FACTA UNIVERSITATIS
Series: **Electronics and Energetics** Vol. 36, Nº 3, September 2023, pp. 353-363
https://doi.org/10.2298/FUEE2303353S

Original scientific paper

ASSESSMENT OF RENEWABLE ENERGY SOURCES USING MCDM METHOD: CASE STUDY

Bojan Stojčetović, Martina Petković, Strahinja Ðurović

Academy of Applied Studies of Kosovo and Metohija, Leposavić, Serbia

Abstract. *Energy is a prerequisite for development of today's economies and societies. Renewable energy sources (RES) are gaining increasing importance and share in the energy systems of many countries. However, assessment and selection among different renewable energy sources request analyzing numerous criteria, limitations, legal regulations etc. For this reason, multi-criteria decision-making methods (MCDM) are often used in the literature and in practice for the assessment of RES projects/technologies. From numerous MCDM methods in this paper analytical hierarchy process (AHP) is selected to assess solar, wind, photovoltaic and biomass sources in Kosovo*. According obtained results first ranked is hydro alternative. Also, for results obtained, sensitivity analysis is conducted. Its show that changes in rank occur exclusively outside the allowable values, so it can be concluded that the results obtained are relevant.*

Key words: *Analytical hierarchy process, renewable energy sources, Kosovo**

1. INTRODUCTION

A secure and uninterrupted supply of electricity is a condition for the survival and development of any modern economy. The crisis in electricity supply, which was pronounced in the last quarter of 2021, is manifesting itself in almost all European countries, and is also current in Kosovo*. In addition to the current energy crisis, Kosovo's* energy sector has other problems too, such as: delays in building new capacity for lignite production, significant technical and commercial losses of electricity in the distribution network, insufficient production capacity to cover peak loads in the winter season, inappropriate use of the potential of renewable energy sources (RES) etc [1]. The main electricity generation capacities in Kosovo* are the two thermal power plants Kosovo A and Kosovo B, which produce 97% of electricity. Thermal power plant Kosovo A consists of five units with installed power capacities as follows: A1 = 65, A2 = 125, A3 = 200, A4 = 200, and A5 = 210 MW, while Kosovo B consists of two units with an overall production

Received December 10, 2022; revised January 21, 2023; accepted January 31, 2023
Corresponding author: Martina Petković
Academy of applied studies of Kosovo and Metohija Leposavić, Serbia
E-mail: martina.petkovic@akademijakm.edu.rs

capacity 2 × 339 MW [2]. Electricity production is based on lignite, whose reserves in Kosovo* are estimated at 12.5 billion tons, which is the second largest reserve in Europe and fifth in the world [1].

The mentioned crisis and problems impose the need to solve the missing quantities of electricity. In this regard, the question arises as to whether the use of renewable energy sources can contribute to a more secure electricity supply. According to [3] RES are the fastest growing sources of electricity generation with an average increase of 2.9% annually from 2012 to 2040. Numerous RES benefits can be listed. Authors in [4] believe that RES can contribute to risk reduction because decentralized RES capacities are less exposed to risk such as sabotage compared to centralized ones. RES are also safer in terms of accidents (except for large hydropower plants). Also, RES contribute to greater security through the diversification of both technology and different energy sources [5]. In addition, RES plants do not require fuel to produce electricity. By developing RES capacity, certain regions can provide enough energy for their needs, which certainly leads to improved energy security [6]. However, and some negative impacts of RES can be listed: negative impact on birds, occupying a large area of land, instability in presence, waste etc. Present-day development of human and environmental protection against a variety of threats requires that ample preventive measures be taken and multi-purpose safety systems introduced. The most important prerequisite for proper planning, organization, and management is having the necessary information, which is obtained only through the development of a well-organized information system for fire and disaster risk management [7].

However, planning, managing and assessment of RES projects is a complex endeavor that has to include a number of criteria (potentials, constraints, legislation, etc.) as well as many stakeholders who often have opposed interests that can lead to conflict situations [8]. Also, taking into account the potential risks, the principle of planned management is the most acceptable one, because only proper planning, risk monitoring, organization, and efficient action in the event of fire guarantee the prevention or at least minimization of losses due to the risk event [9].

