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Preferability Ranking of Alternative Energy Resources Technology Programs in Turkey of using Analytic Hierarchy Process (AHP) Method

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Abstract

Alternative Energy Resources Technology Programs (AERTPs) in Turkey are among attractive programs on vocational schools that has a significant potential to cover employment gap in energy sector. For the participants of these programs, it is a tough decision by making a consistent list of programs associated with participants' preferences including foreign language education, campus life and living facilities of a university, technological investments, and the number of students in a university. According to increasing the number of Alternative Energy Resources Technology Programs in between the terms of 2018-2019 and 2019-2020, this study intends to carry out an updated preferability ranking actively operating in these energy programs using Analytic Hierarchy Process (AHP) method of Multi-Criteria Decision Making Analysis. For that purpose, an applied survey on a hundred students evaluated questions to understand what preferences for selection an energy program that the participants pick. As a consequence, this study provides an opportunity for the participants to make consistent choices with the help of preferability ranking of the energy programs in Turkey.

1 INTRODUCTION

Due to increasing the energy demand of Turkey resulting from a lack of fossil fuel or gas resources, not only does Turkish government establish but also private companies in energy sector started new sustainable/renewable energy facilities to generate electricity with/without license [1]. This circumstance requires increasing number of qualified technicians for the energy sector. It also carries the other necessities to be done that are both a determination of preferability of AERTPs and ranking of AERTPs associated with the applicants' preferences after they obtained their scores in verbal and quantitative fields applying by the examination of higher education institutions (YKS) [2]. A determination of preferability of energy programs is possible once a survey is applied on the participants who intend to select a AERTP whereas ranking of AERTPs is created by using a method of Multı-Criteria Decision Making (MCDM) Analysis including the participants' preferences.

There are various studies developing ranking systems for universities or their sub-programs because of increasing competition and requirements resulting from globalization. It requires a framework by concentrating on different criteria and methodologies. Jesensek, in his study, evaluated the higher education markets and positive competition for the students and universities in terms of the effect of increasing investments' rates by founders of universities [3]. Alma B. et al. [4] and her colleagues studied on various ranks for universities in methodological differences resulting from selection criteria, collected data and the methods of analysis. In order to assess indicators of quality, ranking starts with collecting data, which is provided by surveys in person and supplementary documents such as universities/programs' publications, research expenses, technical equipment. Quality performance of AERTPs and their preferability ranking for indicators need to be developed at first. To ensure that, a total score needs to be obtained using pre-determined weight to each indicator. As a result of various indicators, overall rankings might have differences. Therefore, it is of utmost importance how well an indicator/criteria is founded by whom decision maker and how proper the decision-making process was. For that purpose, according to the realistic criteria, this study utilizes a survey on a hundred high school senior students to make this study more applicable and real.

The application fields of the analysis of Multi-Criteria Decision Making (MCDM) has been widely used in different sectors [5-8]. The application fields of MCDM Analysis are enhanced greatly as new methods are found

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(or old methods of MCDM have been developed). Usage of MCDM analysis' approaches/methods has become a necessity in order to reach the best/most appropriate/efficient solutions in accordance with the criteria, which has superiority compared to each other.

Analytic Hierarchy Process (AHP) method is preferred in this study that allows the formation of decision hierarchy in the performance evaluation process, determination of criteria weights, evaluation of quantitative and qualitative criteria together, determination of consistency of judgments and testing of the sensitivity of the decision model. The most prominent feature of AHP is that it deals with other methods in MCDM and other factors affecting decision-making in situations where the problem is difficult to solve [6]. In AHP method, there exist three basic background axioms, namely the reciprocity feature of comparisons of two aspects, the axiom of homogeneity, and the axiom of independence. The method is also used effectively in case of multi-criteria decision-making with a large number of decision-makers, while selecting from a plurality of alternatives in cases of uncertainty or uncertainty. According to AHP method developed by Saaty [9], this study consists of (i) the generation of the hierarchy model, (ii) the generation of dual comparison (preference) matrices, (iii) determination of the advantages, and (iv) synthesis (integration) steps in general.

