et al. [31], the weights are calculated using the TOPSIS method, developed by Hwang and Yoon [34], and the final ranking will be defined by the average between the ranking proposed by Steffen et al. [31] (AI_i) and the ranking of the TOPSIS method (D_i). The index proposed by Steffen et al. [31] uses some indicators, namely the journal science citation index (JC, like JCR, SNIP, and many others that can be chosen by the researcher), the approximate average citation per year of the article (AC), and the journal selfcitation fraction (JS, the fraction of the citations of the journal that are from the same journal). In general, these data are normalized by the maximums and minimums method, as proposed by Pal et al. [35].

$$x_{ij} = \frac{r_{ij} - r_j^{min}}{r_j^{max} - r_j^{min}}, \text{for j benefit} \tag{1}$$

$$x_{ij} = \frac{r_j^{max} - r_{ij}}{r_j^{max} - r_j^{min}}, \text{for j cost} \tag{2}$$

Using this normalization process, all data will receive a value in a range from zero to one, meaning that for data that penalizes the index, the higher the value, the closer it becomes to zero after the normalization, and the smaller the value, the closer it becomes to one after the normalization. For data increasing the final value of the index, the opposite occurs: higher data become close to one and smaller data close to zero.

In the proposal of Steffen et al. [31], the index of article i is calculated by Eq. (3):

$$AI_i = \left[\alpha \sum_{k=1}^{n} w_k JC_{jk} + \beta \overline{AC}_i\right] (\gamma + JS_j) \tag{3}$$

where, JC_{jk} is the k-th science citation index of the journal j, α, β and γ are non-negative parameters whose values are chosen, in a subjective way, by the researcher, w_k is the fraction weight attributed to the k-th science citation index, JS_j is the journal j fraction of self-citation, and $\overline{AC}_i$ is approximately the number of citations per year of the article i calculated by Eq. (4):

$$\overline{AC}_i = \frac{AC_i}{(1 + AA_i)} \tag{4}$$

where, AC_i is the total number of citations of the paper i up to the search date, information that can be found in Google Scholar [31, 36, 37], AA_i is the "Article Age," i.e., the difference between the year in which the research was carried out and the year the article i was published.

The JC and $\overline{AC}$ indicators are normalized using Eq. (1) and JS is normalized by Eq. (2), because the self-citation practice makes more probable the citation of irrelevant paper.

As JC we used JCR and SNIP. The indicators, SNIP and self-citations are provided by CWTS journal indicators and the numbers of citations are from Google Scholar [30, 37–41]. The indicator JCR (Journal Citation Reports) can be found on the Clarivate website (https://jcr.clarivate.com/jcr).

The method proposed by Steffen et al. [31] is very interesting, but, there is a disadvantage related to the choice of α, β and γ values, that is totally subjective. Thus, our aim is to propose a more robust method related to the index used in the rank using the same indicator as input data, but with a little modification in the equation. As can be seen in Eq. (5), the index is obtained by the weighted sum of indicators.

$$AI_i = \frac{w_1}{n}\sum_{k=1}^{n} JC_{jk} + w_2\overline{AC}_i + w_3 JS_j \tag{5}$$

The determination of criteria weights (w_1, w_2 and w_3) for both methods (Steffen et al. [31] and TOPSIS method) is carried out using the AHP method, proposed by Saaty [42]. TOPSIS and AHP methods are described in the next subsections.

Steps 12-14: Steps 12-13 are based, respectively, on downloading all articles that make up the FP and excluding articles for which downloading the complete article is not possible. Step 14 consists of carrying out a bibliometric and systematic analysis of the articles in the FP, with the aim of determining important points in these publications, as well as possible gaps in the area.

2.2 AHP

The criteria weights were calculated using the AHP method, proposed by Saaty [43], by creating a judgment matrix of the A criteria (with a_{ij} elements). Each matrix element represents the degree of importance of a criterion in relation to another criterion.

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{n1}} & \frac{1}{a_{n2}} & \dots & 1 \end{pmatrix} \tag{6}$$

where:
i) $a_{ij} > 0$
ii) $a_{ij} = \frac{1}{a_{ij}} \rightarrow reciprocal$
iii) $a_{ii} = 1$
iv) $a_{ik} = a_{ij}.a_{jk}$
This matrix was filled according to the scale of Saaty [43], as presented in Table 1:

Table 1. The fundamental scale

Intensity of Importance on an Absolute Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of tile highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

From the matrix of judgments, a new normalized matrix B (composed of b_{ij} elements) is calculated [41], where:

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \ldots, n \tag{7}$$

With the priority eigenvector (W_i) defined as:

$$W_i = \frac{b_{ij}}{n}, ondei = 1, \ldots, n \tag{8}$$

and

$$\sum_{i=1}^{n} W_i = 1 \tag{9}$$

The eigenvector represents the value of the matrix elements in relation to the total. To verify the consistency of the calculations, Saaty [43] created a consistency index (CI), and this index cannot be greater than 10%. For this calculation, first multiply the elements of matrix A by their respective weights (W_i), creating a new matrix C (c_{ij} elements):

$$c_{ij} = W_i * b_{ij} \tag{10}$$

Add each line of C and divide the value by its respective weight W_i, generating an H_i, value, and calculate the eigenvalue associated with this matrix (λ_{max}), which is the arithmetic mean of H_i:

$$\lambda_{max} = \frac{H_i}{n} \tag{11}$$

CI is calculated by:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \cdot \frac{1}{RI} \tag{12}$$

where, *RI* (random index) proposed by Saaty [43] is described in Table 2:

Table 2. Random index by Saaty [43]

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

2.3 TOPSIS

The TOPSIS method was proposed by Hwang and Yoon [34]. The application of the TOPSIS method considering the normalization of maximums and minimums [44]. Therefore, the calculations started with the matrix X.

The next step of the method is the multiplication of the weights of each criterion (which in this case was considered by the average between the weights of the AHP and entropy methods) by the elements of matrix X, generating a new matrix V (with elements v_{ij}).

$$V = \begin{pmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{pmatrix} \tag{13}$$

After that, the ideal and the negative-ideal solution are considered, generating the alternatives A^* e A^-:

$$A^* = \{(max_i\, v_{ij} \mid j \in J),\ (min_i\, v_{ij} \mid j \in J')\},\ para\ i = 1, \ldots, m = \left\{v_1^*,\ v_2^*,\ ..., v_j^*, \ldots, v_n^*\right\} \tag{14}$$

$$A^{-} = \{(min_i\, v_{ij} \,|\, j \in J),\; (max_i\, v_{ij} \mid j \in J\acute{})\},\; para\; i = \; 1, \ldots, m = \left\{v_1^{-},\; v_2^{-},\; ..., v_j^{-}, \ldots, v_n^{-}\right\} \quad (15)$$

where:
$J = \{j = 1, .., n|j\}$ is associated a benefit criteria
$J\acute{} = \{j = 1, .., n|j\}$ is associated a cost criteria
Hwang and Yoon [34] mention that the two alternatives (A^* e A^-) will indicate, respectively, the most preferable alternative (ideal solution) and the least preferable alternative (negative-ideal solution). The calculation of the distances of each alternative m, ideal and negative-ideal, can be measured by the n-dimensional Euclidean distance, presented, respectively in Eqs. (16)-(17):

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^*\right)^2},\; para\; i = 1, \ldots, m \quad (16)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2},\; para\; i = 1, \ldots, m \quad (17)$$

The calculation of the ideal solution is performed by Eq. (23):

$$D_i = \frac{S_i^-}{S_i^- + S_i^*},\; 0 < D_i < 1,\; i = 1, \ldots, m \quad (18)$$

From value D_i, it is possible to create the ranking of the alternatives in descending order, that is, the highest value indicates a better performance of the alternatives in relation to the criteria.

3 Results

3.1 Construction of Portfolio, Bibliometric and Systematic Analysis

After defining the research objectives, preliminary research was carried out to create the portfolio, where the keywords were defined and the search in the considered databases was carried out, with the results presented in Table 3:

Table 3. Initial number of papers

Keywords Combination	Web of Science	Scopus
MCDM_Electric car	5	7
MCDM_Electric vehicle	57	79
MCDA_Electric vehicle	10	20
MCDA_Electric car	0	2
Total per database	72	108
Total initial	180	

The searches were carried out in other databases, which are not included in the analysis, as they did not show results that would alter the FP. Table 4 shows some numbers for the filtering procedures.

Table 4. Filtering procedure

Procedures	Total of Articles
Total initial	180
Duplicates	58
No data	3
Theme	44
Total partial	75

After the filtering procedure, it was decided not to limit the number of papers in the FP, i.e., to consider all 75 articles. Looking for the data on the considered indicators (SNIP, JCR, self-citations, and number of citations), two articles do not have citation and FI indicators, despite being publications over 5 years old, so they were excluded from the portfolio. Therefore, the FP was composed of 73 publications, with all complete files found for download. From the definition of the FP, the criteria weights were constructed using the AHP method. Three criteria were considered: IF, self-citations, and average citations (Citations/(Age+1)). The average of citations was calculated by dividing the number of citations by the age of the article + 1, in order to avoid divisions by 0 for articles published in the year 2023. Table 5 shows the matrix of judgments for the criteria.