For that reason, to overcome mentioned complexity, multi-criteria decision-making methods (MCDM) can be applied to evaluate RES projects/technologies. Numerous MCDM methods can be used: Analytical hierarchy process (AHP), Preference ranking organization method for enrichment evaluation (PROMETHEE), Analytical network process (ANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) etc. Due to its advantages such as ease of use, the existence of numerous software tools which facilitates and accelerates the use of this method, performing sensitivity analysis AHP will be applied in this paper for the assessment of RES in the territory of Kosovo*. AHP method has been successfully applied in many areas: sport [10], tourism [11-12], environment [13], agriculture [14]. Also, AHP is used in the energy sector, among other things to assess RES alternatives [15-17].

The goal of this paper is to assess RES in Kosovo* from the aspect of selected criteria using AHP methodology.

2. Short Review of Renewable Energy Sources Potential in Kosovo*

By signing the Energy Community Treaty, Kosovo* has committed itself RES to participate with 25% in gross final consumption by 2020, while the voluntarily defined target is higher at 29.47%. The goals of RES's share in gross final consumption are defined for: electricity (25.64%), transport (10%) and heating and cooling (45.65%) [18]. However, so far the authors have not been able to find data on the fulfillment of previously defined goals.

The territory of Kosovo* has certain hydro potentials. Based on the feasibility study for the identification of water resources for small hydropower plants in Kosovo*, 77 sites for small hydropower plants with a capacity of about 128 MW and a production of 621 GWh per year under average hydrological conditions have been identified [19].

Table 1 Hydro energetic potential of rivers in Kosovo* [20]

River	Technical utilization hydro energetic potential (GWh/year)	Economical utilization hydro technical potential (GWh/year)
1. Beli Drim	554	554
2. Ibar	103.27	102.17
3. Binačka Morava	8.75	8.75
4. Lepenac	23.8	16.53
Total	689.82	681.45

Total production from biomass in Kosovo* is shown in Table 2. Based on the available data, it can be noticed that biomass from farming and forests has the greatest potential.

Table 2 Total production potential of biomass in Kosovo* [2]

Type of biomass	Total quantity produced (t/year)	Quantity that actually can be utilized from energy needs (t/year)	Exploitable potential energy needs (t/year)
Biomass from forests	1,247,434.00	346,418.00	1,247,434.00
Biomass from agriculture	696,541.00	209,962.00	208,962.00
Biomass from orchards and vineyards	17,356.00	17,356.00	17,356.00
Biomass from farming	4,383,170.00	3,813,358.00	3,813,358.00
Biomass from industrial timber waste	15,138.00	15,138.00	15,138.00
Biomass from urban waste	606,000.00	264,309.00	606,000.00
Total	6,965,639.00	4,665,541.00	5,908,248.00

According to a study conducted by the International Renewable Energy Agency (IRENA) in 2017 regarding RES potential in South East Europe, Kosovo* does not only have a large technical potential for photovoltaic (PV)-based renewable energy, but that a large portion of it is already economically feasible and that it could be realized entirely by 2050. The report identifies 581.3 MW (834.5 GWh) of technical solar PV potential, 436 of which is considered to be cost-competitive at a levelized cost of electricity (LCOE) of EUR 80/MWh [21].

According [22] Kosovo* could utilize both flat-plated and concentrated PVs for solar power generation, considering a 1419.7 to 1641.8 kWh/m2 annual GHI and a 1255.7 to 1546.8 kWh/m2 annual DNI in approximately 40% and 80% of the total area respectively. PV power potential in Kosovo* is shown in Fig. 1 (left) [23]. Wind power potential for 1 m^2 of surface rotor turbine installed at 100 altitudes above the ground level in different Kosovo* area locations is shown in Fig. 1 (right) [24].

