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A Bibliometric Review on Decision Approaches for Clean Energy Systems under Uncertainty

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Abstract: This paper aims to provide a bibliometric review on the diverse decision approaches in uncertain contexts for clean energy system (CES) assessment. A total of 126 publications are analyzed. Previous reviews on CES have discussed several research questions on the decision methods and the applicability of evaluating CES, along with the factors associated with CESs. In the present study, we focus on the bibliometric aspect that attempts to address questions related to the prominence of authors, countries/regions that focus on the current theme, impact of journals, importance of articles in the research community, and so on. The window considered for the study is from 2018 to 2021, with the motive to extend the review process from the preceding works. A review model is presented to address the questions based on the literature evidence. The results infer that CESs are the most viable mode for sustainable development, and the use of decision approaches is apt for the assessment of CESs.

Keywords: bibliometric study; clean energy system; decision approaches; uncertainty

1. Introduction

Clean energy is a desirable option for satisfying the energy demand of the public, as the conventional forms create environmental issues and play a significant role in climate change [1]. To combat the challenge, aggressive measures are taken worldwide to encourage clean energy generation and usage. Recently, in the Paris Accord, countries had a detailed discussion regarding climate change and the possible ways to reduce the carbon footprint. Countries are committed to achieving a considerable reduction in the carbon trace by 2025 [2,3]. The work in [4] reviewed the different decision methods used in clean energy evaluation and proved the power of decision methods for applications involving competing criteria for rating/evaluation. Developing countries, such as India, seek high energy to satisfy the demand of the people, and by 2040–2050, the transformation to CES will become highly essential [5]. The US Energy Information Administration (www.eia.gov, dated 5 April 2021) reported that almost 74% of greenhouse gas emissions are from burning fossil fuels in the US. Further reports indicate that in 2018, air pollution accounted for the cost of 3.3% of global GDP, which was primarily from fossil fuels. It was found that from 1990 to 2013, the total primary energy supply grew to 54.4%, of which only 13.8% was from CESs [4].

These claims drive researchers to put forth computational models to assess CESs and issues associated with them. From the works presented in [6–8], it is clear that decision approaches are very suitable for assessing CESs, as the criteria are conflicting and competing with one another. Furthermore, fuzzy sets can model uncertainty effectively in such decision problems. Earlier literature reviews related to CESs [8–11] provide the following inferences:

- Fuzzy sets are key concepts that are used for modeling uncertainty in the decision process associated with CES.
- Most of the literature studies obtain data as rating information in the Likert-scale form and transform them into fuzzy values to generate decisions.
- The criteria for such applications are competing and conflicting with one another, and the estimation of their relative importance is considered a crucial stage in the existing framework.
- Utility function-based formulation and distance measure-based formulation are popular in ranking CESs and their associated options.
- Earlier literature reviews have also claimed that the assessment of CESs using multi-criteria decision making (MCDM) will grow due to the nature of the problem and the efficacy of the method.

These inferences motivate the current bibliometric literature review. Besides, the existing review articles have paid little attention to the bibliometric theme of review in the CES assessment field. Also, a review of CES-related works after 2018 needs to be well explored. In this paper, we attempt to exploit this direction to give readers clarity of the following review questions (RQs). It must be clearly understood that these RQs are answered based on the data collected and presented in this study, which consist of 134 articles, and so the results are pertaining to these 1 papers that authors attempt to review.

- Which countries prominently contributed to CES-related research based on the data collection by authors?
- Who are the prominent first authors in the CES assessment field based on the collected articles from 2018 to 2021?
- Which publisher and journal(s) dominate and attract articles in the theme of the review?
- What are the popular decision approaches used by researchers to assess CESs rationally?
- What fuzzy sets are prominently used by researchers for CES assessment?
- What are commonly adopted metrics to evaluate the superiority of the proposed decision framework in the current field of study?
- What are the prevalent application areas addressed by researchers in the CES field and what are the future challenges, and how does the future research intuitively look for the current field of study?

The paper is further organized in the following way. Basic concepts related to decision approaches and different fuzzy sets are detailed in Section 2. The review model adopted in the current study and answers to the RQs are given in Section 3. The research challenges encountered for future research in CES, along with the discussion from the review, are given in Section 4. Finally, concluding remarks are provided in Section 5.

2. Decision Approaches and Fuzzy Sets for CES

This section outlines the different decision approaches that are used in the process of CES evaluation and assessment. Additionally, the problem is viewed from the context of uncertainty. Hence, the various fuzzy variants adopted are also outlined to give a preliminary insight into the frameworks that promote the evaluation of CESs.

2.1. Decision-Making Methods

Based on the previous review articles [8–11] in the field of CES evaluation, it is clear that the model frequently adopts integrated approaches, which involve weight estimation and a ranking method. Researchers often develop frameworks with these two critical ideas in the CES context. Weight is determined either with/without partial knowledge [12,13] on the criteria considered for rating CESs. The ranking is performed with the help of pairwise comparison methods, utility functions, or outranking relation-based methods [4,12–18].

Let us briefly discuss some weighting methods and ranking techniques (the list of the abbreviation and expansion of the main methods and approaches is contained in the Appendix A).

Analytical hierarchy process (AHP)

AHP [19,20] is a popular ranking method that follows pairwise comparisons to determine the rank value of an alternative. The works provided in [21,22] describe the importance of AHP and its usefulness in various decision problems. From the review articles, it may be noted that AHP has been widely used by several fuzzy sets, and prominently for weight calculation and ranking. The works from [8–11] indicate that AHP is commonly used in the field of CESs.

Entropy

Entropy [23,24] is another popular method used for weight calculation. The popular entropy measure is the Shannon version that is dominantly used for weight calculation. In the reviews [8–11], Shannon entropy is used by various fuzzy variants for weight calculation. The method is computationally viable, but does not capture interactions among criteria.

Criteria interaction through inter-correlation (CRITIC)

CRITIC [25,26] is an objective weight estimation approach, developed to properly understand the criteria interaction via correlation measures. Review articles [8–11] use this approach for criteria weight calculation, to enhance rationality during CES selection.

Stepwise weight assessment ratio analysis (SWARA)

SWARA [22] is also a popular approach for weight calculation, and determines weights objectively to aid in rational decision making. From [8–11], it is clear that SWARA is widely used for CES selection, and the sustainable criteria are better weighed using this approach. The work provided in [23] shows the variants of SWARA used in different decision applications under different fuzzy contexts.

Utility functions

Once the weights of the criteria are determined, CESs are ranked based on the problem being considered. As discussed earlier, utility function-based ranking is one type of ranking that is commonly used in CES evaluation under different fuzzy sets. The popular methods are complex proportional assessment (COPRAS) [24] and weight arithmetic sum product assessment (WASPAS) [25]. The main theme behind these two methods is that each vector is aggregated in a certain fashion, option-wise, and, finally, the options are arranged based on these values in decreasing order. A detailed review of COPRAS [26] and WASPAS [23] reveals that these two methods are popular and widely used in decision problems under diverse fuzzy contexts.

Compromise solution

The base idea for this ranking theme is adapted from the L_p metric, with p in the range of zero to infinity. A distance norm is used in the formulation to identify suitable options for the problem at hand. Frequently used methods under this category include TOPSIS and VIKOR [27], which follow the interesting comparative investigation and attempt to rank options differently. A review on TOPSIS [28–30] indicates that the method is quite often used in decision-making applications in diverse fields. Nevertheless, a review of the VIKOR method [31,32] also shows that the approach is used dominantly for decision making in several applications.

Outranking methods

Another interesting class of ranking is the outranking category, in which the ranking is performed based on outranking relations. Unlike the earlier categories, the values of each option are not directly aggregated, but are based on the conditions, and acceptance and conflict matrices are formulated that eventually form the ranking of diverse options.

Popular methods include PROMETHEE [33] and ELECTRE [34], along with their variants. Reviews on PROMETHEE [35] and ELECTRE [36] clearly show their usefulness in decision-making applications.