A survey mentioned above is created by reducing to nine criteria in the most frequently considered criteria by the participants. The nine selected criteria are used to accomplish all process with the methods during this study. All the energy programs listed above are ranked at the end of the analyses, eventually. Decision criteria in this study include campus facilities and social life opportunities of the university where the program is located (c1), ranking of the university (KPSS success) whereas the vocational schools students are transferred undergraduated programs (c2), the technological background and laboratories offered by the vocational schools (c3), according to vacancy of the program, the ratio of preference (c4), the number of faculties at each energy program (c5), the number of students who were transferred to another university abroad through the ERASMUS student exchange program (c6), foreign language education at each energy program (c7), the number of program vacancy (c8), the percentage of the province's power plants over installed power plants of Turkey (c9). It is noted that the criteria of c9 was assumed as a percentage of employment opportunities where C_n values are assumed the abbreviations of criteria (n=1,2,…., 9).

In addition, the vocational schools with Alternative Energy Resources Technology Programs are specified as follows:

1. Aksaray University, Aksaray Technical Sciences Vocational School (s1),
2. Ankara University, Gama Vocational School (s2),
3. Ardahan University, Ardahan Technical Sciences Vocational School (s3),
4. Aydın Adnan Menderes University, Buharkent Vocational School (s4),
5. Aydın Adnan Menderes University, Soke Vocational School (s5),
6. Bayburt University, Technical Sciences Vocational School (s6),
7. Bingol University, Bingol Technical Sciences Vocational School (s7),
8. Burdur Mehmet Akif Ersoy University, Bucak E. Gulmez Technical Sciences Vocational School (s8),
9. Canakkale Onsekiz Mart University, Can Technical Sciences Vocational School (s9),
10. Duzce University, Golyaka Technical Sciences Vocational School (s10),
11. Erzincan Binali Yildirim University, Vocational School (s11),
12. Firat University, Baskil Technical Sciences Vocational School (s12),
13. Hacettepe University, Hacettepe Ankara Chamber of Industry 1.OSB Vocational School (S13),
14. Kayseri University, Mustafa Cikrikcioglu Vocational School (s14),
15. Kocaeli University, Uzunçiftlik Nuh Cımento Vocational School (s15),
16. Mugla Sitki Kocman University, Mugla Vocational School (s16),
17. Nevsehir Haci Bektas Veli University, Vocational School (s17),
18. Pamukkale University, Denizli Technical Science Vocational School (s18),
19. Selcuk University, Bozkır Vocational School (s19).
20. Selcuk University, Karapinar Aydoganlar Vocational School (s20).

The programs and universities information are provided by Higher Education Program Guide [10]. KPSS success rates are obtained from the 2018 KPSS Vocational School Evaluation Report of the Measuring, Selection and Placement Center (OSYM) [11]. According to the preference vacancy, the preference rates of the program are obtained from the Higher Education Program Atlas (YOKATLAS) [12]. The data of the percentage of the province's power plant over installed power plants in Turkey was provided from the 2019 sectoral report of electricity market by Turkey's Energy Market Regulatory Authority (EPDK) [1]. Other criterion information was obtained from the official websites of the universities.

According to AHP method, the criteria of nine were formed by making hypothetical values by making pair-wise comparisons on the scale of 1 to 9. Criterion consistency analysis was applied to confirm that the consistency ratio was less than 0.1 ($\lambda = 0.02606$). Thus, the criterion matrix was found to be consistent. Then, for each criterion, an alternative matrix was created as much as the number of criteria for the dual evaluation of universities among themselves. Priorities were calculated with the help of matrix mathematics in alternative matrices that make comparison of the energy programs depending on each criteria. Then, the obtained priority and weighted values and the integrated weight values of the energy programs were computed. The energy programs with the highest integrated weight value stands out as the most appropriate choice based on the comparison criteria of the student that makes the decision in vocational schools.

In this study, the preferability rankings of the AERTPs in Turkey are investigated by adhering to the same criteria using AHP method. Readers find a comprehensive computation steps of analysis process for AHP, in this paper. All computations are additionally made of using the software of Python 3.7.4 version [13] (Python Software Foundation, 2019) for all three methods after creating algorithms of each methods.

2 ANALYTİC HIERARCHY PROCESS (AHP) METHOD

In general, MCDM problems including all methods to solve get involved six components that are defined as follows: (i) a goal or a set of goals that the decision maker wants to achieve, (ii) the decision maker or a group of decision makers involved in the decision making process, and their preferences with respect to the evaluation criteria, (iii) a set of evaluation criteria (objectives and/or physical attributes), (iv) the set of decision alternatives, (v) the set of independent variables or states of nature (decision environment), (vi) the set of outcomes associated with each alternative attribute-pair [14]. In this study, AHP method has applied in the axis of the components mentioned above. Figure 1 shows the main steps in the Analytic Hierarchy Process.