From the matrix of judgments, the weights for the criterion were determined, and the CI was verified. The CI was 0.088, which agrees with what was proposed by Saaty [43]. The criteria weights obtained are presented in Table 6.

Table 5. Decision making on the pairwise comparison matrix for the criteria

Judgment Matrix	Ci/(Age+1)	Average Citations	Self-Citations
Citations	1	4	8
IF	1/4	1	5
Self-citations	1/8	1/5	1

Table 6. Criteria weights

Method	Ci/(Age+1)	Average IF	Self-Citations
AHP	0.689	0.244	0.067

The average number of citations was the criterion with the highest weight, followed by IF and, with the lowest weight, self-citations. The first two criteria are considered "benefit," while self-citations are considered "cost," that is, the lower the better. With the weight of the criteria in hand, the next step was to normalize the data using the maximums and minimums method by Chakraborty and Yeh [44]. With normalized data, the indices proposed by Steffen et al. [31] and the TOPSIS method. For the calculation of the mean, the index values were normalized (D_i and AI_i) and the average of these was calculated, generating the I index. The results of the index I, as well as the ranking of the 10 first articles that make up the FP, are presented in Table 7, while the other articles that make up the final ranking are presented in the appendix.

Table 7. FP

Ranking	1	2	3	4	5	6	7	8	9	10	11
Reference	[45]	[23]	[46]	[47]	[48]	[49]	[50]	[51]	[52]	[53]	[54]
Ranking	12	13	14	15	16	17	18	19	20	21	22
Reference	[55]	[24]	[56]	[57]	[58]	[59]	[60]	[61]	[62]	[63]	[64]
Ranking	23	24	25	26	27	28	29	30	31	32	33
Reference	[65]	[66]	[67]	[68]	[6]	[69]	[70]	[71]	[72]	[73]	[74]
Ranking	34	35	36	37	38	39	40	41	42	43	44
Reference	[75]	[76]	[77]	[78]	[79]	[80]	[81]	[82]	[83]	[84]	[85]
Ranking	45	46	47	48	49	50	51	52	53	54	55
Reference	[86]	[87]	[88]	[89]	[90]	[91]	[92]	[93]	[94]	[95]	[96]
Ranking	56	57	58	59	60	61	62	63	64	65	66
Reference	[97]	[98]	[99]	[25]	[100]	[101]	[102]	[103]	[104]	[105]	[106]
Ranking	67	68	69	70	71	72	73				
Reference	[107]	[108]	[109]	[110]	[111]	[112]	[113]				

The article that ranked first is "Optimal site selection of electric vehicle charging stations by using fuzzy TOPSIS based on sustainability perspective," authored by Gu and Zhao [45], and published in 2015 in the journal Applied Energy. This article had the highest number of citations (375) and the approximate average citation per year, 41.67, with a high IF (the third highest JCR of the FP) and a number of self-citations of 8.1% (among the 15 lowest). Second in the ranking is the article entitled "A consolidated MCDM framework for performance assessment of battery electric vehicles based on ranking strategies," authored by Ecer [23], published in the journal "Renewable and Sustainable Energy Reviews" in 2021. This article did not have the second highest number of citations (101), but it had the second highest approximate average number of citations per year, 33.67, showing the importance of calculating the average number of citations in the analysis, as proposed by Steffen et al. [31], where it is considered that an older article had more time to be cited in relation to a more recent one. The IF (JCR and SNIP) considered in this analysis were the highest for the second article, and the self-citation is among the lowest for the FP (6%). On the other hand, the article "A Fuzzy Analytic Hierarchy Process and VIKOR Framework for Evaluation and Selection of Electric Vehicle Charging Technology for India," authored by Mall and Anbanandam [113] and published in 2022 in the journal Transportation in Developing Economies, ranked last. Despite being recent, the article has 2 citations, but IF equals 0 for SNIP and JCR, which explains its final position. Figure 2 presents the temporal evolution in the number of publications from the FP, where one can see the rise in the number of publications mainly in the last few years.

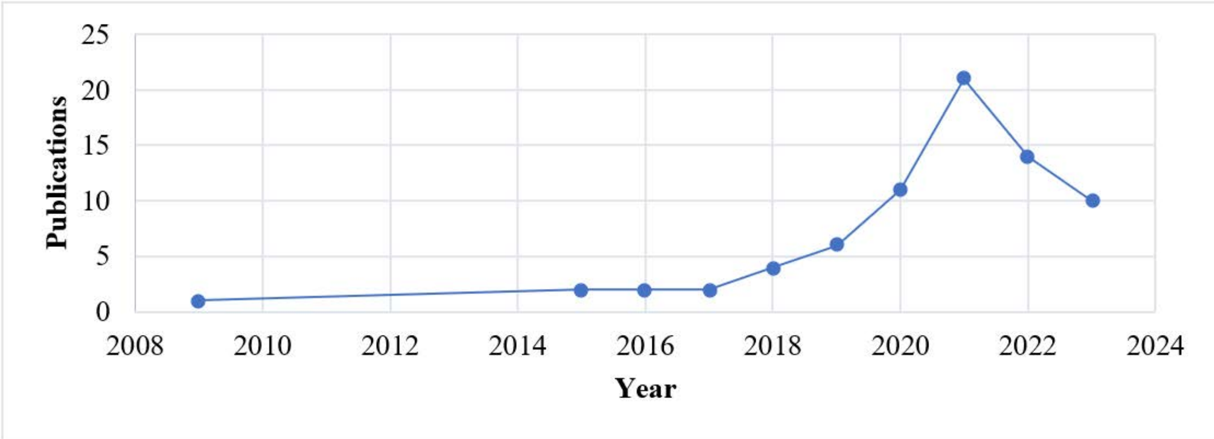

Figure 2. Temporal evolution of publications

The theme "EV" is recent, even more so considering the solution of problems involving MCDM methods, which is noticeable by temporal analysis. Considering the year 2023, whose review was carried out on March 30 (1st quarter), approximately 85% of papers were published in the last 5 years. The first publication found was in 2009, with a 6-year gap for the next two publications in 2015. 2021 had the highest number of publications (21), followed by 2022 with 14. Figure 3 shows the countries with the most contributions to the composition of the FP.

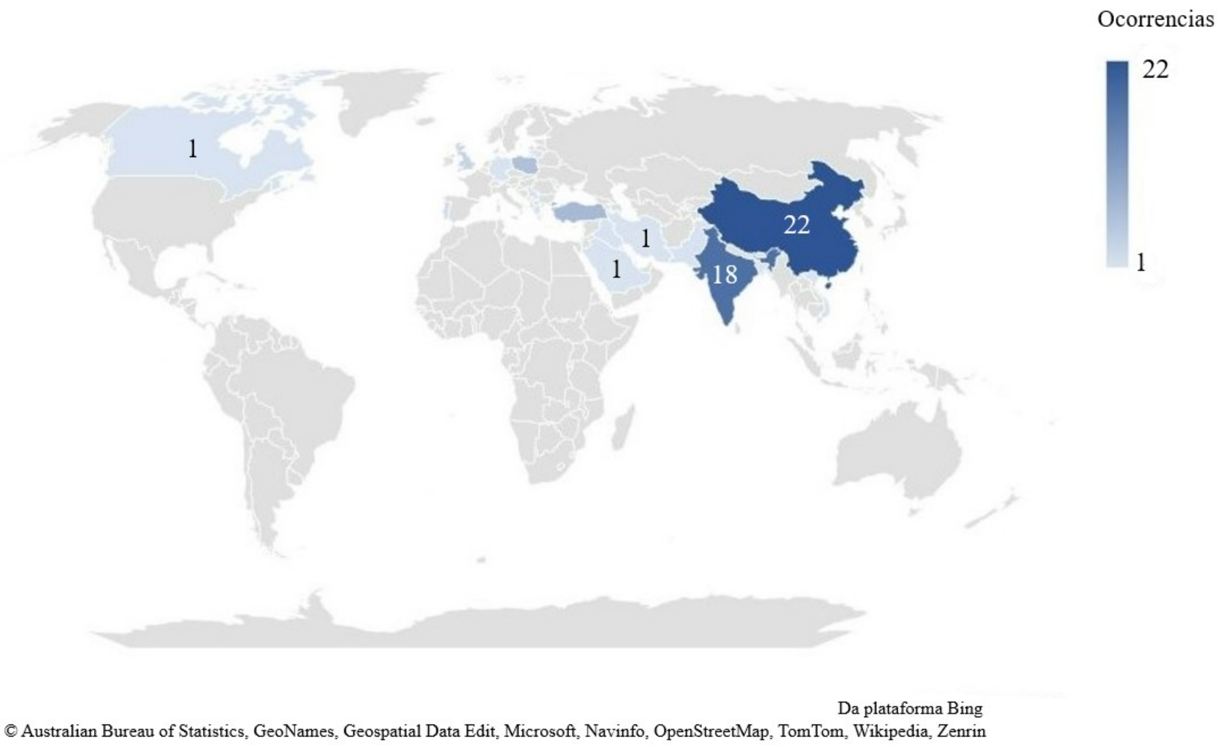

Figure 3. Main countries

China, with 22 publications, is the country that most contributed to the analysis, followed by India, with 18 publications, and Turkey and Poland, with 7 and 6 publications, respectively. These 4 countries represent approximately 72.6% of the FP, while the other 16 countries that are part of the FP had 3 publications or less. To illustrate possible groups that are strongly active in themes related to the subject under study, an analysis was carried out of the universities/companies that participated in the analysis, considering the main author, as presented in Figure 4.