It may be noted that, from the works presented in [8–11], it is clear that the utility and compromise approaches are commonly used for CES evaluation compared to outranking methods.

2.2. Fuzzy Sets

During the CESs evaluation process and its associated entities, uncertainty is an integral part of the process and cannot be simply ignored. To model the uncertainty better, researchers have adopted fuzzy sets and their variants. The typical strategy used by the researchers in this study involves the Likert-scale rating being transformed to respective fuzzy variants, and CESs being evaluated based on decision approaches. The works in [8–11] clearly show that classical fuzzy sets and their variants [37], intuitionistic fuzzy sets (IFS) [38], Pythagorean fuzzy sets (PFS) [39], and hesitant fuzzy sets (HFS) [40] are widely used in CES evaluation and support rational modelling of uncertainty. Reviews on IFS [41,42], PFS [43], and HFS [44] reveal their dominant usage in the decision-making process.

3. Review Model

This section describes the review model developed in this study for carrying out a bibliometric review of CES selection. Based on the past review articles presented above, the window for the current study is set to 2018 to 2021. Also, the authors identified that the bibliometric study was not conducted earlier, so some research questions on the theme are set. All the authors shared their views, and, finally, the questions were framed for the analysis. The keywords used in the study include "clean energy selection", "renewable energy selection using decision-making techniques", "clean energy selection in a fuzzy environment", and "clean energy selection using MCDM". The authors fed the keywords into the Web of Science ISI repository by setting the year bounds from 2018 to 2021, and obtained 542 articles. Later, the authors filtered the articles to obtain 133, by adopting manual reading and reviewing based on the relevance to the theme of the review process.

The authors read all these papers carefully and manually discarded some papers that did not cover the study's core theme. Based on the filtering process, 134 articles are most suitable for the review process during the 2018 to 2021 window. All these articles are from peer-reviewed journals.

A review model developed for properly reviewing the literature studies from 2018 to 2021 is shown in Figure 1. The model initially collects raw data from the Web of Science ISI repository by feeding the desired keywords. Later, the authors read the articles carefully and manually performed filtering of articles based on the core theme of the study. The bibliometric context is adopted to analyze the filtered articles. The authors framed the RQs carefully to obtain interesting information related to the CES field. Tabulations are presented to address the raised RQs, along with an informative description of the tabulated content. Readers are requested to refer to the next section for clarity.

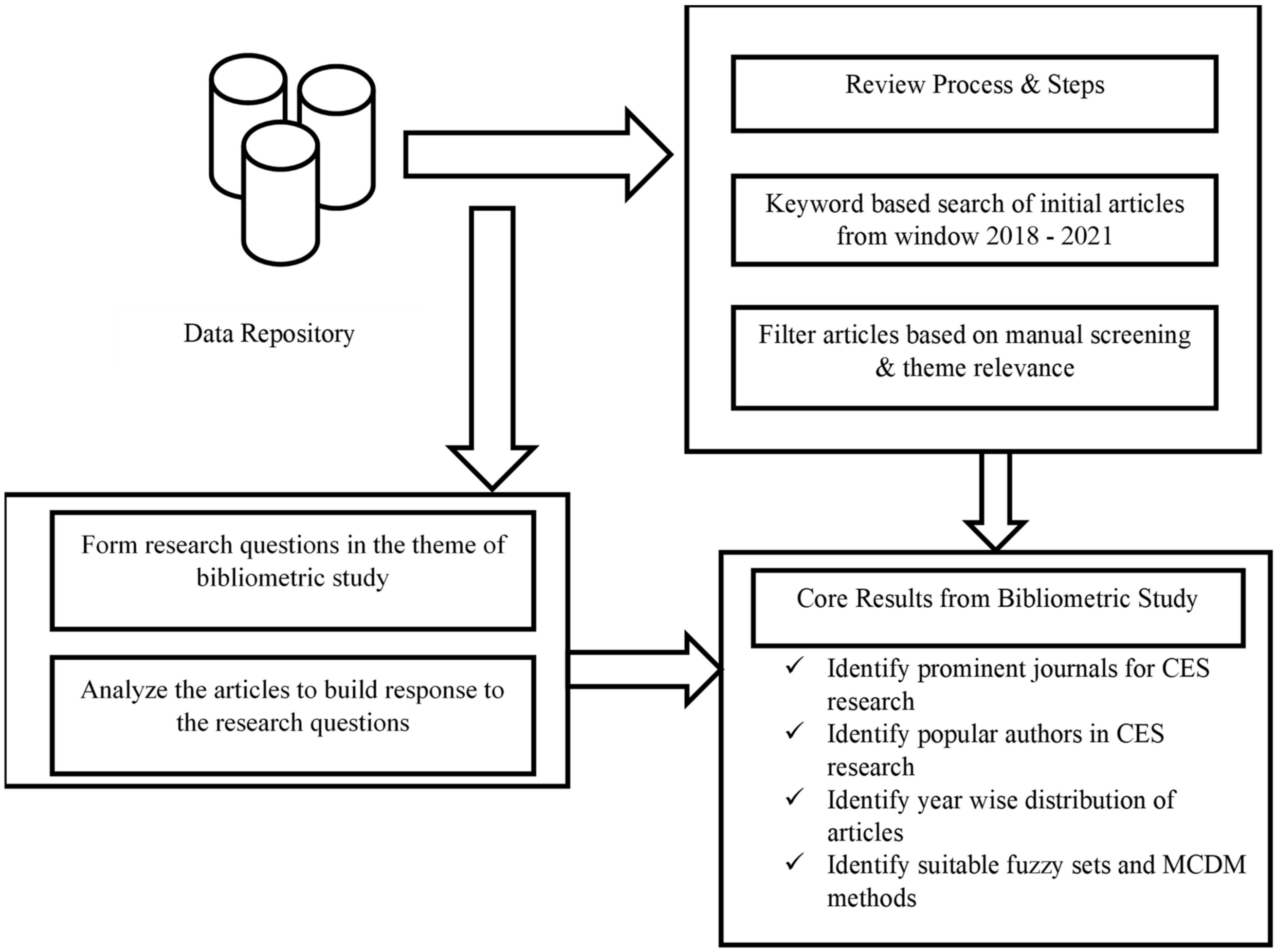

Figure 1. Overview of the review model.

4. Results and Discussion

4.1. Response to RQs

(RQ 1)—What are the popular decision approaches used by researchers to assess CESs rationally?

In this review paper, 76 decision-making approaches have been identified. Some of them have been modified in their respective study to improve the output and obtain better solutions. Table 1 shows the distribution of all the decision approaches used in all the papers studied here. In this distribution, one may use the numerical indexing of each method at the bottom of the table and observe the trend of each method used in the sample of journals included in this study. Each entry from the columns numbered 1 to 8 represents the methods 1 to 8; for instance, if, for any given author, there is a mark in column 1, it should be concluded that the author has made use of the analytical hierarchal process (AHP).

Table 1. Distribution of decision approaches in CES study (2018–2021).

