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Determination of the Focus Strategies Related to Renewable Energy For Turkey by Using the Fuzzy Sectional SWOT

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Abstract

Determining the strategies that Turkey need to focus at the renewable energy field is aimed in this study. For this, an integrated method called the Fuzzy Sectional SWOT consisting of the Fuzzy AHP and the Sectional SWOT methods was used. Some disadvantages of the traditional SWOT analysis are eliminated with the method used. Firstly, the renewable energy field was divided into 6 sub-sections (hyropower, solar, wind, biomass, hydrogen and geothermal) according to the logic of Sectional SWOT analysis. Then strengths, weaknesses, opportunities and threats for each of these sub-sections were determined using the Sectional SWOT analysis. Weights were found with the Fuzzy AHP method for each of the renewable energy sources and they were prioritized according to these weights. Finally, focus strategies related to renewable energy field for Turkey were obtained with the creation of strategies related to renewable energy sources. Consequently, the focus strategies which should be primarily addressed are related to use of renewable energy potential, social awareness about the renewable energy, government supports and incentives related to the renewable energy, selection of suitable areas for renewable energy plants and domestic production of the constituent parts of renewable energy plants.

Keywords: Renewable energy, Sectional SWOT, Fuzzy AHP, Strategy

Bulanık Parçalı SWOT Kullanılarak Türkiye için Yenilenebilir Enerjiye İlişkin Odak Stratejilerin Belirlenmesi

Öz

Bu çalışmada, Türkiye'nin yenilenebilir enerji alanında odaklanması gereken stratejilerin belirlenmesi amaçlanmıştır. Bunun için Bulanık AHP ve Parçalı SWOT yöntemlerinden oluşan Bulanık Parçalı SWOT adı verilen entegre bir yöntem kullanılmıştır. Geleneksel SWOT analizinin bazı dezavantajları, kullanılan yöntemle ortadan kaldırılmıştır. Öncelikle, yenilenebilir enerji alanı Parçalı SWOT analizi mantığına göre 6 alt-bölüme (hidroelektrik, güneş, rüzgar, biyokütle, hidrojen ve jeotermal) ayrılmıştır. Daha sonra, bu alt bölümlerin her biri için güçlü, zayıf yönler, fırsatlar ve tehditler, Parçalı SWOT analizi kullanılarak belirlenmiştir. Bulanık AHP yöntemi ile yenilenebilir enerji kaynaklarının her biri için ağırlıklar bulunmuş ve kaynaklar bu ağırlıklara göre önceliklendirilmiştir. Son olarak, yenilenebilir enerji kaynaklarına ile ilgili stratejilerin oluşturulması ile Türkiye için yenilenebilir enerji alanına ilişkin odak stratejiler elde edilmiştir. Sonuç olarak öncelikli olarak ele alınması gereken odak stratejiler, yenilenebilir enerji potansiyelinin kullanımı, yenilenebilir enerji konusunda toplumsal farkındalık, yenilenebilir enerji ile ilgili devlet destekleri ve teşvikleri, yenilenebilir enerji santralleri için uygun alanların seçimi ve yenilenebilir enerji santrallerinin bileşenlerinin yerli üretimi ile ilgilidir.

Anahtar Kelimeler: Yenilenebilir enerji, Parçalı SWOT, Bulanık AHP, Strateji

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1. Introduction

Due to reasons such as technological developments, industrialization, population growth, the need for energy in the world is constantly increasing and available fossil resources are insufficient to meet this need. Therefore, there has been an acceleration in the search for renewable energy resources (RES) in the world and this development has directed countries to renewable energy. The term "renewable" in RES indicates the main feature of these technologies; the unexplainable and renewable nature and the existence of the basic energy source in human dimensions (Eltrop 2013). The renewable energy is described by Henrik Lund (2010) as "energy that is produced by natural resources - such as sunlight, wind, rain, waves, tides, and geothermal heat - that are naturally replenished within a time span of a few years". The use of renewable energy goes back a long way. Renewable energy sources were largely used before the industrialization period and coal was used as the main energy source in the mid-19th century (Asif and Muneer 2007). Renewable energy and regenerative energy technologies are of great interest today. It is seen that new projects, new technologies and new energy stakeholder groups are emerging everywhere. Countries, regions and cities are competing to be the best in energy rankings. So where does this change in energy come from? (Eltrop 2013). Energy security, economic impacts and CO_2 emission reduction are three main factors which trigger the use RES (Heshmati et al. 2015).

There are enormous potential renewable energy sources worldwide that can provide clean energy such as hydro power, solar, wind and biomass and can increase the long-term supply of sustainable energy (Asif and Muneer 2007). In 2018, the share of RES in total electricity generation in the world was 26%. If it is looked the situation of energy supply world-wide, of the total 13.859.770 ktoe total energy supply in 2018, only 1.975.678 ktoe (hydro: 362.327 ktoe; wind, solar, etc.: 286.376 ktoe; biofuels and waste: 1.326.975 ktoe) belong to RES. If the overall situation of Europe which consists of 43 countries which also contain Turkey is looked, of the total 1.975.678 ktoe total renewable energy supply in 2018, only 303.893 ktoe belong to Europe (IEA, 2021).

According to data of the Republic of Turkey Ministry of Energy and Natural Resources (Online 2020), while %67.1 (from %37.3 coal, %29.8 natural gas) of Turkey electricity production in 2018 were supplied from nonrenewable energy sources, %31.5 (from %19.8 hydraulic energy, %6.6 wind, %2.6 the sun, %2.5 geothermal energy) were supplied from RES and the rest %1,4 were supplied from other sources. As of the end of September 2019, the installed power in electric energy was 90,720 MW and the distribution of this power according to the sources is as in Table 1.

