Ranking Renewable Energy Alternatives by using Triangular Neutrosophic Sets Integrated with MCDM

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Abstract

In this age of ecological sustainability, energy planning has grown more complicated as a result of the inclusion of numerous standards, including technological, political, financial, and environmental considerations. As a result, this places significant limitations on the ability of policymakers to independently and covertly optimize energy sources, which is particularly problematic for rural populations. In contrast, the constraints imposed by the topography of the land on renewable energy (REEN) systems, which are for the most part dispersed across the natural environment, make energy planning more difficult. In these kinds of situations, decision analysis plays a crucial part in the process of creating these kinds of systems by taking into account a wide range of requirements and goals, even at fragmented levels of digitization. Many criterion decision making, often known as MCDM, is a subfield of operational research that focuses on finding optimum outcomes in complicated situations that include various measures, competing goals, and multiple criteria. Because it enables decision-makers to make choices while simultaneously taking into account all of the standards and goals, this tool is gaining traction in the area of energy planning, which is one of the reasons why it is becoming more famous. In this paper, the TOPSIS MCDM methodology is integrated with the triangular neutrosophic sets to rank and select best source of REEN in Egypt. The neutrosophic sets used due to incomplete and uncertainty in this ranking.

Keywords: Triangular Neutrosophic Sets; TOPSIS; Renewable Energy; Fuel; MCDM

1. Introduction

Energy is a fundamental component of human existence as well as an essential component in the expansion and growth of a nation's economy. On the other hand, a high usage of fossil fuels may cause significant environmental issues, like an increase in greenhouse gas emissions (GHG), which in turn has contributed to both climate change and global warming [1], [2]. The vast majority of nations are making concerted efforts to create renewable energy (REEN) or alternative fuels as a response to mounting environmental challenges. From the beginning of the negotiations for the Kyoto Protocol in 1997 to the finish of the Paris Climate Change Conference in 2015, numerous nations have become acutely aware of the immense danger posed by climate change and have committed themselves to the reduction of carbon emissions and the growth of green economies. As a result, making the switch from energy derived from fossil fuels to energy derived from clean sources is a significant concern for many nations [3]–[5].

According to the statistics analysis that was compiled in 2015 by REN21 (REEN Policy Network for the 21st Century), the capacity factor of REEN is equal to 1849 GW, and the total investment amounts to approximately 300 billion US dollars. The amount of supply that comes from renewable energy sources has already reached 23.7%, with an annual growth rate of 5.9%[6]. In addition, the International Renewable Energy Agency (IRENA) predicted that the number of people working in the REEN industry worldwide climbed by 5% and reached 8.1 million in 2015. In addition, IRENA believes that renewable energy will make up approximately forty percent of the world's energy supply by the year 2030 as a direct result of improvements in technological efficiency [7], [8].

In contrast to conventional energy that is derived from fossil fuels, REEN is an environmentally friendly kind of energy that cannot be depleted and has an infinite supply [9], [10]. On the other hand, REEN is plagued with