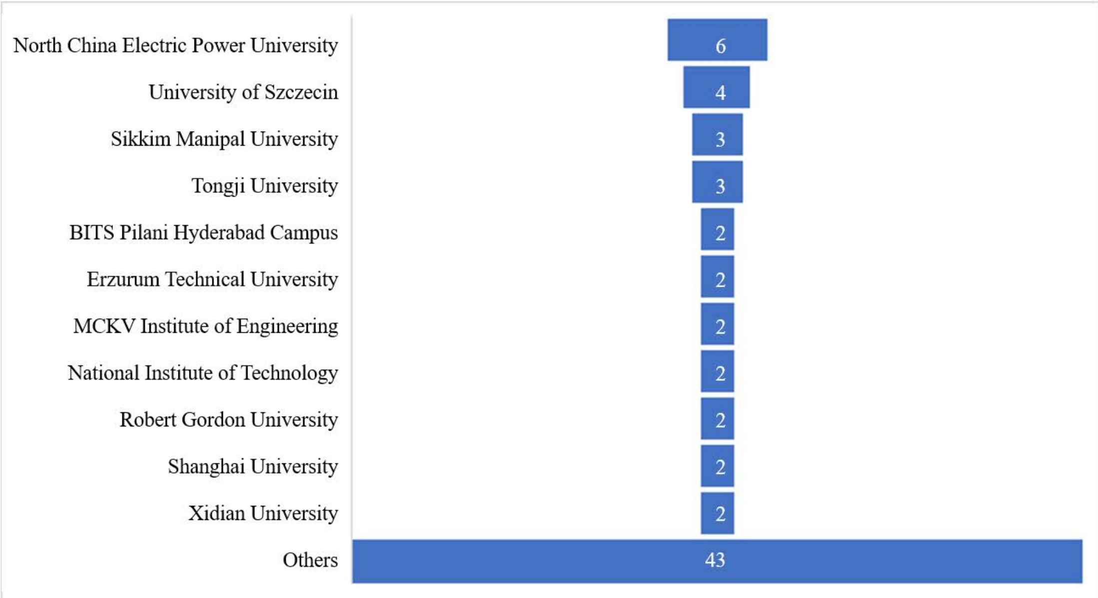

Figure 4. Main institutions

The analysis of possible groups allows researchers interested in the subject to have a direction to seek information and/or partnerships for future studies. There are 11 universities with 2 publications or more and another 43 institutions with 1 publication each, among those that are in the FP. The highlight is North China Electric Power University, which has six publications, followed by the University of Szczecin, with three publications. Figure 5 presents the main journals in the FP.

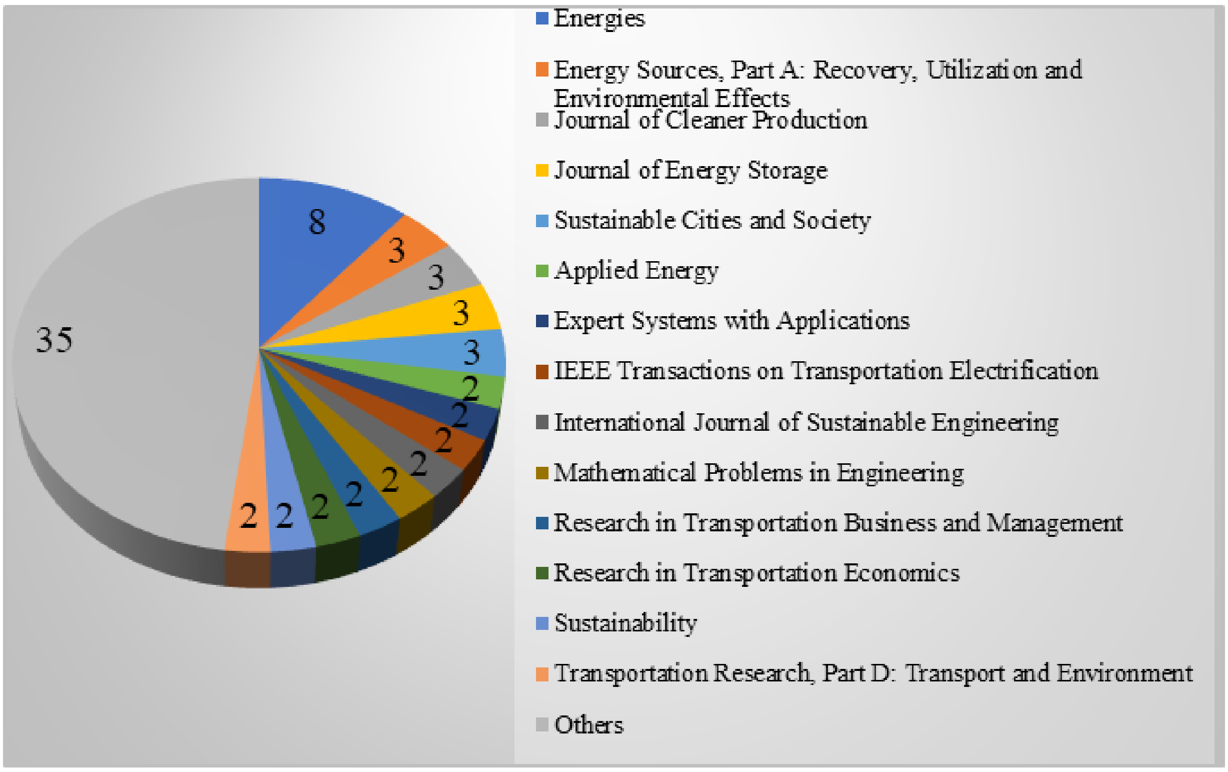

Figure 5. Main journals

Energies is the journal that contributed more to the FP, with 8 publications. Four journals are presented in sequence, with three occurrences: Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, Journal of Cleaner Production, Journal of Energy Storage, and Sustainable Cities and Society. There are nine journals presenting two articles each, and there are another 35 journals that have one publication.

Figure 6 shows the average citation per year. For this construction, the average citations per year have been divided by the number of citations in the year by the number of publications and by the age of the articles. 2015 is the year with the highest average citations, and 2023, on the other hand, is the year with the lowest number of average citations. This can be explained by the fact that the publication that was in first place in the ranking and had the highest number of publications was from 2015, and there was only one more publication in that year, which on average made the number high. Articles of 2022 and 2023 are very recent and, considered the temporal window, had less time to be cited compared to the 2009 article.

Figure 7 presents the density map of the main authors, built using the VOSviewer software. Shabbiruddin is the author with the most participation in publications, with six occurrences, one as the main author and the other five as co-authors. Deveci, M., Liu, H.-C., Pamucar, D., Pradhan, S., and Ziemba, P. contributed 4 publications, and Ghose, D., has 3 publications from the FP. There are 20 authors with two publications, and 188 authors participated in 1 publication each from the portfolio. The author with more publications as the main author was Ziemba, P., namely, 4 publications.

From the bibliometric analysis of the articles, a more detailed analysis was carried out to verify the most used methods, and main applications, among other contributions. The topics addressed in the publications are described in Table 8.

Table 8. Applications

Thematic	Occurrences	References
Charging station	31	[6, 24, 45, 47, 49–51, 53, 55, 56, 58, 60, 62–65, 67, 74, 75, 77, 80, 84, 90, 94, 96, 98, 101, 102, 104, 109, 113]
EV selection	11	[25, 66, 68, 70, 71, 83, 86, 87, 105, 106, 110]
Factors/barriers of adoption of EVs	6	[46, 72, 73, 78, 91, 97]
Battery swapping station	5	[57, 61, 69, 79, 108]
Evaluating EVs	2	[93, 114]
Supplier selection	2	[52, 81]
Comparative performance	1	[103]
Consumer preferences	1	[100]
Criteria EV selection	1	[92]
Design optimization for the reducer housing of EVs	1	[82]
EV service sentre	1	[112]
Fuel supply system	1	[59]
Function deployment	1	[54]
Infrastructure market sustainable growth	1	[111]
Optimal material for solar EV	1	[85]
Parking lots	1	[76]
Performance assessment	1	[23]
Powertrain shift	1	[107]
Public infrastructure	1	[89]
Spatial planning of EV infrastructure	1	[99]
Sustainable development of battery electric	1	[88]
Sustainable	1	[48]

There are 31 studies that carried out an analysis about the installation of a charging station, ranging from charging stations on streets to the installation of charging stations at workstations. EV Selection, Factors/Barriers of Adoption of EVs, and Battery Swapping Station appear next, with 11, 6, and 5 occurrences, respectively. Evaluating EVs and supplier selection, with two contributions each, are also themes found in the FP articles. Table 9 presents the methods most utilized in this analysis.

