Teber, A. & Karakaş, A. (2019). Ranking alternative energy resources technology programs in Turkey based on the methods of multi-criteria decision making analysis. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 20*(3), 1459-1479.

Makalenin Türü / Article Type : Araştırma Makalesi / Researh Article
Geliş Tarihi / Date Received : 04.08.2019
Kabul Tarihi / Date Accepted : 14.08.2020
Yayın Tarihi / Date Published : 15.09.2020

https://dx.doi.org/10.17240/aibuefd.2020..-601398

RANKING ALTERNATIVE ENERGY RESOURCES TECHNOLOGY PROGRAMS IN TURKEY BASED ON THE METHODS OF MULTI-CRITERIA DECISION MAKING ANALYSIS

Ahmet TEBER[1], Ahmet KARAKAŞ[2]

ABSTRACT

The diversity less among the Alternative Energy Resources Technology Programs (AERTPs) in Turkey makes giving the “proper” decision crucial by high school senior students. The literature review exhibits that there exists a need over the expectation for a ranking system of the two-year programs in vocational schools in Turkey so as identifying two-year programs compared to others. In this strategic decision context, it is especially important for the students to make a suitable decision associated with their higher education. Therefore, this study focuses on developing a specific ranking system of two-year energy programs in Turkey. In order to classify the programs, the most important decision criteria should be required. In this aspect, a survey is applied to a hundred high school senior students to recognize which multi-criteria for selection of an energy program they pick. Thus, the survey makes this study is more applicable to build a foundation for a field-based ranking system in Turkey. In this regard, a framework for ranking of AERTPs during the academic year of 2019 in Turkey is accomplished using three methods of Multi-Criteria Decision Making Analysis including Analytic Hierarchy Process (AHP), Simple Multi-Attribute Rating Technique (SMART), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

Keywords: Multi-Criteria Decision Making (MCDM) analysis, higher education, renewable energy, university ranking

ÇOK-KRİTERLİ KARAR VERME ANALİZİ METOTLARINA DAYANARAK TÜRKİYE’DEKİ ALTERNATİF ENERJİ KAYNAKLARI TEKNOLOJİSİ PROGRAMLARININ SIRALANMASI

ÖZ

Türkiye’deki Alternatif Enerji Kaynakları Teknoloji Programları (AERTP) arasında daha az çeşitlilik olması, lise son sınıf öğrencilerinin “uygun” karar vermelerini zorlaştırır. Literatür taraması, meslek yüksekokullarında değerlerine kıyasla iki-yıllık programları tanımlamak için ulusal bir sıralama sistemine beklentinin üzerinde bir ihtiyaç olduğunu göstermektedir. Bu stratejik karar bağlamında, öğrencilerin yüksek öğrenimleriyle ilgili uygun bir karar vermeleri özellikle önemlidir. Bu nedenle, bu çalışma, Türkiye'de iki yıllık enerji programlarının belirli bir sıralama sistemini geliştirmeye odaklanmaktadır. Programları sınıflandırmak için en önemli karar kriterlerini belirlemek bir gerekliliktir. Bu yönüyle, yüz adet öğrenci üzerinde, enerji programı seçimlerinde hangi kriterleri seçtiklerini tanımlanması için çok-kriterli bir anket uygulanmıştır. Dolayısıyla, anket bu çalışmayı belirli bir alan bazlı sıralama sistemi için bir temel oluşturmak adına daha uygulanabilir kılmaktadır. Bu bağlamda, 2019 akademik yılı boyunca Türkiye'deki Alternative Enerji Kaynakları Teknolojisi Programlarının, Analitik Hiyerarşi Süreci (AHP), Temel Çok-Ölçütlü Derecelendirme Tekniği (SMART) ve İdeal Çözüme Benzerliğe GöreTercih Sıralama Tekniği (TOPSIS) olarak üç karar verme yöntemi kullanılarak sıralanması için bir çerçeve gerçekleştirilmiştir.

Anahtar Kelimeler: Çok-Kriterli Karar Verme (ÇKKV), yükseköğretim, yenilenebilir enerji, üniversite sıralama

[1]*Bayburt Üniversitesi, Teknik Bilimler Meslek Yüksekokulu, ahmetteber@bayburt.edu.tr* https://orcid.org/0000-0002-7361-2302
[2]*Gebze Teknik Üniversitesi, Mühendislik Fakültesi, ahmett.karakash@gmail.com* https://orcid.org/0000-0003-0993-5307

1. INTRODUCTION

There exist several studies to develop ranking systems for universities because of increasing competition and requirements for competitiveness resulting from globalization. Researchers have been developing a ranking framework by concentrating on different criteria and various methodologies. In the last two decades, rankings have objectively begun to evaluate the quality of universities. Ranking universities have various goals such as guidance participants to higher educational undergraduate, graduate programs, evaluating the higher education markets, enhancing positive competition for students and faculties, and also increasing investments' rates by the funders of universities (Jesensek, 2006).

The ranking systems produce various ranks for the universities because of the methodological differences resulting from the selection of criteria, weights of criteria, collected data, and the methods of analysis (Alma, 2016). In order to determine indicators of quality, ranking starts with collecting the data, which is provided by many supplementary documents such as university's publications, research expenses, library-equipment, etc. In order to evaluate a university's performance and/or a university rank, a particular explanation and quality performance criteria 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. MCDM has been widely used in different sectors such as marketing, human resources, ranking universities, etc. (Velasquez, & Hester, 2013). When students have challenged multi-dimensional decision-making issues to achieve the most efficient and suitable solutions in their educational life, thanks to MCDM, it has remarkable advantages to rank universities depending on research, educational and university environment. The students, the focus of this study, may have various difficulties in university choices by considering multiple criteria factors/indicators. When considering the limited number of energy programs and their program performances, the participants of the energy programs will have to make the consistent choices among the energy programs according to various criteria, which are the most important factors to make their future life easier and better. The 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 processes 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 province where the program is located (c1), a ranking of the university (KPSS success) whereas the vocational schools' students are transferred undergraduate 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 and the title of faculties (c5), the number of students who were transferred to another university abroad through the ERASMUS student exchange program (c6), foreign language education (c7), the number of program vacancy (c8), the percentage of the province's power plants over installed power plants of Turkey (c9). The criteria of c9 were assumed as a percentage of employment opportunities where C_n values are assumed the abbreviations of criteria (n=1,2,…., 9). Besides, the vocational schools with Alternative Energy Resources Technology Programs are specified as follows: Ankara University, Gama Vocational School (s1), Aydın Adnan Menderes University, Soke Vocational School (s2), Aydın Adnan Menderes University, Buharkent Vocational School (s3), Erzincan Binali Yildirim University, Vocational School (s4), Hacettepe University, Hacettepe Ankara Chamber of Industry 1.OSB Vocational School (S5), Kayseri University, Mustafa Cikrikcioglu Vocational School (s6), MuglaSitkiKocman University, Mugla Vocational School (s7), Nevsehir Haci Bektas Veli University, Vocational School (s8), Pamukkale University, Denizli Technical Science Vocational School (s9), Selçuk University, Karapinar Aydoganlar Vocational School (s10). The programs' and universities' information are provided by the Higher Education Program Guide (Yükseköğretim Kurulu, 2019).

This paper briefly utilizes the criteria to compare/rank these energy programs using three methods of Multi-Criteria Decision Making Analysis including Analytic Hierarchy Process (AHP), Simple Multi-Attribute Rating Technique (SMART), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). These methods are frequently used in ranking one and/or more alternatives from a firm number of alternatives to a random number of alternatives, which is chosen by decision-maker (Dyer et al., 1992). The advantages of the MCDM Methods in this study: (i) AHP is easy to use and scalable. Hierarchy structure can be adjustable to match many sized problems without intensive data. (ii) SMART is a simple usage that requires less effort by decision-makers. (iii) TOPSIS has the advantage of usage in a simple way (Velasquez, 2013). In order to be able to provide accurate data of each criterion, the data analysis/statistics reports by the Turkish Government Agencies are used. Here, the brief Resources of data: (i) KPSS success of vocational schools is obtained from the 2018 KPSS Vocational School Evaluation Report of the Measuring, Selection and Placement Center (OSYM) (Ölçme, Seçme ve Yerleştirme Merkezi Başkanlığı, 2019), (ii) According to the preference vacancy, the preference rates of the program are obtained from the Higher Education Program Guide (Yükseköğretim Kurulu, 2019), (iii) The data of the percentage of the province's power plants over installed power plants in Turkey was provided from the 2019 Sectoral Report of Electricity Market by Turkey's Energy Market Regulatory Authority (Enerji Piyasası Düzenleme Kurumu, 2019), (iv) Other criterion information was obtained from the official websites of the universities.

In this study, the quality and preference rankings of the AERTPs in Turkey are investigated by adhering to the same criteria with three different methodologies. Readers find comprehensive computation steps of analysis process for AHP, SMART and TOPSIS in this paper. All computations are additionally made of using the software of Python 3.7.4 version (Python Software Foundation, 2019) for all three methods after creating algorithms of each method.

1.1. The aim of the study

According to the best of our knowledge in the literature, the ranking systems are rare for vocational schools and their sub-programs. Therefore, two-year program-based system concentrating on a particular program in vocational schools will be a pilot study in Turkey. For this reason, this study intends to develop a ranking framework that concentrates on the AERTPs of Turkish Universities, which is actively operated in the academic year of 2019. A ranking system of AERTPs in Turkey provides benefits such as guiding high school senior students, creation of competition among facilities of each energy programs, and pointing out the presidents of universities to enhance the investments for the energy programs.