Author	Year	1	2	3	4	5	6	7	8	Others
Wu et al. [45]	2018	✓								
Wang et al. [46]	2018	✓						✓		
Büyüközkan et al. [47]	2018	✓								65
Promentilla et al. [48]	2018	✓								66
Lee et al. [49]	2018					✓	✓	✓		54
Ghimire & Kim [50]	2018	✓								

Table 1. *Cont.*

Author	Year	1	2	3	4	5	6	7	8	Others
Chatterjee & Kar [51]	2018		✓							
Chen & Ren [52]	2018		✓					✓		
Boran [53]	2018					✓				
Simsek et al. [54]	2018									10
Sehatpour et al. [55]	2018									17
Li et al. [56]	2018									30
Alizadeh et al. [57]	2018		✓							
Liu et al. [58]	2019							✓		9
Cerón et al. [59]	2019									20
Tarybakhsh et al. [60]	2019									11, 53, 67
Mostafaeipour & Sadeghi-Sedeh [61]	2019	✓				✓		✓		48, 55
Deo et al. [62]	2019									12, 14 17, 18
Kumar et al. [63]	2019									
Essien et al. [64]	2019									
Rani et al. [65]	2019					✓		✓		45
Karunathilake et al. [66]	2019	✓						✓		
Krishankumar et al. [67]	2019									65
Krishankumar et al. [68]	2020							✓		
Rani et al. [69]	2020					✓				
Yousef et al. [70]	2020			✓						56
Asif et al. [71]	2020									57
Muneeza et al. [72]	2020		✓			✓		✓		22
Wu et al. [73]	2020									23
Okokpujie et al. [74]	2020	✓						✓		
Guðlaugsson et al. [75]	2020									
Luo et al. [76]	2020		✓					✓		61
Papanikolaou et al. [77]	2020							✓		
Wang et al. [78]	2020	✓								
Kamari et al. [79]	2020	✓								40, 65
Alkan & Albayrak [80]	2020									
Song et al. [81]	2020									
Hu et al. [82]	2020							✓		
Karaşan et al. [83]	2020	✓								
Ikram et al. [84]	2020	✓				✓			✓	
Guleria & Bajaj [85]	2020					✓		✓	✓	
Ahmadi et al. [86]	2020		✓			✓				25
Li et al. [87]	2020									26
Arriola et al. [88]	2020			✓				✓		13, 17, 40, 59
Albawab et al. [89]	2020									27, 28
Wang et al. [90]	2020	✓						✓		29
Deveci et al. [91]	2020	✓								19, 31, 61
Aryanfar et al. [92]	2020	✓								41
Rivera-Niquepa et al. [93]	2020									32
Ali et al. [94]	2020									16, 33, 34, 35, 36
Afzal & Ramis [95]	2020			✓	✓					13, 37, 38, 39
Xu et al. [96]	2020		✓					✓		41
Wu et al. [97]	2020									41, 55
Mangla et al. [98]	2020	✓	✓							41
Mokarram et al. [99]	2020	✓	✓							
Moradi et al. [100]	2020	✓	✓							
Çolak & Kaya [101]	2020	✓	✓			✓		✓		
Adedeji et al. [102]	2020									
Geng et al. [103]	2020									
Alao et al. [104]	2020							✓		
Pamucar et al. [105]	2020									43, 61
Wu et al. [106]	2020									23
Wu et al. [107]	2020		✓							42
Cheng et al. [108]	2020							✓		41
Tarife et al. [109]	2020									
Feng [110]	2021	✓								
Mrówczyńska et al. [111]	2021	✓								
Kumar et al. [112]	2021	✓						✓		
Krishankumar et al. [113]	2021									21, 55, 62
Liu et al. [114]	2021	✓				✓				46
Ahmad et al. [115]	2021					✓		✓		23
Hashmi et al. [116]	2021				✓					17, 47

Table 1. *Cont.*

Author	Year	1	2	3	4	5	6	7	8	Others
Fetanat et al. [117]	2021								✓	60
Wu et al. [118]	2021	✓								41
Adedeji et al. [119]	2021			✓						13
Malik & Yadav [120]	2021									63
Gulzar et al. [121]	2021									13, 49
Kotb et al. [122]	2021	✓				✓				
Lin et al. [123]	2021									
Wang et al. [124]	2021									50
Wang et al. [125]	2021								✓	40
Mei & Chen [126]	2021									41
Yang & Chang [127]	2021									51
Clauberg et al. [128]	2021									
Yazır et al. [129]	2021									
Sun & Yu [130]	2021							✓	✓	15, 52
Huai et al. [131]	2021									64
Mostafaeipour et al. [132]	2021									35, 61
Balezentis et al. [133]	2021									16, 61
Ghouchani et al. [134]	2021									19
Ullah et al. [135]	2021		✓					✓		35, 40
Cayir Ervural et al. [136]	2021			✓				✓		
Wang et al. [137]	2021							✓		68
Liu et al. [138]	2021			✓						41
Gökgöz & Yalçın [139]	2021									10, 29, 64
Ulutaş & Karaca. [140]	2021									29, 65
Malemnganbi & Shimray [141]	2021	✓								
Ecer [142]	2021									27, 43, 65
Ramos-Escudero [143]	2021					✓				
Gkeka-Serpetsidaki & Tsoutsos [144]	2021	✓								
Kannan et al. [145]	2021					✓				61, 64, 69
Abdul-Basset et al. [146]	2021	✓								35
Xie et al. [147]	2021									41
Saraswat & Digalwar [148]	2021	✓							✓	
Pan & Wang [149]	2021									58
Karaaslan et al. [150]	2021	✓								43
Dang et al. [151]	2021					✓				
Qazi et al. [152]	2021							✓		
Karatop et al. [153]	2021	✓								35
Günen [154]	2021	✓								
Akçay & Atak [155]	2018	✓						✓		
Dominguez et al. [156]	2021									77
Lin & Ren [157]	2021									
Shorabeh et al. [158]	2021		✓					✓		
Lopes et al. [159]	2021							✓		
Rahoma & Obeidat [160]	2021									
Ajanaku et al. [161]	2021	✓								
Asanza et al. [162]	2021	✓								
Ulewicz et al. [163]	2021	✓						✓		
Crivellari et al. [164]	2021									69
Babatunde et al. [165]	2021									35
Prieto-Amparán et al. [166]	2021	✓								
Tercan et al. [167]	2021	✓								
Hwang et al. [168]	2021									
Naegler et al. [169]	2021						✓			
Sipa [170]	2021									40
Lucheroni et al. [171]	2021									71
Castangia et al. [172]	2021									26
Bertolino et al. [173]	2021									72
Derbeli et al. [174]	2021									56
Mohd et al. [175]	2021									73
Alam et al. [176]	2021									74
Alberizzi et al. [177]	2021									20
Martin-Hernandez et al. [178]	2021									75
Oregi et al. [179]	2021									76

Table 1. *Cont.*

Author	Year	1	2	3	4	5	6	7	8	Others
1. AHP	26. LSTM-CNN						51. EVAMIX			
2. ANP	27. ARAS						52. K-MEAN METHOD			
3. PSO	28. SWARA						53. DDSM			
4. MOO	29. CRITIC						54. ELECTRE			
5. VIKOR	30. AUGMENTED ЄCONSTRAINT						55. TODIM			
6. WSM	31. LBWA						56. ANN			
7. TOPSIS	32. PARETO SET						57. MPPT			
8. ENTROPY METHOD	33. IDOCRIW						58. LSGDM			
9. MOPSO	34. CODAS						59. SA			
10. MAUT	35. EDAS						60. LINEAR ASSIGNMENT			
11. SVR	36. MOOSRA						61. BWM			
12. MLR	37. MOGA						62. GINI INDEX			
13. GA	38. NSGA—II						63. FORECASTING			
14. RF	39. MPC						64. GRA			
15. NORMALIZATION METHOD	40. MULTIMOORA						65. COPRAS			
16. WASPAS	41. DEMATEL						66. SFAHNP			
17. GP	42. PROMETHEE						67. FINITE ELEMENT ANALYSIS			
18. M5TREEMODEL	43. MARCOS						68. DEA			
19. DELPHI METHOD	44. IDM						69. MONTE CARLO			
20. MILM	45. DIVERGE MEASURE						70. LCP			
21. MAGDM	46. MEE						71. Value at risk			
22. MCGDM	47. ECP						72. Cumulative impact function; Evolutionary algorithm			
							73. BeWhere model			
23. PROMETHEE—II	48. SAW						74. Technology acceptance model with theory of reason action			
24. MINLP	49. FA						75. First principle/Superstructure model			
25. GIS	50. REGRET THEORY						76. Life cycle assessment 77. Statistical analysis			

Similarly, a mark in column 8 represents that the author has used the entropy method for their study. The column "others" includes the numerical index of the methods themselves. If a particular author has multiple marks in their corresponding row, it is implied that multiple methods have been used together. A similar study approach has been used in other tables as well. It is to be noted that Table 1 considers the decision methods used in the existing works and not the environment.