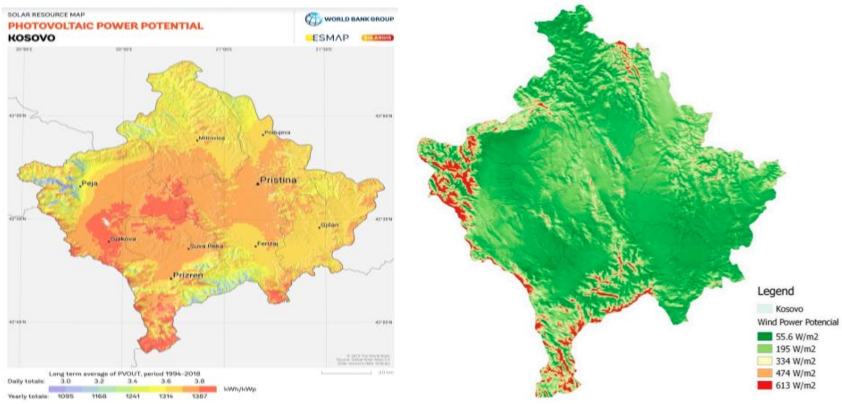

Fig. 1 PV (left) and wind (right) potential in Kosovo*****

The study conducted by IRENA finds Kosovo* to have a large wind technical potential, at 2328.8 MW (3849.5 GWh). However, it also accounts that due to the country's mountainous regions, a much smaller fraction of that potential can be fully utilized to generate power.

To encourage the use of RES there are support scheme through feed-in tariffs for PV (136.4 €/MWh for 12 years), biomass (71.3 €/MWh for 12 years), hydropower (67.3 €/MWh for 10 years) and wind (85 €/MWh for 12 years) [1].

3. METHODOLOGY

To assess different RES in Kosovo* in this paper AHP method is used. The AHP method was developed by Thomas Saaty [25]. By applying the AHP methodology, a complex problem can be decomposed into a multilevel structure of goals, criteria and alternatives [26]. At the top of the structure is the goal, followed by selected criteria at the second as well as alternatives at the third level. More complex problems may include sub-criteria, which in this case occupy a level between criteria and alternatives. Applied decision making model is shown in Fig 2.

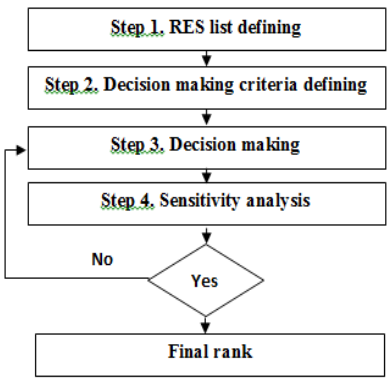

Fig. 2 Proposed decision making model

In order to solve the problem of the hierarchical structure of the AHP, the procedure is defined as follows [27] in first step the hierarchical structure is defined so that the goal is at the top of the hierarchy while the criteria and strategies are positioned in descending order; then in step two at each level, a matrix of pair wise comparisons is obtained. In order to identify the priority of each criterion (alternative) in relation to other criteria (alternative), a scale ranging from 1 (equal importance) to 9 (absolute importance) is used. Finally, in step three all pair wise matrixes are synthesized to calculate the relative and global weights of each criterion, sub-criterion, and alternative.

To perform a pair wise comparison by all relevant criteria/alternatives, an n x n matrix A is formed:

$$A=\begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \tag{1}$$

where a_{ij} values are obtained using a 9-point scale (Table 3).