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productivity and ability restrictions because of the erratic nature of solar and wind power. In instance, the cost of electric production using REEN is now greater than the cost of production using fossil fuels. In addition, the administration of the architecture, also known as IM, is an essential aspect of the development of REEN. Decisions using IM often entail elements of ambiguity, several criteria, and even conflicts between those criteria. Because of this, finding a solution can be more challenging[11], [12]. As a result, the purpose of this study is to construct an MCDM method for the goal of ranking REENS for Egypt's REEN development. The model will take into consideration the economic, technological, environmental, and social elements concurrently. In addition, it may assist those responsible for making decisions in identifying IM issues in Egypt.[13], [14].
On the basis of the aforementioned factors, this research presents certain queries, which are as follows:
Which factors are appropriate for evaluating renewable energy sources in Egypt? Which renewable energy source should be favored in Egypt according to the suitable criteria that have been selected? How are changes in the weighting of the criteria going to affect the outcomes of the ranking?
An embedded MCDM technique is presented in this study, and it is comprised of TOPSIS under triangular neutrosophic sets (TNSs) [15]. Fuzzy systems (FSs) and intuitionistic fuzzy systems (IFSs) are unable to cope satisfactorily with situations in which the conclusion is either sufficient or undesirable[16]–[18], and the decision-pronouncement maker's is ambiguous. As a result, the solution to the issue including ambiguity requires the development of some unique theories. The neutrosophic sets (NSs) represent on the truth, the indeterminacy, and the falsity concurrently, which is more feasible and sufficient than FSs and IFSs in commercial activity, which are unclear, imperfect, and ambiguous in series[19]–[21]. A refinement of NSs, which were first presented by Wang et al., single-valued neutrosophic sets are a kind of neutrosophic set. Ye is credited for simplifying neutrosophic sets, while Peng et al. are credited with defining the unique activities and aggregating operators that they developed[22]–[24]. Last but not least, there are many various extensions of NSs, such as interval neutrosophic sets, bipolar neutrosophic sets, and multi-valued neutrosophic sets. When it comes to research, the challenge of making decisions under ambiguity is of the utmost significance[25]–[30].
Although a great variety of scholars and researchers have operated on the newly invented neutrosophic technique, and have implemented it in the sector of strategic planning, there are still some determine how best describing neutrosophic numbers in various forms, and their relating imprecision is very important. This is the case despite the fact that the method has only been around for a relatively short period of time.
The following is the structure of the paper: In the second section of this paper, we will go through the fundamental ideas TOPSIS method and neutrosophic set theory. The results is included in Section 2 of this document. In Section 4, you'll find the findings laid out.

2. TOPSIS Method

In addition to being a well-liked MCDM approach, TOPSIS is a technique that was first introduced by Hwang and Yoon in order to identify the optimal choice. The most important tenet of TOPSIS is that the optimal option should have the lowest length from the proper solution and the greatest distance from the bad option.
This approach has been extensively embraced as a means of resolving MCDM issues in a variety of different domains. In the field of energy, TOPSIS has been used in several studies to rate the various environmentally friendly methods of producing power.
Following is a presentation of the method that underpins the TOPSIS approach.
Stage 1. Build the decision matrix
Stage 2: Normalize the decision matrix as:

$$\boldsymbol{N} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (1)$$

Where $\boldsymbol{x_{ij}}$ refers to the decision matrix value. $\boldsymbol{i = 1, 2, \dots n; j = 1, 2, \dots m}$. n refers to the criteria and m refers to the number of alternatives.
Stage 3: Compute the weights of criteria by the average method
Stage 4: Compute the weighted normalized decision matrix
Multiply the weights of criteria by the normalization matrix
Stage 5: Compute the best and worst solution

$$\boldsymbol{I^+ = \max WN_{ij}} \text{ or} \quad (2)$$

$$\boldsymbol{I^+ = \min WN_{ij}} \quad (3)$$

$$\boldsymbol{I^- = \max WN_{ij}} \text{ or} \quad (4)$$

$$\boldsymbol{I^- = \min WN_{ij}} \quad (5)$$

Stage 6: Compute the distance form each alternative and best and worst solution

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$$D^{+} = \sqrt{\sum_{j=1}^{n}(WN_{ij} - I_j^{+})} \quad (6)$$

$$D^{-} = \sqrt{\sum_{j=1}^{n}(WN_{ij} - I_j^{-})} \quad (7)$$

Stage 7: Rank the options according to the highest value of

$$E = \frac{D_i^{-}}{D_i^{-} + D_i^{+}} \quad (8)$$

Where the best alternative is the highest value of E and the worst alternative is the least value of E.

3. Results

A Combined neutrosophic MCDM framework that is built on TNSs [15] is provided here as a means of assessing the many REEN choices available to Egypt. An exhaustive analysis is carried out, taking into account technical, social, environmental, political, financial, technological, and biological factors as assessment criteria as shown in Figure 1. A hierarchical framework that consists of seven factors and seven different REEN options for Egypt are employed in order to do an evaluation of these options. Analysis of energy decision making articles found in the literature, as well as the views of industry professionals, led to the establishment of these choices and criteria.