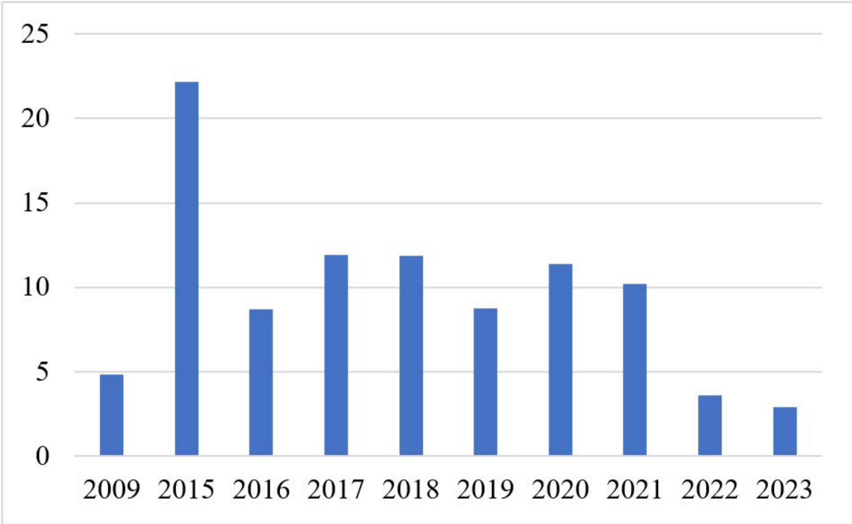

Figure 6. Citation average

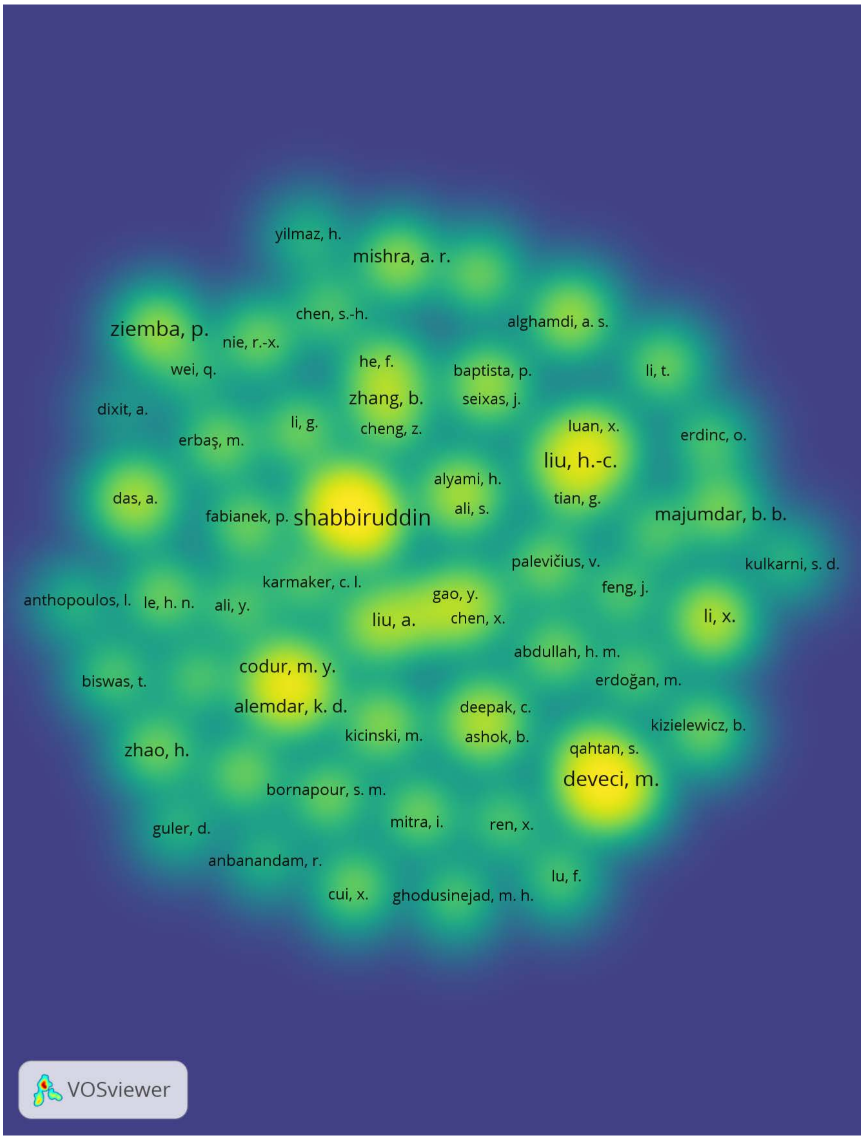

Figure 7. Authors density map

Table 9. Methods

Method	References	Occurrences
Fuzzy	[6, 24, 45, 47, 48, 50, 52–54, 57–60, 62, 64, 66, 69, 80, 84–88, 93, 98, 103, 108–110, 112, 113]	32
AHP	[6, 24, 47, 58, 64, 65, 68, 74–76, 78, 80, 93, 94, 96, 99, 111–113, 115]	20
TOPSIS	[6, 24, 25, 45, 47, 65, 66, 79, 82, 83, 87–89, 93, 97, 98, 104]	17
VIKOR	[52, 54, 55, 62, 67, 79, 81, 97, 106, 111, 113]	11
PROMETHEE	[64, 71, 87, 89, 104, 105, 107, 110]	8
DEMATEL	[24, 51, 54, 61, 72, 73, 92, 106]	8
MULTIMOORA	[49, 51, 61, 65, 97, 108]	7
COPRAS	[6, 23, 25, 69, 85]	5
EWM	[50, 53, 60, 61, 79]	5
SAW	[63, 79, 87, 89]	4
GRA	[60, 62, 95, 104]	4
MARCOS	[23, 48, 59]	3
WASPAS	[56, 84, 97]	3
CRITIC	[70, 79, 95]	3
CoCoSo	[23, 56, 70]	3
BWM	[46, 50, 116]	3

The methods were considered separately, and only those that had more than three occurrences were cited. Fuzzy was the most used method, with 32 occurrences. Other widely used methods are the AHP and TOPSIS methods, with 20 and 17 occurrences, respectively. The CRITIC and EWM methods, as well as the AHP method, are widely used in the literature for calculating scale constants, and both appear among those cited with more than 3 occurrences. On the other hand, only one study used methods from the ELECTRE family [64]. Compared to other methods, Fuzzy stood out. This fact may indicate that there is an environment of uncertainty in solving problems related to the topic of EV, as it is a characteristic of this method. In this context, a literature review has already been carried out around fuzzy MCDM methods in the formulation of energy policies [117], highlighting that these methods are widely used in the area. Another study that indicated fuzzy methods as a widely used technique in the area of sustainability [118]. Table 10 presents the most used methods related to the themes most considered in the FP.

Table 10. Thematics and methods used

Method	Thematic	References	Occurrences
Fuzzy	Charging Station	[6, 24, 45, 47, 50, 58, 60, 62, 64, 67, 80, 84, 101, 109, 113]	15
	EV Selection	[25, 66, 86, 87, 110]	5
	Battery Swapping Station	[57, 61, 69, 108]	4
AHP	Charging Station	[6, 24, 47, 58, 64, 65, 74, 75, 80, 94, 96, 113]	12
TOPSIS	Charging Station	[6, 45, 47, 65, 104]	5
	EV Selection	[66, 83, 87]	3
PROMETHEE	EV Selection	[71, 87, 105, 110]	4
VIKOR	Charging Station	[62, 67, 113]	3
EWM	Charging Station	[50, 53, 60]	3
GRA	Charging Station	[60, 62, 104]	3

Relating the most used methods with the most discussed themes in the articles, it is possible to verify that the most used theme, "Charging Station," when combined with the 3 most used methods (Fuzzy, AHP, and TOPSIS), are the ones that occupy the first positions among the most used combinations, with 15, 12, and 8 occurrences.

Ziemba, P., the author with the most publications as the first author, used methods from the PROMETHEE family in the 4 articles, ranking fourth when considering the methods individually, combined with the topic "EV Selection," the second most discussed. From the 4 articles, 3 were published in the journal Energies, the journal more utilized per article that composed the FP.

4 Conclusions, Limitations and Future Directions Studies

This study addressed a SLR verifying the main aspects between "EVs" and "MCDM." For this, the method proposed by Steffen et al. [31] and the MCDM methods for calculating a ranking of the articles that make up the

FP. Citations remain the most important criterion; however, the importance of considering the average citations, depending on the age of the articles, was shown. In addition, the consideration of other important aspects of journals, such as IF and self-citations, makes the analysis more robust and the placement of articles more coherent.

In the articles that are part of the portfolio, the wide use of fuzzy methods stands out, considering them in general, which are widely used in environments of uncertainty when the decision-maker has doubts about the analysis. Alao et al. [119] mention that to capture possible inaccuracies and uncertainties in the judgment of experts, fuzzy is applied to transform linguistic variables into fuzzy numbers that can later be manipulated. A lot of the time, compensatory multi-criteria methods are used instead of non-compensatory methods. This may be because most of the criteria that are looked at in this type of subject are compensatory. Among the most used methods, non-PROMETHEE methods, widely used in the literature, appear only in fourth place, appearing in 8 publications, while ELECTRE is present in only 1.

