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3E (Energy-Economical-Environmental) Analysis for Electrical Energy Production with a Sustainable Development Approach

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Abstract

Today, policy-makers are aware of the substantial advantages of renewable energies. From the point of view of national and regional decision-makers, the priority of preparing a comprehen-sive energy plan and the second priority of determining the share of renewable energy in the total energy production basket of the country is an essential step in the energy policy process. In choosing from various renewable energy options, environmental dimensions are combined with economic, technical, and social criteria, which show the need to combine these criteria, the multi-criteria of the governing decision-making space, and policy-making. Multi-criteria deci-sion-making techniques can play an important role in choosing the best solution and option. The statistical population of this study is eight cities in the case study. The renewable energy sources studied include wind, solar, water, geothermal, and biomass. First, the potential of renewable energy for the study areas was identified, and then the two main criteria of sustainable devel-opment, economic criteria with 5 sub-criteria and environmental criteria with 3 sub-criteria are analyzed. Finally, using the Economic Analytic Network Process (ANP) sub-criterion, the envi-ronmental sub-criterion of each of the weighted renewable energies is allocated. One of the es-sential results of this research work is the income of $72868.8 from solar power in Ardabil. The cost of energy is $2.72 kWh. The lowest cost per unit of energy produced is related to Khalkhal geothermal energy at $0.144.

Keywords: *Renewable energy; Multi-criteria decision-making; ANP; PROMETHEE.*

1. Introduction

Today, the use of fossil fuels has been increasing gradually, which can be affected by different parameters [1, 2]. The tremendous increase in population is one of these factors that require fuels to provide the required energy. To the contrary, in line with industrial growth and development, the consumption of fossil fuels is appropriate [3, 4]. Because of the anomalous use of fossil fuels, the future generation will face a decrease in these fuel resources; on the other hand, these fuels are comprised of hydrocarbon, due to the combustion causes environmental pollution [5, 6]. Therefore, the alternative ways including renewable energies due to the cleanliness and availability received attention [7, 8]. However, the operation cost of this kind of energy is higher; so before its operation, precise studies should be conducted on the type of applied energy. A majority of studies have worked on the different methods to use renewable energies appropriately, which are elaborated on here [9, 10].

The evolvement of energy projects needs methodological approaches to combine social, environmental, and financial standards into decision-making models including stakeholder involvement [1]. Multi-criteria examination of the MCDM and MCDM procedures have been greatly utilized in energy planning [2-4]. Other studies have been done to decide the level of renewable energy with the PROMETHEE software [10-12]. Studies in the domain of renewable energy have been conducted in Turkey [13], Saudi Arabia [14, 15], and Pakistan [16]. Li to determine the weight of each criterion, the network analysis method (ANP) was used to appraise the significance of each criterion. In addition, multi-criteria decision-making (MCDM) methods such as WSM, TOPSIS, PROMETHEE, ELECTRE, and VIKOR were used to quantitatively appraise renewable energy options so that different methods can assist each other to make the extensive results more persuasive. The results express that energy sustainability indicators have the highest preference among all standards [17]. Troldborg suggested a multi-criteria analysis for the estimation and ranking of renewable energy technologies in Scotland [18]. Malla has used a model to predict the need for different energy). Sections in Romania from 2015-2050 [19]. Khanna created a composite index to compare energy poverty in Southeast Asian countries [20]. Shokatpour *et al*. presented renewable energy technology selection for Iran by using multi-criteria decision-making [21]. Abdullah has made an intuitionistic fuzzy AHP method, which is developed for sustainable energy planning and the choice of technologies. The suggested intuitionistic fuzzy AHP method deals with ambiguity in the decision-making process [22]. Ishak directed a test of liquid waste therapy technology by the use of AHP and PROMETHEE methods. The definition of criteria and weighting is based on skilled agreement using the Delphi approach [10]. The study by the application region and by the used method PROMETHEE, PROMETHEE II: energy policy and project selection evaluation of power generation technologies national planning [23-27]. Ozcan has proposed a methodology, which aims to choose a suitable maintenance approach for hydroelectric power plants. The research work was introduced using the example of Turkey and merges the AHP and TOPSIS methods. By merging the LCA and AHP methods [28], Gao has developed a mixed assessment system for choosing the most optimal nuclear energy production technology through the combination of the AHP, Fuzzy TOPSIS, and PROMETHEE methods [29]. Using the fuzzy AHP method, Ligus was to assess the contribution of low-polluting energy technologies to social well-being study in Poland [30]. Yu utilized the preference ranking organization method for enhancement of the act of evaluating (PROMETHEE) for the evaluation of meteorological risks in China's southeast coastal areas [31]; Seddiki used a fuzzy PROMETHEE model to examine renewable energy alternatives for electricity production in residential buildings in Algeria. They concluded that photo-voltaic panels were the best option due to their good characteristics in return compensation and energy production [32]. Parajuli used the PROMETHEE method for the estimation of biomass energy production technologies. Debbarma *et al*. studied the amounts of pollutants from different energy production technologies by the use of the AHP method for the assessment of the weights of criteria and VIKOR and PROMETHEE II methods for the assessment of ranks of alternatives under research [33]. Most research has been judged in terms of the need to use renewable energy from an economic or environmental or energy angle. In this research work, first, renewable energy is prioritized by taking into account the possibility in the region about weight coefficients achieved from ANP and PROMETHEE methods, then different regions are compared based on sustainable development indicators such as economic and environmental factors.