Table 3 Saaty's 1-9 scale of pairwise comparisons

Intensity of importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one activity over another
5	Strong Importance	Experience and judgment strongly favor one activity over another
7	Very Strong	An activity is favored very strongly over another
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, ,4, 6, 8	Intermediate results	They are used to present a compromise between the priorities listed above

Matrix A is a positive reciprocal matrix in which aij represents the relationship of preference of alternative i and in relation to alternative j. The value of a_{ij} is the reciprocal of the value of a_{ji}. That is,

$$a_{ij} = \frac{1}{a_{ij}}. \tag{2}$$

If the pairwise comparisons are consistent, then the elements of the matrix A satisfy the equation:

$$a_{ij} * a_{jk} = a_{ik}, \text{ for each } i, j, k \qquad .(3)$$

The weighting factor of the criterion / alternative can be denoted by w_i. If the matrix A is consistent a_{ij} can be represented as

$$a_{ij} = \frac{w_i}{w_j} \text{ for each } i \text{ and } j. \tag{4}$$

Therefore, if A is consistent then it is:

$$A*W=\begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \dots & \dots & \dots & \dots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{pmatrix} * \begin{pmatrix} w_1 \\ w_2 \\ \dots \\ w_n \end{pmatrix} = n * \begin{pmatrix} w_1 \\ w_2 \\ \dots \\ w_n \end{pmatrix}. \tag{5}$$

By normalizing the matrix A = $[a_{ij}]$nxn the weight factor is calculated as follows:

$$a*_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \tag{6}$$

for each j=1,2,…,n. Then, it is:

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}}{n}, \tag{7}$$

for each j=1,2,…,n.

To determine the level of consistency, Saaty proposed the Consistency Index (CI), which can be calculated according to the following equation:

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)}, \tag{8}$$

where $\lambda_{\max}$ is the validation parameter in AHP. The closer the value of $\lambda_{\max}$ is to n, the more consistent the estimate is.

The Consistency Ratio (CR) can be calculated by the following formula:

$$CR = \frac{CI}{RI}, \tag{9}$$

where RI (Random Index) is a random consistency index.

When CR <0.10, the matrix can be assessed as acceptable, otherwise, the matrix should be modified until an acceptable value is reached. Homogeneity of factors within each group, fewer factors in the group, and better understanding of decision problems can improve the consistency index [28].

According to [29] AHP is the most frequently used method of all MCDM methods, and one of the reasons may be its simplicity. Some of advantages of AHP include: the possibility of combining with other methods to improve performance; the existence of numerous software tools that are based on AHP; enables decision makers to conduct sensitivity analysis etc. However, in addition to many advantages, there are disadvantages of AHP, which were discussed in the papers [29-35]. Some of the disadvantages of AHP are: in the case of adding a new criterion to the model, the entire decision-making process must be repeated; if there are many criteria and sub-criteria, a large number of pairwise comparisons are required; for an adequate assessment of one criterion in relation to another, a nine-point scale may represent a limitation; subjectivity of decision makers, etc.

4. RESULTS AND DISCUSSION

To assess RES in Kosovo* decision making model proposed in Figure 2. is applied and it is described in text that follows.

Step 1. RES list defining - In this step list of available and sufficient RES for considered territory shall be defined. To that end, it is necessary to research and analyze relevant literature, local and national strategies/analyses, etc. In case of Kosovo* four RES alternatives are selected: photovoltaic (A1), hydro (A2), biomass (A3) and wind (A4).

Step 2. Decision making criteria defining – After RES list is ready decision making criteria shall be defined. This is a very important step and can affect the results of the decision. In literature there are numerous criteria applied for RES assessment and selection. The criteria that are most often used to evaluate RES alternatives can be summarized in several groups: economic, technical, environmental, sociopolitical. In the case of evaluation of RES alternatives at the local level (city, village, municipality...) it is recommended to include stakeholders and experts in the process of defining the criteria. In literature there are papers where the criteria are defined based on the literature overview [36-38]. In this paper authors selected five criteria based on the literature analysis and specificities of the research area (Kosovo*):

Investment (eur/kw) – although RES can be a significant source of profit, significant financial resources are needed for the implementation of RES projects. In this regard, investors seek to minimize costs on the one hand and maximize profits on the other. Therefore, the amount of investment (eur / kw) is a very important criterion that investors in renewable energy sector consider when choosing a RES alternative. The unstable political situation in Kosovo* also represents a greater risk for investors, who will certainly try to minimize investments.