Moreover, this study considers their principal method as the method classifier; for instance, vector-aided technique for order of preference by similarity to ideal solution (TOPSIS) and entropy-based TOPSIS will be classified in the same name class (TOPSIS). However, discretion is required for generalization. In addition, the reader will come across numerous cases where the author has used various methods, such as data envelopment analysis (DEA), additive ratio assessment (ARAS), and analytical hierarchal process (AHP), for the study. For such cases, the authors consider the method that the works used for ranking/selecting CES.

The distribution of the most frequently used decision approaches that are in trend in CES is shown in Table 2. The AHP (analytical hierarchy process) has been used in 38 studies. It covers approximately 31 percent of the content in this review. Bing et al., (2018) used an approach to establish a three-layer decision-making framework, after identifying the influencing factors from previous works, derive the decision matrix by integrating the influencing factor, and obtain the attributes' weights by using the AHP [45]. Wang et al., (2018) conducted research in multiple stages. The first stage includes a fuzzy-AHP model for determining the weight of each potential location for building a wind power plant based on qualitative and quantitative factors.

Furthermore, a TOPSIS approach ranks all the potential alternatives in the final stage [46]. Promentilla et al., (2018) proposes an SFAHNP decision model to address the complexity and uncertainty involved in the clean technology selection process. This method first decomposes the problem into a hierarchical network structure, and then derives the probability distribution of the priority weights needed for ranking [48]. In

2020, Kamari et al., published their research work using fuzzy sets and AHP to extract the necessary criteria for decision making for renewable energy systems [79].

Table 2. The four most prominent decision approaches used in the CES study (window 2018 to 2021).

Method	Studies	Total	Percentage (%)
AHP	[45–48,50,61,66,74–76,80,81,87–89,95,98,107–111,118,121,141,144,147,148,150,153–155,161–163,166,167]	38	30.4%
TOPSIS	[46,49,52,58,61,68,69,72,74,76,77,82,85,88,90,96,104,108,112,115,130,135–137,152,155,158,159,163]	31	24.8%
VIKOR	[49,53,61,66,68,69,73,83,98,111,112,119,140,142,148]	16	12.8%
ANP	[51,52,57,72,76,86,95–98,107,132,155]	14	11.2%

Note: These four methods cover almost 79% of the total articles considered for the review process. Other ranking methods cover the remaining 21%.

TOPSIS (technique for order preference by similarity to ideal solution) has been used in over 31 studies. Lee et al., (2018) performed a comparative analysis of ranking renewable energy sources (RES) for electricity generation in Taiwan, using four MCDM methods—WSM, VIKOR, TOPSIS, and ELECTRE. This study aims to rank the priorities of various RES and propose recommendations for Taiwan's RES development [49]. Chen et al., (2018) developed a multi-attribute sustainability evaluation model for assessing various alternative aviation fuels [52]. Liu et al., (2019) performed an analysis using TOPSIS and VIKOR to study the level of sustainable development of the EU countries. Indicators from the main goals of the SDGs (Sustainable Development Goals) were used for this study [58].

The ANP (analytical network process) has been used 14 times, covering approximately 11 percent. Chen et al., (2018) provided a study to evaluate a multi-attribute sustainability evaluation model for assessing various alternative aviation fuels [52]. VIKOR (Visekriterijumska Optimizacija I Kompromisno Resenje) and PSO (particle swarm optimization) have been used 8 and 4 times, respectively, and equate to 8 and 4 percent of this study. The top five approaches, out of 64 approaches, cumulate about 66% of the total survey.

(RQ 2)—What fuzzy sets are prominently used by researchers for CES assessment?

Table 3 presents the distribution of 8 fuzzy set variants over 134 scholarly research papers, published in 38 journals. These articles presented the core fuzzy/linguistic variants of the ranking schemes for CES evaluation. A numbering system has been introduced to identify all the fuzzy and linguistic approaches and sets. Prominent fuzzy approaches and the most frequently used fuzzy sets have been identified from the study. It has been concluded, from the data, that the fuzzy concept is the most prominent type of method implemented in a range of papers. Research papers have used fuzzy concepts either in their traditional form or variants, and some works have also considered linguistic versions to handle uncertainty.

Table 3. Distribution of fuzzy sets and variants used in decision models for CES study (2018–2021).

Author	Year	1	2	3	4	5	6	7	8
Büyüközkan et al. [47]	2018	✓							
Ghimire & Kim [50]	2018		✓						
Sehatpour et al. [55]	2018		✓						
Tarybakhsh et al. [60]	2019			✓					
Deo et al. [62]	2019		✓						
Kumar et al. [63]	2019	✓							
Essien et al. [64]	2019			✓					
Rani et al. [65]	2019			✓					
Karunathilake et al. [66]	2019	✓							
Krishankumar et al. [67]	2019		✓			✓			
Krishankumar et al. [68]	2020								✓
Rani et al. [69]	2020	✓							
Yousef et al. [70]	2020	✓							
Asif et al. [71]	2020	✓							
Wu et al. [73]	2020			✓					

Table 3. *Cont.*

Author	Year	1	2	3	4	5	6	7	8
Guðlaugsson et al. [75]	2020	✓							
Luo et al. [76]	2020	✓							
Kamari et al. [79]	2020			✓					
Alkan et al. [80]	2020			✓					
Hu et al. [82]	2020		✓						✓
Karaşan et al. [83]	2020	✓						✓	
Guleria & Bajaj [85]	2020							✓	
Arriola et al. [88]	2020	✓							
Deveci et al. [91]	2020		✓	✓					
Aryanfar et al. [92]	2020	✓							
Xu et al. [96]	2020			✓					
Wu et al. [97]	2020			✓					
Çolak & Kaya [101]	2020	✓		✓					
Adedeji et al. [102]	2020			✓					
Geng et al. [103]	2020		✓	✓					
Pamucar et al. [105]	2020			✓					
Wu et al. [106]	2020			✓					
Cheng et al. [108]	2020	✓	✓						
Feng [110]	2021			✓					
Mrówczyńska et al. [111]	2021	✓							
Krishankumar et al. [113]	2021					✓			
Wu et al. [118]	2021			✓					
Adedeji et al. [119]	2021					✓			
Wang et al. [124]	2021				✓				
Wang et al. [125]	2021			✓					
Yang & Chang [127]	2021					✓			
Clauberg et al. [128]	2021			✓					
Yazır & Şahin [129]	2021			✓					
Sun & Yu [130]	2021			✓					
Mostafaeipour et al. [132]	2021			✓					
Wang et al. [137]	2021			✓					
Liu et al. [138]	2021								✓
Abdul-Basset et al. [146]	2021						✓		
Xie et al. [147]	2021			✓					
Pan & Wang [149]	2021				✓				
Dang et al. [151]	2021			✓					
Karatop et al. [153]	2021			✓					

1. hesitant fuzzy set variants
2. intuitionistic fuzzy set variants
3. classical fuzzy set variants
4. linguistic term set variants
5. q-rung orthopair fuzzy set
6. neutrosophic fuzzy set variants
7. Pythagorean fuzzy set variants
8. interval fuzzy set variants

The data show that orthopair versions of fuzzy sets have been widely used to study CES under uncertainty. However, recent studies have also started considering linguistic information directly for CES assessment. Hesitant fuzzy set variants have been observed in 14 studies. Classical fuzzy set variants have been employed in 24 studies, in over 134 papers that have been included in this review.