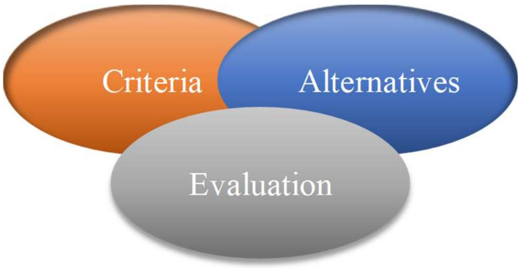

Figure 1. Analytic Hierarchy Process (AHP)

2.1 Analytic Hierarchy Process

The AHP method determines “decision criteria” and “alternatives at first. It is then an obligation to determine the relative weight of the AHP method decision criteria and to determine the relative priorities of alternatives. For this stage, both qualitative and quantitative information can be compared using informed decisions to obtain weight and priorities. Figure 2 shows the steps to create a hierarchy.

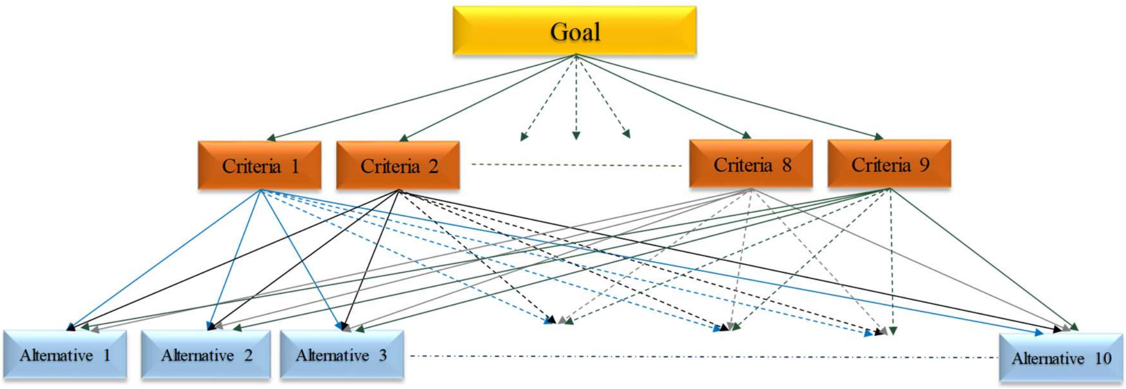

Figure 2. Schematic illustration of Hierarchy (Hierarchy Tree)

AHP requires the relative weights of criteria and the relative priorities of alternatives to be determined. During the analysis for this particular selected method (AHP), we have used the flowchart that implies each steps long story in short.