1.2. The importance of the study

In the case of choosing a particular program to study by the students, rankings give students transparent information about the program performances. AERTPs in Turkey are among the attractive associate two-year programs in vocational schools that offer qualified technicians for the energy sector. Due to increasing the energy demand of Turkey (EPDK, 2019), the energy programs have a significant potential to cover the employment gap. In consequence of the explanations, the importance of this study can be listed as follows:

1- Ranking two-year associate energy programs,
2- Provides an opportunity for the candidates of the energy programs to make consistent choices and ranking the energy programs in Turkey,
3- Create a competition among the AERTPs,
4- Lead to higher educational standards in the energy programs while pointing out the presidents of universities to enhance the investments for these energy programs. That provides indirectly qualified technicians for the energy sector.

2. METHODS OF MULTI-CRITERIA DECISION MAKING ANALYSIS

2.1. Analytic hierarchy process (AHP)

The first step of the AHP method have to create “decision criteria and alternatives” (Figure 1).

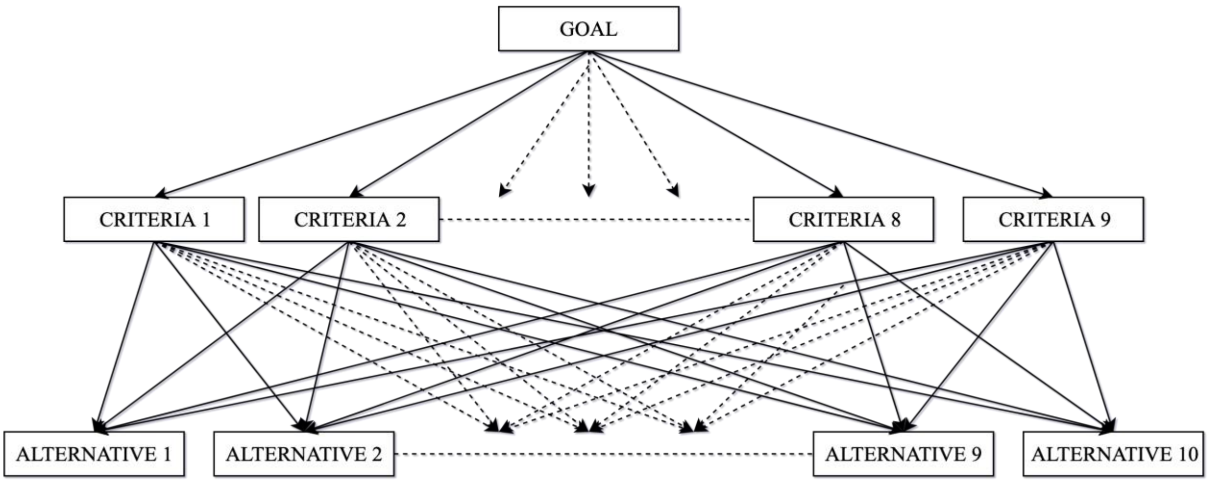

Figure 1. The hierarchy tree of AHP method

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

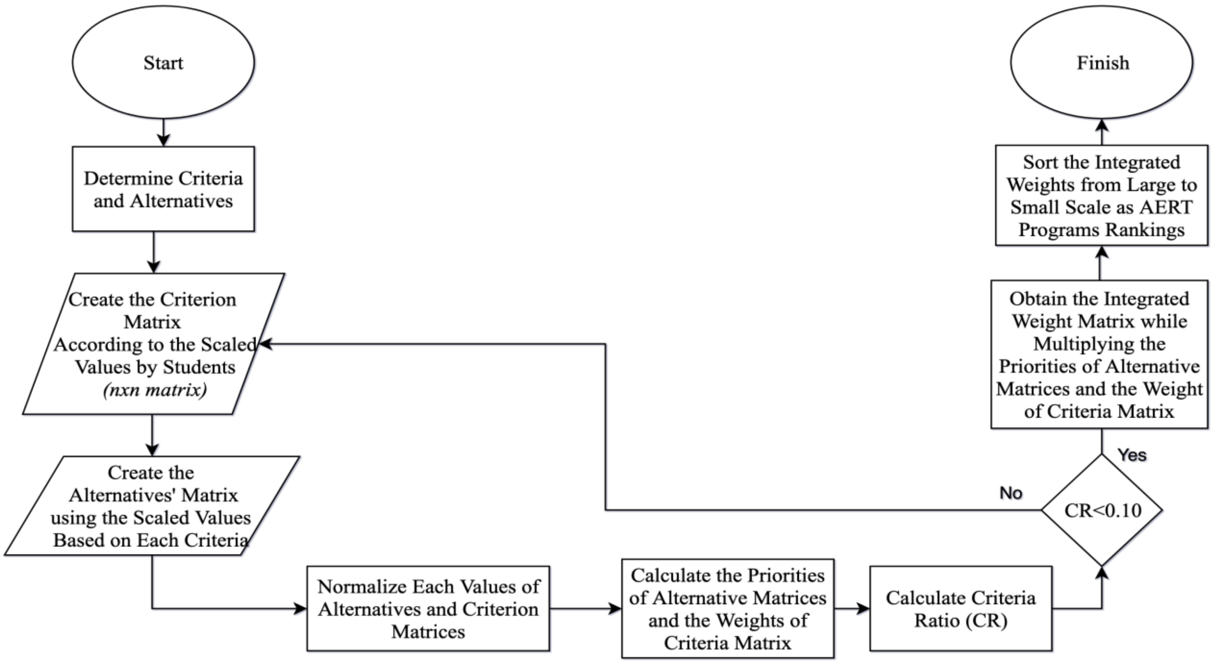

Figure2. The flowchart of analytic hierarchy process (AHP)analysis

2.1.1. ***Ranking of criteria and determining a pair-wise comparison matrix***

Dual comparisons for each criterion 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 the AHP evaluation scale in Table 1.

Note that, in the AHP (and SMART methods for the steps of further analysis), the evaluation matrices are generated by scaling the official data on a scale of 1 through 9 different than the TOPSIS method. AHP can be applied to a multitude of decision-making problems involving a selected number of alternatives as mentioned. Note that we have 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 (Saaty, 2008)

Preference Level	Preferred Numerical Value	Description
1	Equally	Two factors contribute equally to the objective
3	Moderately	Judgment slighyly favor one over the other
5	Strongly	Judgment strongly favor one over the other
7	Very Strongly	Judgement very slightly favor one over the other
9	Extremely	The highest possible validity favor 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 criterion in the evaluation scale of 1 through 9, which shows the importance of each criterion. The diagonal line of the square matrix requires 1. Because each criterion 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 the number of criteria (n=9).

Once the priority of 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 the two scored criteria can be either positive or negative values from the students' scores when comparing the two different criteria in the evaluation scale. Therefore, a conversion table in Table 2 is utilized to obtain consistent scaling scores.

Table 2.
The 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

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 **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 an **rs** rating scale vector as described.

$$A=\begin{bmatrix} 1 & a_{12} & . & . & a_{18} & a_{1n} \\ a_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix}=\begin{bmatrix} 1 & 3 & . & . & a_{18} & a_{1n} \\ 1/3 & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix},\ n=9\ (the\ number\ of\ criteria) \quad (1)$$

At that point, we need to implement a consistency analysis to make sure each criterion 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 equation (2) is applied as shown in equation (3).

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (2)$$

The 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 called the Random Indicator (RI).

$$CR = \frac{CI}{RI} \quad (3)$$

The value corresponding to 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 Table 3.

Table 3.
Random Indicators (Haas & Meixner, 2009)

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 [8]. In other words, a CR value greater than 0.10 indicates either a calculation error in the analysis of the 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 (Sakarya Üniversitesi Bilgi Sistemi, 2019). The Eigenvector $\mathbf{x}=\{x_1,x_2,\ldots,x_9\}^T$ will be provided the priority of each criterion besides giving integrated weights of alternatives.

Note that the alternatives in the AHP method are described as the Alternative Energy Resources Technology Programs (AERTPs) for this study to remember one more time.

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, calculating the Eigenvector is the most critical part of the AHP method. A way to obtain the Eigenvector is by normalizing the elements in each column of the judgment matrix of a pair-wise comparison matrix. Namely, each element of a column should be divided by summing of each element of the column:

$$\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} = b_{ij} \;\; where\, n = 9,\; i = 1,2,....9 \;\; and \;\; j = 1,2,...,9 \tag{4}$$

The normalized matrix is obtained as follow:

$$\mathrm{B} = \begin{bmatrix} 1 & b_{12} & . & . & b_{1(n-1)} & b_{1n} \\ b_{21} & 1 & . & . & . & b_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ b_{(n-1)1} & . & . & . & 1 & b_{8n} \\ b_{n1} & b_{n2} & . & . & b_{n(n-1)} & 1 \end{bmatrix} \tag{5}$$

Then, averaging over each row is required to create the ranking of priorities matrix of size *9x1* using the equation (6):

$$\frac{\sum_{j=1}^{n} b_{ij}}{n} = x_i \quad where\; n = 9,\; i = 1,2,...,9 \;\; and \;\; j = 1,2,....,9 \tag{6}$$

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

$$\mathrm{A} = \begin{bmatrix} 1 & a_{12} & . & . & a_{18} & a_{1n} \\ a_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{(n-1)1} & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix} \rightarrow \mathrm{B} = \begin{bmatrix} 1 & b_{12} & . & . & b_{1(n-1)} & b_{1n} \\ b_{21} & 1 & . & . & . & b_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ b_{(n-1)1} & . & . & . & 1 & b_{8n} \\ b_{n1} & b_{n2} & . & . & b_{n(n-1)} & 1 \end{bmatrix} \rightarrow \mathrm{x} = \begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} \tag{7}$$

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

$$\sum_{i=1}^{n(=9)} x_i = 1 \tag{8}$$

$$\mathrm{Ax} = \begin{bmatrix} 1 & a_{12} & . & . & a_{18} & a_{1n} \\ a_{21} & 1 & . & . & . & a_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{(n-1)1} & . & . & . & 1 & a_{8n} \\ a_{n1} & a_{n2} & . & . & a_{n8} & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} = \lambda_{\max} \begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix} \tag{9}$$

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 the vector λ_{max} 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.