2. Materials and Methods

2.1. Details of the studied area

Ardabil province with an area of 17,800 square kilometers (1.1 percent of the country's total area) is located in the north of the Iran plateau and the northwest of the country. This province is bordered by the Republic of Azerbaijan to the north, Gilan Province to the east, Zanjan Province to the south, and East Azerbaijan Province to the west. The cities that are studied from this province of Ardabil are listed in table 1.

Table 1. Coordinates of the studied areas.

Cities	latitude	Longitude
Namin	38.426333	48.482625
Bilehsavar	39.381094	48.345625
Sarein	38.151875	48.071203
Ardabil	38.24848	48.30013
Meshkinshahr	38.398111	47.677711
Khalkhal	37.624719	48.53135
Germi	39.022022	48.094689
ParsAbad	39.650319	47.91355

2.2. Research methods

First, the potential of renewable energy (solar, wind, hydro, biomass, and geothermal) is determined for eight cities of Ardabil (Ardabil, Khalkhal, Sarein, Meshkinshahr, Namin, Germi, ParsAbad, and Bilehsavar). In the study of potential measurement of renewable energies (solar, wind, hydro, biomass, and geothermal), biomass and urban solid waste are considered in total biomass energy. In solar energy, special attention is paid to solar PV technology and for the hydropower of rivers and dams in operation, the water height behind the dam is 5 meters. Geothermal is considered to be the only source of hot water-based energy available in the studied areas. HOMER software has been used for the economic analysis of renewable energies. Software input includes energy source information, electrical and thermal loads of the system, the size, cost, and life of the power system equipment, and economic information. The best type of energy is selected from among the energies.it is categorized based on the lowest net present cost (NPC) and finally achievable energy with the lowest final net present cost will be chosen as an optimal option for making multi-criteria PROMETHEE decisions and by prioritizing the use of renewable energy from the total economic and environmental dimension.