Table 1. In 2019 distribution of installed power in electric energy according to the sources (Online 2020)

Sources of Energy	Installed Power Capacity
Hydropower	%31.4
Natural gas	%28.6
Coal	%22.4
Wind	%8.1
Solar	%6.2
Geothermal	%1.6
Other sources	%1.7

In this study, determining the focus strategies of Turkey related to renewable energy based on the increasing importance of renewable energy in the world is aimed. The study which is structured based on mentioned purpose, consists of 5 sections, including the introduction. In the second part of the study, related literature was mentioned. In the third part, the Sectional SWOT and the Fuzzy AHP methods that constitute the Fuzzy Sectional SWOT approach proposed in the study, were mentioned. In the fourth part, the proposed model was briefly mentioned and Turkey's focus strategies related to renewable energy were determined by making necessary analyses. In the final part, the results were interpreted and the study was completed.

2. Literature Review

Energy planning problems are in the category of issues that countries should consider carefully. Deciding on suitable energy alternatives and creating energy policies are two important ones of these problems. Since MCDM methods are suitable for the structure of these problems, they are frequently used in the literature to solve these problems. Since more sensitive, concrete and realistic results are obtained with Fuzzy MCDM, they are also widely used in solving these problems. When the current literature is examined, the most used method is Fuzzy AHP is seen. Likewise, one of the most used methods in the literature in strategy formulation is SWOT analysis.

2.1. Use of SWOT analysis or MCDM/fuzzy MCDM methods in energy planning problems

Bas (2013) proposed an integrated SWOT-fuzzy TOPSIS method combined with AHP for the analysis of the electricity supply chain in his study. With the SWOT analysis, the factors related to the electricity supply chain in Turkey were determined, the importance weights of these factors were determined with the AHP, and the SWOT factors evaluated were prioritized with the Fuzzy TOPSIS method. Okello et al. (2014) developed an approach integrating Desirability Functions into SWOT and AHP for participatory evaluation of technologies in their study. The application of the method was made through participatory evaluation of 4 bioenergy technologies in Uganda. The results showed that the method is

effective in assessing stakeholder priorities for bioenergy technology. In their study, Tasri and Susilawati (2014) tried to determine the most suitable renewable energy source for electricity generation in Indonesia. For this purpose, a method based on fuzzy AHP is proposed. When the results of the study were interpreted, it was finalized that hydropower is the best alternative.

Ervural et al. (2018) proposed a SWOT analysis based on ANP and fuzzy TOPSIS for Turkey's energy planning in their study. For solving the problem, SWOT analysis was preferred to determine the criteria and sub-criteria related to Turkey's energy sector, ANP was used to determine the weights of these criteria and sub-criteria, and Fuzzy TOPSIS was used to prioritize alternative energy strategies. Sensitivity analysis was used to confirm the results of the study. Gottfried et al. (2018) applied SWOT-AHP-TOWS analysis to increase private investment to China's biogas sector. For this purpose, investment criteria of private stakeholders have been defined in order to increase the active participation of private investors. SWOT analysis was used to define the investment criteria and then these criteria were prioritized using AHP. Finally, strategies related to investments were created using the TOWS matrix.

Erdin and Ozkaya (2019) discussed the location selection problem related to renewable energy sources for the example of Turkey in their study. Finally, the most suitable energy sources are presented according to the geography and energy potential of the regions. Kaya et al. (2019) conducted a comprehensive literature review in order to examine which fuzzy multi-criteria decision-making techniques are used in creating energy policy in the literature. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was used as the literature review method. Finally, fuzzy AHP was determined as the most used method in the literature on this subject. Solangi et al. (2019) evaluated energy strategies for Pakistan's sustainable energy planning in their study. For this purpose, they proposed an integrated approach based on SWOT, AHP and Fuzzy TOPSIS. SWOT was preferred to determine the factors and sub-factors in sustainable energy planning, AHP was used to determine the weights of all factors and sub-factors, and Fuzzy TOPSIS was used to rank the determined energy strategies. Sensitivity analysis was performed to confirm the results of the study.

Papapostolou et al. (2020) proposed a method based on AHP-SWOT-Fuzzy TOPSIS to establish Cross-Border collaboration on renewable energy sources. SWOT analysis was used to determine the factors and sub-factors related to the subject, AHP was used to determine the weights of these factors and sub-factors, and Fuzzy TOPSIS was used to evaluate the alternatives. Wang et al. (2020) discussed the problem of selection of renewable energy sources that can be used for electricity generation in Pakistan's Sindh and Baluchistan cities in their study. To solve the problem, SWOT was preferred to identify the main factors affecting renewable energy technologies in Pakistan, and Fuzzy AHP was used to evaluate renewable energy alternatives. When the results were commented, it was found that wind energy is the best alternative.

As can be seen from the existing literature, studies on the subject have focused on solving energy planning problems using SWOT and MCDM or Fuzzy MCDM. Therefore, this study contributes to existing literature by making the right investment decisions by creating focus strategies for renewable energy investments using the Fuzzy Sectional SWOT. Because focus strategies were created by the fuzzy sectional SWOT method in this study.

3. Research Methodology

In this study, an approach called the Fuzzy Sectional SWOT which consists of the Fuzzy AHP and the Sectional SWOT, was preferred to decide the focus strategies for renewable energy sources in Turkey. This new approach eliminates some of the shortcomings of the traditional SWOT analysis. Firstly, the Sectional SWOT analysis was developed by extending the SWOT analysis. Then, by integrating the Fuzzy AHP method into the Sectional SWOT method, the Fuzzy Sectional SWOT approach used in the study was obtained.

3.1. A new approach to the SWOT analysis: The Sectional SWOT analysis

Strategies are very important to guide the future of an individual, an event or a company. In general, it is necessary to act from the their current situations in order to determine strategies related to the individual, event or company. The current situation refers to the conditions related to the individual, event or company itself and the environmen that it is located. These conditions are the strengths and weaknesses of the individual, event or company and the opportunities and threats in their environments. These mentioned conditions are investigated with a very famous analysis called as SWOT whose name consists from the combination of first letters of the Strengths, Weaknesses, Opportunities, Threats. The history of the SWOT analysis goes back to the 1960s (Learned et al. 1965) and it was popularized by Andrews (1965), who united the ideas of Peter Drucker, Philip Selznick and Alfred Chandler. The four groups of strategies created by the SWOT analysis are as follows (Sevkli et al. 2012);

1) Strengths and Opportunities (SO) Strategies: Using strengths to take advantage of opportunities.