Price of energy (Usd/kWh) – The living standard of Kosovo* citizens is very low. That is why it is very important to take into account the price of electricity. An increase in the price can lead to a number of other price increases, which can even lead to social unrest.

Efficiency (%) – each of the RES technologies has a different degree of efficiency. Efficiency directly affects the potential profit of investors, so this criterion is very important. Based on the data presented in Table 4, it can be seen that hydro technology is far more efficient than other RES technologies.

Work and maintenance (jobs/MW) - Each RES technology requires a different number of work and maintenance jobs. It can be very important for the development of the Kosovo* local economy.

Land requirements km^2*/1000 MW* – In accordance with the modern tendency to minimize the negative impact on the environment and the rational use of all resources as well as land, projects that require less space for the implementation of RES projects are more acceptable. This criterion has additional weight in the case of Kosovo*, which does not have too much available land.

The specific values of the criteria are shown in the Table 4.

Table 4 Selected criteria

Criteria	Photovoltaic A1	Hydro A2	Biomass A3	Wind A4	Ref.
Investment (eur/kw) (C1)	1,450	2,500	4,500*	1,610	[21]
The price of energy/USD/kWh (C2)	0.085	0.047	0.062	0.056	[39]
Efficiency (%) (C3)	4-22%	80-90%	28%	24-54%	[40-41]
Work and maintenance (jobs/MW) C4)	0.3	2.4	1.5	0.2	[42]
Land requirements km^2/1000 MW (C5)	35	750	5,000	100	[43]

*expert estimation

Step 3. Decision making. AHP method was applied for assessment of RES in Kosovo*. The basics of this method are given in chapter 3. For a more detailed introduction to this method please refer to [25]. The application of the AHP method in this paper was performed using the Expert choice software. The first step is defining the goal of the decision, which in this case is: assessment of RES in Kosovo*. Then, the selected decision criteria are entered into the software. After that, a pair wise comparison is made. First of all, a comparison of criteria in relation to the goal is made (Table 5f). At the same time, the criteria can have the same or different weighting factors in relation to the goal. In this paper, criteria C1 and C5 have the highest weighting factors. Then a comparison of alternatives in relation to criteria is made (Table 5 a-e), while the comparison is based on the criteria values from Table 4.

Table 5 Pair wise comparison

Comparison of alternatives in relation to C1 (Inconsistency=0.08)					Comparison of alternatives in relation to C2 (Inconsistency =0.09)					
(a)	A1	A2	A3	A4	**(b)**	A1	A2	A3	A4	
A1	1	6	8	3	A1	1	1/7	1/4	1/5	
A2		1	4	1/4	A2		1	5	4	
A3			1	1/6	A3			1	1/3	
A4				1	A4				1	
Comparison of alternatives in relation to C3 (Inconsistency=0.04)					Comparison of alternatives in relation to C4 (Inconsistency=0.04)					
(c)	A1	A2	A3	A4	**(d)**	A1	A2	A3	A4	
A1	1	1/7	1/2	1/3	A1	1	1/5	1/3	2	
A2		1	5	4	A2		1	3	5	
A3			1	1/3	A3			1	3	
A4				1	A4				1	
Comparison of alternatives in relation to C5 (Inconsistency=0.07)					Comparison of criteria in relation to the goal (Inconsistency= 0.07)					
(e)	A1	A2	A3	A4	**(f)**	C1	C2	C3	C4	C5
A1	1	4	8	3	C1	1	1	2	3	1/2
A2		1	5	1/3	C2		1	3	1	1
A3			1	1/6	C3			1	1/2	1/2
A4				1	C4				1	1
					C5					1

Finally, after all comparison are done, software synthesize all results and RES rank is obtained and shown in Fig 3. whereby A2 is ranked first.