Economic relations governing HOMER software

The evaluation criteria for HOMER software analysis are (NPC), Renewable Fraction (RF), and payback period. HOMER software calculates the net cost of the system life cycle using equation 1. The mathematical equation used in HOMER to determine NPC is 1.

$$\mathbf{NPC=AC/CRF} \tag{1}$$

The Annual Cost (AC) factor represents the total annual costs of the system components, and the Capital Recovery Factor (CRF) represents the rate of return on investment over N years, i is the real interest rate (Equation 2).

$$\mathbf{CRF} = \frac{[\mathbf{i}(\mathbf{1}+\mathbf{i})^{\mathbf{N}}]}{[(\mathbf{1}+\mathbf{i})^{\mathbf{N}}-\mathbf{1}]} \tag{2}$$

For the payback period, the mathematical relation used in HOMER is given in equation 3 [33].

$$\mathbf{-IC+}\sum_{\mathbf{j=1}}^{\mathbf{P}}\frac{\mathbf{CFj}}{\mathbf{(1+x)^{j}}} = \mathbf{0} \tag{3}$$

For economic analysis in HOMER software, a certain amount of electrical charge is considered for all renewable energies equally according to table 2. The project life is designed for 20 years, in calculating the rate of payback, we consider the project life to be 20 years. Costs are calculated in dollars. 10 kW is the considered load for each household according to table 2 in Homer software. Software settings are obtained for all renewable energies and the results are gained by entering the data.

In the analysis of the environmental sector based on field visits and also the use of data, the amount of pollutants emitted from sources, the environmental status of the country's power plants, which is given in table 3, is the basis for calculation.

Pollution rates of SO_2, Co, Hc, Spm, and CO_2 per kW of electricity generated by fossil power plants are also given in table 4.

Table 2. Daily household consumption [34].

Time	Load rate (kW)	Time	Load rate (kW)	Time	Load rate (kW)	Time	Load rate (kW)
0-1	0.2	6-7	0.5	12-13	0.7	18-19	0.8
1-2	0.2	7-8	0.5	13-14	0.7	19-20	1.2
2-3	0.2	8-9	0.5	14-15	0.7	20-21	1.2
3-4	0.2	9-10	0.5	15-16	0.7	21-22	1.2
4-5	0.2	10-11	0.5	16-17	0.7	22-23	0.8
5-6	0.2	11-12	0.7	17-18	0.8	23-24	0.8

Table 3. Total pollutants emitted from total fossil power plants (in tons) (Iran Energy Balance, 2020).

pollutant	NO_x	SO_2	CO	HC	SPM
Amount	116807	343083	151	4620	14073

Table 4. Emissions per kilowatt of electricity are generated by fossil power plants.

CO_2 (gr/kWh)	Spm (gr/kWh)	Hc (gr/kWh)	CO (gr/kWh)	SO_2 (gr/kWh)
850	0.009	0.029	0.0009	2.2

Spm: airborne

Particles CO_2: carbon dioxide (global greenhouse gas emissions)

Hc: unburned hydrocarbons, SO_2, (regional pollution)

CO: carbon monoxide (health)

Using the results of economic analysis and the amount of electricity generated by the five studied energies, we can calculate the amount of environmental pollution by considering the amount of pollution from fossil power plants and comparing them with renewable power plants.

Effective criteria and sub-criteria for sustainable renewable energy

Decisions about evaluating the most sustainable energy sources are very important and complex. Due to the problems of multidimensional decision-making, the use of multi-criteria decision analysis is necessarily useful and appropriate. Hence, this decision-making problem is solved economically and environmentally. The criteria and sub-criteria used to evaluate sustainable energy options are summarized in the conceptual model of figure 1.

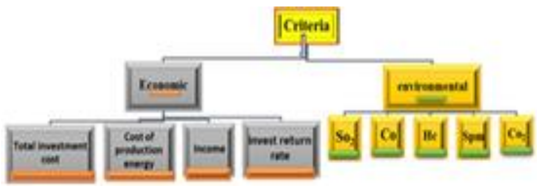


Figure 1. Conceptual model of influential factors of renewable energy.

