IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received June 15, 2020, accepted June 23, 2020, date of publication June 25, 2020, date of current version July 8, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3005064

Analyzing the Investments Strategies for Renewable Energies Based on Multi-Criteria Decision Model

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This work was supported in part by the National Natural Science Foundation of China under Grant 71801049, in part by the Humanities and Social Sciences Foundation of the Ministry of Education (MOE) in China under Grant 17YJC630231, and in part by the FAFU Foundation for Distinguished Young Scholars under Grant xjq201736.

ABSTRACT The purpose of this study is to determine appropriate innovative strategies for the renewable energy investments. For this purpose, a hybrid multi-criteria decision-making (MCDM) model is proposed based on interval type-2 (IT2) fuzzy sets and alpha cut levels. Within this context, hesitant IT2 fuzzy DEMATEL-Based Analytic Network Process (DANP) with alpha cut levels is applied for weighting the customer requirements. Moreover, hesitant IT2 fuzzy technique for order preference by similarity to ideal solution (TOPSIS) with alpha cut levels is used for ranking the TRIZ-based strategies priorities of renewable energy investments based on house of quality technique. These strategies are also ranked with hesitant IT2 fuzzy Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) approach to make a comparative evaluation. The results illustrate that ease of access and security are among the most prominent factors of customer requirements for renewable energy investments. It is also identified that innovative technical requirement entitled cushion in advance has the best choice for the sustainable renewable energy projects. Furthermore, the results of proposed model using hesitant IT2 fuzzy DANP and hesitant IT2 fuzzy TOPSIS are identical for the different levels of alpha cut. In addition, it is also defined that the results of hesitant IT2 fuzzy TOPSIS and hesitant IT2 fuzzy VIKOR are quite coherent. This is a clear evidence that the proposed model is coherent and could provide comprehensive results for the future studies. It is strongly recommended that a detailed analysis is required to identify the risks in renewable energy investment projects. Hence, necessary actions can be taken appropriately so that it can be possible to prevent problems before they grow.

INDEX TERMS TRIZ, house of quality, hesitant IT2 fuzzy DEMATEL, hesitant IT2 fuzzy TOPSIS, renewable energy, strategy development.

I. INTRODUCTION

Renewable energy sources are eco-friendly since they do not emit carbon to the atmosphere. Moreover, they also play a key role in helping countries produce their own energy resources. Hence, the main advantages of renewable energy alternatives are to develop sustainable energy production and reduce dependency on other countries for the energy supply [1]. Thus, for the countries, it has become extremely important to invest in renewable energy sources to maintain the energy-economy-ecology balance (3E) [2]. Although investments in this area have been increasing recently, the production capacity of these resources is still not large enough and full efficiency is not achieved due to the high technical knowledge required by renewable energy sources.

In addition, the establishment of renewable energy generation facilities and networks to distribute this energy require a large financial cost. These technical difficulties and high

The associate editor coordinating the review of this manuscript and approving it for publication was Daniela Cristina Momete.

costs are reflected in the price of the electricity produced and can have negative effects on issues, such as cost and ease of access when viewed from the perspective of the customer [3]. Considering all these positive and negative aspects, while determining renewable energy investments for both countries and companies, many issues should be handled together, and strategies should be produced in different dimensions [4]. Therefore, for this situation, a wide-ranging analysis is needed to generate strategies for renewable energy investments. In this regard, the method to be used is of great importance.

House of quality method allows the products and services to be designed in line with the wishes of the customers. It is the easiest way to associate customer expectations with technical definitions. In the house of quality, which is a two-dimensional matrix, the list of customer expectations and technical definitions are placed perpendicular to each other [5]. In this two-dimensional matrix, the degree of the relationship between customer expectations and technical definitions is shown. By using this method, the risk of product or service dissatisfaction can be reduced, and redesign and engineering changes can be minimized in the early steps of the project [6]. In this way, it provides more systematic access to products and services that require high engineering and reduces costs. Thanks to these benefits, companies can have comparative advantage in the market with the cost advantage they will gain. The use of the house of quality in renewable energy investments that require high technical knowledge and cost provides easier recognition of special competitive advantages for investors in that area [7]. Additionally, this method also increases public acceptance of renewable energy consumption by addressing the customer wishes.

TRIZ (Teoriya Resheniya Izobretatelskikh Zadatch-the Theory of Inventive Problem Solving) is a systematic approach which aims to solve problems with the help of innovative thinking. It was developed by the Soviet inventor Genrich Altshuller and his colleagues by examining the details of many different patents. Hence, it contributes to the development of innovative products by providing structural and innovative thinking. The basic assumption of this model is that each solution creates its own problem [8]. Therefore, this method is also defined as a problem-solving process that considers contradictions. In this context, for the solution of the problem, the contradictions matrix is created, which includes 39 different contradictions parameters. On the other hand, 40 different solution methods are used for the solution of the mentioned problems [9]. In summary, the TRIZ method provides innovative and creative ideas to the decision maker for the solution of existing problems based on the solutions of previous problems [10]. Hence, TRIZ method can be considered for the technical evaluations of the innovative strategic decisions for renewable energy investments.

MCDM methods aim to find the solution among many different alternatives [11]. These approaches are quite helpful to solve the complicated problems while many different criteria have an influence on them. They have some advantages such as reducing subjectivity and considering both financial and non-financial factors in the process of selection [12]. However, these methods are criticized for being based solely on expert opinions, and therefore they are claimed to be supported by another model [13], [14]. Within this framework, these approaches were considered with fuzzy logic by many researchers [15], [16]. In fuzzy logic, interim values are also taken into consideration in the analysis [17]. With the help of this situation, it can be possible to increase the quality of the analyzes.

On the other hand, the fuzzy logic approach is also criticized for some issues. For example, it is difficult to determine membership functions in cases where the problem is complex [18]. In addition, there is no precise method in determining membership functions [19]. This situation shows that uncertainty still continues in the analysis made with fuzzy logic. In these analyzes, IT2 fuzzy numbers are also preferred especially in recent years [20], [21]. IT2 fuzzy logic was developed as an expansion of the traditional fuzzy set concept known as type-1 fuzzy sets [22]. Hence, human perceptions can be represented more effectively. In this way, it is aimed to minimize this uncertainty in fuzzy logic analysis [23].

Another important problem in this stage is that experts can have different opinions about the criteria. For this purpose, in many different studies, this evaluation has been conducted under the hesitancy. The main advantage of this issue is that uncertainty can be minimized when expert team could not reach a consensus [24], [25]. The α-cut operation on the fuzzy set is defined for categorizing the crisp sets into subsets with membership function values greater than or equal to alpha for one specific purpose [26]. In this context, owing to the alpha cuts, it will be possible to perform many arithmetic operations [27]. This situation removes one of the most important constraints of fuzzy mathematics. On the other hand, thanks to the analysis to be made with different alpha sections, the consistency of the analyzes can be determined [28].

The aim of this study is to identify appropriate innovative strategies for the renewable energy investments. For the technical requirement, 11 different factors are identified based on 39 different contradictions parameters of TRIZ methodology. After that, a contradiction matrix is created by considering pairwise comparison of these parameters. As a result of the expert evaluations, 8 different innovative strategies are selected for renewable energy investments out of 40 different strategic principles of TRIZ method. In the next stage, 9 different criteria regarding customer expectations are defined by making a detailed literature review.

Hesitant fuzzy IT2 fuzzy DANP approach is used to weight 9 customer expectations criteria. The main reason of selecting this approach is to get benefit from the advantages of both DEMATEL and ANP methods. In other words, owing to the DEMATEL model, the causality relationship can be evaluated between the criteria as well [29], [30]. On the other side, with the help of ANP methodology, inner dependency situation between the factors can also be considered [31], [32]. This situation makes an important contribution to find the significance of the criteria more effectively. Furthermore, hesitant IT2 fuzzy TOPSIS approach is taken into account to rank 8 different innovative technical requirements based on house of quality technique. The main advantage of this method is the simplicity in terms of mathematical calculation and flexibility in choosing the criteria [33], [34]. In addition to this situation, IT2 fuzzy VIKOR approach is also used to make comparative analysis in the ranking of these strategies.

In this context, a hybrid decision making model is preferred. The main reason is that while evaluating the alternatives with TOPSIS approach, the weights of the criteria should not be accepted as equal. In other words, these criteria should be weighted with another methodology, such as DANP. With the help of this situation, more effective and appropriate results can be achieved. Additionally, in addition to TOPSIS, another approach can be used to rank the alternatives, such as VIKOR to make a comparative evaluation. This situation gives information about the coherency of the results. In summary, DANP approach complement, but VIKOR method can replace with TOPSIS.

The main novelty of this study is making a very comprehensive evaluation to find the most appropriate innovative strategies for renewable energy investment. Because these energy alternatives do not harm the environment and can be produced in the country, the analysis results can make a significant contribution to the social and economic development of the countries. Another important novelty is that TRIZ methodology is used to find the technical requirements in this investment. There is a competitive environment in renewable energy investment market and the costs of these projects are quite high. Therefore, with the help of TRIZ approach, appropriate technical factors can be identified so that no unnecessary investments will be made for this matter.

In addition to them, using house of quality method for renewable energy investment strategies is another novelty of this study. Renewable energy investments need significant technical competence due to their very complex structures. Additionally, there is high competition in this market as well. Thus, owing to the house of quality approach, both technical capacity and customer expectations can be considered together. Moreover, considering TRIZ and HoQ approaches together in the study, it is aimed to increase methodological originality of this evaluation. The methodology of this study is also novel because hesitant IT2 fuzzy DANP and hesitant IT2 fuzzy TOPSIS methods are firstly considered in this study for renewable energy investments by considering alpha cuts.

Moreover, this study has also some practical values. Renewable energy investments are very complex projects which need high engineering knowledge. In addition to this situation, they have also high initial costs. Due to these issues, there is a high risk for the failure of these projects. In order for these projects not to be ineffective, technical requirements should be identified effectively. By defining these requirements with TRIZ approach in this study, it is believed that the risk of failure of renewable energy investment projects is reduced. The main reason is that there are lots of experience in the market that indicates the success of TRIZ approach [35], [36].

There are five different sections in this study. After this part, the literature is evaluated in the second section. Within this scope, significant studies in the literature regarding TRIZ, house of quality and renewable energy investments are detailed in this part separately. The third section is related to the methodology. In this regard, hesitant fuzzy linguistic terms, IT2 fuzzy sets, alpha level tests, IT2 fuzzy DANP and IT2 fuzzy TOPSIS methods are explained. In the fourth section, the analysis is identified. The final section includes discussion and conclusion part.

II. LITERATURE REVIEW

TRIZ method has been considered in many studies related to the energy industry. For instance, Albers *et al.* [37] aimed to develop electricity energy storage system. With respect to the product generation in the automobile industry, the concepts of TRIZ method were taken into consideration. On the other side, Daoping *et al.* [38] made an evaluation regarding coal energy saving. In the analysis process, TRIZ method-based factors are used to generate new products. Similarly, Gomila and Marro [39] also focused on the energy storage systems. In this scope, a detailed technology analysis has been performed by using TRIZ. Additionally, Zheng *et al.* [40] aimed to generate innovative products for energy storage with the help of TRIZ factors. Furthermore, Yong *et al.* [41] made an evaluation to improve energy saving system. In the analysis process of this study, parameters are generated by using TRIZ components.

HoQ has been used in various articles by many researchers as well as companies for many years. For example, Tang and Dincer [42] studied to evaluate the sustainable energy investments. They concluded that capacity issue is a problem that needs to be solved in order investments to be sustained. With this regard, by applying HoQ method, they found that increasing communication with capacity facilities is the best strategy to overcome this problem. Also, Xu *et al.* [43] established an Entropy-House of Quality method to define the main factors that are common in unsustainable electric power system in China. According to results, it is identified that verifying policy-makers' effectiveness is a valuable strategy for blackout prevention. Additionally, HoQ method can also be used in renewable energy alternatives. Within this context, Haktanır and Kahraman [44] integrated Pythagorean fuzzy sets with HoQ. They reached a conclusion that solar photovoltaic technology development can be achieved if the engineers should give the highest importance to battery array density and thermal expansion treatment.

Besides energy, these methods have also been used in many different areas, such as technology and service sector. Efe *et al.* [45] proposed an implementation to increase efficiency of mobile phone selection by using an integrated version of QFD and IT2 fuzzy sets. They identified that the most significant feature of mobile phone is price. Furthermore, Filketu *et al.* [46] analyzed job satisfaction improvement program. In fuzzy QFD framework, they found that remuneration packages are the best way to increase job satisfaction in Ethiopia. Similar to them, Huang *et al.* [47] tried to improve logistics service quality of cross border e-commerce business by using QFD approach. The results showed that the most important point in terms of customer in logistics services is having products without damage. In addition, online shoppers are also concerned about privacy. For this reason, brands should ensure reliable delivery and the privacy of the buyer at the maximum level in logistics services.

The issue of renewable energy has also been handled in the literature for very different purposes. A significant part of the studies stated that renewable energies positively affect the economic development of countries. Renewable energy investments contribute to the development of commercial activities in the countries. In this way, economic growth of countries will be possible [48]. Rahman and Vu [49] conducted a review of renewable energy investments in Canada. In the study using vector error correction method (VECM), it was determined that there is a long-term relationship between renewable energy investments and economic growth. Kim [50] and Özcan and Öztürk [51] also achieved similar results in their analysis of different country groups. In addition to the mentioned issue, renewable energy investments also contribute to countries not being dependent on other countries with respect to the energy supply. The main reason for this is that, thanks to renewable energy sources, countries are able to produce their own energy. Behuria [52] focused on the renewable energy investments in India and concluded that they have a decreasing effect on the energy dependency. Similarly, Aydın [53] and Baloch *et al.* [54] reached the same conclusion for BRICS (Brazil, Russia, India, China and South Africa) countries.