A Pair-wise Comparison Matrix $A = \left(a_{ij}\right)_{mxn}$

Criteria Matrix	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. *Creating of alternative matrices for each criterion*

Alternative matrices (the energy programs' matrices) are required to compare each alternative among themselves for each criterion 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=10) for each criterion using the options of the energy programs are noted as s1 through s10. 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=10) for each criterion. The notation of **S**=$(s_{ij})_{mxm}$ is used in this study.

$$S = \begin{bmatrix} 1 & s_{12} & . & . & s_{19} & s_{1m} \\ s_{21} & 1 & . & . & . & s_{2m} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ s_{(m-1)1} & . & . & . & 1 & s_{8m} \\ s_{m1} & s_{m2} & . & . & s_{m9} & 1 \end{bmatrix} \quad (10)$$

A pair-wise comparison of alternatives for a particular criterion is shown below:

Table 5.

A pair-wise Comparison Matrix of the Alternatives (the Energy Programs) for a Particular Criterion of c2

Alternative Matrix	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	Priority vector [p]
s1	1	3	3	2	1	3	3	3	3	3	0.20490872
s2	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
s3	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
s4	1/2	2	2	1	1/2	2	2	2	2	2	0.12578769
s5	1	3	3	2	1	3	3	3	3	3	0.20490872
s6	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
s7	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
s8	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
s9	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
S10	1/3	1	1	1/2	1/3	1	1	1	1	1	0.06634212
											$\sum =$ **1.00**

λ_{Max}=10.0116, CI=0.0012, RI=1.45, CR=0.0008<0.1 OK.

The alternative matrices are obtained for nine criteria. Here, we added one of a pair-wise comparison matrix of the alternatives for particular criteria of *the ranking of the university (KPSS success) whereas the vocational schools' students are transferred undergraduate programs (c2)*.

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 element of a vector of the normalized matrix must be 1. The normalized matrix is generated by using the equation (11):

$$\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} = n_{ij} \quad where\, n = 9,\ i = 1,2,....9\ and\ j = 1,2,...,9 \tag{111}$$

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 equation 12:

$$\frac{\sum_{i=1}^{n} s_{ij}}{n} = w_k \quad where\ n = 9, k = 10,\ i = 1,2,...,10\ and\ j = 1,2,....,10 \tag{12}$$

The weight matrix [**Z**] is created by collecting each priority vectors into a matrix as columns of the weight matrix so that we provided a weight matrix of size 10x9. The weight matrix is then multiplied by the Eigenvector [**x**] of size 9x1 from x vector to generate the integrated weights matrix of size 10x1. The integrated weights matrix [**I**] is generated as the size of 10x1. Here is the illustration of calculating weight vectors:

$$S = \begin{bmatrix} s_{11} & \cdots & s_{1m} \\ \vdots & \ddots & \vdots \\ s_{1m} & \cdots & s_{mm} \end{bmatrix} \rightarrow Z = \begin{bmatrix} z_{11} & \cdots & n_{1m} \\ \vdots & \ddots & \vdots \\ z_{1m} & \cdots & n_{mm} \end{bmatrix} \Rightarrow I = Zx \begin{bmatrix} x_1 \\ . \\ . \\ . \\ x_9 \end{bmatrix} \Rightarrow I = \begin{bmatrix} I_1 \\ . \\ . \\ . \\ I_{10} \end{bmatrix} \tag{13}$$

This element distribution of I_1, I_2, ..., 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 the Integrated Weight Matrix provides the most convenient or most preferred AERTPs in Turkey by the decision-makers, namely the high school senior students.

2.2. Simple multi-attribute rating technique (SMART) analysis

Multi-criteria Decision Making Analysis (MCDMA) is relatively classified in two categories including Multi-Objective Decision Making and Multi-Attribute Decision Making (Triantaphyllou, 2000). In the Multi-Attribute Decision-Making methods, the goal requires decision making between alternatives so that Multi-Attribute Decision Making is a problem of choice in terms of decision making. Goal programming of the SMART method has been used in the applications of planning, scheduling and selection problems. Therefore, in this study, we want to investigate the ranking in Turkey with three methods of MCDMA including AHP, SMART, and TOPSIS how the distribution of AERTPs is. This section provides the ranking of the energy programs using the SMART method.

2.2.1. ***Determining criteria, alternatives and scoring criteria***

Identifying alternatives provides the outcomes of possible actions and a gathering process of data. Also, identifying criteria is important to limit the dimensions of values as AHP Method, which can be accomplished by restating and combining criteria besides omitting less important criteria.

As described in the introduction section, yet, the students were asked to select the criteria that they would take into consideration when making an associate two-year energy program choice from the criteria table, which is created by the authors over by omitting less important criteria. Thus, the criteria to be applied for the SMART method were determined as the same criteria with AHP Method.

During the analysis for the particular method of Simple Multi-Attribute Rating Technique (SMART), we used the flowchart as shown below:

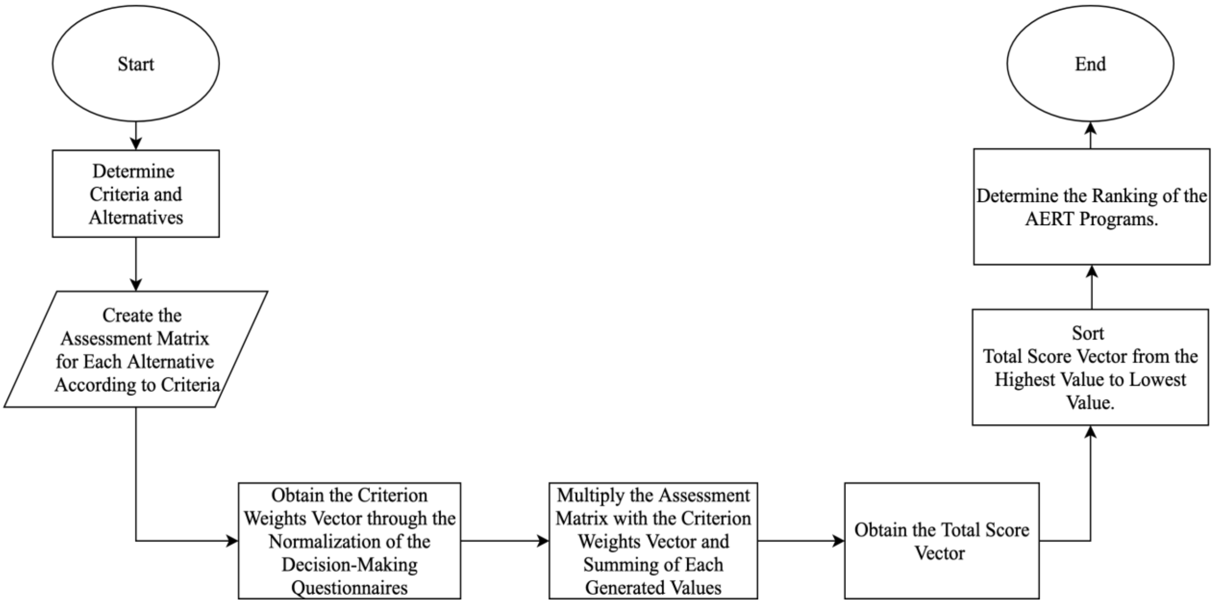

Figure3. The flowchart of simple multi-attribute rating technique (SMART) analysis

The scoring technique in the SMART method is used to compare alternatives (the AERTPs) based on a weighted point system. This allows scoring models to digitize different alternatives using many criteria that identify the criteria and the alternatives. Then, the most relevant dimension is assigned importance of 100 in this study. The next most relevant dimension needs to be assigned a number of reflecting the ratio of relative importance to the most relevant dimension. It is expected that different individuals in a group of 100 students would have different relative scores. More than that in forward, the candidates (or the high school senior students) were asked to assign scores in between 10 and 100 points for each criterion by identification of individual judgments of relative ranking. This next step is to calculate a weighted average of the values assigned by the students to each alternative that allows normalization of the relative importance into weights summing to 1. As a result of this, Table 6 is established to determine the average weights of Criteria. For that purpose, the average criterion was then normalized by dividing each cell's weight over the sum-up of each column in the scored matrix. Then, averaging over each row is required to create the average weights of criteria normalized matrix of size 9x100 using the equation (14):

$$\frac{\sum_{i=1}^{n}\beta_{ij}}{n} = awg_k \quad where\ n = 100,\ i = 1,2,...,9\ and\ j = 1,2,....,9 \tag{14}$$

where c_n and s_n describe the number of criteria and the number of students, respectively. We provided the vector of average weights of criteria as size 9x1.