In 2019, Tarybakhsh et al., conducted a study using an integrated data-driven screening model (DDSM) to improve EOR screening, using the combined capabilities of the fuzzy expert approach (FEA) and support vector regression (SVR) techniques. EOR field data from the past 40 years were reviewed to generate an updated and reliable EOR criteria table as a basis to construct a fuzzy screening model [60]. In the same year, Karunathilake et al., conducted a study using fuzzy logic, fuzzy TOPSIS, trapezoidal fuzzy number, and triangular fuzzy number. However, such decision-making methods are affected by problems such as rank reversal when alternatives are added or removed. The focus of this study was to demonstrate a decision-making process for a community-level energy system; however, further exploring this aspect was considered to be out of its scope [66]. Even though approaches have been identified, a clear distinction cannot be made, since they have been used simultaneously with several other approaches. It is shown that the type of fuzzy sets most used among the 126 studies are triangular fuzzy number and fuzzy sets. They have been used with other different sets, such as hesitant and interval group sets. In 2018, Büyüközkan et al., published research work in the *Energy Journal*, using the HFL term set, HFL-AHP, and HFL-COPRAS to addresses this research gap, and introduced a numerical decision support method for identifying the most suitable renewable energy sources [47]. The same year, Lixia et al., published their study in the *Journal of Hydrology*, developing an inexact interval-valued triangular fuzzy-based multi-attribute preference model (IVTF-MAPM) method to support the selection of remediation strategies of groundwater remediation. Yousef et al., (2020) used experimental data and fuzzy logic to build a robust model that describes the yield of bio-methanol production. Then, the particle swarm optimization (PSO) algorithm was utilized to estimate the optimal values of the operating parameters that maximize the bio-methanol yield [70].

(RQ 3)—Which countries prominently contributed to CES-related research?

A study of the countries where CES research prominently occurs, based on the collected data in the window from 2018 to 2021, has been performed, and is shown in Table 4. It can be observed that some countries are more inclined to a site selection type of decision making, while others are focused towards the source of clean energy. It can be observed that countries such as China, Turkey, and India perform decision making on CES-related fields prominently, compared to Malaysia, Mexico, Serbia, and so on. Readers need to note that these claims are based on the 134 articles collected by the authors in the window from 2018 to 2021. Also, the country with which the first author is affiliated in the research article is taken and depicted in Table 4.

Table 4. Country-wise distribution articles pertaining to CES research.

Country	Papers	Percentage
China	30	22.4%
Turkey	15	11.2%
India	14	10.5%
Iran	10	7.5%
Pakistan	4	3%
Taiwan	4	3%
Brazil	3	2.2%
Nigeria	3	2.2%
Poland	3	2.2%
Australia	2	1.5%
Canada	2	1.5%
Colombia	2	1.5%
Egypt	1	0.7%
Germany	1	0.7%
Singapore	2	1.5%
South Africa	2	1.5%
United Arab Emirates	2	1.5%
United Kingdom	2	1.5%
USA	3	2.2%
Vietnam	2	1.5%
Japan	2	1.5%
Chile	1	
Denmark	1	
France	1	
Greece	1	
Hungary	1	
Iceland	1	$14 \times 0.7 = 10.5\%; 3.7\%; 3\%; 2.2\%$
Italy	5	
Jordan	1	
Lithuanian	1	
Malaysia	3	

Table 4. *Cont.*

Country	Papers	Percentage
Mexico	1	
Philippines	1	
Serbia	1	
Spain	4	
Sri Lanka	1	
Uzbekistan	1	
South Korea	1	
Total	134	100%

The first column represents the source/reference number. The next column includes the country with which the first author is affiliated. This is followed by a column consisting of the counts of research papers. A frequency distribution based on the first author's affiliated country has been calculated in Table 4. China leads the "clean energy selection" research by a huge margin for the sample data of 134 research papers. The research area is in site selection, energy selection, energy system selection, and so on. China contributes to 30 research papers between 2018 and 2021, contributing to around 23% of the total research in the field. Extensive research into both offshore and onshore site selection for wind farms has been a trend in the considered papers. A major section of studies also conducted works in areas related to solar energy, including photovoltaic cells, solar ponds for desalination, site selection for better power output, and affordability. Hydrogen energy also received much attention in the selected sample. Much of the research has been performed on desalination, solar and wind energy, and waste management.

In 2020, Xu et al., developed a novel mathematical framework that assesses the sustainability of different renewable energy-powered desalination systems, which is essential for their portfolio selection, by resorting to the fuzzy multi-attribute decision-making (MAMD) methods. In the framework, an evaluation system including ten attributes from four dimensions is introduced. At the same time, fuzzy triangular numbers and interval values are employed to capture the epistemic and aleatory uncertainties of decision information, respectively [96]. Similarly, another study was conducted to analyze strengths, weaknesses, opportunities, and threats (SWOT), to evaluate the external and internal factors that affect the RET (renewable energy technologies) in Sindh and Baluchistan province. This study uses the fuzzy analytical hierarchy process method, with a multi-perspective approach, including economic, environmental, technical, and socio-political criteria. The study considers four criteria, seventeen sub-criteria, and three RETs—solar, wind, and biomass. Each has been assessed as an alternative in the decision model, to conclude that economic and socio-political criteria are the two most essential criteria in the region, and will be the deciding factor. Moreover, the study also reveals that wind can generate electricity in Sindh and Baluchistan provinces.

(RQ 4)—Who are the prominent first authors in the CES assessment field based on the collected articles from the window 2018 to 2021?

We have identified prominent first authors in the CES field, based on the collected data for the past four years. Wu has published four research papers using AHP, ANP, and PROMETHEE. Krishankumar has authored three papers in the time frame of 2018 to 2021. Rani et al., has contributed to two research studies on clean energy selection (see the Table 5). Approaches such as VIKOR and divergence measures are used in the study with fuzzy/variants information.

(RQ 5)—Which are the popular journals covering research in the CES field?

Table 6 shows the distribution of 12 publishers and 64 internationally accepted journals. The first column represents the journals included in this study. The following column entails the indices on the research paper published in that journal. An analysis shows that Elsevier has a total of 57 research papers from 24 journals. The highest number of research work has been identified from the "*Journal of Cleaner Production*". Twelve research papers have been published in this journal. Elsevier further contributes to seven research works from the "*Journal of Energy Storage*". John Wiley and Son's publishers contribute to 9 journals that provide 18 studies. The *International Journal of Energy Research* contributes to six research works in this study. Five more journals, from three publishers, are responsible for the rest of the research work considered.

Table 5. List of first authors in the CES field who published two or more works (based on the articles collected from 2018 to 2021).

Author Names	Country (Affiliation)	Research Papers
Yunna Wu.	China	4
Raghunathan Krishankumar	India	3
Pratibha Rani	India	2
Mahya Ghouchani	Iran	2
Paul A. Adedeji	South Africa	2

Table 6. Distribution of papers based on journals and publishers.