Many studies in the literature have focused on the positive effects of renewable energy sources on the environment. As a result of producing electricity from these energy types, carbon gas is not released into the atmosphere. In this way, environmental pollution can be prevented [55]. This will contribute to the reduction of the number of patients in the country. Thus, health spending in the country could be reduced. On the other hand, the high number of healthy people in a country will also help increase the workforce [56]. Sharif *et al.* [57] made an evaluation related to renewable energy investments in 74 different nations. They identified that the main advantage of the renewable energy investments is not to damage environment. In addition, Kahia *et al.* [58] focused on the renewable energy production in 12 Middle East and North Africa (MENA) countries and determined that these projects have a significant influence on the reduction of carbon emission.

The literature analysis indicates that renewable energy investment projects play an essential role for both social and economic development of the countries. Hence, there is a strong need for the studies in which innovative strategies are generated to improve these projects. However, it is also obvious that methodologies should be chosen appropriately to reach effective results. Renewable energy investments need significant engineering knowledge. Moreover, the initial costs of these projects are quite high. These conditions increase the risk of failure for these projects. Hence, in the literature, there is a need for the studies in which the technical requirements of these projects are defined with an appropriate approach to increase the opportunity of the effectiveness.

In this framework, for the technical requirements of the renewable energy investments, TRIZ methodology is taken into account in this study. On the other hand, 9 different criteria with respect to the customer expectations are weighted with hesitant fuzzy IT2 fuzzy DANP approach. Furthermore, hesitant IT2 fuzzy TOPSIS approach is used to rank 8

TABLE 1. Selected characteristics of renewable energy investments for contradiction matrix.

Characteristics	Literature
Shape (CR 1)	[69],[70]
Strength (CR 2)	[71],[72]
Power (CR 3)	[71],[73]
Loss of energy (CR 4)	[69],[73]
Reliability (CR 5)	[74],[75]
Manufacturability (CR 6)	[76],[77]
Convenience of use (CR 7)	[69],[74]
Repairability (CR 8)	[70],[74]
Adaptability (CR 9)	[74], [77]
Complexity of control (CR 10)	[78], [79]
Capacity (CR 11)	[73], [76]

TABLE 2. Innovative strategies for renewable energy investments.

Alternatives	TRIZ Number	Definition
Local quality (A1)	3	The function of each part of an object is in the most favorable conditions for its operation.
Asymmetry (A2)	4	It is the transformation of an object's shape from symmetrical to asymmetrical.
Prior Action (A3)	10	It specifies that the necessary changes in an object are made completely or partially in advance.
Cushion in Advance (A4)	11	It defines ensuring the reliability of an object with low reliability before the danger.
Partial or Excessive Action (A5)	16	If a goal is not completely achievable, it indicates making the problem more solvable.
Periodic Action (A6)	19	It refers to using periodic action instead of continuous action.
Feedback (A7)	23	It explains the creation of a feedback mechanism in the design of a process or action.
Rejecting and Regenerating Parts (A8)	34	It refers to the disposal of parts of an object that have fulfilled its functions or to change the order of operations.

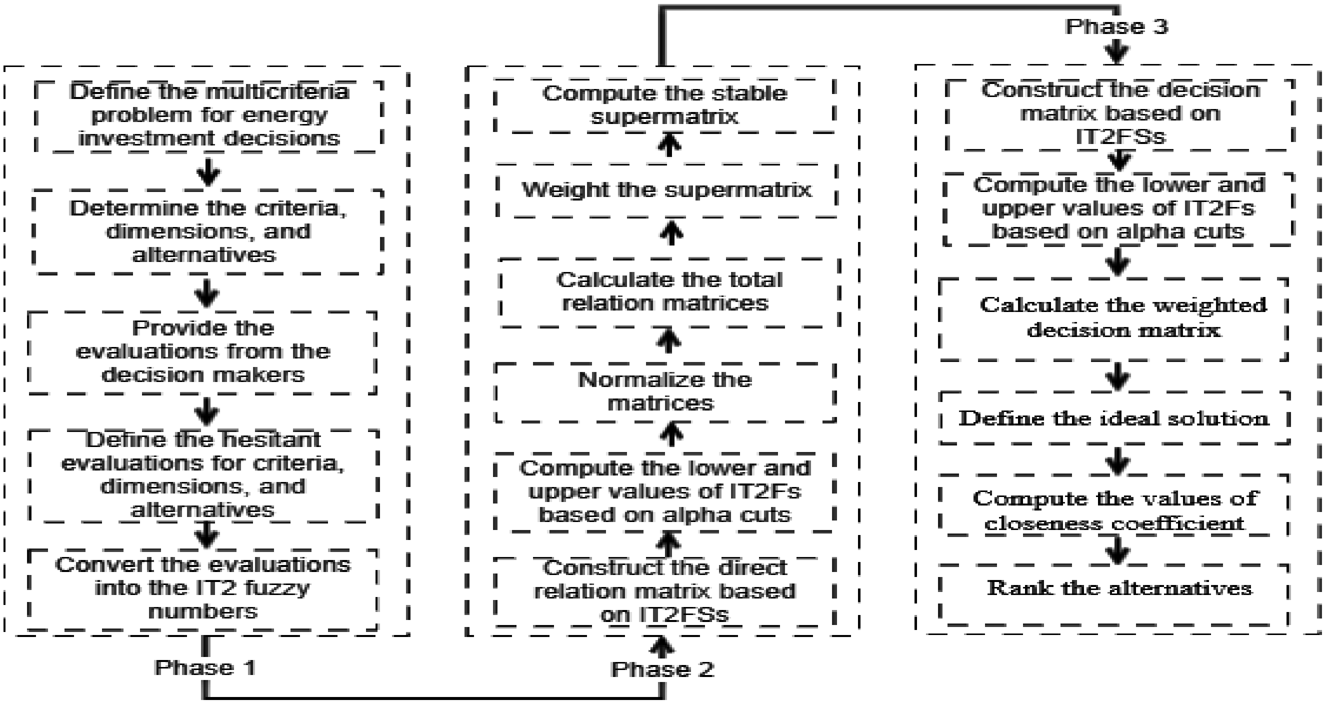

FIGURE 1. The flowchart of proposed model.

TABLE 3. Proposed dimensions and criteria of customer expectations.

Dimensions	Criteria	Literature
Financial (Dimension 1)	Competitive pricing (Criterion 1)	[81]
	Affordability (Criterion 2)	[60],[61]
	Flexibility (Criterion 3)	[64]
Functional (Dimension 2)	Ease of access (Criterion 4)	[82],[83]
	Customer support (Criterion 5)	[84]
	Modularity (Criterion 6)	[66],[68]
Physical (Dimension 3)	Security (Criterion 7)	[85],[86]
	Location (Criterion 8)	[70],[72]
	Facilities (Criterion 9)	[60],[64]

different innovative technical requirements. Also, owing to the house of quality approach, both technical capacity and customer expectations can be considered together. Therefore, this study is thought to make an important contribution to the literature in terms of both the importance of the subject and the originality of the methodology.

III. ANALYSIS ON RENEWABLE ENERGY INVESTMENT STRATEGIES

In this section of the study, the proposed method is explained. Within this framework, theoretical information regarding the methods used in the analysis is shared. However, the mathematical details of these approaches are demonstrated on the appendix A-F. Moreover, in the second part of this section, analysis results are also shared.

TABLE 4. Linguistic scales for criteria and dimensions.

Linguistic Evaluations	IT2 Fuzzy Numbers
Very very low (VVL)	((0,0.1,0.1,0.2;1,1), (0.05,0.1,0.1,0.15;0.9,0.9))
Very low (VL)	((0.1,0.2,0.2,0.35;1,1), (0.15,0.2,0.2,0.3;0.9,0.9))
Low (L)	((0.2,0.35,0.35,0.5;1,1), (0.25,0.35,0.35,0.45;0.9,0.9))
Medium (M)	((0.35,0.5,0.5,0.65;1,1), (0.4,0.5,0.5,0.6;0.9,0.9))
High (H)	((0.5,0.65,0.65,0.8;1,1), (0.55,0.65,0.65,0.75;0.9,0.9))
Very high (VH)	((0.65,0.8,0.8,0.9;1,1), (0.7,0.8,0.8,0.85;0.9,0.9))
Very very high (VVH)	((0.8,0.9,0.9,1;1,1), (0.85,0.9,0.9,0.95;0.9,0.9))

A. PROPOSED METHOD

In this study, it is aimed to identify appropriate innovative strategies for the renewable energy investments. For this purpose, 3 different phases are generated. In the first phase, 11 different factors are identified based on 39 different contradictions parameters of TRIZ methodology for the technical requirements of the renewable energy investments. Additionally, a contradiction matrix is generated by considering pairwise comparison of these parameters in this phase. Based on the expert evaluations, 8 different innovative strategies are defined for renewable energy investments out of 40 different strategic principles of TRIZ method.

TABLE 5. Weights of criteria by alpha level sets.

Criteria	Alpha levels											
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	Average
Criterion 1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Criterion 5	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Criterion 8	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 9	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

TABLE 6. Linguistic scales and fuzzy numbers for alternatives.

Linguistic Scales	IT2 Fuzzy Numbers
Very Low (VL)	((0.00,0.00,0.00,0.10;1.00,1.00), (0.00,0.00,0.00,0.05;0.90,0.90))
Low (L)	((0.00,0.10,0.10,0.30;1.00,1.00), (0.05,0.10,0.10,0.20;0.90,0.90))
Medium Low (ML)	((0.10,0.30,0.30,0.50;1.00,1.00), (0.20,0.30,0.30,0.40;0.90,0.90))
Medium (M)	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))
Medium High (MH)	((0.50,0.70,0.70,0.90;1.00,1.00), (0.60,0.70,0.70,0.80;0.90,0.90))
High (H)	((0.70,0.90,0.90,1.00;1.00,1.00), (0.80,0.90,0.90,0.95;0.90,0.90))
Very High (VH)	((0.90,1.00,1.00,1.00;1.00,1.00), (0.95,1.00,1.00,1.00;0.90,0.90))

Furthermore, in the second phase of the analysis, the strategic priorities of innovative technical requirements are measured for renewable energy investments with house of quality technique. Within this context, firstly, 9 different criteria related to the customer expectations are identified by making a detailed literature review. After that, these factors are evaluated by using hesitant IT2 fuzzy DANP methodology based on the alpha cuts. Hence, the more significant factors can be defined.

Hesitant fuzzy linguistic term sets are mainly considered to obtain the evaluations of the decision makers under the hesitancy [24]. In this framework, membership function can be created based on the preferences of these people. It is obvious that these term sets can be very helpful to provide more appropriate data when there is hesitancy [25]. Fuzzy logic is mainly used to solve complicated problems. IT2 fuzzy sets mainly consider trapezoidal membership function. In this framework, it is mainly aimed to minimize uncertainty occurred in the classical fuzzy sets [22], [23]. Alpha cuts are considered in the fuzzy systems-based decision-making analysis with the aim of solving the problem more effectively and appropriately [27].

DANP methodology is the combination of DEMATEL and ANP methods. This approach is used to solve problem under the complex conditions [29]–[31]. In the calculation process, the direct relation matrix is created based on the expert evaluations. After that, this matrix is normalized, and total influence matrix is also generated. Just then, the defuzzification process has been performed and the weights of the criteria can be calculated. There are some advantages of considering this methodology. Firstly, with the help of DEMATEL approach, causality relationship between the variables can be identified. Additionally, inner dependency between these factors can be considered owing to the ANP methodology. Because of these positive issues, this approach was used in the literature for different purposes, such as project management [59], location selection [60] and prioritizing watersheds [61].

On the other side, in the third phase of the analysis process, the innovative technical requirements are analyzed using house of quality technique. In this context, hesitant IT2 fuzzy TOPSIS methodology is taken into consideration. TOPSIS model is mainly considered to rank different alternatives. In this framework, positive and negative ideal solutions are taken into account [33]. Due to this situation, TOPSIS methodology was also used in many different studies in the literature. For instance, Bera *et al.* [62], Zhong and Yao [63] and Heidarzade *et al.* [64] made a study regarding supplier selection by considering this approach. On the other side, Yüksel and Dinçer [65] tried to rank Turkish banks with IT2 fuzzy TOPSIS regarding the performance in agricultural finance. IT2 fuzzy VIKOR approach is also used in this phase to make a comparative analysis. This method is also used to rank different alternatives. Hence it can be said that TOPSIS and VIKOR method can replace each other. In VIKOR method, fuzzy decision matrix is created based on expert opinions. After that, these matrixes are defuzzified. In the final stage, alternatives are ranked by considering the best and worst values. VIKOR approach was also preferred by many different researchers in the literature [66]–[68].

The details are illustrated on Figure 1. In this figure, three different phases of the analysis process are detailed. The evaluations of the experts for the dimensions, criteria and alternatives are the inputs. On the other side, while examining these inputs, the weights of the criteria can be calculated, and renewable energy investment strategies are ranked. These results are defined as the outputs in the analysis.

TABLE 7. Decision matrix (alpha-level set: 0).