The statistical population of this research is eight cities of Ardabil province (Ardabil, Khalkhal, Sarein, Meshkinshahr, Namin, Germi, ParsAbad, and Bilehsavar). After the determination of the potential of renewable energy and economic analysis using HOMER software, the level of prevention of environmental pollutants in comparison was determined with fossil resources. Then using the analytical network process (ANP) for each of the sub-indicators of the economic dimension, the environmental dimension is assigned to each of the weighted renewable energies. Using the multi-criteria decision method of PROMETHEE, the use of renewable energies (solar, wind, water, biomass, and geothermal) from the economic dimension, the environmental dimension is scored for each of the eight cities studied. Also free R programming software is used for data analysis, implementation of the ANP weighting method, and PROMETHEE multi-criteria decision-making method. The ANP method, which is a generalization of the Analytic Hierarchy Process (AHP) method, does not require a hierarchical structure, and therefore shows the relationship between different levels of a decision in a network. In this research work, in the PROMETHEE method, the preference linear function p (d) is considered, and a net superiority value Φ (·) is obtained for each city.

$$\mathbf{p(d)} = \begin{cases} \mathbf{0} & \mathbf{d \le 0} \\ \mathbf{d/p} & \mathbf{0 \le d \le p} \\ \mathbf{1} & \mathbf{d > p} \end{cases} \tag{4}$$

The net superiority value for region a, Φ (a) is calculated as follows:

$$\boldsymbol{\Phi(a) = \Phi^{+}(a) - \Phi^{-}(a)} \tag{5}$$

$$\boldsymbol{\Phi^{+}(a) = \frac{1}{n-1}\sum_{x\in A} \pi(a,x),} \tag{6}$$

$$\boldsymbol{\Phi^{-}(a) = \frac{1}{n-1}\sum_{x\in A} \pi(x,a),} \tag{7}$$

$$\boldsymbol{\pi(a,x) = \sum_{j=1}^{6} p_j(a,x)\, w_j} \tag{8}$$

$$\boldsymbol{\pi(x,a) = \sum_{j=1}^{6} p_j(x,a)\, w_j} \tag{9}$$

And w_j are the weights assigned by the ANP method to each of the indicators of urban prosperity from an infrastructure perspective. Now if Φ (b) <Φ (a), region a has less urban flourishing than region b, and *vice versa*.

Also to make it easier to interpret the values of superiority between -1 and 1, it can be converted to a score between 0 and 100 using the following conversion [35].

$$\boldsymbol{\Phi'(a) = \frac{\Phi^{+}(a) + (1 - \Phi^{-}(a))}{2} \times 100} \tag{10}$$

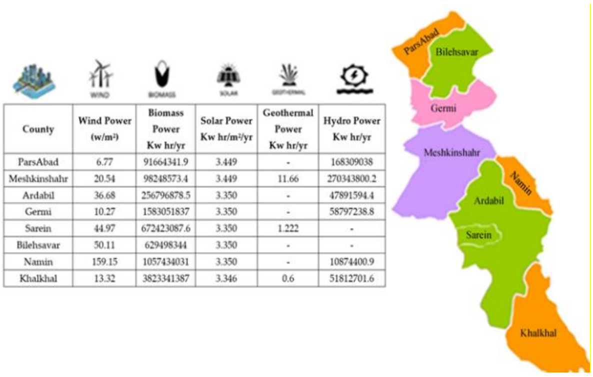
According to the score presented in relation (7), the status of operation of five types of renewable energy in the eight cities studied is classified into five levels ideal (80-100), relatively appropriate (60-80), medium (40-60), relatively inappropriate (20-40), and inappropriate (20-0).

3. Results

The research results are summarized in three sections (potential assessment, economic and environmental analysis, and exploitation prioritization).

3.1. Potential assessment results

The first part includes the potential of renewable energy (solar, wind, hydro, biomass, and geothermal) was assigned for the city of Ardabil province (Ardabil, Khalkhal, Sarein, Meshkinshahr, Namin, Germi, ParsAbad, and Bilehsavar), according to figure 2.