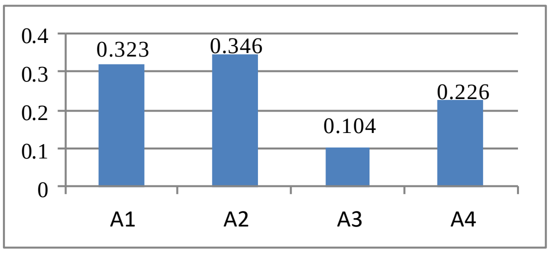

Fig. 3 Final alternative rank (Inconsistency=0.07)

Step 4. Sensitivity analysis - After the results of decision making is obtained the sensitivity analysis is conducted. Sensitivity analysis should determine how changes of the criteria weight coefficient affect the change in rank of RES alternatives. The reference values are decision making results, whereby minimal changes (increase or decrease) of criteria weight coefficients that lead to changes in the ranking were considered (Table 6). Based on the conducted sensitivity analysis, it can be seen that it is a criterion C2 the most sensitive in weight coefficient changes in relation to all other criteria. The lowest change that leads to a change in the ranking of RES alternatives is -0.038 which represents a value ≥10% compared to the reference value of the C2 (0.225). Also, the minimum value of the change in the weighting factor of all other criteria is ≥10%, so it can be said that the obtained results are relevant.

Table 6 Sensitivity analysis

Criteria (Reference values)	Minimal change	New alternative rank
C1 (0.249)	+0.04	A1 (0.337) > A2 (0.334) > A4 (0.229) > A3 (0.101)
C2 (0.225)	-0.038	A1 (0.337) >A2 (0.334) > A4 (0.226) > A3 (0.103)
C3 (0.096)	-0.041	A1 (0.335) > A2 (0.334) > A4 (0.227) > A3 (0.104)
C4 (0.176)	-0.049	A1 (0.336) > A2 (0.334) > A4 (0.235) > A3 (0.095)
C5 (0.254)	+0.042	A1 (0.336) > A2 (0.335) > A4 (0.229) > A3 (0.010)

5. CONCLUSION

Four RES alternatives using five criteria are evaluated in this paper by using AHP method. According to the obtained results the first-ranked alternative is A1 (hydro). However, in practice, the implementation of hydro projects in Kosovo* has often been accompanied by negative reactions from stakeholders. Therefore, it is proposed to involve stakeholders in the decision-making process in future papers, especially in the planning and decision-making phase of projects at the local level. Sensitivity analysis is conducted to check proposed model stability. Minimal changes that lead to changes in RES alternative rank for each of the 5 analyzed criteria are ≥10% compared to the reference values which indicates that the model is stable.

The paper can be used by researchers and practitioners in the RES field, as well as by the state administration that works on the development of strategic documents and the definition of priorities in the energy sector. The proposed model has a universal character and can be used as a starting point that can be upgraded or changed as needed.

We can also mention some limitations of this paper. Stakeholders are not included in the process of selection of criteria and their assessment, so the obtained results do not necessarily reflect the position of all interested parties. Therefore, we recommend that in the case of applying this model in practice, relevant stakeholders and experts should be included in the process of defining decision criteria and the decision-making process, which will result in more objective and acceptable results for all interested parties. The subjectivity of decision makers can also be a limitation. For that reason, in future papers, a fuzzy environment can be used to further determine the reliability of the results obtained and to avoid inaccuracies.

Kosovo* undoubtedly has certain potentials of renewable energy sources. However, based on the analyzed literature, the conclusion is that it is necessary to investigate the existing potentials in more detail. Also, it is necessary to define specific RES projects and identify potential locations where they can be implemented.

REFERENCES

[1] Energy strategy of Kosovo* 2017-2026, Ministry of economic development, Pristina, 2017.

[2] S. Lajqi, D. Đurin, X. Berisha and L. Plantak, "Analysis of the Potential for Renewable Utilization in Kosovo Power Sector", *Environments*, vol. 7, no. 6, p. 49, 2020.

[3] International energy outlook-IEO, U.S. Energy Information Administration, Washington, USA, 2016.

[4] G. E. Francés, J. M. Marín-Quemada and E. S. M. González, "RES and risk: renewable energy's contribution to energy security Aportfolio-based approach", *Renewable and sustainable energy reviews*, vol. 26, pp. 549-559, 2013.