2) Strengths and Threats (ST) Strategies: Using strengths to avoid from threats

3) Weaknesses and Opportunities (WO) Strategies: Overcoming weaknesses by taking advantage of opportunities

4) Weaknesses and Threats (WT) Strategies: Minimizing weaknesses to avoid from threats

In the literature, the criticisms of the traditional SWOT analysis are as follows; creating extremely long lists, no using weights to reflect priorities, using ambiguous words and expressions, conflicts have no solution, there is no obligation to validate ideas with data or analysis, only requires a level of analysis, no logical link to strategy implementation (Hill and Westbrook 1997). However, there is a more effective method, which is an extended variation of the SWOT analysis and was introduced into the literature as Sectional SWOT by Karatop (2015). In the Sectional SWOT analysis, the main topic is divided into sub-sections as different from the SWOT analysis. In this way, the SWOT analysis is converted to multi-criteria structure with the Sectional SWOT analysis. In addition to strengths and weaknesses, opportunities and threats in the environment are determined separately for each of the sub-sections obtained. Thus carring out a more detailed analysis, more appropriate results is obtained for the determination of strategies (Karatop 2015). The general structure of the sectional SWOT analysis is shown in the Table 2.

Table 2. Sectional SWOT (Karatop et al. 2018)

Main criteria	Sub-criteria	Sectional SWOT			
MC_1	**SC_{11}**	G_{111}	Z_{111}	F_{111}	T_{111}
		G_{112}	Z_{112}	F_{112}	T_{112}
		..	..	..	..
	SC_{12}	G_{121}	Z_{121}	F_{121}	T_{121}
		G_{122}	Z_{122}	F_{122}	T_{122}
		..	..	..	..
	..	..	..	..	..
	SC_{1a}	G_{1a1}	Z_{1a1}	F_{1a1}	T_{1a1}
		G_{1a2}	Z_{1a2}	F_{1a2}	T_{1a2}
		..	..	..	..
MC_2	**SC_{21}**	G_{211}	Z_{211}	F_{211}	T_{211}
		G_{212}	Z_{212}	F_{212}	T_{212}
		..	..	..	..
	SC_{22}	G_{221}	Z_{221}	F_{221}	T_{221}
		G_{222}	Z_{222}	F_{222}	T_{222}
		..	..	..	..
	..	..	..	..	..
	SC_{2b}	G_{2b1}	Z_{1b1}	F_{1b1}	T_{1b1}
		G_{2b2}	Z_{1b2}	F_{1b2}	T_{1b2}
		..	..	..	..
..	**..**	..	..	..	..
..	**..**	..	..	..	..
MC_n	**SC_{n1}**	G_{n11}	Z_{n11}	F_{n11}	T_{n11}
		G_{n12}	Z_{n12}	F_{n12}	T_{n12}
		..	..	..	..
	SC_{n2}	G_{n21}	Z_{n21}	F_{n21}	T_{n21}
		G_{n22}	Z_{n22}	F_{n22}	T_{n22}
		..	..	..	..
	..	..	..	..	..
		G_{nz1}	Z_{nz1}	F_{nz1}	T_{nz1}
	SC_{nz}	G_{nz2}	Z_{nz2}	F_{nz2}	T_{nz2}
		..	..	..	..

In the Table 2;
n = number of main criteria,
z = number of sub-criteria belong to nth main criterion,
MC_n = nth main criterion,
SC_{nz} = zth sub-criterion of the nth main criterion
The number of sub-criteria may be different for each main criterion. For example, the sub-criterion number of main criterion MC_1 is a (SC_{11}, SC_{12}, …, SC_{1a}) and the sub criterion number of main criterion MC_2 is b ((SC_{21}, SC_{22}, …, SC_{2b})). In the Table 4, G, Z, F and T respectively represent strengths, weaknesses, opportunities and threats. x, y and z in the expressions G_{xyz}, Z_{xyz}, F_{xyz} and T_{xyz} respectively represent the main criterion, related sub-criterion and sequence number. For example, the expression F_{243} refers to the 3rd opportunity of the 4th sub-criterion of the 2nd main criterion.

3.2. The Fuzzy AHP Method

The Analytical Hierarchy Process (AHP) was developed by Thomas L. Saaty in 1977 and is one of the most widely used multi-criteria decision making techniques in the literature. Although the aim of the AHP is to benefit from expert knowledge, the method may not reflect the way people think exactly. Therefore, the Fuzzy AHP method which is an extended version of the AHP method, was developed to solve hierarchical fuzzy problems. Several fuzzy AHP methods such as Van Laarhoven and Pedrycz Fuzzy AHP Method, Buckley Fuzzy AHP Method, Chang's Extended Analysis Method, are available in the literature (Kahraman et al. 2003). In this study, the Chang's extent analysis method was preferred because it requires less computation, follows the steps of traditional AHP and does not require additional processing (Toksari and Toksari 2011). The method was described in detail below (Chang 1996);

Let $X = \{x_1, x_2, \dots\dots, x_n\}$ be a criterion set and $G = \{g_1, g_2, \dots\dots, g_m\}$ be a objective set. In this method, each criterion is taken and extent analysis is performed for each purpose. Thus, m extent analysis values are obtained for each criterion. These are shown as $M_{g_i}^1, M_{g_i}^2, \dots\dots, M_{g_i}^m \quad i = 1,2, \dots\dots n$ and all the $M_{g_i}^j \ (j = 1,2, \dots\dots m)$ values are triangular fuzzy numbers (TFNs).