Table 6.
The Average Weights of Criteria

	Scored Criteria				Normalized Scores				Average Weights of Criteria
	p1	**p2**	…	**p100**	P_{n1}	P_{n2}	…	P_{n100}	
c1	92	96		88	0,166	0,162		0,163	0,164166266
c2	94	86		75	0,166	0,145		0,139	0,147922910
c3	75	75		65	0,129	0,124		0,124	0,125834066
c4	100	55		80	0,185	0,112		0,158	0,153585381
c5	40	45	…	50	0,074	0,107	…	0,096	0,093839624
c6	20	30		40	0,055	0,091		0,074	0,073897737
c7	10	50		30	0,018	0,091		0,055	0,055327491
c8	40	40		45	0,092	0,082		0,083	0,085742954
c9	50	40		55	0,111	0,082		0,102	0,099683570

The students were also asked to create an assessment matrix as alternatives versus criteria. It means that students scored alternatives for each criterion. The assessment matrix was created by scaling the students' scores for alternatives according to each criterion in the scale of 1 to 9. The most convenient alternative was scored as 9 whereas the less convenient alternative was scored as 1 so that we provided a scale for the alternatives for each criterion among themselves. The assessment matrix of size 10x9 was generated after completing the scoring process by the students.

Table 7.
The Assessment Matrix of SMART Method

	c1	c2	c3	c4	c5	c6	c7	c8	c9
s1	9	9	8	7	6	9	8	8	7
s2	7	7	4	2	2	2	5	1	3
s3	7	7	4	2	2	2	5	1	3
s4	4	8	4	1	2	1	5	1	1
s5	9	9	9	9	9	9	9	9	7
s6	5	5	5	3	2	1	6	3	6
s7	7	7	4	4	2	2	5	2	4
s8	4	4	4	2	2	1	6	1	2
s9	6	6	7	4	2	1	6	3	3
s10	5	5	3	3	2	2	5	2	9

The final step of SMART Analysis is to multiply the assessment matrix with the vector average weights of criteria obtaining the total score vector that presents the ranking of alternatives (the energy programs). Equation (15)is used to obtain the total score vector:

$$Total\ Score = \sum_{i=1}^{n} W_i C_i \tag{15}$$

where W_i is the average weights of criteria ($0 \le W_i \le 1$), C_i is the score of criteria score depending on the selected alternative. According to the results, the alternative with the highest score in the vector of the total score is the most preferred AERTPs in Turkey by the candidate students.

2.3. A technique for order preference by similarity to ideal solution (TOPSIS) analysis

Hwang and Yoon in 1981 created the TOPSIS method to consider that alternatives are represented in both the shortest distance to the positive-ideal solution and the farthest distance to negative-solution. According to the maximum and minimum values of the criteria, a ranking of alternatives is utilized by using the TOPSIS method while evaluating the distances of alternatives to the ideal solution under a certain criterion. The positive and negative-ideal solution distance must be considered to find an ideal solution where a proximity computation is required.

2.3.1. *The process of TOPSIS method*

The best solution is expressed as an ideal or positive ideal solution that maximizes the benefit criterion and minimizes the cost criterion (Wang, & Elhang, 2006). Therefore, all alternatives can be ranked by comparing the relative distances, since the nearest alternative to the positive-ideal solution is described as the farthest alternative to the negative-ideal solution. The steps in the implementation of the TOPSIS method in this study can be summarized as follows:

Step 1: Defining alternatives, criteria, and the criteria weights (w_j): The alternatives are the Alternative Energy Sources Technology Programs in Turkey where the criteria are described as mentioned in the Introduction Section. The weights of criteria (w_j) were created as normalized values of scoring scales between 1 and 9 by the high school senior students or the candidates of energy programs in the vocational schools in Turkey. First, the candidates were asked to score criteria 1 towards 9 depending on their importance. The weights assigned to the criteria can vary from a student to a student (Opricovic, & Tzeng, 2003). Second, each score of the criteria is divided by the summing of each score, separately (Table 4).

Table 8.
Scoring Criteria and Criteria Weights (w_j)

	c1	c2	c3	c4	c5	c6	c7	c8	c9	
Scores	9	7	4	6	2	5	2	2	1	
Criteria Weights	0,237	0,185	0,105	0,158	0,052	0,133	0,052	0,052	0,026	$\sum = 1$

Note that, in the AHP and SMART methods, the evaluation matrices are generated by scaling the official data on a scale of 1 through 9. TOPSIS uses the actual scoring data without any conversion in this study. The evaluation matrix is generated differently from AHP and SMART methods using real data by providing resources such as

EPDK, OSYM, YOKATLAS, and the official websites of the universities. Each element (x_{ij}) evaluation matrix represents the performance value for the j^{th} alternative of the i^{th} criterion. Here is the evaluation matrix (**X**) when the alternative number is denoted by m and the number of criteria is denoted by n.

$$X = \left(x_{jj}\right)_{mn} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (16)$$

Table 9.
The Evaluation Matrix X=[xij]9x10

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10
c1	3	1	1	1	4	2	1	2	2	1
c2	10	8	8	5	10	6	8	5	7	6
c3	9	5	5	5	10	6	5	5	8	4
c4	100	16	16	16	120	40	30	15	40	20
c5	10	3	3	3	14	3	3	3	3	3
c6	116,14	6,608	5,104	2,304	246,48	18,8	23,61	4,68	20,6	5,04
c7	8,16	3,83	3,83	1,07	8,46	7,82	5,65	2,86	4,01	12,52
c8	69,24	66,99	66,99	67,36	69,87	65,51	66,14	65,82	66,24	66,84
c9	1005	192	192	71	1000	39	135	15	3	135

Step 2: After creating the evaluation matrix and criterial weights, the values of the evaluation matrix were normalized in order to be able to independently compare the values of the criteria in the evaluation matrix. The normalized matrix **R** is obtained using the Equation below since the normalized value for the j^{th} criterion of the i^{th} alternative is $\mathbf{r_{ij}}$.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}} = \frac{x_{ij}}{\sqrt{b_i}} \quad (17)$$

Step 3: The normalized values are weighted. The criteria weights corresponding to each criterion determined by the candidates can be revealed as $wj = w_1, w_2, ..., w_n$. The values of the weighted normalized evaluation matrix can be calculated by multiplying each value in the normalized evaluation matrix by weights of v_j belonging to the criteria formulated as:

$$v_{ij} = w_j . r_{ij} \quad (18)$$

Step 4: Finding positive and negative (+/-) ideal solutions: The alternatives for the positive (A^+) and the negative (A^-) solutions are expressed as follows[ref]:

$$A^+ = \{v_1^+, v_2^+, ..., v_n^+\} = \{(\max_i v_{ij} \mid_{j \in J_1}), (\min_i v_{ij} \mid_{j \in J_2}), i = 1, 2, ..., m\} \quad (19)$$

$$A^- = \{v_1^-, v_2^-, ..., v_n^-\} = \{(\min_i v_{ij} \mid_{j \in J_1}), (\max_i v_{ij} \mid_{j \in J_2}), i = 1, 2, ..., m\} \quad (20)$$

where $J_1 = \{j = 1, 2, ..., n\}$ and j is defined as the criterion that provides the benefit. $J_2 = \{j = 1, 2, ..., n\}$ and j is defined as the criterion that causes the loss. If a benefit criterion is considered, it is taken to the set of maximum v_j. What If a criterion causes the negativeness? it is then taken to a minimum v_j positive-ideal set.

Step 5: Calculating the Euclid distance of alternatives to ideal solutions: The distinction distance of each alternative from the positive-ideal solution and the negative-ideal solution were calculated with n-dimensional Euclid distance method. Since the distance of each alternative from the positive-ideal solution is defined as S_i^+ depending on the Euclid conception, the formula was used for calculating these distances.

$$S_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}, i = 1,2,3,....,m \quad (21)$$

The distance of each alternative from the negative-ideal solution was similarly calculated using the equation (22) given below:

$$S_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}, i = 1,2,3,....,m \quad (22)$$

Step 6: Calculating the proximity of alternatives to the ideal solution: The relative proximity of the i^th alternative (A_i) to the positive-ideal solution (A^+) is expressed with C_i^+ calculating by the formula given below:

$$C_i^+ = \frac{S_i^-}{S_i^+ + S_i^-}, i = 1,2,...m \quad (23)$$

where the proximity of the ideal-solution C_i^+ of i^th alternative should be in between zero and 1 as $0 \le C_i^+ \le 1$. That means if $A_i = A^+$, then $C_i^+ = 1$, similarly $A_i = A^-$, then $C_i^- = 0$.

Step 6: Ranking the alternatives: According to the proximity values of the ideal solutions calculated within the existing criteria, the alternatives were ranked. The best preferable alternative (AERTPs in this study) of the students is the closest alternative to the ideal solution.

The flowchart of TOPSIS method in this study is given in Figure 4.