[5] J. Lucas, G. Francés and E. González, "Energy security and renewable energy deployment in the EU: Liaisons Dangereuses or Virtuous Circle? ", *Renewable and sustainable energy reviews*, vol. 62, pp. 1032-1046, 2016.

[6] L. Proskuryakova, "Updating energy security and environmental policy: Energysecurity theories revisited", *Journal of Environmental Management*, vol. 223, pp.203-214, 2018.

[7] M. Petković, "Information systems for fire, disaster and accident risk assessment", Doctoral Thesis, Faculty of Information Technologies, UNIBIT, Sofia.

[8] B. Stojčetović, Dj. Nikolić, M. Jevtić and U. Jakšić, "Development and prioritization of renewable energy scenarios using strengths, weaknesses, opportunities, threat analysis and fuzzy analytical network process methodology", *Thermal science*, vol. 25, no. 3A, pp. 1731-1742, 2021.

[9] M. Petkovic, *Assessing the risk of fires, disasters and accidents,* Sofia, Avangard Prima Publishing House**,** 2021.

[10] S. Lee and P. Walsh, "SWOT and AHP Hybrid Model for Sport Marketing Outsourcing Using a Case of Intercollegiate Sport", *Sport Management Review*, vol. 14, no. 4, pp. 361-369, 2011.

[11] N. Sahani, "Application of hybrid SWOT-AHP-FuzzyAHP model for formulation and prioritization of ecotourism strategies in Western Himalaya, India", *International Journal of Geoheritage and Parks*, vol. 9, no. 3, pp. 349-362, 2021.

[12] B. Stojčetović, S. Marković and Ž. Šarkoćević, "Prioritization of strategies for Brezovica ski resort development using SWOT-AHP methodology", *Modern management tools and economy of tourism sector in present era*, pp. 459-474, 2019.

[13] M. Kurttila, M. Pesonen, J. Kangas and M. Kajanus, "Utilizing the analytic hierarchy process AHP in SWOT analysis - a hybrid method and its application to a forest certification case", *Forest policy and economics*, vol. 1, no. 1, pp. 41-52, 2000.

[14] R. K. Shrestha, J. R. R. Alavalapati and R. S. Kalmbacher, "Exploring the Potential for Silvopasture Adoption in South-Central Florida: An Application of SWOT-AHP Method", *Agricultural Systems*, vol. 81, no. 3, pp. 185-199, 2004.