Step 1: According to criterion i, fuzzy synthetic extent values (S_i) are determined using Eq. (1);

$$S_i = \sum_{j=1}^{m} M_{g_i}^j * \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j\right]^{-1} \quad (1)$$

Fuzzy addition operation is performed on M values by using Eq. (2) to obtain $\sum_{j=1}^{m} M_{g_i}^j$ in the Eq. (1);

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j \, , \sum_{j=1}^{m} m_j \, , \sum_{j=1}^{m} u_j\right) \quad (2)$$

To obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1}$ in the Eq. (1), Eq. (3) and Eq. (4) are used;

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i \, , \sum_{i=1}^{n} m_i \, , \sum_{i=1}^{n} u_i\right) \quad (3)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \quad (4)$$

Step 2: The possibility degree for $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is expressed as $V(M_2 \geq M_1) = sup_{y \geq x}\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right]$. If this equation is analyzed, the Eq. (5) is obtained;

$$V(M_2 \geq M_1) = hgt\,(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1\,, \\ 0, & if\ l_1 \geq u_2\,, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise, \end{cases} \quad (5)$$

In the Eq. (5), d is the ordinate of the highest intersection point between μ_{M_1} and μ_{M_2}. In order to compare M_1 and M_2 values both $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$ values must be known.

Step 3: The possibility degree of a convex number being greater than k convex fuzzy numbers ($M_i \ i = \{1, 2, \dots, k\}$) must also be considered.

$$V(M \geq M_1, \dots, M_k) = V\left[(M \geq M_1)\ and\ (M \geq M_2) and \dots and\ (M \geq M_k)\right] = \min V\,(M \geq M_1) \quad (6)$$

In the Eq. (6), if $d'(A_i) = \min V\,(S_i \geq S_k)$ for i = $\{1,2, \dots, k\}$, weight vectors for k ≠ i are calculated using Eq. (7) as the following;

$$W' = \left(d'(A_1), d'(A_2), \dots, d'(A_n)\right)^T \quad i = \{1,2, \dots, n\} \quad (7)$$

Step 4: The weight vectors are normalized using Eq. (8);

$$W = \left(d(A_1), d(A_2), \dots, d(A_n)\right)^T, i = \{1,2, \dots, n\} \quad (8)$$

In the Eq. (8), W weight vector isn't a fuzzy number. The final alternative weights are found by hierarchically synthesizing obtained these weights.

4. The Proposed Fuzzy Sectional SWOT Approach and Its Application

The proposed model for the determination of Turkey's focus strategies related to renewable energy is as in the Figure 1. As mentioned also in the previous section, there are some criticisms directed the traditional SWOT analysis. Some disadvantages of the traditional SWOT analysis are overcome with the approach called the Fuzzy Sectional SWOT proposed in this study. Mentioned shortcomings and how they were eliminated were mentioned below;

- **No using weights to reflect priorities;** This disadvantage of the traditional SWOT analysis was eliminated by prioritizing renewable energy sources with the Fuzzy AHP method.
- **Using ambiguous words and expressions;** This disadvantage of the traditional SWOT analysis was eliminated by using the fuzzy logic.
- **There is no obligation to verify thoughts by data or analysis;** This disadvantage of the traditional SWOT analysis was eliminated by using the Fuzzy AHP method.
- **It requires only one level of analysis;** This disadvantage of the traditional SWOT analysis was eliminated with the use of Sectional SWOT analysis.
- **There is no logical link to strategy implementation;** This disadvantage of the traditional SWOT analysis was eliminated by determining the most important energy sources and creating the strategies related to them.

Application steps of the proposed model are as follows;

Step 1: Determination of the expert group

At this phase, the experts who are consulted to their opinions about the renewable energy sources addressed, were determined. The expert group consists of engineers working in the renewable energy sector and academicians who are expert in their fields.

Step 2: Application of the Sectional SWOT analysis

At this phase, the renewable energy field was divided into 6 sub-sections (hyropower, solar, wind, biomass, hydrogen and geothermal) according to the logic of Sectional SWOT analysis. Then strengths, weaknesses, opportunities and threats for each of these sub-sections (renewable energy sources) were determined in 3 ways using the Sectional SWOT analysis;

- Literature review,
- Examining the ministry reports,
- Asking questions which are seen in the Table 3 and were prepared to make Sectional SWOT analysis more systematic, to the experts.

Strengths, weaknesses, opportunities and threats related to the renewable energy sources addressed in this study express the following;

- Strengths contain issues that when the current situation for Turkey of addressed renewable energy source is examined, it can gain an advantage over other renewable energy sources.
- Weaknesses contain issues that when the current situation for Turkey of addressed renewable energy source is examined, it is

weak and deficient compared to other renewable energy sources.

- Opportunuties are issues that may create positive results for the related energy source when the current situation for Turkey of addressed renewable energy source is examined.
- Threats are issues that may create undesired results for the related energy source when the current situation for Turkey of addressed renewable energy source is examined.

The strengths, weaknesses, opportunities and threats determined for each of the RES addressed in the study as a result of the literature research, examination of the ministry reports and the informations received from the experts, are as seen in Table 4-Table 9.

Step 3: Prioritization of the renewable energy sources with the Fuzzy AHP

At this stage, firstly weights of the renewable energy sources were found by the Fuzzy AHP method and then they were prioritized according to their weights. For this purpose, firstly the criteria experts used when they compared RES, shown below were determined;

- ✓ Accessibility to renewable energy source,
- ✓ The effect of renewable energy source on the environment,
- ✓ The development of renewable energy source technology,
- ✓ The contribution ability of renewable energy source to technology

Then, the pairwise comparison matrix shown in the Table 11 was obtained with that the experts compared the renewable energy sources according to the above criteria using values in the Table 10.