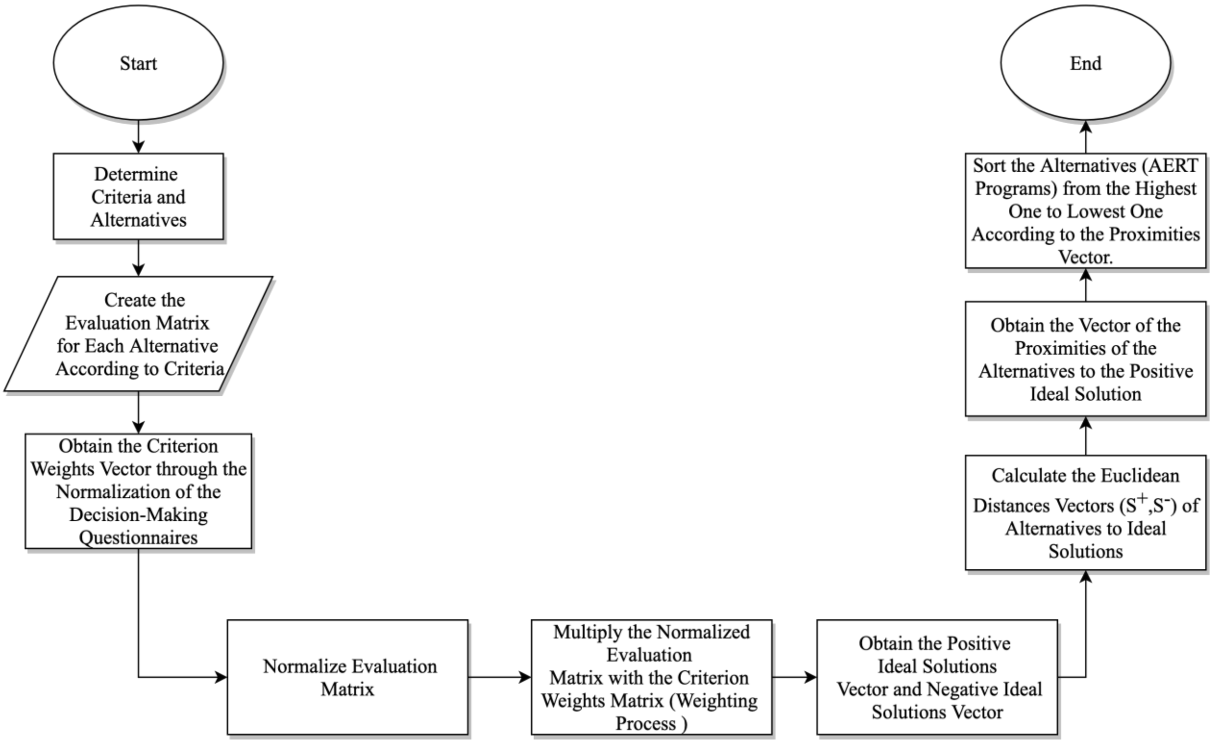

Figure4. The flowchart of technique for order preference by similarity to ideal solution (TOPSIS) analysis

3.FINDINGS

The Alternative Energy Resources Technology Programs in Turkey are included in the ranking performed by Multi-Criteria Decision Making Analysis Methods including AHP, SMART, and TOPSIS in this study. According to the 9 criteria expressed in the *Introduction Section*, the energy programs are ranked using Python

3.7.4 computer program. In Table 10, the Integrated Weighted Vector, the Total Score Vector, and the Proximity Vector have been given depending on the AHP method, SMART method, TOPSIS method, respectively.

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 10.

The Analyses Results including AHP, SMART and TOPSIS Methods

Alternative Energy Resources Technology Programs with LongName	Methods		
	AHP	SMART	TOPSIS
Ankara University, Gama Vocational School (s1)	0,231	0,160	0,241
Aydın Adnan Menderes University, Soke Vocational School (s2)	0,070	0,081	0,066
Aydın Adnan Menderes University, Buharkent Vocational School (s3)	0,070	0,081	0,066
Erzincan Binali Yıldırım University, Vocational School (s4)	0,049	0,066	0,016
Hacettepe University, Ankara Chamber of Industry 1.OSB Vocational School (s5)	0,270	0,178	0,372
Kayseri University, Mustafa Çikrikcioğlu Vocational School (s6)	0,059	0,089	0,045
MuglaSitkiKocman University, Mugla Vocational School (s7)	0,078	0,091	0,069
Nevşehir HaciBektas Veli University, Vocational School (s8)	0,040	0,069	0,020
Pamukkale University, Denizli Technical Science Vocational School (s9)	0,073	0,095	0,062
Selçuk University, KarapinarAydoganlar Vocational School (s10)	0,056	0,089	0,041
$\sum =$	1	1	1

In the last method of this study, TOPSIS, the highest value in Table 10 indicates that the proximate alternative for the positive ideal solution and the farthest alternative for the negative ideal solution. In this way, the ranking from the best alternative to the worst alternative can be reordered depending on the values.

Note that, for SMART and TOPSIS methods, the obtained results at the end of the analysis were not normalized values based on the methods' methodology. To plot all results on the same graph, the actual values provided from SMART and TOPSIS were normalized while each element of these vectors was divided by the sum of each column that the element belongs. According to all three analysis methods, the Alternative Energy Resources Technology Programs in Turkey included in the 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. Mugla Sitki Kocman University, Mugla Vocational School is ranked as 3rd energy program according to the AHP and TOPSIS methods, where it is listed as 4th one according to the SMART method. Pamukkale University, Denizli Technical Science Vocational School is ranked as 4th one according to AHP method while ranking as 3rd one according to the SMART method and ranked as 6th one according to the TOPSIS method.

Aydın Adnan Menderes University, Soke and Buharkent Vocational Schools have the same ranking values. In the figures for results, they are assigned by alphabetical order. Aydın Adnan Menderes University, Buharkent Vocational School is ranked as 5th one according to the AHP method where it is ranked as 7th one according to the SMART method and ranked as 3rd one based on the results of the TOPSIS method. While Aydın Adnan Menderes University, Soke Vocational School is ranked 6th one according to the AHP method where it is ranked as 8th one based on the results of the SMART method and ranked 4th one in the results of the TOPSIS method. Kayseri University, Mustafa Çikrikcioğlu Vocational School is ranked as 7th in the ranking done according to AHP where it is ranked as 5th and 7th one in the SMART and TOPSIS methods, respectively. Selçuk University, KarapinarAydoganlar Vocational School is listed as 8th, 6th, and 8thones in the methods of AHP, SMART, and TOPSIS, sequentially. Erzincan Binali Yildirim University, Vocational School is shown in the ranking scale as 9th one where it is ranked as 10th for both SMART and TOPSIS methods. The last energy program in the NevsehirHaciBektas Veli University, Vocational School is ranked as 10th one while it is ranked 9th one by SMART and TOPSIS methods.

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

According to the best of our literature review, Multi-Criteria Decision making Analyses may not provide similar results based on the same criteria because of the usage of their own algorithms/assumptions, different type of weights of criteria. These different results are expressed by some researchers as the decision-making paradox. The only proper way to obtain the same results is by applying the same deterministic models to the same data set. Each MCDM Analyseshas different nature since its own conception of human participation in the process. Considering that for the same problem, aiming at the same objective, it appears that the differences depend on the subjectivity od decision-maker. In order to obtain the same results, we believe that we can use two or more methods separately for the same problem. For the circumstance of our problem as an example, the weight computation of the AHP is required for the weight computation of criteria in the TOPSIS method. We may use some other methods to calculate criteria weights, however, we would already compute the criteria weights by AHP so that it is useless going forward for some other method once again for the same step.

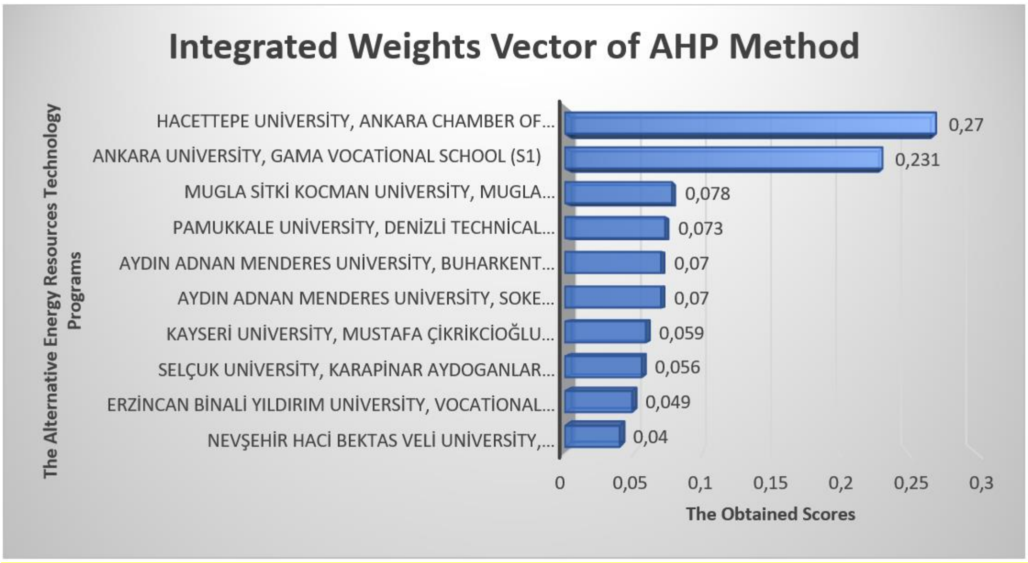

Figure 5. Ranking by analytic hierarchy process (AHP)