The literature has addressed, in most cases involving "EVs" and "MCDM," the issues of charging stations. Although there is a wide choice of analysis in combustion-powered cars, only 11 publications have analyzed this theme in "EVs," or approximately 15.07% of the FP. Generally, electric cars sold in different countries are not the same, as they depend on several factors, such as government and brand interest in entering the market in each country. With this, possible future studies can broadly explore the application of MCDM methods for choosing the best electric car in a given country. It is still possible to explore other techniques, in addition to MCDM, for creating hybrid methods.

As it is a recent topic, the first article found dates from 2009, with most articles published in the last 5 years. Themes involving sustainability are increasingly in focus, in view of the global problems with rising temperatures and carbon dioxide emissions, which directly impact nature. Problems that can solve or minimize these impacts must be increasingly addressed, as they can help decision-makers in their decision-making.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] Z. Hussain, B. Marcel, A. Majeed, and R. S. M. Tsimisaraka, "Effects of transport-carbon intensity, transportation, and economic complexity on environmental and health expenditures," *Environ. Dev. Sustain.*, 2023. https://doi.org/10.1007/s10668-023-03297-8

[2] S. Vieira, M. V. Barros, A. C. N. Sydney, C. M. Piekarski, A. C. de Francisco, L. P. de Souza Vandenberghe, and E. B. Sydney, "Sustainability of sugarcane lignocellulosic biomass pretreatment for the production of bioethanol," *Bioresour. Technol.*, vol. 299, p. 122635, 2020. https://doi.org/10.1016/j.biortech.2019.122635

[3] S. Consul, K. V. Singh, H. O. Bansal, and K. A. Kim, "Intelligent switching mechanism for power distribution in photovoltaic-fed battery electric vehicles," *Environ. Dev. Sustain.*, vol. 26, p. 2735, 2024. https://doi.org/10.1007/s10668-022-02398-0

[4] X. Guo, X. Zhang, J. Dong, and X. Yang, "Optimal allocation of urban new energy vehicles and traditional energy vehicles considering pollution and cost," *Environ. Dev. Sustain.*, vol. 26, no. 3, pp. 1–20, 2023. http://doi.org/10.1007/s10668-023-02948-0

[5] P. M. Sneha Angeline and M. Newlin Rajkumar, "Evolution of electric vehicle and its future scope," *Mater. Today Proc.*, vol. 33, no. 7, pp. 3930–3936, 2020. https://doi.org/10.1016/j.matpr.2020.06.266

[6] A. Ghosh, N. Ghorui, S. P. Mondal, S. Kumari, B. K. Mondal, A. Das, and M. S. Gupta, "Application of hexagonal fuzzy MCDM methodology for site selection of electric vehicle charging station," *Mathematics*, vol. 9, no. 4, p. 393, 2021. https://doi.org/10.3390/math9040393

[7] M. Abdel-Basset, A. Gamal, I. M. Hezam, and K. M. Sallam, "Sustainability assessment of optimal location of electric vehicle charge stations: A conceptual framework for green energy into smart cities," *Environ. Dev. Sustain.*, pp. 1–39, 2023. http://doi.org/10.1007/s10668-023-03373-z

[8] A. Ghosh, "Possibilities and challenges for the inclusion of the electric vehicle (EV) to reduce the carbon footprint in the transport sector: A review," *Energies*, vol. 13, no. 10, p. 2602, 2020. https://doi.org/10.3390/en13102602

[9] L. M. Austmann, "Drivers of the electric vehicle market: A systematic literature review of empirical studies," *Financ. Res. Lett.*, vol. 41, p. 101846, 2021. https://doi.org/10.1016/j.frl.2020.101846

[10] G. Ivanova and A. C. Moreira, "Antecedents of electric vehicle purchase intention from the consumer's perspective: A systematic literature review," *Sustainability*, vol. 15, no. 4, p. 2878, 2023. https://doi.org/10.3390/su15042878

[11] J. P. Torreglosa, P. Garcia-Triviño, D. Vera, and D. A. López-García, “Analyzing the improvements of energy management systems for hybrid electric vehicles using a systematic literature review: How far are these controls from rule-based controls used in commercial vehicles?” *Appl. Sci.*, vol. 10, no. 23, p. 8744, 2020. https://doi.org/10.3390/app10238744

[12] L. Maybury, P. Corcoran, and L. Cipcigan, “Mathematical modelling of electric vehicle adoption: A systematic literature review,” *Transp. Res. Part D Transp. Environ.*, vol. 107, p. 103278, 2022. https://doi.org/10.1016/j.trd.2022.103278

[13] F. Weidt and R. Silva, “Systematic literature review in computer science-A practical guide,” *Relatórios Técnicos Do DCC/UFJF*, vol. 1, no. 8, pp. 1–7, 2016. http://doi.org/10.13140/RG.2.2.35453.87524

[14] N. Ding, K. Prasad, and T. T. Lie, “The electric vehicle: A review,” *Int. J. Electr. Hybrid Veh.*, vol. 9, no. 1, pp. 49–66, 2017. http://doi.org/10.1504/IJEHV.2017.10003709

[15] L. O. Soares, A. D. C. Reis, P. S. Vieira, L. Hernández-Callejo, and R. A. M. Boloy, “Electric vehicle supply chain management: A bibliometric and systematic review,” *Energies*, vol. 16, no. 4, p. 1563, 2023. https://doi.org/10.3390/en16041563

[16] F. Liao, E. Molin, and B. van Wee, “Consumer preferences for electric vehicles: A literature review,” *Transp. Rev.*, vol. 37, no. 3, pp. 252–275, 2017. https://doi.org/10.1080/01441647.2016.1230794

[17] S. Frederhausen and M. Klumpp, “Commercial electric vehicle routing in urban logistics: A systematic literature review,” in *Data Science in Maritime and City Logistics: Data-driven Solutions for Logistics and Sustainability. Proceedings of the Hamburg International Conference of Logistics (HICL), epubli GmbH, Berlin*, 2020, pp. 33–69. https://doi.org/10.15480/882.3142

[18] O. den Bergh, S. Weekx, C. De Cauwer, and L. Vanhaverbeke, “Locating charging infrastructure for shared autonomous electric vehicles and for vehicle-to-grid strategy: A systematic review and research agenda from an energy and mobility perspective,” *World Electr. Veh. J.*, vol. 14, no. 3, p. 56, 2023. https://doi.org/10.3390/wevj14030056

[19] J. B. Gutiérrez-Lopez and D. Möst, “Characterising the flexibility of electric vehicle charging strategies: A systematic review and assessment,” *Transp. Rev.*, vol. 43, no. 6, pp. 1237–1262, 2023. https://doi.org/10.1080/01441647.2023.2217519

[20] B. Pawel, S. Chatterjee, and B. Ciabiada-Bryla, “Consumer adoption of electric vehicles: A systematic literature review,” *Energies*, vol. 16, no. 1, p. 205, 2023. https://doi.org/10.3390/en16010205

[21] C. Corradi, E. Sica, and P. Morone, “What drives electric vehicle adoption? Insights from a systematic review on European transport actors and behaviours,” *Energy Res. Soc. Sci.*, vol. 95, p. 102908, 2023. https://doi.org/10.1016/j.erss.2022.102908

[22] N. C. Onat and M. Kucukvar, “A systematic review on sustainability assessment of electric vehicles: Knowledge gaps and future perspectives,” *Environ. Impact Assess. Rev.*, vol. 97, p. 106867, 2022. https://doi.org/10.1016/j.eiar.2022.106867

[23] F. Ecer, “A consolidated MCDM framework for performance assessment of battery electric vehicles based on ranking strategies,” *Renew. Sustain. Energy Rev.*, vol. 143, p. 110916, 2021. https://doi.org/10.1016/j.rser.2021.110916

[24] A. Karacsan, I. Kaya, and M. Erdougan, “Location selection of electric vehicles charging stations by using a fuzzy MCDM method: A case study in Turkey,” *Neural Comput. Appl.*, vol. 32, pp. 4553–4574, 2020. https://doi.org/10.1007/s00521-018-3752-2

[25] P. Pradhan, Shabbiruddin, and S. Pradhan, “Selection of electric vehicle using integrated Fuzzy-MCDM approach with analysis on challenges faced in hilly terrain,” *Energy Sources, Part A Recover. Util. Environ. Eff.*, vol. 44, no. 2, pp. 2651–2673, 2022. https://doi.org/10.1080/15567036.2022.2056665

[26] A. Liberati, D. G. Altman, J. Tetzlaff, C. Mulrow, P. C. Gøtzsche, J. P. Ioannidis, M. Clarke, P. J. Devereaux, J. Kleijnen, and D. Moher, “The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration,” *Ann. Intern. Med.*, vol. 6, no. 7, p. e1000100, 2009. https://doi.org/10.1371/journal.pmed.1000100

[27] D. Moher, D. J. Cook, S. Eastwood, I. Olkin, D. Rennie, and D. F. Stroup, “Improving the quality of reports of meta-analyses of randomised controlled trials: The quorom statement,” *Lancet*, vol. 354, no. 9193, pp. 1896–1900, 1999. https://doi.org/10.1016/S0140-6736(99)04149-5

[28] L. Ensslin, S. R. Ensslin, R. T. O. Lacerda, and J. E. Tasca, “ProKnow-C, knowledge development process-constructivist,” Processo Técnico Com Patente de Registro Pendente Junto ao INPI. Brasil, 2015.