Table 10. Values for expert evaluations (Karatop et al. 2018)

Importance Degrees	Linguistic Expressions
1	Both factors are equally important
2	1st factor is less important than the 2nd factor.
3	1st factor being averagely important with respect to 2nd factor
4	1st factor is more important than the 2nd factor
5	1st factor is very important than the 2nd factor

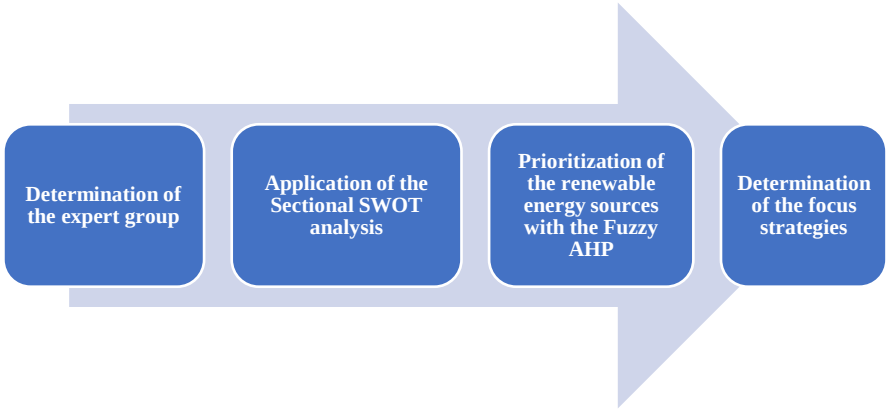

Figure 1. Application steps of the proposed model

Table 3. Questions related to renewable energy sources for the Sectional SWOT analysis

Sectional SWOT	Questions for the Sectional SWOT analysis
STRENGTHS	**1.** What are the advantages Turkey obtains in terms of its renewable energy sources? **2.** Which aspects of Turkey compared to other countries in terms of renewable energy sources are better / could be better? **3.** Do someones looking from the outside / stakeholders see powerful which aspects of the Turkey's renewable energy resources? **4.** In what aspects Turkey's renewable energy resources are in the leading position or have potential to can become leader? **5.** What are the advantages of Turkey's renewable energy resources / What can they happen?
WEAKNESSES	**1.** What are the disadvantages Turkey obtains in terms of its renewable energy sources? **2.** Which aspects of Turkey compared to other countries in terms of renewable energy sources are worse / are open to be improved? **3.** Do someones looking from the outside / stakeholders see weak which aspects of the Turkey's renewable energy resources? **4.** In what aspects Turkey's renewable energy resources aren't in the leading position? **5.** What are the weaknesses of Turkey's renewable energy resources / What can they happen?
OPPORTUNITIES	**1.** What are the opportunities standing in front of the Turkey's renewable energy sources? **2.** What sort of interesting developments take place in the environment related to the Turkey's renewable energy sources? **3.** Which developments in the technology are opportunity for the Turkey's renewable energy resources? **4.** Which opportunities similar practices taking place in other countries provide to the Turkey's renewable energy sources? **5.** Which sources in the environment are opportunity for the Turkey's renewable energy sources? **6.** What sort of opportunities wait the Turkey for renewable energy sources in the coming years?
THREATS	**1.** What are the threats standing in front of the Turkey's renewable energy sources? **2.** What sort of bad developments take place in the environment related to the Turkey's renewable energy sources? **3.** Which developments in the technology are threat for the Turkey's renewable energy resources? **4.** Which threats similar practices taking place in other countries provide to the Turkey's renewable energy sources? **5.** Which sources in the environment are threat for the Turkey's renewable energy sources? **6.** What sort of threats wait the Turkey for renewable energy sources in the coming years?

Table 4. The Sectional SWOT analysis for Hydropower at Turkey

	Strengths	Weaknesses	Opportunities	Threats
HYDROPOWER	Low operational cost (Heshmati et al. 2015;Online 2020; experts)	High initial investment cost (Heshmati et al. 2015, experts)	The Turkey is rich in terms of rivers and lakes (experts)	International problems may arise as a result of building power plants on streams which arise form Turkey and flow to other countries (Karali 2017; experts)
	Environmentally friendly (Heshmati et al. 2015; Online 2020; experts)	Causing displacement of local residents (Heshmati et al. 2015; experts)	Rough structure of the Turkey (experts)	-
	Ability to store energy (Heshmati et al. 2015; experts)	Damage to the environment during hydropower construction due to large engineering works (Heshmati et al.	Arising awareness about renewable energy (experts)	-

	2015; experts)			
	Suppling water for agriculture, household, and industrial use (Heshmati et al. 2015; experts)	-	-	-
	No fuel costs (Online 2020; experts)	-	-	-
	Highly productive (Online 2020; experts)	-	-	-
	Long-lived (Online 2020; experts)	-	-	-
	Reducing the occurrence of natural hazards such as soil erosion, flood etc. (Gedik 2015; Karali 2017; experts)	-	-	-
	Reducing external dependence and ensures supply security (Karali 2017; experts)	-	-	-
	Providing employment opportunities (experts)	-	-	-

Table 5. The Sectional SWOT analysis for Wind Energy at Turkey

	Strengths	Weaknesses	Opportunities	Threats
WIND ENERGY	Low maintenance and operational costs (Online 2020; experts)	High initial investment cost (Online 2020; experts)	Having adequate capacity for the plant installation of the Aegean and Marmara coasts (Karali 2017; experts)	Inadequate legal incentives in Turkey (Karali 2017; experts)
	Environmentally friendly (Online 2020; experts)	Low capacity factors (Online 2020; experts)	The constituent parts of the power plant are produced in Turkey (Karali 2017; experts)	May require outsourcing for power plant investment (Karali 2017; experts)
	Reaching of its cost to a level that can compete with today's power plants (Online 2020; experts)	Changing energy production (Online 2020; experts)	Avaliability of technological developments (Karali 2017; experts)	Inability to interfere with wind speed and it damage equipment at high speeds (Gedik 2015; experts)
	Installation and operating of its technology is relatively simple (Online 2020; experts)	Arising of additional cost from power transmission to residential areas (Ngô and Natowitz 2009; experts)	It is supported by European Union (EU) harmonization laws (Karali 2017; experts)	-
	Start-up of it can takes place in a short time (Online 2020; experts)	Intermittent structure (Ngô and Natowitz 2009; experts)	Arising awareness about renewable energy (experts)	-
	No risk of depletion and over time price increase (Online 2020; experts)	Causing bird deaths (Karali 2017; experts)	-	-
	Providing economic contributions related to renting, purchase etc. to the people in the power plant area (Karali 2017; experts)	-	-	-
	Providing employment opportunities (experts)	-	-	-