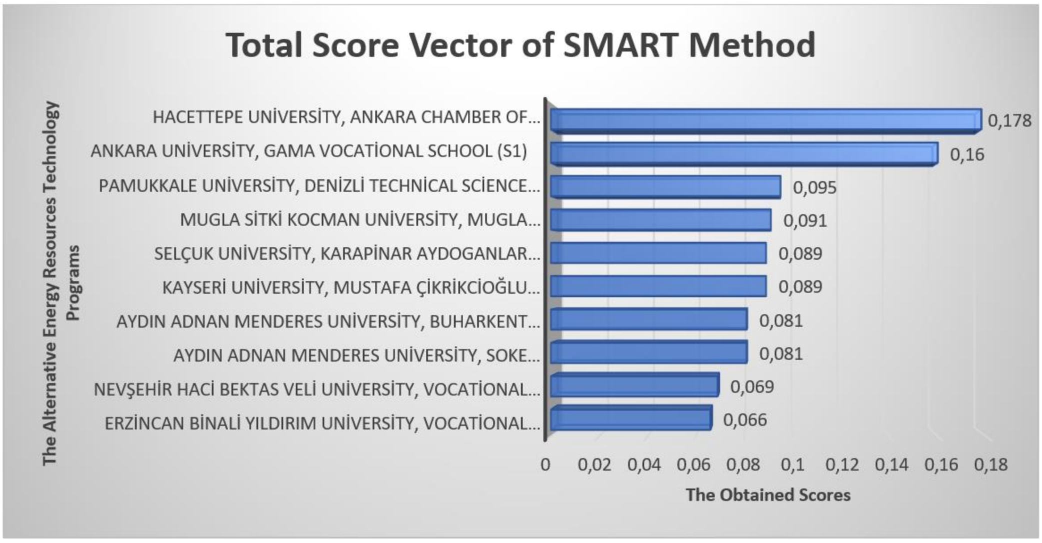

Figure 6. Ranking by simple multi-attribute rating technique (SMART)

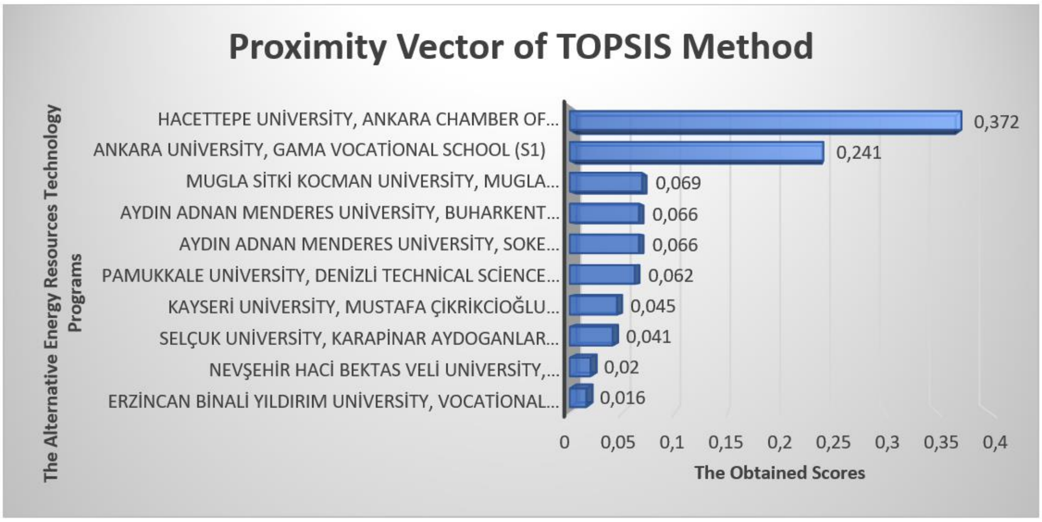

Figure 7. Ranking by technique for order preference by similarity to ideal solution (TOPSIS)

4.DISCUSSION and RESULTS

The accelerated globalization causes a competitive environment and enhancing requirements for competitiveness in the education sector. The need for ranking universities and their sub-programs individually has been enhancing considering many different comparable criteria with regards to universities/their sub-programs. It is very common to rank universities with not only with the domestic universities but also with the universities abroad. As it is known, ranking systems are generally made in the classification of national, global, and web-based based on sub-criteria (McClenney, 2004). Besides the impact of ranking systems on higher education and its stakeholders (Thakur, 2007), there are contradictions between both scientists and sources of news between the types of ranking mentioned above. Community colleges (or associate colleges) also take into account the criteria which are the most important factors in determining the field preferences of high school senior students, who are the target audience. For this reason, the ranking of energy programs based on the criteria that students consider when choosing associate colleges has been the subject of this study. It is not readily available in such a ranking system in Turkey. On the other hand, although lists of the 2-year community colleges (or associate schools) in Europe and the United States has been made, a ranking system as sub-department (energy, education, etc.) in associate colleges in the USA is not made in terms of the college quality the perspective of students who prefer. Also, although 2-year community colleges are listed in Europe in more detail based on area (technical, social, etc.), it is prominent information in our best literature research that the general ranking of these colleges is not made on the student preferability scale. In contrast with these studies, ranking sub-programs is very rare in Turkey especially. This circumstance creates a chaotic environment among the candidates of universities or their sub-programs. In Turkey’s case as an example, the high school senior students have challenges to make a consistent choice to be participants of undergraduate programs or sub-programs under vocational schools. For that purpose, field-based ranking system for two-year associate programs will be a pilot study. Alternative Energy Resources Technology Programs are chosen as a particular sub-program in vocational schools due to increasing the demand for energy in Turkey and increasing the employment (technicians) gap in the energy sector indirectly. The other benefit of this study is 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 hard to enhance the investments for the energy programs.

In the previously published article of us (Karakaş, & Teber, 2019) titled Place of Alternative Energy Resources Technology Program / Bayburt University in Turkey's Ranking and the Impact of Improvement Studies, it was observed that the university's place in the field ranking will positively rise based on the student selection criteria with the developments to be taken by either the university administration or the university investors. Since only the following 3 criteria (a. Energy program, campus facilities, b. technology infrastructure and laboratories, c. The number of students sent abroad with ERASMUS student exchange programs), among the 9 criteria are developed in the university, It was determined that the ranking of energy program of Bayburt University rises in the list of preferability. At that point, it is recommended that the universities or founders need to be considered the students’ criteria to rise their place among the other universities in that way.

The other important part of this study was applying a survey. A questionnaire was conducted with students who will choose from information technologies, renewable energy resources technologies, science, and fields without discrimination regardless of gender. Also considering the possibility of regional differences can influence the students' preferences, surveys participation of the different numbers of students from different regions of Turkey are provided. We recommend that the number of participants can be increased to much more precise values.

Table 11.
The Cities and the Numbers of Students where join the questionnaire

The Cities	Ankara	Bayburt	Bursa	Erzurum	Erzincan	Gaziantep	Hatay	İstanbul	Kahramanmaraş	Kars	Kayseri	Kocaeli	Malatya	Manisa	Mersin	Rize	Sakarya	Şanlıurfa	Trabzon
The Numbers of Students	5	10	6	7	5	4	3	14	2	2	4	16	2	3	2	3	10	1	1

The results obtained to determine the top two Alternative Energy Resources Technology Programs at Hacettepe University, Hacettepe Ankara Chamber of Industry 1.OSB Vocational School, and Ankara University, Gama Vocational School with the priority order in a huge gap than the other energy programs.

The findings of this study also provide that a preference guide of Alternative Energy Resources Technology Programs in Turkey for the high school senior students make a consistent/right choice as a participant of colleges/vocational schools. This study is also suggesting that the universities/programs in the lower ranks can be part of higher ranks for further years by taking into consideration the specified criteria in the declared study once they enhance the investments not only technological investments but also educational investments.

REFERENCES

Alma, B., Coşkun, E., & Övendireli, E. (2016). University ranking systems and proposal of a theoretical framework for ranking of Turkish universities: A case of management departments. *Procedia-Social and Behavioral Sciences*, *235*, 128-138. https://doi.org/10.1016/j.sbspro.2016.11.008

Dyer, J. S., Fishburn, P. C., Steuer, R. E., Wallenius, J., & Zionts, S. (1992). Multiple criteria decision making, multi attribute utility theory: The next ten years. *Management science*, *38*(5), 645-654. https://doi.org/10.1287/mnsc.38.5.645

Enerji Piyasası Düzenleme Kurumu (EPDK), (2019, July). *Elektrik piyasası sektör raporu listesi*. https://www.epdk.org.tr/Detay/Icerik/3-0-23/elektrikaylik-sektor-raporlar

Haas, R., & Meixner, O. (2009, July). *An illustrated guide to the Analytic Hierarcy Process* [Lecture notes]. Institute of Marketing & Innovation, University of Natural Resources. https://eclass.aueb.gr/modules/

Jesensek, M. (2006). Why the rankings are important. *Katedra (Maribor)*, *1*(4), 6-7.

Karakaş, A. & Teber, A. (2019). Bayburt Üniversitesi/Alternatif Enerji Kaynakları Teknolojisi Programı'nın Türkiye sıralamasındaki yeri ve iyileştirme çalışmalarının etkisi. *Bayburt Üniversitesi Fen Bilimleri Dergisi*, *2*(2), 176-182.

McClenney, K. M. (2004). Redefinning quality in community colleges: Focusing on good educational practice. *Change: The Magazine of Higher Learning*, *36*(6), 16-21. https://doi.org/10.1080/00091380409604239

Opricovic, S., & Tzeng, G. H. (2003). Defuzzification within a multicriteria decision model. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, *11*(5), 635-652. https://doi.org/10.1142/S0218488503002387

Ölçme, Seçme ve Yerleştirme Merkezi Başkanlığı (OSYM). (2018, March). *KPSS ön lisans değerlendirme raporu*. https://www.osym.gov.tr/TR,15635/2018-kpss-on-lisans-degerlendirme-raporu.html

Python Software Foundation. (2019, July). *Current release Python 3.7.4*. https://www.python.org/

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Servicessciences*, *1*(1), 83-98. https://doi.org/10.1504/IJSSci.2008.01759

Saaty, T. L., & Vargas, L. G. (2012). *Models, methods, concepts & applications of the analytic hierarchy process*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4614-3597-6

Sakarya Üniversitesi Bilgi Sistemi (2019, July). *Analytic hierarcy process (AHP)*. http://content.lms.sabis.sakarya.edu.tr/Uploads/49858/27314/week-10-ahp-analytical_hierarchy_process.pdf

Thakur, M. (2007). The impact of ranking systems on higher education and its stakeholders. *Journal of Institutional Research*, *13*(1), 83-96.