Criteria / Alternatives		Technical Requirements							
		A1	A2	A3	A4	A5	A6	A7	A8
Customer Expectations	C1	[0.75,0.98]	[0.84,0.99]	[0.75,0.98]	[0.74,0.94]	[0.75,0.98]	[0.55,0.85]	[0.25,0.55]	[0.84,0.99]
	C2	[0.65,0.91]	[0.55,0.85]	[0.55,0.85]	[0.45,0.75]	[0.55,0.85]	[0.25,0.55]	[0.45,0.75]	[0.45,0.75]
	C3	[0.65,0.91]	[0.45,0.75]	[0.45,0.75]	[0.45,0.75]	[0.55,0.85]	[0.25,0.55]	[0.75,0.98]	[0.45,0.75]
	C4	[0.74,0.94]	[0.35,0.65]	[0.84,0.99]	[0.65,0.91]	[0.65,0.91]	[0.55,0.85]	[0.84,0.99]	[0.45,0.75]
	C5	[0.35,0.65]	[0.35,0.65]	[0.55,0.85]	[0.55,0.85]	[0.55,0.85]	[0.55,0.85]	[0.45,0.75]	[0.45,0.75]
	C6	[0.25,0.55]	[0.65,0.91]	[0.35,0.65]	[0.55,0.85]	[0.45,0.75]	[0.55,0.85]	[0.25,0.55]	[0.84,0.99]
	C7	[0.84,0.99]	[0.65,0.91]	[0.75,0.98]	[0.75,0.98]	[0.35,0.65]	[0.55,0.85]	[0.45,0.75]	[0.55,0.85]
	C8	[0.45,0.75]	[0.35,0.65]	[0.75,0.98]	[0.75,0.98]	[0.35,0.65]	[0.35,0.65]	[0.75,0.98]	[0.55,0.85]
	C9	[0.45,0.75]	[0.84,0.99]	[0.65,0.91]	[0.65,0.91]	[0.55,0.85]	[0.55,0.85]	[0.84,0.99]	[0.45,0.75]

TABLE 8. Defuzzified decision matrix (alpha-level set: 0).

Criteria	A1	A2	A3	A4	A5	A6	A7	A8
C1	0.86	0.91	0.86	0.84	0.86	0.70	0.40	0.91
C2	0.78	0.70	0.70	0.60	0.70	0.40	0.60	0.60
C3	0.78	0.60	0.60	0.60	0.70	0.40	0.86	0.60
C4	0.84	0.50	0.91	0.78	0.78	0.69	0.91	0.60
C5	0.50	0.50	0.69	0.70	0.70	0.70	0.60	0.60
C6	0.40	0.78	0.50	0.70	0.60	0.70	0.40	0.91
C7	0.91	0.78	0.86	0.86	0.50	0.69	0.60	0.70
C8	0.60	0.50	0.86	0.86	0.50	0.50	0.86	0.70
C9	0.60	0.91	0.78	0.78	0.69	0.69	0.91	0.60

TABLE 9. Weighted decision matrix (alpha-level set: 0).

Criteria	A1	A2	A3	A4	A5	A6	A7	A8
C1	0.10	0.10	0.10	0.09	0.10	0.08	0.05	0.10
C2	0.08	0.07	0.07	0.06	0.07	0.04	0.06	0.06
C3	0.09	0.07	0.07	0.07	0.08	0.05	0.10	0.07
C4	0.10	0.06	0.11	0.09	0.09	0.08	0.11	0.07
C5	0.06	0.06	0.08	0.08	0.08	0.08	0.07	0.07
C6	0.04	0.08	0.05	0.08	0.06	0.08	0.04	0.10
C7	0.11	0.09	0.10	0.10	0.06	0.08	0.07	0.08
C8	0.07	0.06	0.10	0.10	0.06	0.06	0.10	0.08
C9	0.06	0.09	0.08	0.08	0.07	0.07	0.09	0.06

B. ANALYSIS RESULTS

Phase 1: Innovative technical requirements are defined for renewable energy investments with TRIZ technique

First of all, 11 different factors are identified based on 39 different contradictions parameters of TRIZ methodology for the technical requirements of the renewable energy investments. These factors are given on Table 1.

After that, a contradiction matrix is created by considering pairwise comparison of these parameters. With the help of expert evaluations, 8 different innovative strategies are selected for renewable energy investments out of 40 different strategic principles of TRIZ method created by Al'tshuller [80]. The details of these 40 TRIZ principles are given on the appendix G. In the other hand, appendix H gives information about the contradiction matrix. On the other side, the details of these 8 renewable energy investment strategies are given on Table 2.

Phase 2: Measuring the strategic priorities of innovative technical requirements for renewable energy investments with house of quality technique.

In this phase, 9 different criteria regarding customer expectations are defined by making a detailed literature review. The details of them are demonstrated on Table 3.

In the energy consumption process, it is seen that financial factors affect customer satisfaction. One of the most important issues in this process is the reasonable price [81]. In this way, customers will be able to purchase electricity easily [61]. Flexible payment opportunities also play an important role in this process [64]. On the other hand, some functional issues are also important in terms of customer expectations. For example, factors such as easy access to energy and the availability of customer support for a possible problem are factors that increase customer satisfaction [82]–[84]. In addition, thanks to the modularity of the product, its adaptation to different conditions can be easily increased, thus customer expectations can be met [68]. Physical conditions are also important for customer expectations in energy consumption. One of the most important roles in this process is security [85]. In addition, the distance of the location to the center is also important for customer satisfaction [72]. These customer requirements are weighted by using hesitant IT2 fuzzy DANP approach. The linguistic scales used in this condition are defined in Table 4.

Table 4 indicates 7 different evaluation scales. In this context, VVL gives information about the least influence whereas VVH demonstrates the greatest influence. In this process, the opinions of 3 different experts are considered. They have at least 15-year experience in renewable energy companies as top managers. Within this framework, hesitant evaluations are obtained for both dimensions and criteria and they are detailed on appendix I and J. For instance, on appendix I, experts evaluated the importance of criterion 1 on criterion 2 as "M and H". In the next stage, trapezoidal fuzzy relation matrixes are generated. They are demonstrated on Appendix K and L. After that, these matrixes are normalized. By using these new values, total relation matrixes are created. In the next stage, unweighted supermatrixes are generated for different alpha levels. Hence, total relation matrixes can be identified for both dimensions and criteria. Later, limit

TABLE 10. Ranking results by alpha level sets.

Alternatives	Alpha Levels											
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	Average
A1	4	4	3	3	3	3	3	3	3	3	3	3
A2	5	5	5	5	5	5	5	5	5	5	5	5
A3	2	2	2	2	2	2	2	2	2	2	2	2
A4	1	1	1	1	1	1	1	1	1	1	1	1
A5	6	6	6	6	6	6	6	6	7	7	7	6
A6	8	8	8	8	8	8	8	8	8	8	8	8
A7	7	7	7	7	7	7	7	7	6	6	6	7
A8	3	3	4	4	4	4	4	4	4	4	4	4

TABLE 11. Comparative Results with IT2 Fuzzy TOPSIS and IT2 Fuzzy VIKOR (alpha-level set: 0).

Alternatives	Ranking with IT2 Fuzzy TOPSIS	Ranking with IT2 Fuzzy VIKOR
A1	4	6
A2	5	4
A3	2	2
A4	1	1
A5	6	5
A6	8	8
A7	7	7
A8	3	3

supermatrix values are calculated. The details are stated on the appendix M-T. As a result, the weights of the criteria can be identified for different alpha values and they are given on Table 5.

Table 5 shows that weights of all criteria are quite similar. On the other side, it is also identified that criterion 4 (ease of access) and criterion 7 (security) have slightly higher weights in comparison with the others. These results were supported by some researchers in the literature. For instance, Pettifor *et al.* [87] and Chaloux *et al.* [88] underlined the importance of ease of access for the satisfaction of energy consumers. Moreover, Yaghoubi *et al.* [89] and Ganguly *et al.* [90] stated the importance of security for this situation. In other words, it is defined that customers prefer to access the products very easily and fell themselves secure while consumer energy. On the other side, it is also concluded that criterion 9 (facilities) has the weakest effect on the customer expectations.

Phase 3: Rank the innovative technical requirements with Hesitant IT2 fuzzy TOPSIS using house of quality technique

In this phase, it is aimed to define the most appropriate innovative technical requirements. Within this scope, the most relevant principles of renewable energy are taken into consideration. These 8 different innovative strategies are selected for renewable energy investments out of 40 different strategic principles of TRIZ method in the first phase and they are ranked in this phase by considering hesitant IT2 fuzzy TOPSIS. In this framework, the evaluations are performed by considering house of quality approach. In this context, linguistic scales and IT2 fuzzy numbers, which are considered, are shown in Table 6.

After that, hesitant evaluations are also provided from the experts for the alternatives. By considering these values, hesitant evaluation values can be calculated for the alternatives. With the help of them, trapezoidal fuzzy decision matrix is generated. They are demonstrated on the appendix U and V. Later, the decision matrix can be created as in Table 7.

In the next step, defuzzified decision matrix is generated. In this framework, lower and upper values $(a_{i1}^{L}(\alpha), a_{i1}^{U}(\alpha))$ are computed by the equations (16) and (17) respectively and average values are used to obtain the defuzzified values of the relation matrix. Thus, new matrix can be generated as in Table 8.

Similarly, weighted decision matrix is created and detailed in Table 9.

Next, performance results are calculated for the alternatives. This analysis has also been performed for different alpha values and the results are demonstrated on Table 10.

Table 10 states that cushion in advance (A4) is the most appropriate innovation strategy for renewable energy investment projects. Additionally, it is also concluded that prior action (A3) is another significant strategy for these investors. It is seen that the results are almost similar for all alpha levels. This situation states that the analysis results are quite coherent. In addition to this issue, these alternatives are also ranked by using IT2 fuzzy VIKOR method. In this context, it is aimed to make a comparative evaluation. These results are stated in Table 11.

Table 11 demonstrates that the results of IT2 fuzzy TOPSIS and IT2 fuzzy VIKOR are quite coherent.

IV. CONCLUSION

In this study, it is aimed to determine appropriate innovative strategies for the renewable energy investments. There are three different phases in the analysis process. In the first phase, 11 different factors are defined based on 39 different contradictions parameters of TRIZ methodology. Next, pairwise comparison has been made by the experts so that a contradiction matrix is created. With the help of this evaluation, 8 different innovative strategies are selected for renewable energy investments out of 40 different strategic principles of TRIZ method. Moreover, in the second phase, the strategic priorities of innovative technical requirements for renewable energy investments are measured with house of quality technique. For this purpose, 9 different criteria regarding customer expectations are defined. Additionally, hesitant IT2 fuzzy DANP is considered to evaluate these criteria. On the other hand, in the third phase, the most appropriate innovative technical requirements are identified with the help of hesitant IT2 fuzzy TOPSIS. The findings indicate that ease of access and security are the most important factors for the customer satisfaction in the renewable energy consumption. In addition, it is also concluded that facilities have the weakest effect on the customer expectations. A comparative evaluation has also been performed with IT2 fuzzy VIKOR and it is defined that the results are quite coherent.

V. LIMITATIONS AND IMPLICATIONS

The results of the study give information that customers prefer to access the products very easily and fell themselves secure while consumer energy. In other words, customers demand constant access to the energy they will use. In this process, it is important to present the energy to be produced uninterruptedly and easily to the customer. Hosseini and Wahid [91] made a study about the hydrogen generation from the solar energy. They mainly discussed that the sources of the energy should be sustainable. Similarly, Mombeuil [92] evaluated the energy industry in Haiti. It is identified that for sustainable economic development, uninterrupted energy production plays an essential role. Considering that customers also attach importance to energy security, it will be appropriate to take necessary measures in risky processes such as storage and transportation of energy. Gan *et al.* [93] and Salimi *et al.* [94] focused on the energy production in different country groups and defined that energy security should be obtained.

It is also determined that cushion in advance is the most appropriate innovation strategy for renewable energy investment projects. In addition to this issue, it is also defined that prior action is another important strategy for these investors. In this framework, a detailed analysis is required to identify the risks in renewable energy investment projects. Then, it is important to take the necessary measures to manage these risks effectively. In this way, it will be possible to prevent problems before they grow. This will contribute to the success of renewable energy investments. Qiu *et al.* [95] and Zhou and Yang [96] made an evaluation for the wind energy investment projects. They mainly claimed that effective risk management is a significant issue for the sustainable performance of these projects.

The main limitation of this study is to evaluate renewable energy investments generally. Hence, in the future studies, more specific topics in this framework can be examined. For instance, this kind of analysis can be performed for wind or solar energy specifically. In addition to this condition, some countries or country groups can be taken into account in these studies. This situation can be very helpful to understand important factors based on the profiles of the countries. Moreover, different methodologies can also be considered in new studies. This issue provides an opportunity to make a comparative analysis.

APPENDIX

APPENDIX A - HESITANT FUZZY LINGUISTIC TERMS

The details of these sets are demonstrated in the equations (1), as shown at the bottom of the page, and (2), as shown at the bottom of the page. In these equations, G_H explains context-free grammar. Additionally, $S = \{S_0, S_1, \ldots, S_t\}$ gives information about the linguistic term set. On the other side, h_S indicates the ordered finite subset of these term sets.