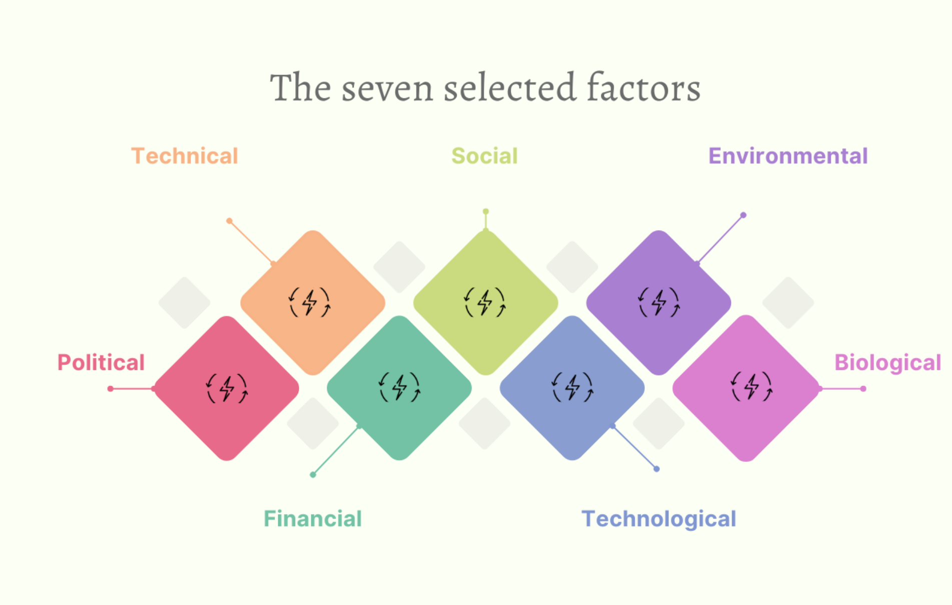

Figure 1: The seven selected factors.

In this investigation, the weights of the factors were determined via the reviews of professionals who have prior experience working with issues pertaining to energy decision making. In order to achieve this goal, questionnaires are being produced that include requirements and alternative forms of REEN. These questionnaires have been examined by three professionals utilizing linguistic factors.

Let experts to evaluate the criteria. Then aggregate their opinions. Then compute the weights of criteria. Table 1 shows the opinions of experts to criteria. Figure 2 shows the weights of factors.

Table 1: Data of seven factors.

	$REENC_1$	$REENC_2$	$REENC_3$	$REENC_4$	$REENC_5$	$REENC_6$	$REENC_7$
Expert 1	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
Exp	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>

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ert 2							
Expert 3	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
Expert 4	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>

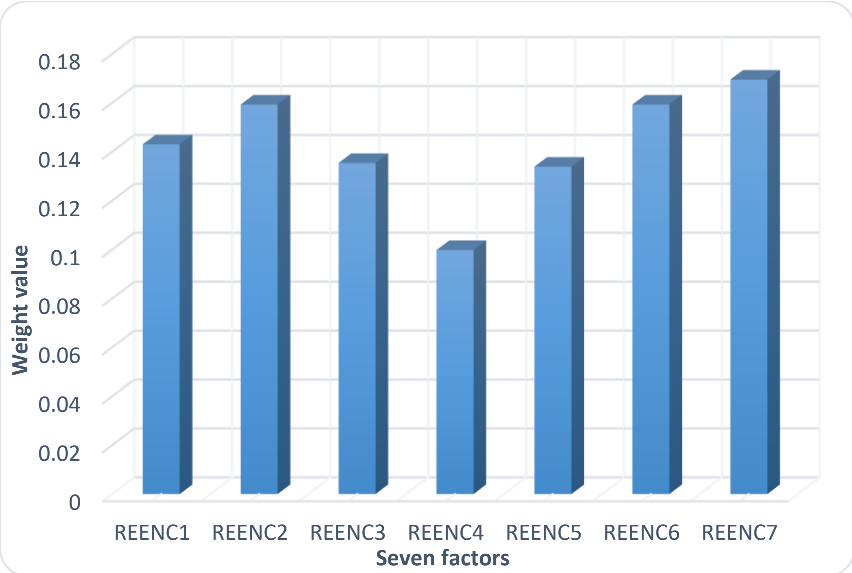

Figure 2: The weights of seven factors.