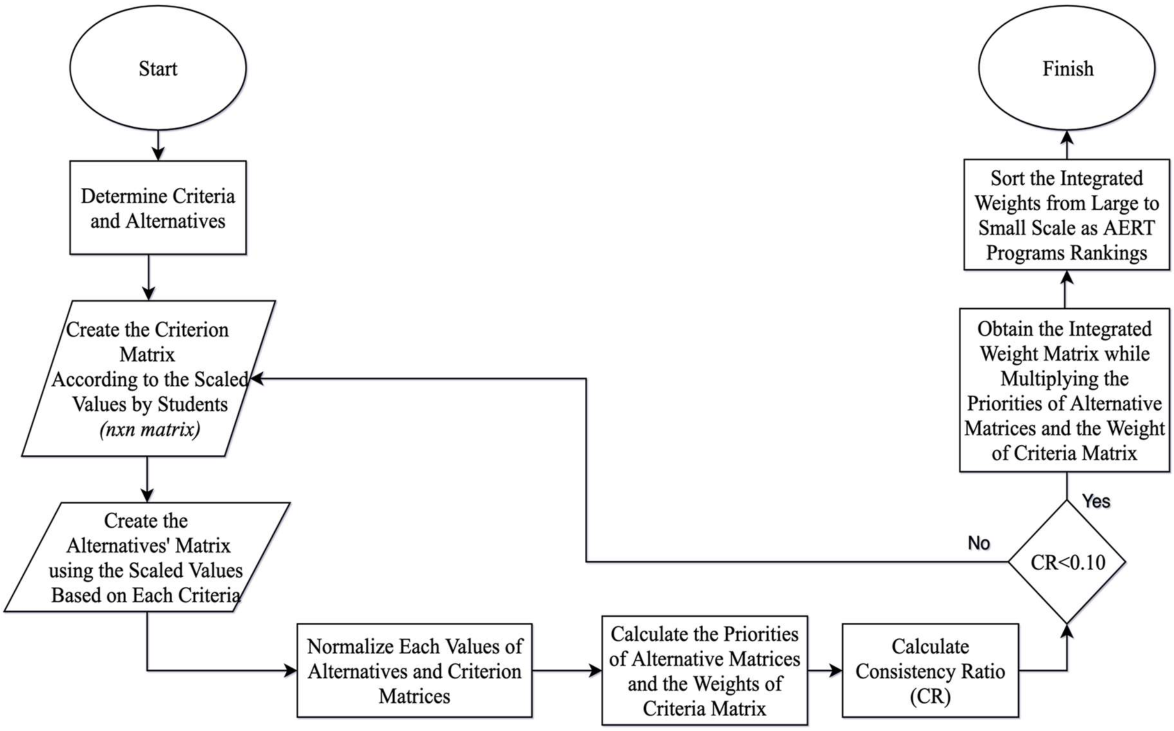

Figure 3. Flowchart of Analytic Hierarchy Process (AHP)

2.1.1 Criteria Ranking and Defining a Pair-wise Comparison

AHP can be applied to a multitude of decision making problems involving a selected number of alternatives. Dual comparisons for each criteria and alternatives are required in the AHP method. A reasonable assumption for scaling in between 1 and 9 are used for this method to compare criteria. The criteria and alternative matrices for computation are obtained by using AHP evaluation scale in Table 1. In addition, we used a standard notation where all square matrices are in uppercase boldface, e.g. $\mathbf{A}=(a_{ij})_{nxn}$ where vectors are noted in bold lowercase as $\mathbf{w} = \{w_1, w_2,\dots,w_n\}^T$ in this study. The set of numbers is $\mathbb{R}$.

Table 1. Standard Preference Table of AHP Method [15]

PREFERENCE LEVEL	PREFERRED NUMERICAL VALUE	DESCRIPTION
1	Equally	Two factors contribute equally to the objective
3	Moderately	Judgement slighlty favour one over the other
5	Strongly	Judgement strongly favour one over the other
7	Very Strongly	Judgement very slighlty favour one over the other
9	Extremely	The highest possible validity favour one over the other
2,4,6,8	Intermediate Values	Preference values are close to each other

An applied survey on a hundred high school senior students is to score each criteria in the evaluation scale of 1 through 9, which shows the importance of each criteria. The diagonal line of the square matrix requires 1. Because each criteria is compared by itself ($i=j$). The rating scale vector (**rs**) is created by using the students' scores as defined by $\mathbf{rs}= \{r_1, r_2,\dots,r_n\}^T$ where n equals to the number of criteria (n=9). Once the priority of a criteria to the other is considered such as $r_1 \succ r_3 \succ r_2 \succ r_4$ where $l_i \succ l_j$ means that the alternative r_i is preferred to r_j. The distinction between two scored criteria can be either positive or negative values from the students' scores when comparing two different criteria in the evaluation scale. Therefore, a conversion table in Table 2 is utilized to obtain consistent scaling scores. Let's consider r_1 is preferred 3 times better to r_3 ($r_1 \succ r_3$) in the condition of comparing criteria 1 and criteria 3 (c_1 and c_3) elements in the pair-wise comparison criteria matrix (**A**), which is defined as $\mathbf{A}=(a_{ij})_{nxn}$. Due to the condition of multiplicative reciprocity $a_{ij}=1/a_{ij}$ $\forall_{i,j}$ of AHP method, the simplified structure of a pair-wise comparison matrix allows the assumption is that if, a_{12} 3 times better than a_{21}, then we can conclude that a_{21} must be 1/3 as good as a_{12}. The rest of the **A** matrix is completed using **rs** rating scale vector as described.