APPENDIX B - IT2 FUZZY SETS

$\tilde{A}$ gives information about the set. On the other hand, $\mu_{\tilde{A}(x,u)}$ explains the membership function by considering type 2 fuzzy numbers. Furthermore, $\int\int$ states the union over all admissible x and u. Equations (3) and (4) indicate the details of these issues.

$$\tilde{A} = \left\{\left((x, u), \mu_{\tilde{A}(x,u)}\right) \mid \forall_x \in X, \quad \forall_u \in J_x \subseteq [0, 1]\right\}, \text{ or}$$
$$\tilde{A} = \int_{x\in X}\int_{u\in J_x} \mu_{\tilde{A}}(x, u) / (x, u) J_x \subseteq [0, 1] \tag{3}$$

$$G_H = (V_N, V_T, I, P) \tag{1}$$
$$V_N = \left\{\begin{array}{c}\langle \text{primary term} \rangle, \langle\text{composite term}\rangle \\ \langle\text{unary term}\rangle, \langle\text{binary term}\rangle, \langle\text{conjunction}\rangle\end{array}\right\},$$
$$V_T = \left\{\begin{array}{l}\text{lower than, greater than, at least, at most,} \\ \text{between, and}, S_0, S_1, \ldots, S_t\end{array}\right\}, \quad I \in V_N,$$
$$P = \{I ::= \langle\text{primary term}\rangle \mid \langle\text{compositeterm}\rangle, \quad \langle\text{composite term}\rangle$$
$$::= \langle\text{composite term}\rangle\ \langle\text{primary term}\rangle$$
$$\left|\begin{array}{l}\langle\text{binary relation}\rangle\ \langle\text{primary term}\rangle \\ \langle\text{conjunction}\rangle\ \langle\text{primary term}\rangle,\end{array}\right. \quad \langle\text{primaryterm}\rangle ::= S_0 \mid S_1 \mid \ldots \mid S_t, \ \langle\text{unary relation}\rangle$$
$$::= \text{lowerthan} \mid \text{greater than} \mid \text{at least} \mid \text{at most},$$
$$\langle\text{binary relation}\rangle ::= \text{between}, \ \langle\text{conjunction}\rangle ::= \text{ and}\}.$$
$$h_S = \{S_i, S_{i+1}, \ldots, S_j\} \tag{2}$$

$$\tilde{A} = \int_{x\in X}\int_{u\in} J_x 1/(x,u) J_x \subseteq [0,1] \tag{4}$$

In this framework, $\tilde{A}_i^U$ and $\tilde{A}_i^L$ indicate upper and lower trapezoidal membership functions. Furthermore, $a_{i1}^U, \ldots, a_{i4}^L$ explain the reference values. In the other hand, $H_j\left(\tilde{A}_i^U\right)$ and $H_j\left(\tilde{A}_i^L\right)$ show the membership values in the upper and lower functions. The details of this process are given in the equations (5)-(10), as shown at the bottom of the page.

APPENDIX C - ALPHA LEVEL SETS

These sets are detailed in the equations (11) and (12).

$$X(\alpha) = \{x \mid \mu_X(x) \geq \alpha\} = [a(\alpha), b(\alpha)] \tag{11}$$

$$\begin{aligned}\tilde{X}(\alpha) &= \left\{x \mid \underline{\mu}_{\tilde{X}}(x) \geq \alpha, \bar{\mu}_{\tilde{X}}(x) \geq \alpha\right\}\\ &= [a(\alpha), b(\alpha)]\end{aligned} \tag{12}$$

In these equations, $X(\alpha)$ and $\tilde{X}(\alpha)$ indicate the α cut of type 1 and type 2 fuzzy sets.

Similarly, $a(\alpha)$ and $b(\alpha)$ are also detailed on the equations (13) and (14).

$$a(\alpha) \in \begin{cases} [a_l(\alpha), a_r(\alpha)], & a \in \left[0, H_j\left(\tilde{A}_i^L\right)\right] \\ [a_l(\alpha), b_r(\alpha)], & a \in \left[H_j\left(\tilde{A}_i^L\right), 1\right] \end{cases} \tag{13}$$

$$b(\alpha) \in \begin{cases} [b_l(\alpha), b_r(\alpha)], & a \in \left[0, H_j\left(\tilde{A}_i^L\right)\right] \\ [a_l(\alpha), b_r(\alpha)], & a \in \left[H_j\left(\tilde{A}_i^L\right), 1\right] \end{cases} \tag{14}$$

APPENDIX D - IT2 FUZZY DANP BASED ON ALPHA CUTS

In the first step, direct relation matrix is generated as in the equation (15).

$$\tilde{A} = \begin{bmatrix} a_{11} & a_{22} & a_{13} & & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & & \vdots \\ a_{n1} & a_{n2} & a_{n3} & & \cdots & a_{nn} \end{bmatrix} \tag{15}$$

$$\begin{aligned}\tilde{A}_i &= \left(\tilde{A}_i^U, \tilde{A}_i^L\right)\\ &= \begin{pmatrix} \left(a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1\left(\tilde{A}_i^U\right), H_2\left(\tilde{A}_i^U\right)\right), \\ \left(a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1\left(\tilde{A}_i^L\right), H_2\left(\tilde{A}_i^L\right)\right) \end{pmatrix}\end{aligned} \tag{5}$$

$$\begin{aligned}\tilde{A}_1 \oplus \tilde{A}_2 &= \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \oplus \left(\tilde{A}_2^U, \tilde{A}_2^L\right)\\ &= \begin{pmatrix} \begin{pmatrix} a_{11}^U + a_{21}^U, a_{12}^U + a_{22}^U, a_{13}^U + a_{23}^U, a_{14}^U + a_{24}^U; \\ \min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right) \end{pmatrix}, \\ \begin{pmatrix} a_{11}^L + a_{21}^L, a_{12}^L + a_{22}^L, a_{13}^L + a_{23}^L, a_{14}^L + a_{24}^L; \\ \min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right) \end{pmatrix} \end{pmatrix}\end{aligned} \tag{6}$$

$$\begin{aligned}\tilde{A}_1 \ominus \tilde{A}_2 &= \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \ominus \left(\tilde{A}_2^U, \tilde{A}_2^L\right)\\ &= \begin{pmatrix} \begin{pmatrix} a_{11}^U - a_{24}^U, a_{12}^U - a_{23}^U, a_{13}^U - a_{22}^U, a_{14}^U - a_{21}^U; \\ \min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right) \end{pmatrix}, \\ \begin{pmatrix} a_{11}^L - a_{24}^L, a_{12}^L - a_{23}^L, a_{13}^L - a_{22}^L, a_{14}^L - a_{21}^L; \\ \min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right) \end{pmatrix} \end{pmatrix}\end{aligned} \tag{7}$$

$$\begin{aligned}\tilde{A}_1 \otimes \tilde{A}_2 &= \left(\tilde{A}_1^U, \tilde{A}_1^L\right) \otimes \left(\tilde{A}_2^U, \tilde{A}_2^L\right)\\ &= \begin{pmatrix} \begin{pmatrix} a_{11}^U \times a_{21}^U, a_{12}^U \times a_{22}^U, a_{13}^U \times a_{23}^U, a_{14}^U \times a_{24}^U; \\ \min\left(H_1\left(\tilde{A}_1^U\right), H_1\left(\tilde{A}_2^U\right)\right), \min\left(H_2\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_2^U\right)\right) \end{pmatrix}, \\ \begin{pmatrix} a_{11}^L \times a_{21}^L, a_{12}^L \times a_{22}^L, a_{13}^L \times a_{23}^L, a_{14}^L \times a_{24}^L; \\ \min\left(H_1\left(\tilde{A}_1^L\right), H_1\left(\tilde{A}_2^L\right)\right), \min\left(H_2\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_2^L\right)\right) \end{pmatrix} \end{pmatrix}\end{aligned} \tag{8}$$

$$k\tilde{A}_1 = \begin{pmatrix} k \times a_{11}^U, k \times a_{12}^U, k \times a_{13}^U, k \times a_{14}^U; \\ H_1\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_1^U\right) \end{pmatrix}, \quad \begin{pmatrix} k \times a_{11}^L, k \times a_{12}^L, k \times a_{13}^L, k \times a_{14}^L; \\ H_1\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_1^L\right) \end{pmatrix} \tag{9}$$

$$\frac{\tilde{A}_1}{k} = \begin{pmatrix} \frac{1}{k} \times a_{11}^U, \frac{1}{k} \times a_{12}^U, \frac{1}{k} \times a_{13}^U, \frac{1}{k} \times a_{14}^U; \\ H_1\left(\tilde{A}_1^U\right), H_2\left(\tilde{A}_1^U\right) \end{pmatrix}, \begin{pmatrix} \frac{1}{k} \times a_{11}^L, \frac{1}{k} \times a_{12}^L, \frac{1}{k} \times a_{13}^L, \frac{1}{k} \times a_{14}^L; \\ H_1\left(\tilde{A}_1^L\right), H_2\left(\tilde{A}_1^L\right) \end{pmatrix} \tag{10}$$

The second step is related to the identification of the lower and upper values ($a_{ij}^{L}(\alpha)$, $a_{ij}^{U}(\alpha)$) with the help of the equations (16) and (17).

$$a_{i1}^{L}(\alpha) = \frac{\left(a_{i1}^{L} + \left(a_{i2}^{L} - a_{i1}^{L}\right) * \alpha\right) + \left(a_{i1}^{U} + \left(a_{i2}^{U} - a_{i1}^{U}\right) * \alpha\right)}{2} \tag{16}$$

$$a_{i1}^{U}(\alpha) = \frac{\left(a_{i4}^{L} - \left(a_{i4}^{L} - a_{i3}^{L}\right) * \alpha\right) + \left(a_{i4}^{U} - \left(a_{i4}^{U} - a_{i3}^{U}\right) * \alpha\right)}{2} \tag{17}$$

Normalized direct relation matrix (N) is generated with the equations (18) and (19) in the third step.

$$N = \frac{\tilde{A}}{s} \tag{18}$$

$$s = max\left[\begin{array}{c} max \\ 1 \le i \le n \end{array} \sum_{J=1}^{n} a_{ij},\ \begin{array}{c} max \\ 1 \le j \le n \end{array} \sum_{i=1}^{n} a_{ij}\right] \tag{19}$$

The fourth step is related to the calculation of the total influence matrix (T) as in the equation (20).

$$T = N\left(I - N^{h}\right)(I - N)^{-1} = N(I - N)^{-1} \tag{20}$$

The fifth step includes the identification of the network relation map by considering the equations (21)-(23).

$$T = \left[t_{ij}\right]_{n \times n}, \quad i, j = 1, 2, \ldots, n \tag{21}$$

$$r = \left[\sum_{j=1}^{n} t_{ij}\right]_{n \times 1} = (r_i)_{n \times 1} = (r_1, \ldots, r_i, \ldots, r_n) \tag{22}$$

$$y = \left[\sum_{i=1}^{n} t_{ij}\right]_{1 \times n}^{\prime} = (y_j)_{1 \times n}^{\prime} = (y_1, \ldots, y_i, \ldots, y_n) \tag{23}$$

In the sixth step, the unweighted supermatrix (W) is constructed with the help of the equations (24)-(28).

$$
T_c = \begin{array}{ll}
& \begin{array}{ccccccccc} D_1 & & \cdots & & D_i & & \cdots & & D_n \\ D_1\ c_{11} & c_{12} & \cdots & c_{1m1} & \cdots & c_{n1} & c_{n2} & \cdots & c_{nm_n} \end{array} \\
\begin{array}{ll} & c_{11} \\ & c_{12} \\ \vdots & \vdots \\ & c_{1m1} \\ D_j & \vdots \\ & c_{n1} \\ \vdots & c_{n2} \\ D_n & \vdots \\ & c_{nm_n} \end{array} &
\begin{bmatrix} T_c^{11} & \ldots & T_c^{1j} & \ldots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \ldots & T_c^{ij} & \ldots & T_c^{in} \\ \vdots & & \vdots & & \vdots \\ T_c^{n1} & \ldots & T_c^{nj} & \ldots & T_c^{nn} \end{bmatrix}
\end{array} \tag{24}
$$

$$
\boldsymbol{T_c^{\beta}} = \begin{array}{ll}
& \begin{array}{ccccccccc} D_1 & & \cdots & & D_i & & \cdots & & D_n \\ D_1\ c_{11} & c_{12} & \cdots & c_{1m1} & \cdots & c_{n1} & c_{n2} & \cdots & c_{nm_n} \end{array} \\
\begin{array}{ll} & c_{11} \\ & c_{12} \\ \vdots & \vdots \\ & c_{1m1} \\ D_j & \vdots \\ & c_{n1} \\ \vdots & c_{n2} \\ D_n & \vdots \\ & c_{nm_n} \end{array} &
\begin{bmatrix} T_c^{\beta 11} & \ldots & T_c^{\beta 1j} & \ldots & T_c^{\beta 1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{\beta i1} & \ldots & T_c^{\beta ij} & \ldots & T_c^{\beta in} \\ \vdots & & \vdots & & \vdots \\ T_c^{\beta n1} & \ldots & T_c^{\beta nj} & \ldots & T_c^{\beta nn} \end{bmatrix}
\end{array} \tag{25}
$$

$$d_i^{11} = \sum_{j=1}^{m_1} t_{c^{ij}}^{11}, \quad i = 1, 2, \ldots, m_1 \tag{26}$$

$$
\begin{aligned}
\boldsymbol{T_c^{\beta 11}} &= \begin{bmatrix} t_{c^{11}}^{11}/d_1^{11} & \cdots & t_{c^{1j}}^{11}/d_1^{11} & \cdots & t_{c^{1m_1}}^{11}/d_1^{11} \\ \vdots & & \vdots & & \vdots \\ t_{c^{i1}}^{11}/d_i^{11} & \cdots & t_{c^{ij}}^{11}/d_i^{11} & \cdots & t_{c^{im_1}}^{11}/d_i^{11} \\ \vdots & & \vdots & & \vdots \\ t_{c^{m1}1}^{11}/d_{m_1}^{11} & \cdots & t_{c^{m1j}}^{11}/d_{m_1}^{11} & \cdots & t_{c^{m1m1}}^{11}/d_{m_1}^{11} \end{bmatrix} \\
&= \begin{bmatrix} t_{11}^{\beta_{11}} & \cdots & t_{1j}^{\beta_1} & \cdots & t_{1m}^{\beta_{1n}} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\beta_{n1}} & \cdots & t_{ij}^{\beta_n} & \cdots & t_{im}^{\beta_m} \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{\beta_{n1}} & \cdots & t_{mj}^{\beta_{mj}} & \cdots & t_{mn}^{\beta_{mn}} \end{bmatrix}
\end{aligned} \tag{27}
$$

$$
W = (T_c^{\beta})' = \begin{array}{ll}
& \begin{array}{ccccccccc} D_1 & & \cdots & & D_i & & \cdots & & D_n \\ D_1\ c_{11} & c_{12} & \cdots & c_{1m1} & \cdots & c_{n1} & c_{n2} & \cdots & c_{nm_n} \end{array} \\
\begin{array}{ll} & c_{11} \\ & c_{12} \\ \vdots & \vdots \\ & c_{1m1} \\ D_j & \vdots \\ & c_{n1} \\ \vdots & c_{n2} \\ D_n & \vdots \\ & c_{nm_n} \end{array} &
\begin{bmatrix} W_{11} & \ldots & W_{i1} & \ldots & W_{n1} \\ \vdots & & \vdots & & \vdots \\ W_{1j} & \ldots & W_{ij} & \ldots & W_{nj} \\ \vdots & & \vdots & & \vdots \\ W_{1n} & \ldots & W_{in} & \ldots & W_{nn} \end{bmatrix}
\end{array} \tag{28}
$$