Triantaphyllou, E. (2000). Multi-criteria decision making methods. In *Multi-criteria decision making methods: A comparative study*. Springer. https://doi.org/10.1007/978-1-4757-3157-6_2

Velasquez, M., & Hester, P. T. (2013). An analysis of multi-criteria decision making methods. *International Journal of Operations Research*, *10*(2), 56-66.

Wang, Y. M., & Elhag, T. M. (2006). Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment. *Expert systems with applications*, *31*(2), 309-319. https://doi.org/10.1016/j.eswa.2005.09.040

Yükseköğretim Kurulu. (2019, July). *Yükseköğretim program atlası*. https://yokatlas.yok.gov.tr/

GENİŞLETİLMİŞ ÖZET

1. Giriş

Çok-Kriterli Karar Analizleri (ÇKKA) geçtiğimiz yıllarda giderek artan, ihtiyaç duyulan bir hale gelmektedir. Eski yöntemler geliştirilerek günümüz koşullarında kullanılmakta ve bunun yanında yeni yöntemler geliştirilmektedir. Geliştirilen yöntemler aracılığıyla birden çok faktörün etki ettiği problemler çözülebilmektedir. Durum böyleyken birçok sektörde farklı mesleklerden insanlar bu yöntemleri kullanmaya eğilim göstermektedir. Bahsedilen insan gruplarından bir örneklem olarak öğrenci grubunu ele alacak olursak, öğrencilerin ÇKKA'ya ihtiyaç duyabileceği en büyük problemlerden biri şüphesiz üniversite tercihleri olacaktır. Öğrencilerin geleceklerini inşa edeceği üniversitelerin tercihinde birden çok kriterin bulunduğu aşikârdır. Bu nedenle öğrencilerin bu ÇKKA yöntemleri aracılığıyla "doğru/tutarlı" tercih(leri) yardımıyla daha iyi bir gelecek için seçimler yapmaları sağlanmış olacaktır.

Üniversite tercihinde lisans programına yerleşemeyen adaylar için ön lisans programları fırsat oluşturmaktadır. Bu sayede sene kaybı olmadan eğitimine devam edecek ve üniversite hayatlarına başlamış olacaklardır. Türkiye'nin artan enerji ihtiyacı ve fosil yakıt kaynaklarının dünya genelinde ciddi bir azalış göstermesi dikkate alındığında, enerji sektöründe yetenekli ve alanında uzman tekniker açığı meydana getirmektedir. Son yıllarda Alternatif Enerji Kaynakları Teknolojisi Programı ön lisans aday öğrencileri için göze çarpan programlar arasında yer almaktadır.

Literatür üzerinde yapılan araştırma çalışmaları neticesinde gerek üniversiteler gerekse üniversitelerin lisans programları üzerinde sıralama çalışmalarının olduğu görülmektedir. Lakin üniversitelerde bulunan meslek yüksekokulları ve onların alt programları arasında bir sıralama sisteminin olmadığı gözlemlenmiştir.

Bu çalışmamızda Türkiye'de son yıllarda ilgi odağı hâline gelen ön lisans programlarından biri olan Alternatif Enerji Kaynakları Teknolojisi Programları için ÇKKA yöntemleri ile sıralanması amaçlanmaktadır. Bu sayede öğrencilerin bu ön lisans programını tercih edecek öğrenciler için bir rehber oluşturulacak bu sayede doğru program tercihi yapmaları sağlanmış olacaktır. Ayrıca bu çalışma sayesinde üniversite yönetimlerinin dikkatini çekmeyi başararak bu programlar için gerek üniversite yönetimleri gerekse akademik personelin kendi bölümlerinin sıralamalarını üst sıralara çıkarmak için bir rekabet ortamı oluşturmak hedeflenmektedir.

Çalışmamızın başlangıcında Türkiye'de bulunan Alternatif Enerji Kaynakları Teknolojisi Programları ÇKKA için alternatifler olarak belirlenmiştir. 2018-2019 eğitim öğretim yılı dikkate alınarak faaliyet gösteren alternatif enerji programları: Ankara Üniversitesi, Gama Meslek Yüksekokulu; Aydın Adnan Menderes Üniversitesi, Söke Meslek Yüksekokulu; Aydın Adnan Menderes Üniversitesi Buharkent Meslek Yüksekokulu; Erzincan Binali Yıldırım Üniversitesi Meslek Yüksekokulu; Hacettepe Üniversitesi, Hacettepe Ankara Sanayi Odası 1.OSB Meslek Yüksekokulu; Kayseri Üniversitesi Mustafa Çıkrıkçıoğlu Meslek Yüksekokulu; Muğla Sıtkı Koçman Üniversitesi, Muğla Meslek Yüksekokulu; Nevşehir Hacı Bektaş Veli Üniversitesi Meslek Yüksekokulu; Pamukkale Üniversitesi, Denizli Teknik Bilimler Meslek Yüksekokulu, Selçuk Üniversitesi, Karapınar Aydoğanlar Meslek Yüksekokulu olmak üzere on adet olarak sıralanmıştır. Daha sonra ÇKKA için gereken kriterlerin/ölçütlerin belirlenmesi için yüz öğrenci ile anket yapılmıştır. Anket sonuçları neticesinde ÇKKA için gereken kriterlerönem derecesine göre öğrenciler tarafından en çok onaylanan dokuz kritere indirgenmiştir. Bu kriterler şöyle sıralanmaktadır: kampüs olanakları ve üniversitenin kurulu olduğu şehrin sosyal yaşam olanakları, programın bulunduğu üniversitenin ön lisans KPSS başarı oranları, enerji programının bulunduğu üniversite ya da meslek yüksekokulunun sunduğu teknolojik altyapı ve laboratuvarları, programın kontenjanına göre tercih edilme oranı, programda görev yapan akademik kadro sayısı ve ünvanları, programın bulunduğu üniversitenin ERASMUS öğrenci değişim programı ile yurtdışına gönderilen öğrenci sayısı, dil eğitimi, program kontenjan sayısı, programın bulunduğu ilin enerji gücünün, Türkiye'nin kurulu enerji gücüne oran yüzdesi(mezun olduktan sonra iş olanağı sağlama yüzdesi olarak kabul edildi).

2. Yöntem

ÇKKA için kriterler ve alternatifler belirlendikten sonra sıralama işleminde kullanılacak olan ÇKKA yöntemleri Analitik Hiyerarşi Prosesi (AHP), Temel Çok-Ölçütlü Değerlendirme Tekniği (SMART), veİdeal Çözüme Benzerliğe Göre Tercih Sıralama Tekniği (TOPSIS) olarak avantajları nispetinde belirlendi. Birden fazla ÇKKA yönteminin kullanılmasında temel amaç, yöntemlerin çalışma mantıklarından dolayı AERTP programların sıralamasında oluşabilecek farklılıklar sonucunda öğrencilerin elde edilen sıralama sonuçları yardımıyla kararlarını daha tutarlı bir şekilde vermelerine olanak sağlamaktır.

AHP Metodunda önceden belirlenen alternatiflerin ve kriterlerin yönteme dâhil edilmesi gerekmektedir. Sonrasında kriterlerin ikili karşılaştırmalarını yapabilmek için bir matris oluşturulmak gerekliliktir. Karşılaştırma işlemi sırasında kriterler birbirlerine olan üstünlük derecelerini belirlemek için önceden belirlenmiş (yüz adet öğrenci ile gerçekleştirilmiş anket neticesinde) ölçekle değerleri ile her bir kriter için seçeneklerin ikili karşılaştırılabilmesi yapabilmek için kriter matrisi oluşturuldu. Kriterlerin karşılaştırılmasında olduğu gibi alternatiflerin karşılaştırılmasında da önceden belirlenen aynı ölçek kullanıldı. Sonrasında matris matematiği işlemleri uygulanarak kriter ağırlıkları vektörü elde edildi. Bulunan bu kriter ağırlıkları vektörü, kriterlerin tutarlı bir şekilde oluşturulup oluşturulmadığını test etmek için tutarlılık analizinde kullanıldı. Yapılan tutarlılık analizi sonucunda tutarlılık oranı (<0,1) uygun çıktığı için kriter karşılaştırma tablosu doğru kabul edildi. Alternatiflerin kendi aralarında her bir kritere göre karşılaştırıldığı matrisler her bir seçenek için ağırlık vektörü elde edildi. Elde edilen vektörler yan yana sıralanarak bir matris elde edildi. Elde edilen bu matris ile kriter ağırlıkları vektörü çarpılarak birleşik ağırlıklar vektörü hesaplandı. Birleşik ağırlıklar vektöründe bulunan her bir eleman (değer) büyükten küçüğe doğru sıralanarak Alternatif Enerji Kaynakları Teknolojisi Programların sıralanması sağlandı.