County	Wind Power (w/m²)	Biomass Power Kw hr/yr	Solar Power Kw hr/m²/yr	Geothermal Power Kw hr/yr	Hydro Power Kw hr/yr
ParsAbad	6.77	91664341.9	3.449	-	168309038
Meshkinshahr	20.54	98248573.4	3.449	11.66	270343800.2
Ardabil	36.68	256796878.5	3.350	-	47891594.4
Germi	10.27	1583051837	3.350	-	58797238.8
Sarein	44.97	672423087.6	3.350	1.222	-
Bilehsavar	50.11	629498344	3.350	-	-
Namin	159.15	1057434031	3.350	-	10874400.9
Khalkhal	13.32	3823341387	3.346	0.6	51812701.6

Figure 2. Potential assessment in the studied areas.

3.2. Results of effective factors of renewable energy

The second part includes the results of the factors affecting the economic criteria using HOMER software and the necessary calculations are listed in table 5, and the results of environmental calculations are mentioned in figures 3 to 5.

In the analysis of the environmental sector, based on the comparison of the emissions of pollutants emitted from the country's power plants with renewable energy power plants, the results are listed in figures 3 to 5. By using renewable energy according to the results obtained in the table, the release of environmental pollution is prevented.

Table 5. Emissions per kilowatt of electricity are generated by fossil power plants.

Cities	Energy sources	Electricity generated kWh/yr	Total investment cost is $	Cost of production energy $/kWh	Revenue $	Capital return rate yr
Ardabil	solar	17582	110187	1.580	42196.8	2.610
	wind	30362	187042	2.727	72868.8	2.56
	biomass	256799878.5	11726021.85	0.616	-	0.019
	hydro	4326812	10586229	156.2	10384347	1.21
	Geothermal	-	-	-	-	-
Khalkhal	solar	11769	108431	1.560	28245.6	3.830
	wind	29935	187042	2.727	71844	2.6
	biomass	3823341387	174581798.5	0.917	-	0.019
	hydro	3673837.8	10815832.8	157.6	8817210.7	1.21
	geothermal	0.06	0.0015	0.144	-	0.01
Sarein	solar	11846	108431	1.560	28430.4	3.830
	wind	30362	187042	2.727	72868.8	2.56
	biomass	672423087.6	30704250.58	0.161	-	0.019
	hydro	-	-	-	-	-
	geothermal	1.222	0.030	2.93	-	0.01
Meshkinshahr	solar	12037	98555	1.418	28888.8	3.410
	wind	30370	187042	2.729	72888	2.56
	biomass	98248573.4	4486236.22	0.235	-	0.019
	hydro	10991100.4	145341918	2119	26378641	1.21
	geothermal	11.41	0/285	27.384	-	0.01
Namin	solar	11796	108431	1.560	24771.6	3.830
	wind	30362	187042	2.727	72868.8	2.56
	biomass	1057434031	48284658.95	0.253	-	0.019
	hydro	2570215.6	7512210	109.5	6168517.6	1.21
	geothermal	-	-	-	-	-
Germi	solar	11849	108431	1.560	28437.6	3.810
	wind	30327	187042	2.727	72784.8	2.56
	biomass	1593051837	72742093.01	0.382	-	0.019
	hydro	5818035.6	33309319.8	485.5	13963285.4	1.21
	geothermal	-	-	-	-	-
ParsAbad	solar	12037	98555	1.418	28888.8	3.410
	wind	30341	187042	2/727	72818/4	2/56
	biomass	91664341.9	4185586.38	0.2126	-	0.019
	hydro	29481057.2	86081048.7	125.5	70754537.4	1.21
	geothermal	-	-	-	-	-
Bilehsavar	solar	11739	108431	1.560	28173.6	3.840
	wind	30327	187042	2.727	72784.8	2.56
	biomass	629498344	28744216.62	0.151	-	0.019
	hydro	-	-	-	-	-
	geothermal	-	-	-	-	-