In the final step, weighted super matrix W^β is calculated by using the equations (29) and (30).

$$W^\beta = \begin{bmatrix} t_{11}^{D_{11}} & \cdots & t_{1j}^{D_{1j}} & \cdots & t_{1m}^{D_{1m}} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{D_{i1}} & \cdots & t_{ij}^{D_{ij}} & \cdots & t_{im}^{D_{im}} \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{D_{m1}} & \cdots & t_{mj}^{D_{mj}} & \cdots & t_{mm}^{D_{mm}} \end{bmatrix} \quad (29)$$

$$d_i = \sum_{j=1}^{m} t_{ij}^{D_{ij}}, \quad i = 1, 2, \ldots, m \quad (30)$$

T_D^β can be identified by normalizing T_D by considering the equation (31).

$$= \begin{bmatrix} t_{11}^{D_1}/d_1 & \cdots & t_{1j}^{D_1}/d_1 & \cdots & t_{1m}^{D_n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{D_1}/d_i & \cdots & t_{ij}^{D_n}/d_i & \cdots & t_{im}^{D_{n-1}}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{D_{n-1}}/d_m & \cdots & t_{nj}^{D_n}/d_m & \cdots & t_{mn}^{D_{n-1}}/d_n \end{bmatrix}$$

$$= \begin{bmatrix} t_{11}^{\beta_{11}} & \cdots & t_{1j}^{\beta_1} & \cdots & t_{1m}^{\beta_{1n}} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\beta_{11}} & \cdots & t_{ij}^{\beta_n} & \cdots & t_{im}^{\beta_{n=1}} \\ \vdots & & \vdots & & \vdots \\ t_{m1}^{\beta_{n1}} & \cdots & t_{mj}^{\beta_{nj}} & \cdots & t_{mm}^{\beta_{m-}} \end{bmatrix} \quad (31)$$

As a result, weighted super-matrix W^β can be calculated as in the equation (32).

$$W^\beta = \begin{bmatrix} t_{11}^{\beta_{11}} \times W_{11} & \cdots & t_{i1}^{\beta_{i1}} \times W_{i1} & \cdots & t_{m1}^{\beta_{m1}} \times W_{n1} \\ \vdots & & \vdots & & \vdots \\ t_{1j}^{\beta_{1j}} \times W_{1j} & \cdots & t_{ij}^{\beta_{ij}} \times W_{ij} & \cdots & t_{mj}^{\beta_{mj}} \times W_{nj} \\ \vdots & & \vdots & & \vdots \\ t_{1m}^{\beta_{1m}} \times W_{1n} & \cdots & t_{im}^{\beta_{im}} \times W_{in} & \cdots & t_{mm}^{\beta_{mm}} \times W_{nn} \end{bmatrix} \quad (32)$$

Finally, while considering the weighted matrix in the power of 2k+1, the limit supermatrix can be created.

APPENDIX E - IT2 FUZZY TOPSIS BASED ON ALPHA CUTS

The first step is related to the generation of decision matrix as in the equations (33)-(35).

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} X1 & X2 & X3 & & \ldots & Xn \end{array} \\ \begin{bmatrix} A_{11} & A_{12} & A_{13} & & \cdots & A_{1n} \\ A_{21} & A_{22} & A_{23} & & \cdots & A_{2n} \\ A_{31} & A_{32} & A_{33} & & \cdots & A_{3n} \\ \vdots & \vdots & \vdots & \ddots & & \vdots \\ A_{m1} & A_{m2} & A_{m3} & & \cdots & A_{mn} \end{bmatrix} \end{array} \quad (33)$$

$$A_{ij} = \frac{1}{k}\left[\sum\nolimits_{e=1}^{k} A_{ij}^e\right] \quad (34)$$

$$A_{ij} = \left[A_{ij}^L, A_{ij}^U\right] = \begin{bmatrix} \left(a_{1ij}^L, a_{2ij}^L, a_{3ij}^L, a_{4ij}^L; h_{ij}^L\right), \\ \left(a_{1ij}^U, a_{2ij}^U, a_{3ij}^U, a_{4ij}^U; h_{ij}^U\right) \end{bmatrix} \quad (35)$$

The positive and negative ideal solutions $((A^+), (A^-))$ are defined in the second step by considering the equation (36).

$$\begin{aligned} A^+ &= max(v_1, v_2, v_3, \ldots v_n); \\ A^- &= min(v_1, v_2, v_3 \ldots v_n) \end{aligned} \quad (36)$$

In the third step, D^+ and D^- values are calculated with the equations of (37) and (38).

$$D_i^+ = \sqrt{\sum_{i=1}^{m}(v_i - A_i^+)^2} \quad (37)$$

$$D_i^- = \sqrt{\sum_{i=1}^{m}(v_i - A_i^-)^2} \quad (38)$$

The closeness coefficient (CC_i) is defined in the final step with the equation (39).

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (39)$$

APPENDIX F - IT2 FUZZY VIKOR

Firstly, fuzzy decision matrix (X_{ij}) is generated by considering the equations (40) and (41).

$$X_{ij} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \ldots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \ldots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \ldots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \ldots & x_{3n} \\ \vdots & \vdots & \ddots & \ldots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \ldots & x_{mn} \end{bmatrix} \end{array} \quad (40)$$

$$X_{ij} = \frac{1}{K}\left[\sum_{e=1}^{n} X_{ij}^e\right], \quad i = 1, 2, 3, \ldots, m \quad (41)$$

After that, the defuzzification process is performed with the help of the equations (42)-(45).

$$\begin{aligned} Def(x_{ij}) &= Rank(\tilde{x}_{ij})_{m \times n} \\ &= M_1(\tilde{A}_i^U) + M_1(\tilde{A}_i^L) + M_2(\tilde{A}_i^U) \end{aligned}$$

$$
\begin{aligned}
&+M_2(\tilde{A}_i^L)+M_3(\tilde{A}_i^U)+M_3(\tilde{A}_i^L)\\
&-\frac{1}{4}(S_1(\tilde{A}_i^U)+S_1(\tilde{A}_i^L)+S_2(\tilde{A}_i^U)+S_2(\tilde{A}_i^L)\\
&+S_3(\tilde{A}_i^U)+S_3(\tilde{A}_i^L)\\
&+S_4(\tilde{A}_i^U)+S_4(\tilde{A}_i^L))+H_1(\tilde{A}_i^U)+H_1(\tilde{A}_i^L)\\
&+H_2(\tilde{A}_i^U)+H_2(\tilde{A}_i^L)
\end{aligned}
\tag{42}
$$

$$M_p\left(\tilde{A}_i^j\right)=\frac{\left(d_{ip}^j+d_{i(p+1)}^j\right)}{2} \tag{43}$$

$$S_q\left(\tilde{A}_i^j\right)=\sqrt{\frac{1}{2}\sum_{k=q}^{q+1}\left(d_{ik}^j-\frac{1}{2}\sum_{k=q}^{q+1}d_{ik}^j\right)^2} \tag{44}$$

$$S_4\left(\tilde{A}_i^j\right)=\sqrt{\frac{1}{4}\sum_{k=1}^{4}\left(d_{ik}^j-\frac{1}{4}\sum_{k=1}^{4}d_{ik}^j\right)^2} \tag{45}$$

In the next step, the best and worst values (fj*, fj-) are defined by considering the equations (46).

$$f_J^*=\max_i x_{ij} \text{ and } f_J^-=\min_i x_{ij} \tag{46}$$

After that, Si and Ri values are calculated with the equations (47) and (48).

$$S_i=\sum_{i=1}^{n}w_j\frac{\left(\left|f_j^*-x_{ij}\right|\right)}{\left(\left|f_j^*-f_j^-\right|\right)} \tag{47}$$

TABLE 12. Innovative Strategic Principles for TRIZ.

1.Segmentation	11.Cushion in Advance	21.Rushing Through	31.Porous Materials
2.Extraction	12.Equipotentiality	22.Convert Harm into Benefit	32.Changing the Color
3.Local quality	13.Do It in Reverse	23.Feedback	33.Homogeneity
4.Asymmetry	14.Spheroidality	24.Mediator	34.Rejecting and Regenerating Parts
5.Consolidation	15.Dynamicity	25.Self Service	35.Transformation Properties
6.Universality	16.Partial or Excessive Action	26.Copying	36.Phase Transition
7.Nesting (Matrioshka)	17.Transition Into a New Dimension	27.Dispose	37.Thermal Expansion
8.Counterweight	18.Mechanical Vibration	28.Replacement of Mechanical System	38.Accelerated Oxidation
9.Prior Counteraction	19.Periodic Action	29.Pneumatic or Hydraulic Construction	39.Inert Environment
10.Prior Action	20.Continuity of Useful Action	30.Flexible Films or Thin Membranes	40.Composite Materials

TABLE 13. Contradiction Matrix for renewable energy investments.

	Worsening characteristics											
Improving characteristics	**Characteristics**	**CR1**	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**	**CR7**	**CR8**	**CR9**	**CR10**	**CR11**
	CR1	-	3,	3,	3,4,10,11	3,11	3,4,19	10,34	16,19	16,19	10	3
	CR2	16	-	19,23	16,19	11	3,10	11,23	10,19,34	34		16
	CR3	3,16	3	-		11	23		23	19	11	
	CR4	3,4			-	11	23	3	3,23			10
	CR5					-	3,19,23	23	10,19	34	34	
	CR6	3	16	16,19	16	10,11	-	3,23	11,34	3,10,19		16
	CR7	3,4	10	10,19	3		10,16,19	-	23,34	34	3,23	3,24
	CR8				10,16,19	3,23	34	23,34	-	3,23	23	
	CR9				10,16	23	34	34	3	-	11,23	
	CR10	3,11,23	10,16		16,19	3,23	11,34	11,23	16,19	34	-	34
	CR11	11,23	11,16	19	16,19	3,4,23	10,11,16	23,34	10,11,16	34	23,34	-

TABLE 14. Hesitant evaluations for dimensions.

Dimensions	Dimension 1	Dimension 2	Dimension 3
Financial (Dimension 1)	-	{H, VH}	{H}
Functional (Dimension 2)	{M, H}	-	{M}
Physical (Dimension 3)	{M, H}	{M}	-

TABLE 15. Hesitant evaluations for criteria.

Criteria	C1	C2	C3	C4	C5
C1	-	{M, H}	{M, H}	{H, VH}	{M, H}
C2	{VH}	-	{H, VH}	{M}	{M, H}
C3	{M, H}	{M, H, VH}	-	{M}	{H}
C4	{M}	{M, H}	{M, H, VH}	-	{VL, L, M}
C5	{M, H, VH}	{M, H}	{M, H}	{L}	-
C6	{L, M}	{VL, L}	{M}	{M}	{L, M}
C7	{M, H}	{L, M}	{L, M}	{VH}	{H, VH}
C8	{H}	{M, H}	{M, H, VH}	{H, VH}	{M, VH}
C9	{M}	{H}	{M, VH}	{M, H, VH}	{M, H}
Criteria	**C6**	**C7**	**C8**	**C9**	
C1	{H, VH}	{H, VH}	{H}	{H}	
C2	{M, VH}	{VH}	{M}	{H}	
C3	{M, VH}	{M, H}	{VL, M}	{VVL, VL, M}	
C4	{VL}	{M, H}	{M, H}	{VL, M}	
C5	{L, M}	{H}	{VH}	{VL, L, M}	
C6	-	{L, M}	{M, H}	{H, VH}	
C7	{H, VH}	-	{M, H}	{M, H}	
C8	{VL, M}	{L, M, H}	-	{L, M, H}	
C9	{M, H}	{H}	{M}	-	

TABLE 16. Trapezoidal Fuzzy relation matrix for dimensions.