<table>
<tr><th>Publisher</th><th>Journal Name</th><th>Count of Paper</th><th>Percentage</th></tr>
<tr><td rowspan="2">Academic Press Inc.</td><td>Environmental Research</td><td>1</td><td rowspan="7">7×0.75=5.25%</td></tr>
<tr><td>Journal of Environmental Management</td><td>1</td></tr>
<tr><td>Design Engineering</td><td>Others</td><td>1</td></tr>
<tr><td rowspan="29">Elsevier</td><td>Applied Soft Computing</td><td>1</td></tr>
<tr><td>Combustion and Flame</td><td>1</td></tr>
<tr><td>Computer and Chemical Engineering</td><td>1</td></tr>
<tr><td>Computers & Industrial Engineering</td><td>1</td></tr>
<tr><td>Energy</td><td>5</td><td>3.7%</td></tr>
<tr><td>Energy Conversion and Management</td><td>1</td><td>0.75%</td></tr>
<tr><td>Energy for Sustainable Development</td><td>1</td><td>0.75%</td></tr>
<tr><td>Energy Policy</td><td>2</td><td>1.5%</td></tr>
<tr><td>Energy Reports</td><td>3</td><td>2.2%</td></tr>
<tr><td>Energy Strategy Reviews</td><td>1</td><td>0.75%</td></tr>
<tr><td>Experts Systems with Applications</td><td>1</td><td>0.75%</td></tr>
<tr><td>Heliyon</td><td>2</td><td>1.5%</td></tr>
<tr><td>International Journal of Hydrogen Energy</td><td>3</td><td>2.2%</td></tr>
<tr><td>International Journal of Production Economics</td><td>1</td><td>0.75%</td></tr>
<tr><td>Journal of Air Transport Management</td><td>1</td><td>0.75%</td></tr>
<tr><td>Journal of Cleaner Production</td><td>17</td><td>12.7%</td></tr>
<tr><td>Journal of Energy Storage</td><td>7</td><td>5.2%</td></tr>
<tr><td>Land Use Policy</td><td>1</td><td rowspan="4">4×0.75=3%</td></tr>
<tr><td>Ocean and Coastal Management</td><td>1</td></tr>
<tr><td>Ocean Engineering</td><td>1</td></tr>
<tr><td>Procedia Manufacturing</td><td>1</td></tr>
<tr><td>Renewable and sustainable energy Reviews</td><td>9</td><td>6.7%</td></tr>
<tr><td>Renewable Energy</td><td>7</td><td>5.2%</td></tr>
<tr><td>Sustainable Cities and Society</td><td>3</td><td>2.2%</td></tr>
<tr><td>Sustainable Energy Technologies and Assessments</td><td>5</td><td>3.7%</td></tr>
<tr><td>Sustainable Operations and Computers</td><td>1</td><td rowspan="8">10×0.75=7.5%</td></tr>
<tr><td>Technological Forecasting & Social Change</td><td>1</td></tr>
<tr><td>Technological Forecasting and Social Change</td><td>1</td></tr>
<tr><td>Thermal Science and Engineering Progress</td><td>1</td></tr>
<tr><td rowspan="4">IEEE</td><td>Environmental Science and Pollution Research</td><td>1</td></tr>
<tr><td>TRANSACTIONS ON ENGINEERING MANAGEMENT</td><td>1</td></tr>
<tr><td>Others</td><td>1</td></tr>
<tr><td>ICRERA</td><td>1</td></tr>
</table>

Table 6. *Cont.*

Publisher	Journal Name	Count of Paper	Percentage
John Wiley and Sons Ltd.	Business Strategy and the Environment	1	
	Canadian Journal of Chemical Engineering	1	
	Energy Science and Engineering	4	3%
	Engineering Reports	1	0.75%
	International Journal of Energy Research	6	4.5%
	International Journal of Intelligent System	1	
	International Transactions on Electrical Energy Systems	1	
	Sustainable Development	1	
KeAi Publishing Communications Ltd.	Global Energy Interconnection	1	**6×0.75=4.5%**
Korean Association of Shipping and Logistics, Inc.	Asian Journal of Shipping and Logistics	1	
MDPI	Applied Sciences (Switzerland)	1	
	Energies	3	2.2%
	Land	1	1.5%
	Mathematics	1	3.7%
	Sustainability	5	
Springer	Archives of Computational Methods in Engineering	1	
	Energy Systems Evaluation	1	
	Environmental Science and Pollution Research	1	
	GeoJournal	1	
	Renewable Energy	1	
	Others	1	
	Celal Bayar University Journal of Science	1	
	Advances in Intelligent Systems and Computing Annals of Operations Research	2(1 + 1)	**14×0.75+1.5=12%**
Taylor & Francis	ENERGY SOURCES	1	
	International Journal of Sustainable Energy	1	
Wiley-Blackwell Publishing Ltd	Food and Energy Security	1	
Others	Low Carbon Energy Technologies in Sustainable Energy Systems	1	
	Renewable Energy Research and Application	1	
	Technological and Economic Development of Economy	1	
	Others	1	
Grand Total		134	100%

The study suggests that the authors have performed a wide range of research work in the *Journal of Cleaner Production*, in areas of energy facility location [102,103], energy source selection [113], energy system selection [48,65,94], decision analysis, [99], sustainability evaluation [96,98,124], and process optimization [63]. In this journal, for the energy system selection criteria, Angelo et al., (2018) [48] proposes an SFAHNP decision model to address the complexity and uncertainty involved in the clean technology selection process. This method first decomposes the problem into a hierarchical network structure, and then derives the probability distribution of the priority weights needed for ranking. Zhenfeng et al., (2018) performed a research study that allows multiple stakeholders to participate in decision making. They are also allowed to use linguistic variables to rate the alternatives and determine the weights of the evaluation criteria. Kumar et al.'s [63] study focused on determining the optimal processing conditions to minimize multi-performance features, such as surface roughness, roundness error, and run-out, in the thermal drilling of galvanized steel using the grey fuzzy logic technique. The implemented method combines the GRA with the FL technique, which allows the GFRG to be determined based on the GRC of each response. Rani et al. [65] designed and implemented the dioxide reforming of methane (CDRM) in her research, using divergence and entropy measures, VIKOR. The developed strategy successfully modeled a "real-world" environment, as experienced in the process industries. A flow term was introduced that served as a control element. In addition to this, the mathematical model of the reactor was modified to include time dependency for dynamicity.

Table 7 identifies the studies that have used sensitivity and/or comparative analysis to check the robustness of their findings and the system itself. The first column entails two analysis categories that have been in trend as per the present data analysis. The following column entails the indices of the research paper that has used either of the methods. Sensitivity analysis determines how many target variables have been affected, based on changes in input variables. This financial model is also referred to as "what-if" or "simulation analysis". It simulates results and predicts the outcome of a decision given a certain range of variables.

Table 7. Distribution of papers based on sensitive and comparative analysis.

Analysis Type	Studies	Total	Percentage
Sensitivity analysis	[52,76,82,89,94,98,100,101,103,106,122,124,131,133,149,155,160,165,166]	14	17.234%
Comparative analysis	[47,49,58,72,76,99,101,103,105,106,113]	12	14.815%
	Total	26	32.098%

(RQ 6) How many studies have performed comparative and sensitive analysis?

(RQ 7) How are papers distributed based on an application basis?

Table 8 identifies the distribution of studies based on several application classes. Energy facility location has been used as an application area for 27 research works, and constitutes 21% of the entirety. This application area further considers offshore wind farms, wind power plants, small hydropower plant location selection, nuclear power plant site selection, incineration plant site selection, hydrogen power plant site selection, wind-powered pumped storage power plant site selection, the framework of photovoltaic hybrid projects as an area of study, and the output solution for site selection using a wide range of fuzzy sets. Some miscellaneous papers on several classes are in the following table.

Energy system selection, with 18 research studies, makes up 14% of the entire survey. It classifies application areas into even more specific classes, which are composed of carbon nanotube synthesis methods, nutrient removal treatment technology options for municipal wastewater, low-carbon electricity sources, windfarm energy storage systems, energy storage systems, utilization of renewable energy sources, photovoltaic energy systems, renewable energy technology selection, regional hybrid energy systems, energy-driven desalination irrigation systems, thermal performance in the battery system, framework for photovoltaic power coupling hydrogen storage project, waste to energy technology selection, a framework for photovoltaic power coupling hydrogen storage project, optimal design of solar, wind, diesel-based RO (reverse osmosis) desalination integrating flow battery and pumped-hydro storage, and selection of new design gas carriers. Sustainability evaluation contributes to 24 research papers and further classifies the application areas into categories of solving renewable energy source selection problems, sustainable development goals, concentrated solar power, selection of the most appropriate casting gating system, optimization to sustainable energy technologies, sustainability performance index for ranking energy storage technologies, potential photovoltaic assessment, renewable energy-powered desalination systems, sustainability in energy system management in an emerging economy context, windfarm site selection, sustainable aviation fuel production pathways, sustainability conditions of small hydro plants, evaluation and selection of sustainable hydrogen production technology, and scheme selection of design for disassembly. Energy selection and energy source selection have been implemented in 11 articles, and further classify the application area into categories of structuring local energy policies, electricity or power generation, renewable energy selection for net-zero energy communities, evaluation, and selection of sustainable hydrogen production technology. The miscellaneous papers includes categories such as material selection pertaining to energy domain, energy utilization, efficiency evaluation, benefit evaluation screening, evaluation of options, sustainability, resource selection problem.