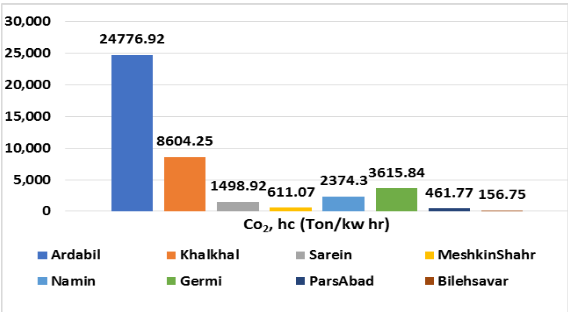


Figure 3. Environmental sub-criteria regional pollution.

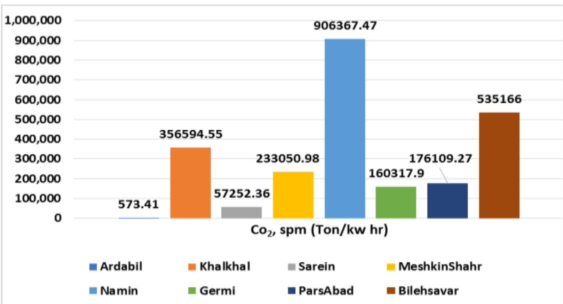


Figure 4. Environmental sub-criteria global greenhouse gas emissions.

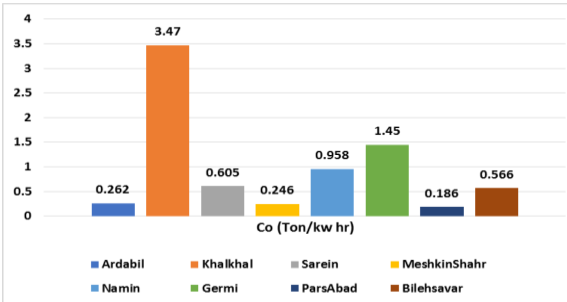


Figure 5. Environmental sub-criteria regional health.

3.3. Operation prioritization results

In this section, first, the status of exploitation of five types of renewable energy in the eight cities was studied separately, and classified from the perspective of each of the two criteria economic and environmental, and in five ideal situations, relatively appropriate, moderate, relatively unsuitable, and Inappropriate. In the following, the exploitation status of five types of renewable energy in eight cities is reviewed together with all 9 sub-criteria reported in table 6.

Table 6. Nine sub-criteria of exploitation of five types of renewable energy.

Criteria	Sub-criteria	Unit	Symbol	Optimal impact
Economic	Total investment cost	$	X1	Min
	Cost of production energy	$/kWh	X2	Min
	Revenue	$	X3	Max
	Capital return rate	yr	X4	Min
Environmental	SO_2	ton/kWh	X5	Min
	CO	ton/kWh	X6	Min
	Hc	ton/kWh	X7	Min
	Spm	ton/kWh	X8	Min
	CO_2	ton/kWh	X9	Min

3.4. Results of Economic and environmental criteria

In this case, both economic and environmental criteria of the exploitation of the five types of energy studied with 9 sub-criteria were examined and expressed in table 7. The weight of each of these 9 sub-criteria was calculated by the ANP method using R software, and is reported in table 7.

Table 7. Weight of each of the 9 sub-criteria of the utilization of five types of renewable energy was calculated ANP method.