	D1	D2	D3
D1	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.58,0.73,0.73,0.85;1,1), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.50,0.65,0.65,0.80;1,1), (0.55,0.65,0.65,0.75;0.90,0.90))
D2	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90, 0.90))
D3	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.35,0.50,0.50,0.65;1,1), (0.40,0.50,0.50,0.60;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))

$$R_i = max\ j\left[w_j\frac{\left(\left|f_j^* - x_{ij}\right|\right)}{\left(\left|f_j^* - f_j^-\right|\right)}\right] \tag{48}$$

Finally, Q_i is calculated as in the equation (49). In this equation, S^* and R^* gives information about the minimum values whereas S^- and R^- show maximum values.

$$Q_i = \frac{v\left(S_i - S^*\right)}{\left(S^- - S^*\right)} + (1-v)\frac{\left(R_i - R^*\right)}{\left(R^- - R^*\right)} \tag{49}$$

The analysis results should satisfy two different conditions underlined in the equations (50) and (51).

$$Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right) \geq \frac{1}{(j-1)} \tag{50}$$

$$Q\left(A^{(M)}\right) - Q\left(A^{(1)}\right) < \frac{1}{(j-1)} \tag{51}$$

APPENDIX G: INNOVATIVE STRATEGIC PRINCIPLES FOR TRIZ

See Table 12.

APPENDIX H: CONTRADICTION MATRIX FOR RENEWABLE ENERGY INVESTMENTS

See Table 13.

APPENDIX I: HESITANT EVALUATIONS FOR DIMENSIONS

See Table 14.

TABLE 17. Trapezoidal fuzzy relation matrix for criteria.

	C1	C2	C3	C4	C5
C1	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))
C2	((0.65,0.80,0.80,0.90;1,1), (0.70,0.80,0.80,0.85;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))
C3	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))
C4	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.22,0.35,0.35,0.50;1,1), (0.27,0.35,0.35,0.45;0.90,0.90))
C5	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.20,0.35,0.35,0.50;1,1), (0.25,0.35,0.35,0.45;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))
C6	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))	((0.15,0.28,0.28,0.43;1,1), (0.20,0.28,0.28,0.38;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))
C7	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))	((0.65,0.80,0.80,0.90;1,1), (0.70,0.80,0.80,0.85;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))
C8	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))
C9	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))

	C6	C7	C8	C9
C1	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))
C2	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.65,0.80,0.80,0.90;1,1), (0.70,0.80,0.80,0.85;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))

APPENDIX J: HESITANT EVALUATIONS FOR CRITERIA

See Table 15.

APPENDIX K: TRAPEZOIDAL FUZZY RELATION MATRIX FOR DIMENSIONS

See Table 16.

TABLE 17. ***(Continued.)*** **Trapezoidal fuzzy relation matrix for criteria.**

	C6	C7	C8	C9
C3	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.23,0.35,0.35,0.50;1,1), (0.28,0.35,0.35,0.45;0.90,0.90))	((0.15,0.28,0.28,0.43;1,1), (0.20,0.28,0.28,0.38;0.90,0.90))
C4	((0.10,0.20,0.20,0.35;1,1), (0.15,0.20,0.20,0.30;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.23,0.35,0.35,0.50;1,1), (0.28,0.35,0.35,0.45;0.90,0.90))
C5	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.65,0.80,0.80,0.90;1,1), (0.70,0.80,0.80,0.85;0.90,0.90))	((0.22,0.35,0.35,0.50;1,1), (0.27,0.35,0.35,0.45;0.90,0.90))
C6	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.28,0.43,0.43,0.58;1,1), (0.33,0.43,0.43,0.53;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))
C7	((0.58,0.73,0.73,0.85;1.00,1.00), (0.63,0.73,0.73,0.80;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))
C8	((0.23,0.35,0.35,0.50;1,1), (0.28,0.35,0.35,0.45;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))
C9	((0.43,0.58,0.58,0.73;1,1), (0.48,0.58,0.58,0.68;0.90,0.90))	((0.50,0.65,0.65,0.78;1,1), (0.55,0.65,0.65,0.73;0.90,0.90))	((0.35,0.50,0.50,0.65;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0,0,0,0;1,1), (0,0,0,0;0.90,0.90))

TABLE 18. **Normalized relation matrix for dimensions (alpha-level set: 0).**

Dimensions	Dimension 1	Dimension 2	Dimension 3
Dimension 1	[0,0]	[0.36,0.50]	[0.32,0.47]
Dimension 2	[0.27,0.42]	[0,0]	[0.23,0.38]
Dimension 3	[0.27,0.42]	[0.23,0.38]	[0,0]

APPENDIX L: TRAPEZOIDAL FUZZY RELATION MATRIX FOR CRITERIA

See Table 17.

APPENDIX M: NORMALIZED RELATION MATRIX FOR DIMENSIONS (ALPHA-LEVEL SET: 0)

See Table 18.

TABLE 19. **Total relation matrix for dimensions (alpha-level set: 0).**

Dimensions	Dimension1	Dimension 2	Dimension 3
Dimension 1	[0.32,1.96]	[0.61,2.34]	[0.56,2.28]
Dimension 2	[0.46,2.02]	[0.27,1.77]	[0.44,2.00]
Dimension 3	[0.46,2.02]	[0.45,2.04]	[0.25,1.72]

APPENDIX N: TOTAL RELATION MATRIX FOR DIMENSIONS (ALPHA-LEVEL SET: 0)

See Table 19.

APPENDIX O: UNWEIGHTED SUPERMATRIX FOR DIMENSIONS BY ALPHA LEVEL SETS

See Table 20.

TABLE 20. Unweighted supermatrix for dimensions by alpha level sets.

α: 0				α: 0.1				α: 0.2			
	D1	D2	D3		D1	D2	D3		D1	D2	D3
D1	0.28	0.36	0.36	D1	0.28	0.36	0.36	D1	0.27	0.36	0.36
D2	0.37	0.29	0.36	D2	0.37	0.29	0.36	D2	0.37	0.29	0.36
D3	0.35	0.35	0.28	D3	0.35	0.35	0.28	D3	0.35	0.35	0.28
α: 0.3				α: 0.4				α: 0.5			
	D1	D2	D3		D1	D2	D3		D1	D2	D3
D1	0.27	0.36	0.36	D1	0.27	0.37	0.37	D1	0.26	0.37	0.37
D2	0.37	0.28	0.36	D2	0.38	0.28	0.37	D2	0.38	0.28	0.37
D3	0.36	0.35	0.27	D3	0.36	0.36	0.27	D3	0.36	0.36	0.27
α: 0.6				α: 0.7				α: 0.8			
	D1	D2	D3		D1	D2	D3		D1	D2	D3
D1	0.26	0.37	0.37	D1	0.26	0.37	0.37	D1	0.27	0.37	0.38
D2	0.38	0.27	0.37	D2	0.38	0.27	0.37	D2	0.37	0.27	0.36
D3	0.36	0.36	0.26	D3	0.36	0.36	0.26	D3	0.36	0.37	0.26
α: 0.9				α: 1				α: average values			
	D1	D2	D3		D1	D2	D3		D1	D2	D3
D1	0.26	0.37	0.37	D1	0.26	0.37	0.37	D1	0.27	0.37	0.37
D2	0.38	0.27	0.37	D2	0.38	0.27	0.37	D2	0.37	0.28	0.37
D3	0.36	0.36	0.26	D3	0.36	0.36	0.26	D3	0.36	0.36	0.27

TABLE 21. Total relation matrix for criteria (alpha-level set: 0).

Criteria	C1	C2	C3	C4	C5
C1	[0.10,0.70]	[0.16,0.76]	[0.17,0.81]	[0.19,0.82]	[0.16,0.79]
C2	[0.20,0.82]	[0.09,0.66]	[0.19,0.82]	[0.16,0.79]	[0.17,0.78]
C3	[0.15,0.70]	[0.15,0.68]	[0.08,0.61]	[0.14,0.69]	[0.15,0.70]
C4	[0.13,0.65]	[0.13,0.63]	[0.15,0.67]	[0.07,0.57]	[0.11,0.62]
C5	[0.16,0.73]	[0.14,0.69]	[0.15,0.73]	[0.12,0.70]	[0.08,0.61]
C6	[0.11,0.64]	[0.09,0.60]	[0.13,0.66]	[0.13,0.66]	[0.11,0.63]
C7	[0.16,0.76]	[0.13,0.70]	[0.14,0.74]	[0.19,0.78]	[0.17,0.76]
C8	[0.17,0.75]	[0.15,0.71]	[0.17,0.75]	[0.18,0.76]	[0.16,0.74]
C9	[0.15,0.75]	[0.16,0.73]	[0.17,0.77]	[0.17,0.77]	[0.15,0.75]
Criteria	C6	C7	C8	C9	
C1	[0.18,0.77]	[0.19,0.84]	[0.17,0.80]	[0.16,0.74]	
C2	[0.17,0.76]	[0.21,0.84]	[0.15,0.77]	[0.17,0.74]	
C3	[0.15,0.67]	[0.15,0.72]	[0.12,0.66]	[0.10,0.60]	
C4	[0.09,0.58]	[0.14,0.68]	[0.13,0.65]	[0.10,0.58]	
C5	[0.12,0.66]	[0.17,0.75]	[0.18,0.73]	[0.11,0.63]	
C6	[0.06,0.53]	[0.12,0.66]	[0.13,0.65]	[0.15,0.62]	
C7	[0.17,0.73]	[0.10,0.68]	[0.16,0.74]	[0.15,0.69]	
C8	[0.12,0.67]	[0.15,0.76]	[0.09,0.63]	[0.13,0.67]	
C9	[0.15,0.72]	[0.17,0.79]	[0.14,0.73]	[0.08,0.59]	

APPENDIX P: TOTAL RELATION MATRIX FOR CRITERIA (ALPHA-LEVEL SET: 0)

See Table 21.

APPENDIX R: UNWEIGHTED SUPERMATRIX FOR CRITERIA (ALPHA-LEVEL SET: 0)

See Table 22.

APPENDIX S: WEIGHTED SUPERMATRIX FOR CRITERIA (ALPHA-LEVEL SET: 0)

See Table 23.

APPENDIX T: LIMIT SUPERMATRIX FOR CRITERIA (ALPHA-LEVEL SET: 0)

See Table 24.

TABLE 22. Unweighted supermatrix for criteria (alpha-level set: 0).

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Criterion 1	0.30	0.37	0.36	0.33	0.34	0.34	0.35	0.34	0.33
Criterion 2	0.34	0.27	0.35	0.32	0.32	0.31	0.32	0.32	0.33
Criterion 3	0.36	0.36	0.29	0.35	0.34	0.35	0.34	0.34	0.34
Criterion 4	0.35	0.34	0.33	0.31	0.36	0.37	0.35	0.36	0.35
Criterion 5	0.33	0.33	0.34	0.36	0.30	0.35	0.33	0.34	0.33
Criterion 6	0.33	0.33	0.33	0.33	0.34	0.28	0.32	0.30	0.32
Criterion 7	0.36	0.36	0.37	0.36	0.36	0.33	0.31	0.37	0.38
Criterion 8	0.33	0.32	0.33	0.34	0.35	0.34	0.36	0.30	0.35
Criterion 9	0.31	0.31	0.30	0.30	0.29	0.33	0.33	0.33	0.27

TABLE 23. Weighted supermatrix for criteria (alpha-level set: 0).

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Criterion 1	0.08	0.10	0.10	0.12	0.12	0.12	0.12	0.12	0.12
Criterion 2	0.10	0.08	0.10	0.12	0.11	0.11	0.11	0.11	0.12
Criterion 3	0.10	0.10	0.08	0.12	0.12	0.13	0.12	0.12	0.12
Criterion 4	0.13	0.12	0.12	0.09	0.10	0.11	0.12	0.13	0.12
Criterion 5	0.12	0.12	0.12	0.11	0.09	0.10	0.12	0.12	0.12
Criterion 6	0.12	0.12	0.12	0.10	0.10	0.08	0.11	0.11	0.11
Criterion 7	0.12	0.13	0.13	0.13	0.12	0.12	0.09	0.11	0.11
Criterion 8	0.12	0.11	0.12	0.12	0.12	0.12	0.10	0.08	0.10
Criterion 9	0.11	0.11	0.10	0.10	0.10	0.12	0.09	0.09	0.08

TABLE 24. Limit supermatrix for criteria (alpha-level set: 0).

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
Criterion 1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 2	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 3	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 4	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Criterion 5	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 6	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 7	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Criterion 8	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Criterion 9	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

APPENDIX U: HESITANT EVALUATIONS FOR ALTERNATIVES

See Table 25.

APPENDIX V: TRAPEZOIDAL FUZZY DECISION MATRIX

See Table 26.

TABLE 25. Hesitant evaluations for alternatives.