Table 6. The Sectional SWOT analysis for Solar Energy at Turkey

	Strengths	Weaknesses	Opportunities	Threats
SOLAR ENERGY	Ease of installation and use (Online 2020; experts)	Releasing of chemicals routinely and accidental (Tsoutsos et al. 2005; experts)	High solar energy potential of Turkey due to its geographical location (Online 2020; experts)	Due to climate changes the sunlight is not of good quality (Karali 2017; experts)
	Environmentally friendly (Online 2020; experts)	Use of land (Tsoutsos et al. 2005; experts)	Avaliability of appropriate lands for plant installation (Karali	Inadequate legal incentives (Karali 2017; experts)

			2017; experts)	
	No harmful waste (Online 2020; experts)	Impacts of large PV systems to ecosystems (Tsoutsos et al. 2005; experts)	With the rapid development of technology, it can be used more widely (Karali 2017; experts)	Interruption of the agriculture due to the use of agricultural land (Karali 2017; experts)
	Providing employment opportunities (experts)	Construction activities due to solar thermal energy (Tsoutsos et al. 2005; experts)	Arising awareness about renewable energy (experts)	-
	Low maintenance cost of power plants (experts)	Depending on weather conditions (Ngô and Natowitz 2009; experts)	-	-
	Possibleness to use it in every area where energy is needed (experts)	Availability just during daylight hours (Ngô and Natowitz 2009; experts)	-	-
	Increasing production power and efficiency with solar panels (experts)	Visual impact on buildings' aesthetics (Tsoutsos et al. 2005; experts)	-	-
	Sustainable (experts)	Intermittent structure (experts)	-	-
	-	Its investment cost is high (experts)	-	-

Table 7. The Sectional SWOT analysis for Geothermal Energy at Turkey

	Strengths	Weaknesses	Opportunities	Threats
GEOTHERMAL ENERGY	Environmentally friendly (Online 2020; experts)	High investment costs (Purkus and Barth 2011; experts)	Being rich in terms of geothermal due to geographical location (Online 2020; experts)	Inadequate legal incentives in Turkey (Karali 2017; experts)
	Cheap (Online 2020; experts)	Risk of insufficient heat (Purkus and Barth 2011; experts)	It is supported by EU harmonization laws (Karali 2017; experts)	May require outsourcing due to investment cost (Karali 2017; experts)
	Continuous structure (Heshmati et al. 2015; experts)	-	Arising awareness about renewable energy (experts)	-
	Independence from weather conditions (Fridleifsson and Freeston 1994; experts)	-	-	-
	Providing employment opportunities (experts)	-	-	-

Table 8. The Sectional SWOT analysis for Biomass Energy at Turkey

	Strengths	Weaknesses	Opportunities	Threats
BIOMASS ENERGY	Availability of it widely in all places (Tester et al. 2005; experts)	May environmentally hazardous (Evli 2018; experts)	Economic use in the countryside (Karali 2017; experts)	It is also raw material of other industries (Karali 2017; experts)
	Continuous structure (Gedik 2015; experts)	Increasing of food prices (Evli 2018; experts)	Arising awareness about renewable energy (experts)	Competition with agricultural products due to energy raw material (Karali 2017; experts)
	Easy storage (Gedik 2015; experts)	Low energy content compared to other non-renewable energy sources (experts)	-	-
	Providing employment opportunities (Gedik 2015; experts)	High transport and storage costs compared to other energy types (experts)	-	-
	Reducing dependence on fossil energy sources (Evli	-	-	-

	2018; experts)			
	Increasing of woodlands (Evli 2018; experts)	-	-	-
	Prevention of both damage to the environment and diseases stem from wastes (Evli 2018; experts)	-	-	-

Table 9. The Sectional SWOT analysis for Hydrogen Energy at Turkey

	Strengths	Weaknesses	Opportunities	Threats
HYDROGEN ENERGY	Environmentally friendly (Evli 2018; experts)	More expensive than other sources (Evli 2018; experts)	It is supported by EU harmonization laws (Karali 2017; experts)	Inadequate legal incentives in Turkey (Karali 2017; experts)
	Can be used for multiple purposes (Evli 2018; experts)	Environmentally harmful gases may ocur (Evli 2018; experts)	The presence of hydrogen stored chemically at the base of the Black Sea (Karali 2017; experts)	Potential users do not have sufficient information (Karali 2017; experts)
	More efficient than other fuels (Evli 2018; experts)	-	Arising awareness about renewable energy (experts)	Using the generated energy as an explosive weapon (Karali 2017; experts)
	Safer than other fuels (Evli 2018; experts)	-	-	-
	Providing employment opportunities (experts)	-	-	-

Table 11. Pairwise comparison matrix related to the renewable energy sources

	Hydropower	Wind	Solar	Geothermal	Biomass	Hydrogen
Hydropower	1	3	3	4	3	2
Wind	0.33	1	0.5	3	1	0.33
Solar	0.33	2	1	3	1	0.33
Geothermal	0.25	0.33	0.33	1	0.5	0.25
Biomass	0.33	1	1	2	1	0.25
Hydrogen	0.5	3	3	1	4	1

The obtained weight values and priority order determined according to the weights of RES as a result of the analyze are as in Table 12.