Let four experts to evaluate the criteria and alternatives to build four decision matrix as shown in Tables A.1-A.4 in appendix A. Then aggregate these matrices into on matrix as shown in Table 2.

Table 2: The aggregated decision matrix.

	$REENC_1$	$REENC_2$	$REENC_3$	$REENC_4$	$REENC_5$	$REENC_6$	$REENC_7$
$REENA_1$	2.11248	1.979	2.21665	2.21665	1.87483	2.32083	2.11248
$REENA_2$	1.58958	1.45	2.0083	1.533	1.58958	1.45	1.979
$REENA_3$	1.533	1.77065	1.72915	1.4915	2.0083	1.99365	2.32083
$REENA_4$	2.21665	2.425	1.65183	1.72915	1.58958	1.9375	1.88948
$REENA_5$	1.72915	1.7499	2.425	1.88948	1.65183	1.9729	2.32083
$REENA_6$	1.533	2.0083	2.425	1.979	1.533	2.0083	1.58958
$REENA_7$	1.88948	1.58958	1.533	1.58958	1.65183	1.9375	1.88948

Then normalize the decision matrix by using Equation (1) as shown in Table 3. Then compute the weighted normalized decision matrix as shown in Table 4.

Table 3: The normalized decision matrix.

	$REENC_1$	$REENC_2$	$REENC_3$	$REENC_4$	$REENC_5$	$REENC_6$	$REENC_7$
$REENA_1$	0.438928	0.398544	0.413216	0.4674	0.415003	0.447499	0.393511
$REENA_2$	0.33028	0.29201	0.374377	0.323246	0.351861	0.279588	0.368647
$REENA_3$	0.318525	0.356585	0.322339	0.314495	0.444548	0.384414	0.432322
$REENA_4$	0.460573	0.488362	0.307924	0.364606	0.351861	0.373587	0.35197

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$REENA_5$	0.359281	0.352406	0.452056	0.398412	0.365641	0.380413	0.432322
$REENA_6$	0.318525	0.404445	0.452056	0.417289	0.339338	0.387238	0.296105
$REENA_7$	0.392593	0.320119	0.285774	0.335175	0.365641	0.373587	0.35197

Table 4: The weighted normalized decision matrix

	$REENC_1$	$REENC_2$	$REENC_3$	$REENC_4$	$REENC_5$	$REENC_6$	$REENC_7$
$REENA_1$	0.06276	0.063475	0.05594	0.046641	0.055553	0.071271	0.066683
$REENA_2$	0.047225	0.046507	0.050682	0.032256	0.047101	0.044529	0.06247
$REENA_3$	0.045544	0.056792	0.043637	0.031383	0.059508	0.061224	0.07326
$REENA_4$	0.065854	0.07778	0.041686	0.036383	0.047101	0.0595	0.059644
$REENA_5$	0.051371	0.056126	0.061198	0.039756	0.048945	0.060587	0.07326
$REENA_6$	0.045544	0.064414	0.061198	0.04164	0.045425	0.061674	0.050177
$REENA_7$	0.056134	0.050984	0.038687	0.033446	0.048945	0.0595	0.059644

Then compute the positive and negative ideal solution as shown in Equations (2-5). All criteria are positive criteria. Then compute the distance between positive and negative ideal solution and the alternatives. Then compute the closeness value. Then rank the alternatives according to the highest value of closeness. Figure 3 shows the rank of alternative. From Figure 3, the alternative 4 is the best alternative and alternative 7 is the worst alternative.