Criteria	Local Quality (A1)	Asymmetry (A2)	Prior Action (A3)	Cushion in Advance (A4)
C1	{H}	{H, VH}	{H}	{MH, H, VH}
C2	{MH, H}	{MH}	{MH}	{M, MH}
C3	{MH, H}	{M, MH}	{M, MH}	{M, MH}
C4	{MH, H, VH}	{M}	{H, VH}	{MH, H}
C5	{ML, MH}	{M}	{M, MH, H}	{MH}
C6	{ML, M}	{MH, H}	{M}	{MH}
C7	{H, VH}	{MH, H}	{H}	{H}
C8	{M, MH}	{M}	{H}	{H}
C9	{M, MH}	{H, VH}	{MH, H}	{MH, H}
Criteria	**Partial or Excessive Action (A5)**	**Periodic Action (A6)**	**Feedback (A7)**	**Rejecting and Regenerating Parts (A8)**
C1	{H}	{MH}	{ML, M}	{H, VH}
C2	{MH}	{ML, M}	{M, MH}	{M, MH}
C3	{MH}	{ML, M}	{H}	{M, MH}
C4	{MH, H}	{M, MH, H}	{H, VH}	{M, MH}
C5	{MH}	{MH}	{M, MH}	{M, MH}
C6	{M, MH}	{MH}	{ML, M}	{H, VH}
C7	{M}	{M, MH, H}	{M, MH}	{MH}
C8	{M}	{ML, M, MH}	{H}	{MH}
C9	{M, MH, H}	{M, MH, H}	{H, VH}	{M, MH}

TABLE 26. Trapezoidal fuzzy decision matrix.

Criteria	A1	A2	A3	A4
C1	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))
C2	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C3	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C4	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))
C5	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))

TABLE 26. ***(Continued.)*** **Trapezoidal fuzzy decision matrix.**

Criteria	A1	A2	A3	A4
C6	((0.20,0.40,0.40,0.60;1,1), (0.30,0.40,0.40,0.50;0.90,0.90))	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))
C7	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90))	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.7,0.9,0.9,1;1,1), (0.8,0.9,0.9,0.95;0.90,0.90))
C8	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.7,0.9,0.9,1;1,1), (0.8,0.9,0.9,0.95;0.90,0.90))
C9	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))

Criteria	A5	A6	A7	A8
C1	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.20,0.40,0.40,0.60;1,1), (0.30,0.40,0.40,0.50;0.90,0.90)	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)
C2	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.20,0.40,0.40,0.60;1,1), (0.30,0.40,0.40,0.50;0.90,0.90)	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C3	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.20,0.40,0.40,0.60;1,1), (0.30,0.40,0.40,0.50;0.90,0.90)	((0.7,0.9,0.9,1;1,1), (0.8,0.9,0.9,0.95;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C4	((0.6,0.8,0.8,0.95;1,1), (0.7,0.8,0.8,0.88;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C5	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))
C6	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.20,0.40,0.40,0.60;1,1), (0.30,0.40,0.40,0.50;0.90,0.90)	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)
C7	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))
C8	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.30,0.50,0.50,0.70;1.00,1.00), (0.40,0.50,0.50,0.60;0.90,0.90))	((0.70,0.87,0.87,0.97;1,1), (0.78,0.87,0.87,0.92;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))
C9	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.50,0.70,0.70,0.90;1,1), (0.60,0.70,0.70,0.80;0.90,0.90))	((0.80,0.95,0.95,1;1,1), (0.88,0.95,0.95,0.98;0.90,0.90)	((0.40,0.60,0.60,0.80;1,1), (0.50,0.60,0.60,0.70;0.90,0.90))

REFERENCES

[1] F. Liu, S. Tait, A. Schellart, M. Mayfield, and J. Boxall, "Reducing carbon emissions by integrating urban water systems and renewable energy sources at a community scale," *Renew. Sustain. Energy Rev.*, vol. 123, May 2020, Art. no. 109767.

[2] R. Akram, F. Chen, F. Khalid, Z. Ye, and M. T. Majeed, "Heterogeneous effects of energy efficiency and renewable energy on carbon emissions: Evidence from developing countries," *J. Cleaner Prod.*, vol. 247, Feb. 2020, Art. no. 119122.

[3] H. Chamandoust, G. Derakhshan, S. M. Hakimi, and S. Bahramara, "Tri-objective scheduling of residential smart electrical distribution grids with optimal joint of responsive loads with renewable energy sources," *J. Energy Storage*, vol. 27, Feb. 2020, Art. no. 101112.

[4] J. Leithon, S. Werner, and V. Koivunen, "Cost-aware renewable energy management: Centralized vs. distributed generation," *Renew. Energy*, vol. 147, pp. 1164–1179, Mar. 2020.

[5] J. Xie, Q. Qin, and M. Jiang, "Multiobjective decision-making for technical characteristics selection in a house of quality," *Math. Problems Eng.*, vol. 2020, pp. 1–12, Apr. 2020.

[6] H. Dinçer and S. Yüksel, "Analysis of the customer-based efficiency at workplace for tourism industry using house of quality," in *Handbook of Research on Positive Organizational Behavior for Improved Workplace Performance*. Hershey, PA, USA: IGI Global, 2020, pp. 310–329.

[7] M. Ozalp, D. Kucukbas, E. Ilbahar, and S. Cebi, "Integration of quality function deployment with IVIF-AHP and Kano model for customer oriented product design," in *Customer Oriented Product Design*. Cham, Switzerland: Springer, 2020, pp. 93–106.

[8] T. W. Liskiewicz, K. J. Kubiak, D. L. Mann, and T. G. Mathia, "Analysis of surface roughness morphology with TRIZ methodology in automotive electrical contacts: Design against third body fretting-corrosion," *Tribology Int.*, vol. 143, Mar. 2020, Art. no. 106019.

[9] C.-H. Lee, C.-H. Chen, F. Li, and A.-J. Shie, "Customized and knowledge-centric service design model integrating case-based reasoning and TRIZ," *Expert Syst. Appl.*, vol. 143, Apr. 2020, Art. no. 113062.

[10] B. Taşkın, N. Başoğlu, T. Daim, and H. Barham, "Creativity in design process using TRIZ: Application to smart kitchen design," in *R&D Management in the Knowledge Era*. Cham, Switzerland: Springer, 2019, pp. 223–236.

[11] M. Mohammadi and J. Rezaei, "Ensemble ranking: Aggregation of rankings produced by different multi-criteria decision-making methods," *Omega*, vol. 96, Oct. 2020, Art. no. 102254.

[12] F. Sari, I. Kandemir, D. A. Ceylan, and A. Gül, "Using AHP and PROMETHEE multi-criteria decision making methods to define suitable apiary locations," *J. Apicultural Res.*, pp. 1–12, Feb. 2020.

[13] M. Yazdani, P. Zarate, E. Kazimieras Zavadskas, and Z. Turskis, "A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems," *Manage. Decis.*, vol. 57, no. 9, pp. 2501–2519, Oct. 2019.

[14] S. Shahba, R. Arjmandi, M. Monavari, and J. Ghodusi, "Application of multi-attribute decision-making methods in SWOT analysis of mine waste management (case study: Sirjan's Golgohar Iron Mine, Iran)," *Resour. Policy*, vol. 51, pp. 67–76, Mar. 2017.

[15] A. Arabsheybani, M. M. Paydar, and A. S. Safaei, "An integrated fuzzy MOORA method and FMEA technique for sustainable supplier selection considering quantity discounts and supplier's risk," *J. Cleaner Prod.*, vol. 190, pp. 577–591, Jul. 2018.

[16] T.-Y. Chen, "Remoteness index-based pythagorean fuzzy VIKOR methods with a generalized distance measure for multiple criteria decision analysis," *Inf. Fusion*, vol. 41, pp. 129–150, May 2018.

[17] A. Ilyas, M. R. Khan, and M. Ayyub, "FPGA based real-time implementation of fuzzy logic controller for maximum power point tracking of solar photovoltaic system," *Optik*, vol. 213, Jul. 2020, Art. no. 164668.

[18] S. Moussa and S. B. Hadj Kacem, "Symbolic approximate reasoning with fuzzy and multi-valued knowledge," *Procedia Comput. Sci.*, vol. 112, pp. 800–810, Jan. 2017.

[19] E. Salimi, A. H. Cadenbach, and A. E. Abbas, "Survey of four uncertainty quantifications methods in systems engineering," in *Disciplinary Convergence in Systems Engineering Research*. Cham, Switzerland: Springer, 2018, pp. 945–957.

[20] S. Wang, J. Ha, H. Kalkavan, S. Yüksel, and H. Dinçer, "IT2-based hybrid approach for sustainable economic equality: A case of e7 economies," *SAGE Open*, vol. 10, no. 2, Apr. 2020, Art. no. 215824402092443.

[21] H. Li, C. Wu, X. Jing, and L. Wu, "Fuzzy tracking control for nonlinear networked systems," *IEEE Trans. Cybern.*, vol. 47, no. 8, pp. 2020–2031, Aug. 2017.

[22] P. Maji and P. Garai, "Rough hypercuboid based generalized and robust IT2 fuzzy C-means algorithm," *IEEE Trans. Cybern.*, early access, Jul. 16, 2019, doi: 10.1109/TCYB.2019.2925130.

[23] D. Wu and J. M. Mendel, "Recommendations on designing practical interval type-2 fuzzy systems," *Eng. Appl. Artif. Intell.*, vol. 85, pp. 182–193, Oct. 2019.

[24] Y. Liu, J. Carlos, R. Alcantud, R. M. Rodríguez, K. Qin, and L. Martínez, "Intertemporal hesitant fuzzy soft sets: Application to group decision making," *Int. J. Fuzzy Syst.*, vol. 22, pp. 619–635, Feb. 2020.

[25] F. Zhang, J. Li, J. Chen, J. Sun, and A. Attey, "Hesitant distance set on hesitant fuzzy sets and its application in urban road traffic state identification," *Eng. Appl. Artif. Intell.*, vol. 61, pp. 57–64, May 2017.

[26] S. Hussain, M. A. Ahmed, and Y.-C. Kim, "Efficient power management algorithm based on fuzzy logic inference for electric vehicles parking lot," *IEEE Access*, vol. 7, pp. 65467–65485, 2019.

[27] H. Hamrawi, S. Coupland, and R. John, "Type-2 fuzzy alpha-cuts," *IEEE Trans. Fuzzy Syst.*, vol. 25, no. 3, pp. 682–692, Jun. 2017.

[28] Y.-Y. Yang, X.-W. Liu, and F. Liu, "Trapezoidal interval type-2 fuzzy TOPSIS using alpha-cuts," *Int. J. Fuzzy Syst.*, vol. 22, no. 1, pp. 293–309, Feb. 2020.

[29] W. Song, Y. Zhu, and Q. Zhao, "Analyzing barriers for adopting sustainable online consumption: A rough hierarchical DEMATEL method," *Comput. Ind. Eng.*, vol. 140, Feb. 2020, Art. no. 106279.

[30] W. Fan and F. Xiao, "A new conflict management in evidence theory based on DEMATEL method," *J. Sensors*, vol. 2019, pp. 1–12, Nov. 2019.

[31] L. E. Quezada, H. A. López-Ospina, P. I. Palominos, and A. M. Oddershede, "Identifying causal relationships in strategy maps using ANP and DEMATEL," *Comput. Ind. Eng.*, vol. 118, pp. 170–179, Apr. 2018.

[32] C.-C. Chou, "Application of ANP to the selection of shipping registry: The case of taiwanese maritime industry," *Int. J. Ind. Ergonom.*, vol. 67, pp. 89–97, Sep. 2018.

[33] X. Li, Y. Han, X. Wu, and D. A. Zhang, "Evaluating node importance in complex networks based on TOPSIS and gray correlation," in *Proc. Chin. Control Decis. Conf. (CCDC)*, Jun. 2018, pp. 750–754.

[34] S. A. Rakhshan, "Efficiency ranking of decision making units in data envelopment analysis by using TOPSIS-DEA method," *J. Oper. Res. Soc.*, vol. 68, no. 8, pp. 906–918, Aug. 2017.

[35] I. Belski, "TRIZ thinking heuristics to nurture future generations of creative engineers," *Australas. J. Eng. Educ.*, vol. 24, no. 2, pp. 86–97, Jul. 2019.

[36] D. Casner, P. Livotov, and P. K. da Silva, "TRIZ-based approach for process intensification and problem solving in process engineering: Concepts and research agenda," in *Advances and Impacts of the Theory of Inventive Problem Solving*. Cham, Switzerland: Springer, 2018, pp. 217–229.

[37] A. Albers, D. Wagner, L. Kern, and T. Höfler, "Adaption of the TRIZ method to the development of electric energy storage systems," *Procedia CIRP*, vol. 21, pp. 509–514, Jan. 2014.

[38] W. Daoping, S. Qingbin, and N. Jing, "Research on knowledge base system of coal energy saving based on TRIZ theory," *Procedia Eng.*, vol. 29, pp. 447–451, Jan. 2012.

[39] J. M. Vicente Gomila and F. Palop Marro, "Combining tech-mining and semantic-TRIZ for a faster and better technology analysis: A case in energy storage systems," *Technol. Anal. Strategic Manage.*, vol. 25, no. 6, pp. 725–743, Jul. 2013.

[40] H. Zheng, H.-C. Zhang, and F.-Y. Zhang, "An innovative design of energy-saving products based on QFD/TRIZ/DEA integration," in *Proc. IEEE 17Th Int. Conf. Ind. Eng. Eng. Manage.*, Oct. 2010, pp. 831–834.

[41] P. Yong, Y. Wenhui, and W. Heng, "The study on energy saving and output enhancement of pumping well based on the theory of QFD/TRIZ," in *Proc. Int. Conf. Energy Environ. Technol.*, Oct. 2009, pp. 449–453.

[42] Z. Tang and H. Dinçer, "Selecting the house-of-quality-based energy investment policies for the sustainable emerging economies," *Sustainability*, vol. 11, no. 13, p. 3514, Jun. 2019.

[43] J. Xu, M. Ye, X. Peng, and Z. Li, "Influential factor analysis of China's unsustainable electric power system: A case study of Chengdu electric bureau," *Energy Policy*, vol. 129, pp. 975–984, Jun. 2019.