Table 8. Distribution of papers based on different applications in the CES domain.

Applications	Studies	Total	Percentage
Energy Facility Location	[45,46,72,73,76,85,86,91,100,102,103,107,110,119,127–129,137,139,140,147,148,151,152,159,163,169]	27	21%
Energy Source Selection	[47,49,59,66,113,126,133,149,156,160]	10	8%
Energy System Selection	[48,56,58,65,71,79,81–83,89,94,95,97,101,106,122,130,162]	18	14%
Decision Analysis	[75,97,99,111,117,135,153,155,157,165,167,169]	12	9%
Strategy Selection	[60,64,118,123,133]	7	6%
Sustainability Evaluation	[52,54,77,88,89,92,96,110,115,124–126,128,131,132,136,141–143,145,154,159,161,166]	24	19%
Forecasting	[62,87,102,119,120]	5	4%
Process Optimization	[63,70,93,121]	4	3%
Ranking	[80,89,105,130,138]	5	4%
Miscellaneous	[61,74,84,90,112,114,144,146,150,168,170–174]	15	12%

(RQ 8) What are the categories of renewable energy sources that have been considered in this study?

Table 9 shows the distribution of research work based on renewable energy resources. It classifies all the application purposes for a particular energy class into one. Some research studies use multiple renewable energy sources, and provide a classification amongst multiple renewable energy sources to choose the best amongst them. Wind energy has been part of 15 research studies and constitutes 12% of the entire study. The segregation includes onshore, offshore, horizontal blades, vertical blades, and even wind farm site selection in one category. Based on the region, it spans over China, Vietnam, Iran, Turkey, and South Africa; while China has the majority of wind energy-related research. Solar energy, with seven research works, contributed to 8.642% of the study, and was performed in Chile, Vietnam, Pakistan, Iran, China, and Taiwan. Iran contributes the majority of the research in solar energy. It has been studied in India, China, the United Kingdom, and Taiwan, with China contributing the most to the study. It has also been studied in Iran, Singapore, Pakistan, and Brazil.

Figure 2 provides the distribution of articles considered year-wise in this review study under the CES field. The authors concentrated on the window from 2018 to 2021, and paid much attention to the last two years of CES research. It becomes substantial for the research community to clearly understand the trend and the direction of future research in the CES field. Some interesting challenges in the CES field that need further exploration from the research community are also discussed in this review paper, to give insights into future research in the CES field.

Table 9. Distribution of studies based on the prominent renewable energy source.

Renewable Energy	Studies	Total	Percentage
Wind Energy	[45,46,58,74,86,91,100,107,110,119,120,131,141,144,146]	15	12%
Solar Energy	[54,61,71,92,99,103,106,138,141,164]	10	8%
Hydrogen Energy	[85,97,105,106,126]	5	4%
Nuclear	[73,118,121]	3	2%
Hydro Energy	[72,128]	2	2%

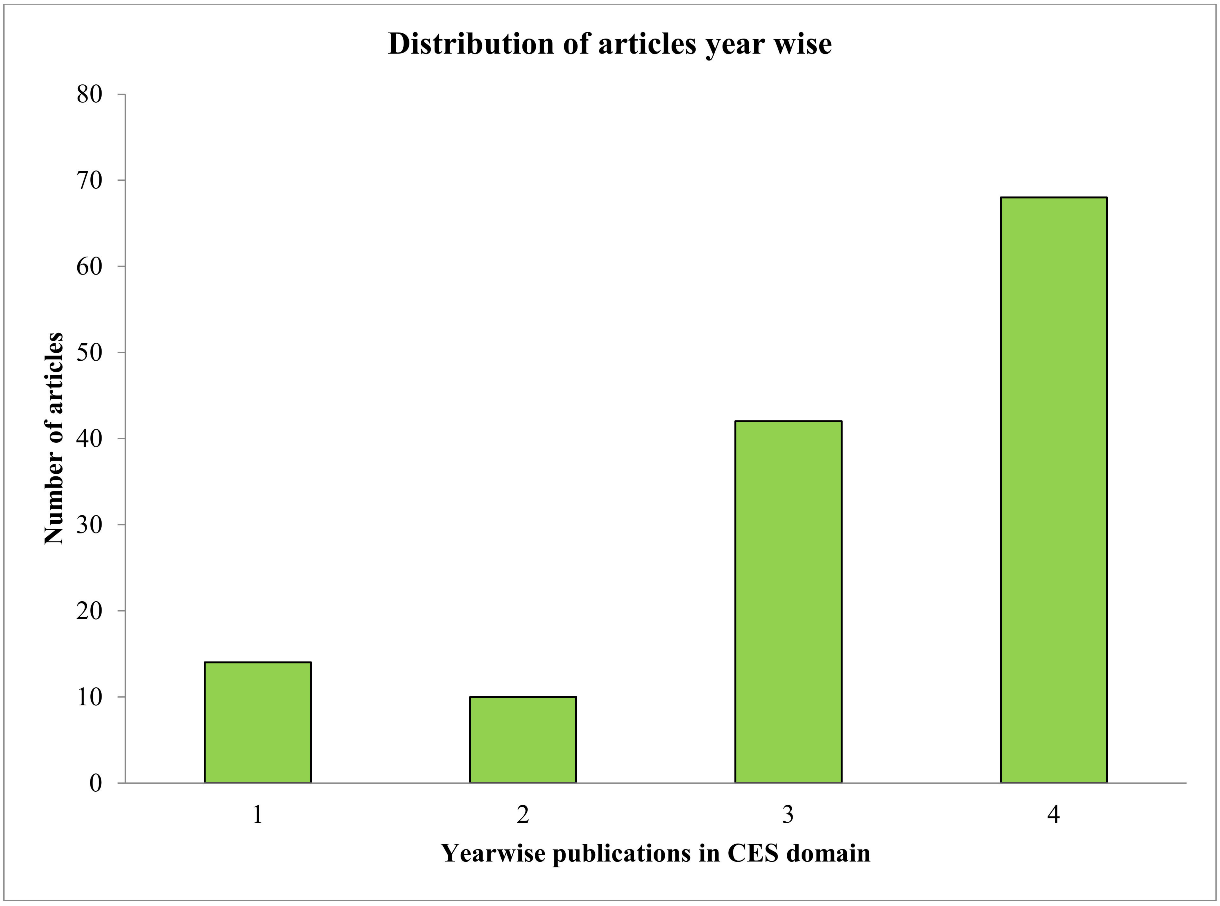

Figure 2. Year-wise publications of articles (*X*-axis—1 is 2018, 2 is 2019, 3 is 2020, 4 is 2021).

4.2. Challenges in CES Evaluation for Future Research

This section discusses the inferences gained from the review process, and presents future directions for research in the CES field.

- The tabulations clearly show that fuzzy-based approaches involving rating data transformation to fuzzy variants are popular in CES selection. Tables 1 and 3 provide evidence to the claim.
- Another notable inference is that the authors commonly adopt AHP, VIKOR, and TOPSIS under fuzzy contexts (from Table 2) to gain rational decisions on the CES field. Variants of AHP are also commonly adopted. Researchers recently adopted integrated schemes where fuzzy set ideas are integrated with machine learning methods, which gained a lot of attention in the CES field. The net contribution from the review process is observed to be close to 50%.