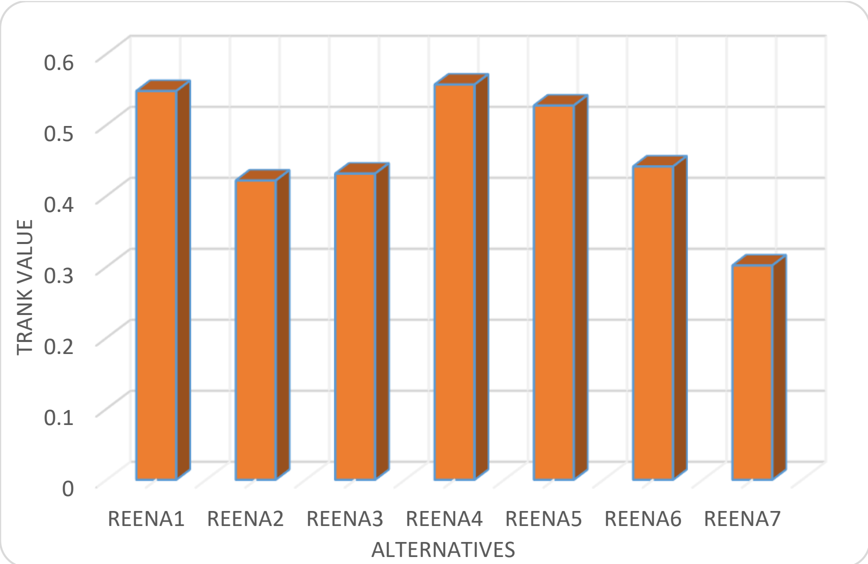

Figure 3: The rank of alternatives.

4. Conclusions

Power is the fundamental engine that powers the expansion and development of economies. On the other hand, a considerable quantity of greenhouse gases (GHG) are created as a result of the production and marketing of energy, which leads to global warming. There is no disconnect between energy, the economy, and the environment. It should be possible to achieve the purpose of energy policy, which is to enhance energy efficiency while also developing renewable energy and ensuring a safe energy supply. The task of deciding which energy policy should be supported and which REEN should be deployed by makers is a difficult one. The energy policy of a nation is shaped in a way that is appropriate for its stage of economic growth, taking into account its natural advantages, environmental assets, and level of economic growth, in addition to the current state of international affairs and other factors. This study utilized a TOPSIS MCDMs under neutrosophic environment in order to gain an understanding of how different circumstances lead to corresponding REEN. The seven criteria and seven alternatives are used in this paper. As a result, policymakers are now able to identify the RES that are suitable for different policies and could serve as a reference point for the development of RE.

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Appendix A

Table A.1. The first decision maker decision matrix.

	$REENC_1$	$REENC_2$	$REENC_3$	$REENC_4$	$REENC_5$	$REENC_6$	$REENC_7$

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REENA$_1$	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA$_2$	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_3$	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_4$	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA$_5$	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_6$	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>
REENA$_7$	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>

Table A.2. The second decision maker decision matrix.

	REENC$_1$	REENC$_2$	REENC$_3$	REENC$_4$	REENC$_5$	REENC$_6$	REENC$_7$
REENA$_1$	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_2$	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>
REENA$_3$	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_4$	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>
REENA$_5$	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA$_6$	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>

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REENA_7	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>

Table A.3. The third decision maker decision matrix.

	REENC$_1$	REENC$_2$	REENC$_3$	REENC$_4$	REENC$_5$	REENC$_6$	REENC$_7$
REENA_1	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA_2	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>
REENA_3	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA_4	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA_5	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA_6	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>
REENA_7	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>

Table 4. The fourth decision maker decision matrix.

	REENC$_1$	REENC$_2$	REENC$_3$	REENC$_4$	REENC$_5$	REENC$_6$	REENC$_7$
REENA_1	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REENA_2	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA_3	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REENA_4	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>

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REEN A_5	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>
REEN A_6	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,3,5;0.5,1.5,2.5;1.2,2.7,4.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>
REEN A_7	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.3,1.2,2.8;0.5,1.5,2.5;0.8,1.7,2.7>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>	<0.5,1.5,2.5;0.3,1.3,2.2;0.7,1.7,2.2>	<1,2,3;0.5,1.5,2.5;1.2,2.7,3.5>

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