[44] E. Haktanır and C. Kahraman, "A novel interval-valued pythagorean fuzzy QFD method and its application to solar photovoltaic technology development," *Comput. Ind. Eng.*, vol. 132, pp. 361–372, Jun. 2019.

[45] B. Efe, M. A. Yerlikaya, and Ö. F. Efe, "Mobile phone selection based on a novel quality function deployment approach," *Soft Comput.*, pp. 1–15, Mar. 2020.

[46] S. Filketu, A. Dvivedi, and B. B. Abebe, "Decision-making on job satisfaction improvement programmes using fuzzy QFD model: A case study in Ethiopia," *Total Qual. Manage. Bus. Excellence*, vol. 30, nos. 9–10, pp. 1068–1091, 2019.

[47] J. Huang, X.-Y. You, H.-C. Liu, and S.-L. Si, "New approach for quality function deployment based on proportional hesitant fuzzy linguistic term sets and prospect theory," *Int. J. Prod. Res.*, vol. 57, no. 5, pp. 1283–1299, Mar. 2019.

[48] M. W. Zafar, M. Shahbaz, F. Hou, and A. Sinha, "From nonrenewable to renewable energy and its impact on economic growth: The role of research & development expenditures in Asia–Pacific economic cooperation countries," *J. Cleaner Prod.*, vol. 212, pp. 1166–1178, Mar. 2019.

[49] M. M. Rahman and X.-B. Vu, "The nexus between renewable energy, economic growth, trade, Urbanisation and environmental quality: A comparative study for Australia and Canada," *Renew. Energy*, vol. 155, pp. 617–627, Aug. 2020.

[50] S. Kim, "The effects of foreign direct investment, economic growth, industrial structure, renewable and nuclear energy, and urbanization on Korean greenhouse gas emissions," *Sustainability*, vol. 12, no. 4, p. 1625, Feb. 2020.

[51] B. Ozcan and I. Ozturk, "Renewable energy consumption-economic growth nexus in emerging countries: A bootstrap panel causality test," *Renew. Sustain. Energy Rev.*, vol. 104, pp. 30–37, Apr. 2019.

[52] P. Behuria, "The politics of late late development in renewable energy sectors: Dependency and contradictory tensions in India's national solar mission," *World Develop.*, vol. 126, Feb. 2020, Art. no. 104726.

[53] M. Aydin, "The effect of biomass energy consumption on economic growth in BRICS countries: A country-specific panel data analysis," *Renew. Energy*, vol. 138, pp. 620–627, Aug. 2019.

[54] M. A. Baloch, N. Mahmood, and J. W. Zhang, "Effect of natural resources, renewable energy and economic development on CO_2 emissions in BRICS countries," *Sci. Total Environ.*, vol. 678, pp. 632–638, 2019.

[55] M. A. Destek and A. Aslan, "Disaggregated renewable energy consumption and environmental pollution nexus in G-7 countries," *Renew. Energy*, vol. 151, pp. 1298–1306, May 2020.

[56] Y. Chen, Z. Wang, and Z. Zhong, "CO_2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China," *Renew. Energy*, vol. 131, pp. 208–216, Feb. 2019.

[57] A. Sharif, S. A. Raza, I. Ozturk, and S. Afshan, "The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: A global study with the application of heterogeneous panel estimations," *Renew. Energy*, vol. 133, pp. 685–691, Apr. 2019.

[58] M. Kahia, M. Ben Jebli, and M. Belloumi, "Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries," *Clean Technol. Environ. Policy*, vol. 21, no. 4, pp. 871–885, May 2019.

[59] R. Kiani Mavi and C. Standing, "Critical success factors of sustainable project management in construction: A fuzzy DEMATEL-ANP approach," *J. Cleaner Prod.*, vol. 194, pp. 751–765, Sep. 2018.

[60] A. Karaşan and C. Kahraman, "A novel intuitionistic fuzzy DEMATEL–ANP–TOPSIS integrated methodology for freight village location selection," *J. Intell. Fuzzy Syst.*, vol. 36, no. 2, pp. 1335–1352, Mar. 2019.

[61] S. L. Razavi Toosi and J. M. V. Samani, "Prioritizing watersheds using a novel hybrid decision model based on fuzzy DEMATEL, fuzzy ANP and fuzzy VIKOR," *Water Resour. Manage.*, vol. 31, no. 9, pp. 2853–2867, Jul. 2017.

[62] A. K. Bera, D. K. Jana, D. Banerjee, and T. Nandy, "Supplier selection using extended IT2 fuzzy TOPSIS and IT2 fuzzy MOORA considering subjective and objective factors," *Soft Comput.*, vol. 24, pp. 8899–8915, Nov. 2019.

[63] L. Zhong and L. Yao, "An ELECTRE I-based multi-criteria group decision making method with interval type-2 fuzzy numbers and its application to supplier selection," *Appl. Soft Comput.*, vol. 57, pp. 556–576, Aug. 2017.

[64] A. Heidarzade, I. Mahdavi, and N. Mahdavi-Amiri, "Supplier selection using a clustering method based on a new distance for interval type-2 fuzzy sets: A case study," *Appl. Soft Comput.*, vol. 38, pp. 213–231, Jan. 2016.

[65] S. Yüksel and H. Dinçer, "SERVQUAL-based performance analysis of agricultural financing in E-banking industry: An evaluation by IT2 fuzzy decision-making model," in *Tools and Techniques for Implementing International E-Trading Tactics for Competitive Advantage*. Hershey, PA, USA: IGI Global, 2020, pp. 21–41.

[66] Z. Ren, Z. Xu, and H. Wang, "Dual hesitant fuzzy VIKOR method for multi-criteria group decision making based on fuzzy measure and new comparison method," *Inf. Sci.*, vols. 388–389, pp. 1–16, May 2017.

[67] M. Ikram, Q. Zhang, and R. Sroufe, "Developing integrated management systems using an AHP–fuzzy VIKOR approach," *Bus. Strategy Environ.*, pp. 1–19, Apr. 2020.

[68] H. Safari, Z. Faraji, and S. Majidian, "Identifying and evaluating enterprise architecture risks using FMEA and fuzzy VIKOR," *J. Intell. Manuf.*, vol. 27, no. 2, pp. 475–486, Apr. 2016.

[69] A. E. D. Ribeiro, M. C. Arouca, and D. M. Coelho, "Electric energy generation from small-scale solar and wind power in Brazil: The influence of location, area and shape," *Renew. Energy*, vol. 85, pp. 554–563, Jan. 2016.

[70] U. E. Hansen, C. Gregersen, R. Lema, D. Samoita, and F. Wandera, "Technological shape and size: A disaggregated perspective on sectoral innovation systems in renewable electrification pathways," *Energy Res. Social Sci.*, vol. 42, pp. 13–22, Aug. 2018.

[71] M. A. H. Mondal, D. Hawila, S. Kennedy, and T. Mezher, "The GCC countries RE-readiness: Strengths and gaps for development of renewable energy technologies," *Renew. Sustain. Energy Rev.*, vol. 54, pp. 1114–1128, Feb. 2016.

[72] D. Wu, G. Li, M. Javadi, A. M. Malyscheff, M. Hong, and J. N. Jiang, "Assessing impact of renewable energy integration on system strength using site-dependent short circuit ratio," *IEEE Trans. Sustain. Energy*, vol. 9, no. 3, pp. 1072–1080, Jul. 2018.

[73] L. W. Chong, Y. W. Wong, R. K. Rajkumar, R. K. Rajkumar, and D. Isa, "Hybrid energy storage systems and control strategies for stand-alone renewable energy power systems," *Renew. Sustain. Energy Rev.*, vol. 66, pp. 174–189, Dec. 2016.

[74] T. Adefarati and R. C. Bansal, "Reliability, economic and environmental analysis of a microgrid system in the presence of renewable energy resources," *Appl. Energy*, vol. 236, pp. 1089–1114, Feb. 2019.

[75] E. Heylen, G. Deconinck, and D. Van Hertem, "Review and classification of reliability indicators for power systems with a high share of renewable energy sources," *Renew. Sustain. Energy Rev.*, vol. 97, pp. 554–568, Dec. 2018.

[76] R. Randoll, W. Wondrak, and A. Schletz, "Lifetime and manufacturability of integrated power electronics," *Microelectron. Rel.*, vol. 64, pp. 513–518, Sep. 2016.

[77] P.-T. Hsiao, W.-T. Hung, Y.-C. Chen, L.-K. Huang, C.-C. Chang, C.-F. Chen, H.-W. Chen, M.-D. Lu, Y.-P. Lin, and Y.-L. Tung, "Pilot operation and lifetime assessment for indoor light energy harvesting photovoltaics," *Renew. Energy*, vol. 152, pp. 67–74, Jun. 2020.

[78] A. Kumar, B. Sah, A. R. Singh, Y. Deng, X. He, P. Kumar, and R. C. Bansal, "A review of multi criteria decision making (MCDM) towards sustainable renewable energy development," *Renew. Sustain. Energy Rev.*, vol. 69, pp. 596–609, Mar. 2017.

[79] A. Göllei, P. Görbe, and A. Magyar, "Measurement based modeling and simulation of hydrogen generation cell in complex domestic renewable energy systems," *J. Cleaner Prod.*, vol. 111, pp. 17–24, Jan. 2016.

[80] G. S. Al'tshuller, *The Innovation Algorithm: TRIZ, Systematic Innovation and Technical Creativity*. Worcester, MA, USA: Technical Innovation Center, 1999.

[81] E. Foster, M. Contestabile, J. Blazquez, B. Manzano, M. Workman, and N. Shah, "The unstudied barriers to widespread renewable energy deployment: Fossil fuel price responses," *Energy Policy*, vol. 103, pp. 258–264, Apr. 2017.

[82] D. J. Davidson, "Exnovating for a renewable energy transition," *Nature Energy*, vol. 4, no. 4, pp. 254–256, Apr. 2019.

[83] R. Kardooni, S. B. Yusoff, and F. B. Kari, "Renewable energy technology acceptance in peninsular malaysia," *Energy Policy*, vol. 88, pp. 1–10, Jan. 2016.

[84] E. Bacchetti, "A design approach with method and tools to support SMEs in designing and implementing distributed renewable energy (DRE) solutions based on sustainable product-service system (S.PSS)," *Procedia CIRP*, vol. 64, pp. 229–234, Jan. 2017.

[85] T. Aized, M. Shahid, A. A. Bhatti, M. Saleem, and G. Anandarajah, "Energy security and renewable energy policy analysis of Pakistan," *Renew. Sustain. Energy Rev.*, vol. 84, pp. 155–169, Mar. 2018.

[86] J. N. V. Lucas, G. E. Francés, and E. S. M. González, ''Energy security and renewable energy deployment in the EU: Liaisons dangereuses or virtuous circle?'' *Renew. Sustain. Energy Rev.*, vol. 62, pp. 1032–1046, Sep. 2016.

[87] H. Pettifor, C. Wilson, S. Bogelein, E. Cassar, L. Kerr, and M. Wilson, ''Are low-carbon innovations appealing? A typology of functional, symbolic, private and public attributes,'' *Energy Res. Social Sci.*, vol. 64, Jun. 2020, Art. no. 101422.

[88] N. Chaloux, G. Boisjoly, E. Grisé, A. El-Geneidy, and D. Levinson, ''I only get some satisfaction: Introducing satisfaction into measures of accessibility,'' *Transp. Res. F, Traffic Psychol. Behav.*, vol. 62, pp. 833–843, Apr. 2019.

[89] J. Yaghoubi, M. Yazdanpanah, and N. Komendantova, ''Iranian agriculture advisors' perception and intention toward Biofuel: Green way toward energy security, rural development and climate change mitigation,'' *Renew. Energy*, vol. 130, pp. 452–459, Jan. 2019.

[90] P. Ganguly, S. Poddar, S. Dutta, and M. Nasipuri, ''Analysis of the security anomalies in the smart metering infrastructure and its impact on energy profiling and measurement,'' in *Proc. 5th Int. Conf. Smart Cities Green ICT Syst.*, Apr.2016, pp. 1–7.

[91] S. E. Hosseini and M. A. Wahid, ''Hydrogen from solar energy, a clean energy carrier from a sustainable source of energy,'' *Int. J. Energy Res.*, vol. 44, no. 6, pp. 4110–4131, May 2020.

[92] C. Mombeuil, ''Institutional conditions, sustainable energy, and the UN sustainable development discourse: A focus on haiti,'' *J. Cleaner Prod.*, vol. 254, May 2020, Art. no. 120153.

[93] W. Gan, X. Ai, J. Fang, M. Yan, W. Yao, W. Zuo, and J. Wen, ''Security constrained co-planning of transmission expansion and energy storage,'' *Appl. Energy*, vol. 239, pp. 383–394, Apr. 2019.

[94] A. A. Salimi, A. Karimi, and Y. Noorizadeh, ''Simultaneous operation of wind and pumped storage hydropower plants in a linearized security-constrained unit commitment model for high wind energy penetration,'' *J. Energy Storage*, vol. 22, pp. 318–330, Apr. 2019.

[95] D. Qiu, H. Dinçer, S. Yüksel, and G. G. Ubay, ''Multi-faceted analysis of systematic risk-based wind energy investment decisions in e7 economies using modified hybrid modeling with IT2 fuzzy sets,'' *Energies*, vol. 13, no. 6, p. 1423, Mar. 2020.

[96] S. Zhou and P. Yang, ''Risk management in distributed wind energy implementing analytic hierarchy process,'' *Renew. Energy*, vol. 150, pp. 616–623, May 2020.

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