[29] L. Ensslin, A. Dutra, S. R. Ensslin, L. C. Chaves, and V. Dezem, “Research process for selecting a theoretical framework and bibliometric analysis of a theme: Illustration for the management of customer service in a bank,” *Mod. Econ.*, vol. 6, no. 6, pp. 782–796, 2015. http://doi.org/10.4236/me.2015.66074

[30] R. N. Pagani, J. L. Kovaleski, and L. M. Resende, “Methodi ordinatio: A proposed methodology to select and

rank relevant scientific papers encompassing the impact factor, number of citation, and year of publication," *Scientometrics*, vol. 105, no. 3, pp. 2109–2135, 2015. https://doi.org/10.1007/s11192-015-1744-x

[31] V. Steffen, M. S. de Oliveira, C. Z. Brusamarello, and F. Trojan, "A new normalized index for ranking papers in systematic literature reviews," *Decis. Anal. J.*, vol. 10, p. 100439, 2024. https://doi.org/10.1016/j.dajour.2024.100439

[32] B. Kitchenham, "Procedures for performing systematic reviews," Keele University Technical Report TR/SE-0401, Technical Report 33, 2004. https://www.inf.ufsc.br/~awangenh/kitchenham.pdf

[33] R. N. Pagani, B. Pedroso, C. B. dos Santos, C. T. Picinin, and J. L. Kovaleski, "Methodi ordinatio 2.0: Revisited under statistical estimation, and presenting finder and rankin," *Qual. Quant.*, vol. 57, p. 4563–4602, 2022. https://doi.org/10.1007/s11135-022-01562-y

[34] C. L. Hwang and K. Yoon, "Multiple attribute decision making," in *Lecture Notes in Economics and Mathematical Systems*. Berlin, Heidelberg: Springer Berlin Heidelberg, 1981. https://doi.org/10.1007/978-3-642-48318-9

[35] A. Pal, A. Bhattacharya, and A. K. Chakraborty, "Allocation of electric vehicle charging station considering uncertainties," *Sustain. Energy, Grids Networks*, vol. 25, p. 100422, 2021. https://doi.org/10.1016/j.segan.2020.100422

[36] M. S. de Oliveira, V. Steffen, and F. Trojan, "A systematic review of the literature on video assistant referees in soccer: Challenges and opportunities in sports analytics," *Decis. Anal. J.*, vol. 7, p. 100232, 2023. https://doi.org/10.1016/j.dajour.2023.100232

[37] M. S. de Oliveira, V. Steffen, A. C. de Francisco, and F. Trojan, "Integrated data envelopment analysis, multi-criteria decision making, and cluster analysis methods: Trends and perspectives," *Decis. Anal. J.*, vol. 8, p. 100271, 2023. https://doi.org/10.1016/j.dajour.2023.100271

[38] E. Helmers, J. Dietz, and M. Weiss, "Sensitivity analysis in the life-cycle assessment of electric vs. combustion engine cars under approximate real-world conditions," *Sustainability*, vol. 12, no. 3, p. 1241, 2020. https://doi.org/10.3390/su12031241

[39] M. Lizot, P. P. A. Júnior, F. Trojan, C. S. Magacho, S. S. Thesari, and A. S. Goffi, "Analysis of evaluation methods of sustainable supply chain management in production engineering journals with high impact," *Sustainability*, vol. 12, no. 1, p. 270, 2019. https://doi.org/10.3390/su12010270

[40] A. Corsi, F. F. de Souza, R. N. Pagani, and J. L. Kovaleski, "Big data analytics as a tool for fighting pandemics: A systematic review of literature," *J. Ambient Intell. Humaniz. Comput.*, vol. 12, no. 10, pp. 9163–9180, 2021. https://doi.org/10.1007/s12652-020-02617-4

[41] S. S. Thesari, M. Lizot, and F. Trojan, "Municipal public budget planning with sustainable and human development goals integrated in a multi-criteria approach," *Sustainability*, vol. 13, no. 19, p. 10921, 2021. https://doi.org/10.3390/su131910921

[42] T. L. Saaty, *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. McGraw-Hill, 1980.

[43] T. L. Saaty, "How to make a decision: The analytic hierarchy process," *Eur. J. Oper. Res.*, vol. 48, no. 1, pp. 9–26, 1990. https://doi.org/10.1016/0377-2217(90)90057-I

[44] S. Chakraborty and C. H. Yeh, "A simulation based comparative study of normalization procedures in multiattribute decision making," in *Proceedings of the 6th WSEAS Int. Conf. on Artificial Intelligence, Knowledge Engineering and Data Bases, Corfu Island, Greece*, 2007, pp. 102–109.

[45] S. Guo and H. Zhao, "Optimal site selection of electric vehicle charging station by using fuzzy TOPSIS based on sustainability perspective," *Appl. Energy*, vol. 158, pp. 390–402, 2015. https://doi.org/10.1016/j.apenergy.2015.08.082

[46] P. K. Tarei, P. Chand, and H. Gupta, "Barriers to the adoption of electric vehicles: Evidence from India," *J. Clean. Prod.*, vol. 291, p. 125847, 2021. https://doi.org/10.1016/j.jclepro.2021.125847

[47] M. Erbaş, M. Kabak, E. Özceylan, and C. Çetinkaya, "Optimal siting of electric vehicle charging stations: A GIS-based fuzzy multi-criteria decision analysis," *Energy*, vol. 163, pp. 1017–1031, 2018. https://doi.org/10.1016/j.energy.2018.08.140

[48] D. Pamucar, F. Ecer, and M. Deveci, "Assessment of alternative fuel vehicles for sustainable road transportation of United States using integrated fuzzy FUCOM and neutrosophic fuzzy MARCOS methodology," *Sci. Total Environ.*, vol. 788, p. 147763, 2021. https://doi.org/10.1016/j.scitotenv.2021.147763

[49] P. Rani and A. R. Mishra, "Fermatean fuzzy einstein aggregation operators-based MULTIMOORA method for electric vehicle charging station selection," *Expert Syst. Appl.*, vol. 182, p. 115267, 2021. https://doi.org/10.1016/j.eswa.2021.115267

[50] J. Zhou, Y. Wu, C. Wu, F. He, B. Zhang, and F. Liu, "A geographical information system based multi-criteria decision-making approach for location analysis and evaluation of urban photovoltaic charging station: A case

study in Beijing," *Energy Convers. Manag.*, vol. 205, p. 112340, 2020. https://doi.org/10.1016/j.enconman.2019.112340

[51] H. C. Liu, M. Yang, M. Zhou, and G. Tian, "An integrated multi-criteria decision making approach to location planning of electric vehicle charging stations," *IEEE Trans. Intell. Transp. Syst.*, vol. 20, no. 1, pp. 362–373, 2019. https://doi.org/10.1109/TITS.2018.2815680

[52] A. Liu, Y. Xiao, H. Lu, S. B. Tsai, and W. Song, "A fuzzy three-stage multi-attribute decision-making approach based on customer needs for sustainable supplier selection," *J. Clean. Prod.*, vol. 239, p. 118043, 2019. https://doi.org/10.1016/j.jclepro.2019.118043

[53] J. Feng, S. X. Xu, and M. Li, "A novel multi-criteria decision-making method for selecting the site of an electric-vehicle charging station from a sustainable perspective," *Sustain. Cities Soc.*, vol. 65, p. 102623, 2021. https://doi.org/10.1016/j.scs.2020.102623

[54] S. M. Wu, H. C. Liu, and L. E. Wang, "Hesitant fuzzy integrated MCDM approach for quality function deployment: A case study in electric vehicle," *Int. J. Prod. Res.*, vol. 55, no. 15, pp. 4436–4449, 2017. https://doi.org/10.1080/00207543.2016.1259670

[55] Ö. Kaya, A. Tortum, K. D. Alemdar, and M. Y. Çodur, "Site selection for evcs in istanbul by gis and multi-criteria decision-making," *Transp. Res. PART D-TRANSPORT Environ.*, vol. 80, p. 102271, 2020. https://doi.org/10.1016/j.trd.2020.102271

[56] N. Erdogan, D. Pamucar, S. Kucuksari, and M. Deveci, "An integrated multi-objective optimization and multi-criteria decision-making model for optimal planning of workplace charging stations," *Appl. Energy*, vol. 304, p. 117866, 2021. https://doi.org/10.1016/j.apenergy.2021.117866

[57] R. Wang, X. Li, and C. Li, "Optimal selection of sustainable battery supplier for battery swapping station based on triangular fuzzy entropy -MULTIMOORA method," *J. Energy Storage*, vol. 34, p. 102013, 2021. https://doi.org/10.1016/j.est.2020.102013

[58] D. Guler and T. Yomralioglu, "Suitable location selection for the electric vehicle fast charging station with ahp and fuzzy ahp methods using gis," *Ann. GIS*, vol. 26, no. 2, pp. 169–189, 2020. https://doi.org/10.1080/19475683.2020.1737226

[59] S. Qahtan, H. A. Alsattar, A. A. Zaidan, M. Deveci, D. Pamucar, and W. Ding, "A novel fuel supply system modelling approach for electric vehicles under pythagorean probabilistic hesitant fuzzy sets," *Inf. Sci.*, vol. 622, pp. 1014–1032, 2023. https://doi.org/10.1016/j.ins.2022.11.166