Table 2. Conversion Table

CLASSIFICATION	SCORED VALUES																
Distinction	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Assigned Scores	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9

At that point, we need to implement a consistency analysis to make sure each criteria make sense by themselves. Thanks to AHP, in order to determine the consistency of the criteria matrix in the dual comparisons between two criteria of the decision maker, the criteria consistency analysis should be performed. This consistency analysis yields a consistency ratio (CR). In the AHP method, the CR calculation is essential based on the comparison of the number of criteria and finding the Eigenvalue ($\lambda_{max} \in \mathbb{R}$). The Consistency Index (CI) formula in the Equation 1 is applied as shown in the Equation 2.

$$CI = {\lambda\text{max} - \text{n}}/{n-1} \quad (1)$$

Final step for the calculation of CR: The CI value is calculated by dividing the value corresponding to the number of criteria in Table 3, which is titled the Random Indicator (RI).

$$CR = {\text{CI}}/{RI} \quad (2)$$

The value corresponding the number of criteria is selected from the table of Random Indicators (Saaty & Vargas, 2012). For instance, the RI value to be used in a 9^{th} comparison factor would be 1.45 from the Table 3.

Table 3. Random Indicators [16]

n	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

This ratio must be less than 0.1 (CR <0.1). The fact that the CR value is less than 0.1 indicates that the dual comparisons between the criteria of the decision maker are consistent [17]. In other words, a CR value greater than 0.10 indicates either a calculation error in the analysis of AHP method or inconsistency in decision-making comparisons.

Let's figure out how the Eigenvector is calculated for the further step of AHP Analysis. To do that, we considered [$\mathbf{A}x=\lambda_{max}x$] where **A** is the pair-wise comparison matrix for n criteria as called weight matrix, x is the Eigenvector of size nx1 as described weight vector [17]. The Eigenvector $\mathbf{x}=\{x_1,x_2,\ldots,x_9\}^T$ will be provided the priority of each criteria besides giving integrated weights of alternatives.

The distribution of the elements in the integrated weights matrix reveals the order of importance of the high value element compared to the others. Therefore, calculation of the Eigenvector is most critical part of the AHP method. A way to obtain the Eigenvector is by normalizing the elements in each column of the judgement matrix of a pair-wise comparison matrix. Namely, each element of a column should be divided by summing of each elements of the column:

$$\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} = b_{ij} \text{ } where \text{ } n = 9, i = 1,2, \ldots .9 \text{ } and \text{ } j = 1,2, \ldots ..9 \quad (3)$$

After the normalized matrix is obtained, averaging over each row is required to create the ranking of priorities matrix of size *9x1* using the Equation 4:

$$\frac{\sum_{j=1}^{n} b_{ij}}{n} = x_i \text{ } where \text{ } n = 9, i = 1,2, \ldots .9 \text{ } and \text{ } j = 1,2, \ldots ..9 \quad (4)$$

Namely, summing of the line vectors of the newly created matrix is then calculated and divided by the number of criteria to find the Eigenvector. In addition, the Eigenvector is described as follow:

$$A=\begin{bmatrix} 1 & a_{12} & . & . & a_{18} & a_{1n} \\ a_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{(n-1)1} & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix} \rightarrow B=\begin{bmatrix} 1 & b_{12} & . & . & b_{18} & a_{1n} \\ b_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ b_{(n-1)1} & . & . & . & 1 & a_{8n} \\ b_{n1} & b_{n2} & . & . & a_{n8} & 1 \end{bmatrix} \rightarrow x=\begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} \quad (5)$$

The sum of the elements of the Eigenvector (**x**) must be 1 because of normalization process:

$$\sum_{i=1}^{n(=9)} x_i = 1 \quad (6)$$

$$A=\begin{bmatrix} 1 & a_{12} & . & . & a_{18} & a_{1n} \\ a_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{(n-1)1} & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} = \lambda\text{max}\begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} \quad (7)$$

In the summarize of calculating the Eigenvalues, we provided one Eigenvector only. Using [$\mathbf{A}x=\lambda_{max}x$] as illustrated below, λ_{max} is then calculated as a vector. The mean of the elements of λ_{max} vector is eventually calculated so that λ_{max} is obtained the Eigenvalue as a real number. At the end of the consistency analysis, the assigned values of pair-wise comparisons with the Eigenvector are gathered into Table 4. The results are proofed CR is less than 0.1. It means that the dual comparisons between the criteria of the high school senior students are consistent.