Table 12. Weight scores and priority order of the renewable energy sources

Renewable Energy Sources	Weight Scores	Priority Order
Hydropower	0.2710	1
Wind	0.2026	3
Solar	0.2186	2
Geothermal	0.0563	6
Biomass	0.1366	4
Hydrogen	0.1149	5
TOTAL	1	

Step 4: Determination of the focus strategies

At this stage, focus strategies have been created by using the strengths, weaknesses, opportunities and threats related to renewable energy sources determined by the Sectional SWOT analysis. The use of Sectional SWOT analysis enables to be created better focused strategies related to the renewable energy in Turkey. Strategies were generally structured on that using positive aspects (strengths and opportunities) to increase positive aspects and to turne negative aspects (weakneses and threats) to positive aspects or to neutralize. The focus strategies which were created related to the renewable energy for Turkey, are as follows;

- **Hydropower**

SO Strategy; The strategy created to further strengthen "Suppling water for agriculture, household, and industrial use", "Reducing the occurrence of natural disasters such as soil erosion, flood etc.", "Reducing external dependence and ensures supply security" and "Providing employment opportunities" strengths by taking advantage of "The Turkey is rich in terms of rivers and lakes" and "Rough structure of the Turkey" opportunities is as follows;

"Doing studies to can use whole of hydropower potential of the country"

WO Strategy; The strategy created to strengthen "Causing displacement of local residents" weakness by

taking advantage of "Arising awareness about renewable energy" opportunity is as follows;

"Doing activities to expand awareness even more related to renewable energy for the whole society and especially the society that is negatively affected by renewable energy investment".

- **Solar Energy**

SO Strategies;

Strategy 1: The strategy created to further strengthen "Providing employment opportunities" and "Possibleness to use it in every area where energy is needed" strengths by taking advantage of "High solar energy potential of Turkey due to its geographical location" and "Avaliability of appropriate lands for plant installation" opportunities is as follows;

"Giving support and incentive to increase the investments in solar energy"

Strategy 2: The strategy created to further strengthen "Possibleness to use it in every area where energy is needed" strength by taking advantage of "With the rapid development of technology, it can be used more widely" opportunity is as follows;

"Promoting R&D studies related to the solar energy"

ST Strategy; The strategy created to protect from "Due to climate changes the sunlight is not of good quality" and "Inadequate legal incentives" threat by using "Increasing production power and efficiency with solar panels" strength is as follows;

"Giving support and incentive for being used new technology in the solar power plants"

WO Strategies;

Strategy 1: The strategy created to strengthen "Depending on weather conditions", "Availability just during daylight hours" and "Intermittent structure" weaknesses by taking advantage of "High solar energy potential of Turkey due to its geographical location" opportunity is as follows;

"Doing studies to can use whole of the solar energy potential in the country"

Strategy 2: The strategy created to strengthen "Use of land" weakness by taking advantage of "Avaliability of appropriate lands for plant installation" opportunity is as follows;

"Allowing solar power plants to be installed only on suitable lands"

Strategy 3: The strategy created to strengthen "Depending on weather conditions", "Availability just during daylight hours" and "Intermittent structure" weaknesses by taking advantage of "With the rapid development of technology, it can be used more widely" opportunity is as follows;

"Supporting and encouraging the studies which increase production power and efficiency"

WT Strategies;

Strategy 1: The strategy created to protect "Depending on weather conditions" and "Intermittent structure" weaknesses from "Due to climate changes the sunlight is not of good quality" threat is as follows;

"Supporting and encouraging the use of technologies which increase production power and efficiency"

Strategy 2: The strategy created to protect "Its investment cost is high" weakness from "Inadequate legal incentives" threat is as follows;

"**Stressing the importance of solar energy, encouraging investors doing studies to produce the constituent parts of solar power plants cheaper and in the country**"

Strategy 3: The strategy created to protect "Use of land" weakness from "Interruption of the agriculture due to the use of agricultural land" threat is as follows;

"Using only suitable empty lands for installation of the solar energy plants"

- **Wind Energy**

SO Strategies;

Strategy 1: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "Having adequate capacity for the plant installation of the Aegean and Marmara coasts" opportunity is as follows;

"Building wind power plant in the areas with sufficient capacity"

Strategy 2: The strategy created to further strengthen "Start-up of it can takes place in a short time" strength by taking advantage of "The constituent parts of the power plant are produced in Turkey" opportunity is as follows;

"Using as much as possible domestic production parts while wind power plants are built"

Strategy 3: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "The constituent parts of the power plant are produced in Turkey" opportunity is as follows;

"Government's encouraging investors to produce the constituent parts of wind power plants"

Strategy 4: The strategy created to further strengthen "Reaching of its cost to a level that can

compete with today's power plants" strength by taking advantage of "Avaliability of technological developments" opportunity is as follows;

"Reducing the costs related to wind power plants by following the technological developments"

Strategy 5: The strategy created to further strengthen "Installation and operating of its technology is relatively simple" strength by taking advantage of "Avaliability of technological developments" opportunity is as follows;

"Implementing of the technological developments which facilitate the implementation of wind energy technology"

Strategy 6: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "It is supported by EU harmonization laws" opportunity is as follows;

"Promoting the establishment of wind power plants as part of the studies related to EU accession process"

ST Strategies;

Strategy 1: The strategy created to protect from "Inadequate legal incentives in Turkey" threat by using "Low maintenance and operational costs" strength is as follows;

"Providing consultancy service to support wind energy companies"

Strategy 2: The strategy created to protect from "Inadequate legal incentives in Turkey" and "May require outsourcing for power plant investment" threats by using "Reaching of its cost to a level that can compete with today's power plants" strength is as follows;

"Stressing the importance of wind energy, encouraging investors doing studies to produce the constituent parts of wind power plants cheaper and in the country"

WO Strategies;