[60] A. Liu, Y. Zhao, X. Meng, and Y. Zhang, "A three-phase fuzzy multi-criteria decision model for charging station location of the sharing electric vehicle," *Int. J. Prod. Econ.*, vol. 225, p. 107572, 2020. https://doi.org/10.1016/j.ijpe.2019.107572

[61] R. Wang, X. Li, C. Xu, and F. Li, "Study on location decision framework of electric vehicle battery swapping station: Using a hybrid MCDM method," *Sustain. Cities Soc.*, vol. 61, p. 102149, 2020. https://doi.org/10.1016/j.scs.2020.102149

[62] H. Zhao and N. Li, "Optimal siting of charging stations for electric vehicles based on fuzzy delphi and hybrid multi-criteria decision making approaches from an extended sustainability perspective," *Energies*, vol. 9, no. 4, p. 270, 2016. https://doi.org/10.3390/en9040270

[63] A. R. Mishra, P. Rani, and A. Saha, "Single-valued neutrosophic similarity measure-based additive ratio assessment framework for optimal site selection of electric vehicle charging station," *Int. J. Intell. Syst.*, vol. 36, no. 10, pp. 5573–5604, 2021. https://doi.org/10.1002/int.22523

[64] O. Kaya, K. D. Alemdar, A. Atalay, M. Y. Çodur, and A. Tortum, "Electric car sharing stations site selection from the perspective of sustainability: A GIS-based multi-criteria decision making approach," *Sustain. Energy Technol. Assessments*, vol. 52, p. 102026, 2022. https://doi.org/10.1016/j.seta.2022.102026

[65] B. Yagmahan and H. Yilmaz, "An integrated ranking approach based on group multi-criteria decision making and sensitivity analysis to evaluate charging stations under sustainability," *Environ. Dev. Sustain.*, vol. 25, no. 1, pp. 96–121, 2023. https://doi.org/10.1007/s10668-021-02044-1

[66] F. Khan, Y. Ali, and A. U. Khan, "Sustainable hybrid electric vehicle selection in the context of a developing country," *Air Qual. Atmos. Heal.*, vol. 13, no. 4, pp. 489–499, 2020. https://doi.org/10.1007/s11869-020-00812-y

[67] F. B. Cui, X. Y. You, H. Shi, and H. C. Liu, "Optimal siting of electric vehicle charging stations using pythagorean fuzzy vikor approach," *Math. Probl. Eng.*, vol. 2018, p. 9262067, 2018. https://doi.org/10.1155/2018/9262067

[68] H. C. Sonar and S. D. Kulkarni, "An integrated AHP-MABAC approach for electric vehicle selection," *Res. Transp. Bus. Manag.*, vol. 41, p. 100665, 2021. https://doi.org/10.1016/j.rtbm.2021.100665

[69] K. Koirala, M. Tamang, and Shabbiruddin, "Planning and establishment of battery swapping station - A support for faster electric vehicle adoption," *J. Energy Storage*, vol. 51, p. 104351, 2022. https://doi.org/10.1016/j.est.2022.104351

[70] T. Biswas, P. Chatterjee, and B. Choudhuri, “Selection of commercially available alternative passenger vehicle in automotive environment,” *Oper. Res. Eng. Sci. Theory Appl.*, vol. 3, no. 1, pp. 16–27, 2020. http://doi.org/10.31181/oresta200113b

[71] P. Ziemba, “Multi-criteria stochastic selection of electric vehicles for the sustainable development of local government and state administration units in Poland,” *Energies*, vol. 13, no. 23, p. 6299, 2020. https://doi.org/10.3390/en13236299

[72] H. C. Liu, X. Y. You, Y. X. Xue, and X. Luan, “Exploring critical factors influencing the diffusion of electric vehicles in China: A multi-stakeholder perspective,” *Res. Transp. Econ.*, vol. 66, pp. 46–58, 2017. https://doi.org/10.1016/j.retrec.2017.10.001

[73] T. Palit, A. B. M. M. Bari, and C. L. Karmaker, “An integrated principal component analysis and interpretive structural modeling approach for electric vehicle adoption decisions in sustainable transportation systems,” *Decis. Anal. J.*, vol. 4, p. 100119, 2022. https://doi.org/10.1016/j.dajour.2022.100119

[74] M. H. Ghodusinejad, Y. Noorollahi, and R. Zahedi, “Optimal site selection and sizing of solar EV charge stations,” *J. Energy Storage*, vol. 56, no. 1, p. 105904, 2022. https://doi.org/10.1016/j.est.2022.105904

[75] P. Fabianek, C. Will, S. Wolff, and R. Madlener, “Green and regional? A multi-criteria assessment framework for the provision of green electricity for electric vehicles in Germany,” *Transp. Res. Part D Transp. Environ.*, vol. 87, p. 102504, 2020. https://doi.org/10.1016/j.trd.2020.102504

[76] Z. Sadreddini, S. Guner, and O. Erdinc, “Design of a decision-based multicriteria reservation system for the EV parking lot,” *IEEE Trans. Transp. Electrif.*, vol. 7, no. 4, pp. 2429–2438, 2021. https://doi.org/10.1109/TTE.2021.3067953

[77] N. Erdogan, D. Pamucar, S. Kucuksari, and M. Deveci, “A hybrid power heronian function-based multicriteria decision-making model for workplace charging scheduling algorithms,” *IEEE Trans. Transp. Electrif.*, vol. 9, no. 1, pp. 1564–1578, 2023. https://doi.org/10.1109/TTE.2022.3186659

[78] M. Patil and B. B. Majumdar, “An investigation on the key determinants influencing electric two-wheeler usage in urban Indian context,” *Res. Transp. Bus. Manag.*, vol. 43, p. 100693, 2022. https://doi.org/10.1016/j.rtbm.2021.100693

[79] Y. Song, Y. Li, H. Zhu, and G. Li, “A decision support model for buying battery electric vehicles considering consumer learning and psychological behavior,” *J. Retail. Consum. Serv.*, vol. 73, p. 103303, 2023. https://doi.org/10.1016/j.jretconser.2023.103303

[80] P. G. Panah, S. M. Bornapour, S. M. Nosratabadi, and J. M. Guerrero, “Hesitant fuzzy for conflicting criteria in multi-objective deployment of electric vehicle charging stations,” *Sustain. Cities Soc.*, vol. 85, p. 104054, 2022. https://doi.org/10.1016/j.scs.2022.104054

[81] Q. Wei and C. Zhou, “A multi-criteria decision-making framework for electric vehicle supplier selection of government agencies and public bodies in China,” *Environ. Sci. Pollut. Res.*, vol. 30, no. 4, pp. 10 540–10 559, 2023. https://doi.org/10.1007/s11356-022-22783-6

[82] X. Xu, X. B. Chen, Z. Liu, J. H. Yang, Y. N. Xu, Y. Zhang, and Y. K. Gao, “Multi-objective reliability-based design optimization for the reducer housing of electric vehicles,” *Eng. Optim.*, vol. 54, no. 8, pp. 1324–1340, 2022. https://doi.org/10.1080/0305215X.2021.1923704

[83] J. Wieckowski, J. Watrobski, B. Kizielewicz, and W. Salabun, “Complex sensitivity analysis in multi-criteria decision analysis: An application to the selection of an electric car,” *J. Clean. Prod.*, vol. 390, p. 136051, 2023. https://doi.org/10.1016/j.jclepro.2023.136051

[84] P. Zhang, Z. J. Zhang, D. Q. Gong, and X. K. Cui, “A novel normal wiggly hesitant fuzzy multi-criteria group decision making method and its application to electric vehicle charging station location,” *Expert Syst. Appl.*, vol. 223, p. 119876, 2023. https://doi.org/10.1016/j.eswa.2023.119876

[85] D. Ghose, S. Pradhan, P. Tamuli, and Shabbiruddin, “Optimal material for solar electric vehicle application using an integrated fuzzy-copras model,” *Energy Sources, Part A Recover. Util. Environ. Eff.*, vol. 45, no. 2, pp. 3859–3878, 2023. https://doi.org/10.1080/15567036.2019.1668879

[86] Z. P. Tian, H. M. Liang, R. X. Nie, W. Wang, and J. Qi, “Data-driven multi-criteria decision support method for electric vehicle selection,” *Comput. Ind. Eng.*, vol. 177, p. 109061, 2023. https://doi.org/10.1016/j.cie.2023.109061

[87] P. Ziemba, “Selection of electric vehicles for the needs of sustainable transport under conditions of uncertainty-A comparative study on fuzzy mcda methods,” *Energies*, vol. 14, no. 22, p. 7786, 2021. https://doi.org/10.3390/en14227786

[88] Y. J. Wang, G. G. Zhou, T. Li, and X. Wei, “Comprehensive evaluation of the sustainable development of battery electric vehicles in China,” *Sustainability*, vol. 11, no. 20, p. 5635, 2019. https://doi.org/10.3390/su11205635

[89] V. Palevičius, A. Podviezko, H. Sivilevičius, and O. Prentkovskis, “Decision-aiding evaluation of public infrastructure for electric vehicles in cities and resorts of Lithuania,” *Sustainability*, vol. 10, no. 4, p. 904, 2018.