Table 4. Pair-wise Comparison Matrix of Criteria $A=(a_{ij})_{mxn}$

	C1	C2	C3	C4	C5	C6	C7	C8	C9	Eigenvector [x]
C1	1	3	6	4	8	5	8	8	9	0.36083251
C2	1/3	1	4	2	6	3	6	6	7	0.20566094
C3	1/6	1/4	1	1/3	3	1/2	3	3	4	0.07585948
C4	1/4	1/2	3	1	4	2	4	4	6	0.13705870
C5	1/8	1/6	1/3	1/4	1	1/3	1	1	2	0.03528869
C6	1/5	1/3	2	1/2	3	*1*	*3*	*3*	*4*	*0.09191300*
C7	1/8	1/6	1/3	1/4	1	*1/3*	*1*	*1*	*2*	*0.03528898*
C8	1/8	1/6	1/3	1/4	1	*1/3*	*1*	*1*	*2*	*0.03528898*
C9	1/9	1/7	1/4	1/6	1/2	*1/4*	*1/2*	*1/2*	*1*	*0.02280873*
										$\sum$ = **1.00**
λ_{Max}=9.3023, CI=0.0377, RI=1.45, CR=0.026<0.1 OK.										

2.1.2 Generating of Alternative Matrices for Each Criteria

Alternative (the energy programs') matrices are required to compare each alternative among themselves for each criteria depending on the students' scores. Namely, dual comparisons of entire criteria and matrix operations are repeated for the alternatives. Moreover, the alternatives' matrices of size mxm (m=20) for each criteria using the options of the energy programs are noted as s1 through s20. In the other words, dual comparison and matrix operations are repeated for the number of criteria (n = 9). After each comparison process is completed using the Conversion in Table 2, we provided the alternative matrices [**S**] of size *mxm* (m=20) for each criteria. The notation of $\mathbf{S}=(s_{ij})_{mxm}$ is used in this study. A pair-wise Comparison Matrix of the Alternatives (the Energy Programs) for a particular Criterion of c1.

The alternative matrices are obtained for nine criteria. Here, we added one of a pair-wise comparison matrix of the alternatives for a particular criteria of *ranking of the university (KPSS success) whereas the vocational schools students are transferred undergraduated programs (c1).*

Each alternative matrices will need to be normalized to generate priority vectors of ten, which are column vectors of size mx1. The sum of each elements of a vector of normalized matrix must be 1. The normalized matrix is generated by using the Equation 8:

Table 5. Pair-wise Comparison Matrix of Alternatives $A = (a_{ij})_{mxn}$

	S1	S2	S3	S4	S5	..	S_n	S_{n+1}	¨	S18	S19	S20	Eigenvector [x]
S1	1	0,17	1	0,25	0,25					0,33	0,50	0,5	0.01925673
S2	6	1	6	3	3					4	5	5	0.15359946
S3	1	0,16	1	0,25	0,25					0,33	0,5	0,5	0.01925673
S4	4	0,33	4	1	1					2	3	3	0.0781074
S5	4	0,33	4	1	1					2	3	3	0.0781074
S6	2	0,20	2	0,33	0,33					0,5	1	1	0.03247351
S7	0,5	0,14	0,5	0,2	0,2					0,25	0,33	0,33	0.01254176
S8	1	0,16	1	0,25	0,25					0,33	0,5	0,5	0.01925673
S9	3	0,25	3	0,5	0,5					1	2	2	0.05156927
S10	1	0,17	1	0,25	0,25		...			0,33	0,5	0,5	0.01925673
S11	1	0,16	1	0,25	0,25					0,33	0,5	0,5	0.01925673
S12	1	0,16	1	0,25	0,25					0,33	0,5	0,5	0.01925673
S13	6	1	6	3	3					4	5	5	0.15359946
S14	2	0,2	2	0,33	0,33					0,5	1	1	0.03247351
S15	4	0,33	4	1	1					2	3	3	0.0781074
S16	4	0,33	4	1	1					2	3	3	0.0781074
S17	1	0,16	1	0,25	0,25					0,33	0,5	0,5	0.01925673
S18	3	0,25	3	0,5	0,5					1	2	2	0.05156927
S19	2	0,2	2	0,33	0,33					0,5	1	1	0.03247351
S20	2	0,2	2	0,33	0,33	..	S_n	S_{n+1}	..	0,5	1	1	0.03247351
													$\sum$ = **1.00**
λ_{Max}=9.3023, CI=0.0377, RI=1.45, CR=0.026<0.1 OK.													