Diğer bir yöntem olan SMART Metodu dikkate alındığında, ilk olarak AHP yönteminde olduğu gibi kriterler ve alternatifler SMART yöntemine dâhil edildi. Daha sonra AHP Metodunda olduğu gibi öğrenciler üzerinde yapılan anket neticesinde belirlenen bir ölçekle alternatiflerin (enerji programlarının) kriterlere göre puanlaması yapıldı ve değerler bir matrise atandı. Matris değerleri kullanılarak kriterlerin ortalama ağırlıkları vektörü normalize edilen değerler yardımıyla hesaplandı. Bu kriter ağırlıkları vektörü ile puanlama işlemini yaptığımız matris çarpılarak elde edilen sonuçlar her bir alternatifin, kriterlerine göre toplamı hesaplanarak Toplam Skor Vektörüne atandı. Bu vektördeki değerler büyükten küçüğe doğru sıralanarak Alternatif Enerji Kaynakları Teknolojisi Programlarının sıralaması elde edilmiş oldu.

Bu çalışmada en son kullandığımız ÇKKA yöntemi, İdeal Çözüme Benzerliğe Göre Tercih Sıralama Tekniği (TOPSIS)'dir. İlk olarak, diğer iki yöntemde olduğu gibi, kriterlerin ve alternatiflerin yönteme dâhil edilmesi sağlandı. Sonrasında kriter ağırlıklarını yönteme ekleyebilmek için kriterlerin ağırlıkları ile ilgili öğrencilere yapılan anketin sonuçları normalize edilerek hesaplanan değerler kriter ağırlıkları vektörüne yazıldı. Daha sonra bir değerlendirme matrisi elde edildi. Bu yöntemde diğer iki yöntemden farklı olarak alternatiflerin belirlenen kriterlere göre puanlanmasında herhangi bir ölçek kullanılmadı. Çünkü TOPSIS yönteminin ileri adımlarındaki matematiksel işlemler puanlama için gereken ölçek ihtiyacını ortadan kaldırmaktadır. Elde edilen değerlendirme matrisindeki değerler normalleştirilerek yeni bir matris oluşturuldu. Oluşturulan bu matris ile kriter ağırlıkları çarpılarak ağırlıklandırılmış değerlendirme matrisi bulundu. Sonrasında bu matrisin kriter satırlarında en büyük değer ideal pozitif, en küçük değer ideal negatif olarak belirlenir. Bu işlemden sonra her bir seçenek için ideal çözümlere Euclid uzaklıkları hesaplandı. HesaplananEuclid uzaklıklarının ideal çözüme uzaklıkları elde edildi ve uzaklık vektörüne atandı. Bu vektördeki değerler büyükten küçüğe doğru sıralanarak Alternatif Enerji Kaynakları Teknolojisi Programlarının sıralaması elde edilmiş oldu.

3. Bulgular, Tartışma ve Sonuçlar

Hızlı küreselleşme, rekabetçi bir ortama ve eğitim sektöründe rekabet edebilirlik için gereksinimlerin arttırılmasına neden olmaktadır. Üniversiteleri ve alt programlarını ayrı ayrı sıralama ihtiyacı, üniversiteler / alt programları ile ilgili olarak birçok karşılaştırılabilir kriter göz önünde bulundurularak artmaktadır. Literatürde üniversiteleri sadece yerel üniversitelerle değil, aynı zamanda yurtdışındaki üniversitelerle de sıralamak çok yaygındır.

Bilindiği gibi sıralama sistemleri genel olarak ulusal, global ve web tabanlı olarak alt kriterlere göre sınıflandırılır (McClenney, 2004). Sıralama sistemlerinin yükseköğretim ve paydaşları üzerindeki etkisinin yanı sıra (Thakur, 2007), yukarıda bahsedilen sıralama türleri arasında hem bilim adamları hem de haber kaynakları arasında çelişkiler vardır. Topluluk kolejleri (veya yüksekokullar), hedef kitle olan lise son sınıf öğrencilerinin alan tercihlerini belirlemede en önemli faktör olan kriterleri de dikkate alır. Bu nedenle, öğrencilerin önlisans okullarını seçerken dikkate aldıkları kriterlere göre enerji programlarının sıralanması bu çalışmanın konusu olmuştur. Türkiye'de böyle bir sıralama sistemi mevcut değildir. Öte yandan, Avrupa ve Amerika Birleşik Devletleri'ndeki 2 yıllık topluluk kolejlerinin (veya yüksekokulların) listeleri yapılmış olsa da, ABD'deki önlisans kolejlerinde alt bölüm (enerji, eğitim vb.) olarak bir sıralama sistemi üniversite kalitesi açısından ve tercih eden öğrencilerin bakış açısından yapılmamıştır. Ek olarak, Avrupa'da 2 yıllık topluluk kolejleri, alan bazında (teknik, sosyal vb.) daha ayrıntılı olarak listelenmesine rağmen, en iyi literatür araştırmamızda bu kolejlerin genel sıralamasının öğrenci tercih ölçeği baz alınarak yapılmadığı öne çıkan bilgilerdir.

Bu çalışmaların aksine, özellikle Türkiye'de, alt programların sıralanması üzerine neredeyse herhangi bir sıralama olmadığı gözlemlenmiştir. Bu durum, üniversite adayları veya alt programları arasında bir kaos ortamı yaratır. Türkiye örneğinde, lise son sınıf öğrencileri, lisans programlarına veya yüksekokul programlarına yerleşmek için tutarlı bir seçim yapma konusunda zorluk çekmektedir. Bu amaçla, bu çalışma (Alternatif Enerji Kaynakları Teknolojisi Programı) alan tabanlı bir sıralama sistemi olması için pilot bir uygulama olarak gerçekleştirilmiştir. Alternatif Enerji Kaynakları Teknoloji Programları, Türkiye'de enerji talebinin artması ve enerji sektöründeki istihdam (teknisyenlerin) açığının olmasından dolaylı pilot program olarak seçilmiştir. Bu çalışmanın diğer yararı, enerji programları arasında daha yüksek eğitim standartlarına öncülük etmek için enerji programları arasında bir rekabet yaratmaktır; böylece fon verenler ve / veya fakülteler, enerji programlarına yönelik yatırımları artırmak zorunda kalacaklardır.

Daha önce yayınladığımız (Karakaş & Teber, 2019) yazımızda öğrenci seçim kriterlerinde üniversite yönetimi veya üniversite yatırımcıları tarafından yapılacak iyileştirmeler ile üniversitenin alan sıralamasındaki yerinin olumlu yönde yükseleceği gözlemlenmiştir. Çalışmamızda, 9 kriterden sadece aşağıdaki 3 kriter (a. Enerji programı, kampüs tesisleri, b. Teknoloji altyapısı ve laboratuvarlar, c. ERASMUS öğrenci değişim programları ile yurt dışına gönderilen öğrenci sayısı) geliştirildiğinde, Bayburt Üniversitesinin enerji programı sıralamasının tercih edilebilirlik sıralamasında yükseldiği gözlemlendi. Bu noktada, üniversitelerin veya kurucuların, diğer üniversiteler arasında bu şekilde yerlerini yükseltmek için öğrencilerin kriterlerini dikkate almaları önerilmektedir.

Bu çalışmadaki diğer önemli bölüm anket kısmıdır. Bilişim teknolojileri, yenilenebilir enerji kaynakları teknolojileri, bilim ve alanlardan cinsiyet ayrımı gözetmeksizin seçim yapacak öğrencilerle anket yapıldı. Ayrıca bölgesel farklılıkların öğrencilerin tercihlerini etkileyebileceği göz önünde bulundurularak, Türkiye'nin farklı bölgelerinden farklı sayıda öğrencinin anketlere katılımı sağlanmaktadır. Katılımcı sayısının çok daha kesin değerlere çıkarılmasını tavsiye edilmektedir.

Elde edilen sonuçlar, Hacettepe Üniversitesi, Hacettepe Ankara Sanayi Odası 1.OSB Meslek Yüksekokulu ve Ankara Üniversitesi Gama Meslek Yüksekokulu'ndaki ilk iki Alternatif Enerji Kaynakları Teknolojisi Programını, diğer enerji programlarından daha büyük bir oranda önceliğe sahip olduğu gözlemlenmiştir.

Bu çalışmanın bulguları, Türkiye'deki meslek okullarının katılımcısı olan lise son sınıf öğrencileri için tutarlı / doğru bir seçim yapabilmeleri için Alternatif Enerji Kaynakları Teknolojisi Programları tercih rehberinin yapılmasını sağlamaktadır. Bu çalışma aynı zamanda, diğerlerine göre düşük sıralamada ki üniversitelerin / programların, eğitim/öğretim ve teknolojik yatırımları arttırdıklarında, beyan edilen çalışmada belirtilen kriterleri göz önünde bulundurarak, gelecek yıllarda daha üst sıralarda yer almasının mümkün olabileceğini ileri sürmektedir.

ETİK BEYANNAME

Bu çalışmanın araştırma ve yazım sürecinde araştırmacı / araştırmacılar tarafından bilimsel ve etik kurallara uyulduğunu, farklı eserlerden yararlanılması durumunda atıfta bulunulduğunu, kullanılan verilerde herhangi bir tahrifat yapılmadığını, araştırmanın tamamının veya bir kısmının farklı bir akademik yayın platformuna yayımlanmak üzere gönderilmediğini, belirtilen konularda araştırmanın yazarının / yazarlarının bilgi sahibi olduğunu ve gerekli kurallara uyulduğunu beyan ederim. 11/09/2020..

Ahmet TEBER

Araştırmanın Sorumlu Yazarı