- Furthermore, it can be inferred that the triangular fuzzy number is a popular fuzzy variant adopted by researchers as preference information in the CES field. The orthopair variants constitute around 32%, indicating the popularity of numeric decision making in the CES domain.
- Contributions from China and India to the field of CES are around 44%, with a prime focus on integrated decision approaches under the fuzzy context (from Table 4). The selection of apt energy sources for the demand satisfaction and location identification of plant construction are interesting applications that are explored by the countries' researchers.
- Elsevier has dominated publication in the CES field, with popular journals, such as the *Journal of Cleaner Production*, *Energy*, and *Renewable and Sustainable Reviews*, that attract readership in the CES field (from Table 5). These journals follow a rigorous review process to ensure quality research is given to their readers.

Based on these observations, certain challenges that need to be addressed in the future are listed below:

- Certain research has started with linguistic decision models for the CES field, which could be further enhanced by bringing sophisticated linguistic models for data acquisition from agents involved in the CES domain.
- Human intervention causes biases and inaccuracies in the decision process. Therefore, models must be developed with less human intervention and an acceptable level of complexity.
- Research relating to the integration of machine learning concepts with decision models has begun in the CES domain. Further exploration is required to develop approaches to solve large-scale decision problems better, which is lacking at the present stage.
- Finally, researchers must work on creating usable products that aid policymakers in making choices in critical situations.

5. Conclusions

This review article aims to identify the extent to which decision models are used in the CES field under different fuzzy contexts. To extend the review of different researchers, this paper considers a window of 2018 to 2021. Around 129 articles are reviewed under the different perceptions that constitute eight research questions. These research questions adhere to the bibliometric theme, and the responses to the questions add high value to further research in the CES field. Three significant publishers, viz., Elsevier, Wiley, and Springer, are considered for data collection, and the journals are all indexed in the Web of Science ISI repository. Popular journals, such as the *Journal of Cleaner Production, Energy,* and *Renewable and Sustainable Reviews,* are prevalent in attracting readership in the CES field. AHP, VIKOR, and TOPSIS are usually the employed methods under fuzzy contexts. Researchers recently also proposed integrated approaches using fuzzy logic and machine learning methods, which attracted strong interest in the CES field. The review adds to the literature studies that had already been conducted by considering the window of 2018 to 2021, so that the research community can gain sufficient knowledge on the current scenario in the CES field. Our research provides intuitive information on the trend line of CES evaluation, as well as providing evidence on the appropriate journals for the CES field, the nation-wise contribution to the field, and so on.

The authors organized the articles into eight research questions to obtain valuable knowledge from year-wise publications on the distribution of articles from the diverse point of views in CES. The review paper acts as a base for other researchers to build their new research ideas and carry forward reviews in the years to come. These research questions would surely help the research community to understand the CES field better from diverse perceptions/contexts. As a future direction for review, new questions can be developed, along with responses to these questions. In the future, reviews on other decision applications such as in Refs. [180–183]; specific energy sources can also aid researchers in the field of study.

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Appendix A

Table A1. List of abbreviations and expansions.

Abbreviation	Expansion
AHP	Analytical Hierarchy Process
ANP	Analytic Network Process
PSO	Particle Swarm Optimization
MOO	Multi-Objective Optimization
VIKOR	VIsekriterijumska Optimizacija I Kompromisno Resenje
WSM	Weighted Sum Method
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
MOPSO	Multi-Objective Particle Swarm Optimization
MAUT	Multi-Attribute Utility Theory
SVR	Support Vector Regression
MLR	Multiple Linear Regression
GA	Genetic Algorithm
RF	Random Forest
WASPAS	Weighted Aggregated Sum Product Assessment
INRM	Influential Network Relationship Map
MAGDM	Multi-Attribute Group Decision Making
MCGDM	Multi-Criteria Group Decision Making
MODA	Multi-Objective Decision Approaches
MGU	Maximum Group Utility
LSTM-CNN	Long Short Term Memory—Convolutional Neural Network
ARAS	Additive Ratio Assessment
SWARA	Stepwise Weight Assessment Ratio Analysis
CRITIC	Criteria Index Correlation
LBWA	Level Based Weight Assessment
IDOCRIW	Integrated Determination of Objective Criteria Weights
CODAS	Combinative Distance-based Assessment
EDAS	Evaluation Based on Distance from Average Solution
MOOSRA	Multi-Objective Optimization based on Simple Ratio Analysis
MOGA	Multi-Objective Genetic Algorithm
NSGA—II	Nondominated Sorting Genetic Algorithm II
MPC	Model Predictive Control
MULTIMOORA	Multiple Objective Optimization based on Ratio Analysis
DEMATEL	Decision-Making Trail and Evaluation Laboratory
PROMETHEE	Preference Ranking Organization Method for Enrichment of Evaluations
MARCOS	Measurement Alternatives and Ranking according to Copromise Solution
IDM	Investment Decision Making
MEE	Matter Element Extension
ECP	Expected Constraint Programming

Table A1. *Cont.*

Abbreviation	Expansion
SAW	Simple Additive Weighting
FA	Firefly Algorithm
EVAMIX	Evaluation of Mixed
DDSM	Data-Driven Screening Model
ELECTRE	Elimination Et Choix Traduisant la Realité (ELimination Et Choice Translating Reality)
ANN	Artificial Neural Network
MPPT	Maximum Power Point Tracking
SA	Simulated Annealing
BWM	Best-Worst Method
COPRAS	Complex Proportional Assessment
IRS	Ideal Referential Solution
GRA	Grey Relational Analysis
SW	Sum Weighted
FSM	Fuzzy Satisfaction Method
HFL	Hesitant Fuzzy Linguistic
IVF	Interval-Valued Fuzzy
TRI-FUZZY NUMBER	Triangular Fuzzy Number
TRAP-FUZZY NUMBER	Trapezoidal Fuzzy Number
PYTH-FUZZY NUMBER	Pythagorean Fuzzy Number
ANFIS	Adaptive Neural Fuzzy Inference System
I2TLIFN	Interval 2 Tuple Linguistic Fuzzy Number
SFAHNP	Stochastic Fuzzy Analytic Hierarchical Network Process
FUZZY-MAPM	Fuzzy Multi-Attribute Preference Model
FUZZY MOD	Fuzzy Multi-Objective Decision
FEA	Fuzzy Expert Approach
ICFHHA	Intuitionistic Cubic Fuzzy Hamacher Hybrid Averaging
ICFHOWA	Intuitionistic Cubic Fuzzy Hamacher Weighted Averaging
ICFS	Intuitionistic Cubic Fuzzy Set
LINEAR PROG	Linear Programming
TIFH	Trapezoidal Intuitionistic Fuzzy Number
FUCOM	Full Consistency Method
DEA	Data Envelopment Analysis
IQ-ROFPWMM	Interval Q-Rung Orthopair Weighted Power Muirhead Mean
A-SVN-DM	Aggregated Single-Valued Neutrosophic Decision Matrix
FAHP	Fuzzy AHP
CoCoSo	Combined Compromise Solution
CM	Compromise Measure (CM)
DEs	Decision experts
EWP	Exponentially Weighted Product
FS	Fuzzy Set
GHG	Greenhouse Gas
GUM	Group Utility Measure
IFS	Intuitionistic Fuzzy Set
IRM	Individual Regret Measure
LVs	Linguistic Values
MCDM	Multi-criteria Decision Making
NS	Neutrosophic Set
RES	Renewable Energy Source
SVNS	Single-Valued Neutrosophic Set
SVN	Single-Valued Neutrosophic
SVN-SWARA-CoCoSo	Single-Valued Neutrosophic-SWARA-CoCoSo
SVN-TOPSIS	Single-Valued Neutrosophic TOPSIS
SVN-VIKOR	Single-Valued Neutrosophic VIKOR
SVN-WASPAS	Single-Valued Neutrosophic WASPAS
SAW	Simple Additive Weighting
WEEE	Waste Electrical and Electronic Equipment
WSM	Weighted Sum Model
WPM	Weighted Product Model

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