$$\frac{a_{ij}}{\sum_{k=1}^{N} a_{kj}} = n_{ij} \; where \; n = 9, i = 1,2,\ldots,9 \; and \; j = 1,2,\ldots.,9 \tag{8}$$

After this step, the sum up of each row is divided by the number of criteria to obtain the priority vectors [**p**] of nine for each alternative. That is required creation of the priority vectors, which implies alternatives versus criteria using the Equation 9:

$$\frac{\sum_{i=1}^{n} s_{ij}}{n} = w_k where \; n = 9, i = 1,2,\ldots,20 \; and \; j = 1,2,\ldots.,20 \tag{9}$$

The weight matrix [**Z**] is created collecting each priority vectors into a matrix as columns of the weight matrix so that we provided a weight matrix of size 20x9. The weight matrix is then multiplied by the Eigenvector [**x**] of size 9x1 from x vector to generate the integrated weights matrix of size 20x1. The integrated weights matrix [**I**] is generated as the size of 20x1. Here is the illustration of calculating weight vectors:

$$S = \begin{bmatrix} S_{11} & \cdots & S_{1m} \\ \vdots & \ddots & \vdots \\ S_{1m} & \cdots & S_{mm} \end{bmatrix} \rightarrow Z = \begin{bmatrix} Z_{11} & \cdots & n_{1m} \\ \vdots & \ddots & \vdots \\ Z_{1m} & \cdots & n_{mm} \end{bmatrix} \Rightarrow I = Zx \begin{bmatrix} x_1 \\ . \\ . \\ x_9 \end{bmatrix} = \begin{bmatrix} I_1 \\ . \\ . \\ I_{20} \end{bmatrix} \tag{9}$$

This element distribution of $I_1, I_2, \ldots, I_{10}$ in the Integrated Weight Matrix [**I**] reveals the order of importance from the highest value to the lowest one. In this study, the distribution of Integrated Weight Matrix provides the most convenient or most preferred AERTPs in Turkey by the decision makers, namely the high school senior students.

3 RESULTS

The Alternative Energy Resources Technology Programs in Turkey are included in the ranking performed by Multi-Criteria Decision Making Analysis Methods including AHP only in this study. According to the 9 criteria expressed in the Introducion Section, the energy programs are ranked using Python 3.7.4 computer program. In Table 6, the Integrated Weighted Vector have given depending on AHP method.

In the AHP method, the energy programs are enumerated in order from the highest value of Integrated Weights Vector to the smallest value. It gives us the rank of the energy programs depending on their importance. For the SMART method, the energy program with the highest score stands out as the most preferred one by the high school senior students.

Table 6. The Analysis Results of AHP Method

ALTERNATİVE ENERGY RESOURCES TECHNOLOGY PROGRAMS WİTH LONG NAME	AHP METHOD
Aksaray University, Aksaray Technical Sciences Vocational School (s1)	0,0263750073882672
Ankara University, Gama Vocational School (s2)	0,1207551776741990
Ardahan University, Ardahan Technical Sciences Vocational School (s3)	0,0214193910476647
Aydın Adnan Menderes University, Buharkent Vocational School (s4)	0,0528516962328869
Aydın Adnan Menderes University, Soke Vocational School (s5)	0,0520371885612590
Bayburt University, Technical Sciences Vocational School (s6)	0,0363058948414836
Bingol University, Bingol Technical Sciences Vocational School (s7)	0,0362754973663894
Burdur Mehmet Akif Ersoy University, Bucak E. Gulmez Technical Sciences Vocational School (s8)	0,0468808113029592
Canakkale Onsekiz Mart University, Can Technical Sciences Vocational School (s9)	0,0501127799691308
Duzce University, Golyaka Technical Sciences Vocational School (s10)	0,0360011838435392
Erzincan Binali Yildirim University, Vocational School (s11)	0,0385512957663663
Firat University, Baskil Technical Sciences Vocational School (s12)	0,0409162142185775
Hacettepe University, Hacettepe Ankara Chamber of Industry 1.OSB Vocational School (S13)	0,1284504521264960
Kayseri University, Mustafa Cikrikcioglu Vocational School (s14)	0,0365776599010268
Kocaeli University, Uzunciftlik Nuh Cimento Vocational School (s15)	0,0525954887302779
Mugla Sitki Kocman University, Mugla Vocational School (s16),	0,0563795949830259
Nevsehir Haci Bektas Veli University, Vocational School (s17),	0,0268005463679477
Pamukkale University, Denizli Technical Science Vocational School (s18),	0,0525144903671221
Selcuk University, Bozkır Vocational School (s19).	0,0452337745620387
Selcuk University, Karapinar Aydoganlar Vocational School (s20).	0,0429658547493402
$\sum =$	1.00

According to AHP method, the Alternative Energy Resources Technology Programs in Turkey included in top two are in Hacettepe Ankara Chamber of Industry 1.OSB Vocational School, Ankara University, Gama Vocational School with the priority order as ranked first and second one, respectively. All the energy programs positions are listed in Table 7.