Strategy 1: The strategy created to strengthen "Low capacity factors" weakness by taking advantage of "Having adequate capacity for the plant installation of the Aegean and Marmara coasts" opportunity is as follows;

"Establishment of wind power plants in the areas with adequate capacity"

Strategy 2: The strategy created to strengthen "High initial investment cost" weakness by taking advantage of "The constituent parts of the power plant are produced in Turkey" opportunity is as follows;

"Giving support or incentive for wind energy investments to accelerate R&D activities"

Strategy 3: The strategy created to strengthen "High initial investment cost" weakness by taking advantage of "It is supported by EU harmonization laws" opportunity is as follows;

"Giving support or incentive for R&D studies related to wind energy investments as part of the studies related to EU accession process"

WT Strategies;

Strategy 1: The strategy created to protect "High initial investment cost" weakness from "Inadequate legal incentives in Turkey" threat is as follows;

"Doing R&D studies of the government on wind energy investments"

Strategy 2: The strategy created to protect "High initial investment cost" weakness from "May require outsourcing for power plant investment" threat is as follows;

"Giving support or incentive for R&D studies related to wind energy investments"

- **Biomass Energy**

SO Strategy; The strategy created to further strengthen "Providing employment opportunities", "Reducing dependence on fossil energy sources", "Increasing of woodlands", "Prevention of both damage to the environment and diseases stem from wastes" strengths by taking advantage of "Economic use in the countryside" and "Arising awareness about renewable energy" opportunities is as follows;

"Giving support and incentive to investors to they invest in biomass energy"

ST Strategy; The strategy created to protect from "It is also raw material of other industries" and "Competition with agricultural products due to energy raw material" threats by using "Availability of it widely in all places" strength is as follows;

"**Ensuring to benefit from everything which can be raw materials for the production of biomass energy"**

WT Strategy; The strategy created to protect "Increasing of food prices" weakness from "It is also raw material of other industries" and "Competition with agricultural products due to energy raw material" threats is as follows;

"Separate production of common raw materials used by biomass energy and other sectors"

- **Hydrogen Energy**

SO Strategies;

Strategy 1: The strategy created to further strengthen "Providing employment opportunities"

strength by taking advantage of "The presence of hydrogen stored chemically at the base of the Black Sea" opportunity is as follows;

"Forming public opinion for processing of the hydrogen energy reserves in country"

Strategy 2: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "It is supported by EU harmonization laws" opportunity is as follows;

"Processing of hydrogen energy reserves in the country as part of the studies related to EU accession process"

WO Strategy; The strategy created to strengthen "More expensive than other sources" weakness by taking advantage of "The presence of hydrogen stored chemically at the base of the Black Sea" opportunity is as follows;

"Reducing costs by using existing hydrogen energy reserves in the country"

WT Strategy; The strategy created to protect "More expensive than other sources" weakness from "Inadequate legal incentives in Turkey" threat is as follows;

"Doing studies to reduce costs related to hydrogen energy"

- **Geothermal Energy**

SO Strategies;

Strategy 1: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "Being rich in terms of geothermal due to geographical location" opportunity is as follows;

"Using geothermal energy reserves in the country as much as possible"

Strategy 2: The strategy created to further strengthen "Providing employment opportunities" strength by taking advantage of "It is supported by EU harmonization laws" opportunity is as follows;

"Processing of geothermal energy reserves in the country as part of the studies related to EU accession process"

WO Strategy; The strategy created to strengthen "High investment costs" weakness by taking advantage of "It is supported by EU harmonization laws" opportunity is as follows;

"Doing studies to reduce investment costs by using supports and incentives given to geothermal energy which are a part of the studies related to EU accession process"

WT Strategy; The strategy created to protect "High investment costs" weakness from "Inadequate legal incentives in Turkey" threat is as follows;

"Doing studies to reduce costs related to geothermal energy"

5. Conclusions

Renewable energy has become a very popular type of energy all over the world due to its features such as providing security of energy supply, reducting the CO_2 emission and positive economic effects. Countries attach great importance to renewable energy and make their energy plans according to it. Based on the current importance of the subject, in the study it focused on determining of the Turkey's focus strategies related to renewable energy. This study contributes to existing literature by making the right investment decisions by creating focus strategies for renewable energy investments using the Fuzzy Sectional SWOT. For the aforementioned purpose, an integrated approach called the Fuzzy Sectional SWOT which consists of the Fuzzy AHP and the Sectional SWOT methods, is used. Some disadvantages of the traditional SWOT analysis are eliminated with the method used. Firstly, the renewable energy field was divided into 6 sub-sections (hyropower, solar, wind, biomass, hydrogen and geothermal) according to the logic of Sectional SWOT analysis. Then strengths, weaknesses, opportunities and threats for each of these sub-sections (renewable energy sources) were determined using the Sectional SWOT analysis. Weights were found with the Fuzzy AHP method for each of the RES and resources were prioritized according to these weights. Finally, focus strategies related to renewable energy field for Turkey were obtained with the creation of strategies related to renewable energy sources.

In the study, the order of importance of renewable energy resources from most important to less important was found as follows; hydropower, solar, wind, biomass, hydrogen, geothermal. Therefore, among the focus strategies obtained, the strategies to be taken into consideration at first are ones related to hydropower, solar and wind energies. However, this does not mean that the focus strategies related to biomass, hydrogen and geothermal energies can be neglected. For this reason, the focus strategies which should be primarily addressed related to renewable energy can be summarized as follows;

- Doing studies to use whole of the renewable energy potential in the country,
- Increasing social awareness related to the renewable energy,
- Providing necessary supports and incentives of the government,
- Selection of suitable areas for the installation of renewable energy plants,

- Producing the parts used in the installation of renewable energy plants, in the country.

The limitation of the study is the small number of experts who contributed to the study and therefore subjective judgment may predominate. Therefore, it would be good to increase the number of experts in future studies.

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