[15] B. Haddad, A. Liazid and P. Ferreira, "A multi-criteria approach to rank renewable for the Algerian electricity system", *Renewable energy*, vol. 107, pp. 462-472, 2017.
[16] B. Stojčetović, M. Mišić and A. Đorđević, "Multicriteria assessment of renewable energy sources in Serbia", *Tehnika*, vol. 3, pp. 379-385, 2021.
[17] H. Al Garni, A. Kassem, A. Awasthi, D. Komljenovic and K. Al-Haddad, "A multicriteria decision making approach for evaluating renewable power generation sources in Saudi Arabia", *Sustainable energy technologies and assessments*, vol. 16, pp. 137-150, 2016.
[18] National action plan for renewable energy sources 2011-2020, Ministry of Economic Development, Pristina, 2013.
[19] Kosovo Potentials for Water Energy Generation (in Albanian). Available at: https://me.rks-gov.net/repository/docs/Potencialet_e_Kosoves_per_Gjenerim_te_Energjise_Ujore.pdf
[20] Report: Water Situation in Kosovo (in Albanian), Ministry of Environment and Spatial Planning and Kosovo Environmental Protection Agency. Pristina, 2010. Available at: http://www.ammk-rks.net/repository/docs/raporti_ujrave%202010_shq.pdf
[21] Cost-Competitive Renewable Power Generation: Potential across South East Europe, IRENA. 2017. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/IRENA_Cost-competitive_power_potential_SEE_2017.pdf
[22] R. Prăvălie, C. Patriche and G. Bandoc, "Spatial assessment of solar energy potential at global scale. A geographical approach", *Journal of Cleaner Production*, vol. 209, pp. 692-721, 2019.
[23] Global Solar Atlas for Kosovo. Available at: https://globalsolaratlas.info/download/kosovo
[24] Global Wind Atlas for Kosovo. Available at: https://globalwindatlas.info/area/Kosovo
[25] T. L. Saaty, *The Analytic Hierarchy Process: planning*, priority Setting, resource allocation, New York, USA: McGraw-Hill, 1980.
[26] M. J. Sharma, I. Moon and H. Bae, "Analytic hierarchy process to assess and optimize distribution network", *Applied mathematics and computation*, vol. 202, no. 1, pp. 256-265, 2008.
[27] R. S. Shahabi, M. H. Basiri, M. R. Kahag and S. A. Zonouzi, "An ANP SWOT approach for interdependency analysis and prioritizing the Iran's steels crap industry strategies", *Resources policy*, vol. 42, pp. 18-26, 2014.
[28] T. L. Saaty, "The Analytic Hierarchy Process: a 1993 overview", *Central European journal of operation research and economics*, vol. 2, no. 2, pp.119-137, 1993.
[29] R. A. Taha and T. Daim, in *Research and Technology Management in the Electricity Industry*, edited by T. Daim, T. Oliver and J. Kim, Springer, London, 2013, pp. 17-30.
[30] T. L. Saaty and P. K. Kearns, *Analytical Planning; The Organization of Systems*. Oxford: Pergamon Press, 1985.
[31] P. T. Harker and L. G. Vargas, "The theory of ratio scale estimation: Saaty's analytic hierarchy process", *Management science*, vol. 33, no. 1, pp. 1383-1403, 1987.
[32] R. P. Hamalainen, "Reversing the perspective on the applications of decision analysis", *Decision analysis*, vol.1, no. 1, pp. 26-31, 2004.
[33] E. Triantaphyllou, Multi-Criteria Decision Making Methods: A Comparative Study. New York. Springer, 2000.
[34] V. Belton, "A comparison of the Analytic Hierarchy Process and a simple multiattribute value function", *European journal of operational research*, vol. 26, pp. 7-21, 1986.
[35] A. A. Salo and R.P. Hamalainen, "On the measurement of preferences in the Analytic Hierarchy Process", *Journal of multiple criteria decision analysis*, vol. 6, pp. 309-319, 1999.
[36] J. R. Cristóbal, "Multi-criteria decision-making in the selection of a renewable energy project in Spain: the VIKOR method", *Renewable Energy*, vol. 36, pp. 498-502, 2011.
[37] B. Haddad, A. Liazid and P. Ferreira, "A multi-criteria approach to rank renewable for the Algerian electricity system", *Renewable energy*, vol. 107, pp. 462-472, 2017.
[38] M. Çolak and I. Kaya, "Prioritization of renewable energy alternatives by using an integrated fuzzy MCDM model: A real case application for Turkey", *Renewable and sustainable energy reviews*, vol. 80, pp. 840-853, 2017.
[39] *Renewable Power Generation Costs in 2018*, International Renewable Energy Agency, Abu Dhabi, 2019.
[40] A. Evans, V. Strezov and T.J. Evans, "Assessment of sustainability indicators for renewable energy technologies", *Renewable and sustainable energy reviews*, vol. 13, pp.1082-1088, 2009.
[41] A. I. Chatzimouratidis and P. A. Pilavachi, "Sensitivity analysis of technological, economic and sustainability evaluation of power plants using the analytic hierarchy process", *Energy policy*, vol. 37, pp. 788-798, 2009.
[42] I. Meyer and W. M. Sommer, "Employment Effects of Renewable Energy Supply - A Meta Analysis", *International Journal of Sustainable Development*, vol. 10, pp. 1-29, 2014.
[43] A. I. Chatzimouratidis and P.A. Pilavachi, "Multicriteria evaluation of power plants impact on the living standard using the analytic hierarchy process", *Energy policy*, vol. 36, pp.1074-1089, 2008