Table 7. The AERTPs' Positions

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
19	2	20	4	7	15	16	9	8	17	13	12	1	14	5	3	18	6	10	11

The findings show that the Alternative Energy Resources Technology Programs at Hacettepe and Ankara Universities have a significant difference among the all energy programs in terms of ranking calculated using same criteria and different methodology with different weights for AHP method.

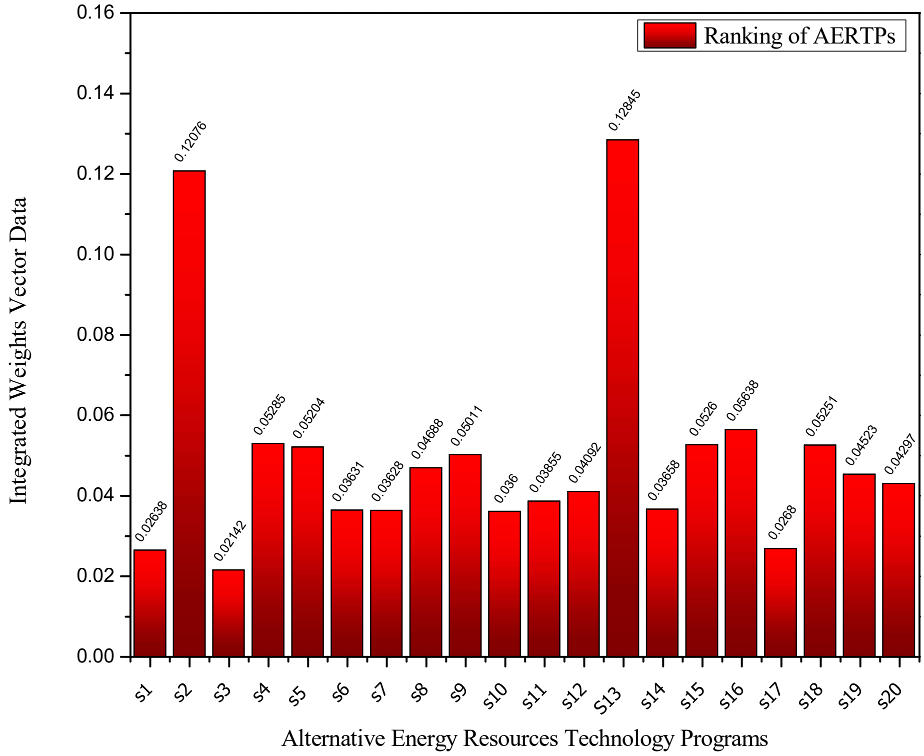

Figure 4. Ranking of AERTPs for 2019-2020 Term using Analytic Hierarchy Process (AHP)

4 CONCLUSION

Ranking sub-programs (two year college degree programs) is very rare in Turkey. This circumstance creates some chaos environment among the applicants of sub-programs. In Turkey case, a field based ranking system for college programs will be updated as a pilot study. Alternative Energy Resources Technology Programs is choosen as a particular sub-program in the vocational schools because of increasing the demand of energy in Turkey and increasing the employment (technicians) gap in the energy sector indirectly. The other benefit of this study are to create a competition among the energy programs to lead higher educational standards in the energy programs so that the funders and/or faculties work well-disciplined to enhance the investments for the energy programs. It is also possible for the energy programs in the lower ranks to be part of higher ranks for further years by taking into consideration on the specified criteria in the declareted study once they enhance the investments not only technological investments, but also educational investments. The energy programs have been operating during the 2019-2010 education year, actively. Newly operated energy programs for 2019-2020 academic year were added in this paper while there were only energy programs of ten on a study of authors' previous work. In this respect this study will be updated in the literature by the authors' previous work, which is conducted for only ten alternative energy resources technology programs.

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