https://doi.org/10.3390/su10040904
[90] M. Schmidt, P. Zmuda-Trzebiatowski, M. Kicinski, P. Sawicki, and K. Lasak, "Multiple-criteria-based electric vehicle charging infrastructure design problem," *Energies*, vol. 14, no. 11, p. 3214, 2021. https://doi.org/10.3390/en14113214
[91] M. B. Barfod, S. Kaplan, I. Frenzel, and J. Klauenberg, "COPE-SMARTER - A decision support system for analysing the challenges, opportunities and policy initiatives: A case study of electric commercial vehicles market diffusion in Denmark," *Res. Transp. Econ.*, vol. 55, pp. 3–11, 2016. https://doi.org/10.1016/j.retrec.2016.04.005
[92] C. W. Lin, S. H. Chen, and G. H. Tzeng, "Constructing a cognition map of alternative fuel vehicles using the DEMATEL method," *J. Multi-Criteria Decis. Anal.*, vol. 16, no. 1-2, pp. 5–19, 2009. https://doi.org/10.1002/mcda.438
[93] W. Alosaimi, M. Ansari, A. Alharbi, H. Alyami, S. Ali, A. Agrawal, and R. Khan, "Toward a unified model approach for evaluating different electric vehicles," *Energies*, vol. 14, no. 19, p. 6120, 2021. https://doi.org/10.3390/en14196120
[94] M. Mahdy, A. S. Bahaj, P. Turner, N. Wise, A. S. Alghamdi, and H. Hamwi, "Multi criteria decision analysis to optimise siting of electric vehicle charging points—Case study Winchester District, UK," *Energies*, vol. 15, no. 7, p. 2497, 2022. https://doi.org/10.3390/en15072497
[95] T. K. L. Nguyen, H. N. Le, V. H. Ngo, and B. A. Hoang, "CRITIC method and grey system theory in the study of global electric cars," *World Electr. Veh. J.*, vol. 11, no. 4, p. 79, 2020. https://doi.org/10.3390/wevj11040079
[96] L. Anthopoulos and P. Kolovou, "A multi-criteria decision process for EV charging stations' deployment: Findings from Greece," *Energies*, vol. 14, no. 17, p. 5441, 2021. https://doi.org/10.3390/en14175441
[97] M. Patil and B. B. Majumdar, "Prioritizing key attributes influencing electric two-wheeler usage: A multi criteria decision making (MCDM) approach - A case study of hyderabad, India," *Case Stud. Transp. Policy*, vol. 9, no. 2, pp. 913–929, 2021. https://doi.org/10.1016/j.cstp.2021.04.011
[98] A. Nath, Z. Rather, I. Mitra, and L. Sahana, "Multi-criteria approach for identification and ranking of key interventions for seamless adoption of electric vehicle charging infrastructure," *IEEE Trans. Veh. Technol.*, vol. 72, no. 7, pp. 8697–8708, 2023. https://doi.org/10.1109/TVT.2023.3252273
[99] E. Costa, A. Paiva, J. Seixas, G. Costa, P. Baptista, and B. O. Gallachoir, "Spatial planning of electric vehicle infrastructure for Belo Horizonte, Brazil," *J. Adv. Transp.*, vol. 2018, p. 8923245, 2018. https://doi.org/10.1155/2018/8923245
[100] G. D. Oliveira, L. M. C. Dias, and P. C. S. D. Santos, "Modelling consumer preferences for electric vehicles in Portugal: An exploratory study," *Manag. Environ. Qual. An Int. J.*, vol. 26, no. 6, pp. 929–950, 2015. https://doi.org/10.1108/MEQ-03-2014-0047
[101] S. Pradhan, D. Ghose, and Shabbiruddin, "Planning and design of suitable sites for electric vehicle charging station- A case study," *Int. J. Sustain. Eng.*, vol. 14, no. 3, pp. 404–418, 2021. https://doi.org/10.1080/19397038.2020.1862347
[102] F. Lu, L. Yan, and B. Huang, "Site selection for shared charging and swapping stations using the SECA and TRUST methods," *Energy Reports*, vol. 8, pp. 14 606–14 622, 2022. https://doi.org/10.1016/j.egyr.2022.10.378
[103] M. C. Das, A. Pandey, A. K. Mahato, and R. K. Singh, "Comparative performance of electric vehicles using evaluation of mixed data," *Opsearch*, vol. 56, pp. 1067–1090, 2019. https://doi.org/10.1007/s12597-019-00398-9
[104] H. M. Abdullah, A. Gastli, L. Ben-Brahim, and S. O. Mohammed, "Integrated multi-criteria model for long-term placement of electric vehicle chargers," *IEEE Access*, vol. 10, pp. 123 452–123 473, 2022. https://doi.org/10.1109/ACCESS.2022.3224796
[105] P. Ziemba and I. Gago, "Compromise multi-criteria selection of e-scooters for the vehicle sharing system in Poland," *Energies*, vol. 15, no. 14, p. 5048, 2022. https://doi.org/10.3390/en15145048
[106] X. S. Ren, S. Sun, and R. Yuan, "A study on selection strategies for battery electric vehicles based onsentiments, analysis, and the MCDM model," *Math. Probl. Eng.*, vol. 2021, p. 9984343, 2021. https://doi.org/10.1155/2021/9984343
[107] B. Ashok, K. M. Usman, R. Vignesh, C. Deepak, R. Ramesh, T. M. V. Narendhra, and C. Kavitha, "Transition to electric mobility in India: Barriers exploration and pathways to powertrain shift through MCDM approach," *J. Inst. Eng. Ser. C*, vol. 103, no. 5, pp. 1251–1277, 2022. https://doi.org/10.1007/s40032-022-00852-6
[108] K. Koirala and Shabbiruddin, "Optimal selection of sustainable battery supplier for electric vehicle battery swapping station," *Energy Sources Part A Recovery Util. Environ. Eff.*, vol. 45, no. 1, pp. 2206–2227, 2023. https://doi.org/10.1080/15567036.2023.2185702
[109] L. Yang, Z. Cheng, B. Zhang, and F. Ma, "Electric vehicle charging station location decision analysis for a two-stage optimization model based on shapley function," *J. Math.*, vol. 2021, p. 5098378, 2021. https://doi.org/10.1155/2021/5098378

[110] P. Ziemba, "Monte Carlo simulated data for multi-criteria selection of city and compact electric vehicles in Poland," *DATA Br.*, vol. 36, p. 107118, 2021. https://doi.org/10.1016/j.dib.2021.107118

[111] A. Dixit, "Electric vehicle infrastructure market sustainable growth in Indian scenario, needs and suggestions," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 11, pp. 242–245, 2019. https://doi.org/10.35940/ijitee.K1048.09811S19

[112] Shabbiruddin, D. Ghose, and S. Pradhan, "Analysis of challenges for one point solution study of electric vehicle service centre (EVSC) using fuzzy- methodology," *Int. J. Sustain. Eng.*, vol. 14, no. 6, pp. 1893–1906, 2021. https://doi.org/10.1080/19397038.2021.1986589

[113] S. Mall and R. Anbanandam, "A fuzzy analytic hierarchy process and vikor framework for evaluation and selection of electric vehicle charging technology for India," *Transp. Dev. Econ.*, vol. 8, no. 1, p. 14, 2022. http://doi.org/10.1007/s40890-022-00150-x

[114] C. N. Wang, H. T. Tsai, H. Thanh Phong, N. Van Thanh, and Y. F. Huang, "Multi-criteria decision making (MCDM) model for supplier evaluation and selection for oil production projects in Vietnam," *Processes*, vol. 8, no. 2, p. 134, 2020. https://doi.org/10.3390/pr8020134

[115] M. C. Das, B. Sarkar, and S. Ray, "A decision support framework for performance evaluation of Indian technical institutions," *Decis. Sci. Lett.*, vol. 2, no. 4, pp. 257–274, 2013. https://doi.org/10.5267/j.dsl.2013.06.005

[116] J. Liang, H. Zhou, J. Li, W. Kong, Z. Ma, and L. Sun, "Comparison of dynamic performances for heat integrated reactive distillation considering safety," *Chem. Eng. Process. Process Intensif.*, vol. 160, p. 108294, 2021. https://doi.org/10.1016/j.cep.2020.108294

[117] I. Kaya, M. Colak, and F. Terzi, "A comprehensive review of fuzzy multi criteria decision making methodologies for energy policy making," *Energy Strategy Reviews*, vol. 24, pp. 207–222, 2019. https://doi.org/10.1016/j.esr.2019.03.003

[118] P. H. Dos Santos, S. M. Neves, D. O. Sant'Anna, C. H. de Oliveira, and H. D. Carvalho, "The analytic hierarchy process supporting decision making for sustainable development: An overview of applications," *J. Clean. Prod.*, vol. 212, pp. 119–138, 2019. https://doi.org/10.1016/j.jclepro.2018.11.270

[119] M. A. Alao, O. M. Popoola, and T. R. Ayodele, "A novel fuzzy integrated MCDM model for optimal selection of waste-to-energy-based-distributed generation under uncertainty: A case of the city of Cape Town, South Africa," *J. Clean. Prod.*, vol. 343, p. 130824, 2022. https://doi.org/10.1016/j.jclepro.2022.130824