		Sub-criteria								
Weight ANP	**Energy**	X1	X2	X3	X4	X5	X6	X7	X8	X9
	Solar	0.0983	0.1175	0.0464	0.1056	0.0514	0.1050	0.0551	0.0732	0.0804
	Wind	0.0994	0.1156	0.0457	0.1069	0.0538	0.1061	0.0553	0.0740	0.0813
	Hydro	0.0994	0.1085	0.0465	0.1050	0.0613	0.1044	0.0641	0.0796	0.0855
	Biomass	0.1145	0.0885	0.0330	0.1232	0.0539	0.1223	0.0575	0.0853	0.0828
	Geothermal	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833

also using the PROMETHEE method for each of the eight cities of Ardabil province, the values of superiority $\Phi^-(\cdot)$ و $\Phi^+(\cdot)$، , the value of net superiority $\Phi(\cdot)$, and the superiority score $\Phi'(\cdot)$ is calculated in R software to exploit five the type of energy studied and is reported in table 8 to table 12. Note that the table numbers are trended up to 4 decimal places.

Table 8. Values of solar energy utilization in each of the studied cities according to the scores obtained.

Cities	(Score 100-0) Φ '	Φ	Φ^+	Φ^-	Utilization	Ranking
Ardabil	63.47608	0.269522	0.307666	0.038144	relatively appropriate	8
ParsAbad	65.7918	0.315836	0.321201	0.005365	relatively appropriate	1
Sarein	64.97634	0.299527	0.308321	0.008794	relatively appropriate	6
Meshkinshahr	64.74189	0.294838	0.310688	0.01585	relatively appropriate	7
Namin	65.13433	0.302687	0.31558	0.012893	relatively appropriate	5
Germi	65.19105	0.303821	0.313298	0.009477	relatively appropriate	4
Khalkhal	65.21316	0.304263	0.309229	0.004966	relatively appropriate	3
Bilehsavar	65.41928	0.308386	0.315433	0.007048	relatively appropriate	2

Table 9. Values of solar energy utilization in each of the studied cities according to the scores obtained.

Cities	(Score 100-0) Φ '	Φ	Φ^+	Φ^-	Utilization	Ranking
Ardabil	64.51062	0.290212	0.303043	0.012831	relatively appropriate	7
Namin	65.69735	0.313947	0.318097	0.00415	relatively appropriate	1
Sarein	65.47332	0.309466	0.316718	0.007252	relatively appropriate	2
Meshkinshahr	64.27815	0.285563	0.3	0.014437	relatively appropriate	8
Khalkhal	64.5429	0.290858	0.30482	0.013962	relatively appropriate	6
Germi	65.46293	0.309259	0.316701	0.007443	relatively appropriate	3
ParsAbad	65.04839	0.300968	0.303871	0.002903	relatively appropriate	4
Bilehsavar	64.90793	0.298159	0.30482	0.006662	relatively appropriate	5

Table 10. Values of the superiority of hydropower utilization of each according to the scores obtained.

Cities	(Score 100-0) Φ '	Φ	$Φ^+$	$Φ^-$	Utilization	Ranking
Ardabil	64.407	0.28814	0.33454	0.0464	relatively appropriate	4
Khalkhal	64.07774	0.281555	0.331247	0.049692	relatively appropriate	6
Sarein	67.66821	0.353364	0.361371	0.008006	relatively appropriate	1
Meshkinshahr	61.88709	0.237742	0.309341	0.071599	moderate	8
Namin	65.70512	0.314102	0.347521	0.033419	relatively appropriate	3
Germi	64.76945	0.295389	0.338164	0.042775	relatively appropriate	4
ParsAbad	63.81718	0.276344	0.328642	0.052298	relatively appropriate	7
Bilehsavar	67.66821	0.353364	0.361371	0.008006	relatively appropriate	1

Table 11. Values of the superiority of hydropower utilization of each according to the scores obtained.

Cities	(Score 100-0) Φ '	Φ	$Φ^+$	$Φ^-$	Utilization	Ranking
Meshkinshahr	66.15326	0.323065	0.336954	0.013889	relatively appropriate	1
Sarein	65	0.3	0.324306	0.024306	relatively appropriate	2
Khalkhal	63.95833	0.279167	0.320833	0.041667	moderate	3

Table 12. Values of the superiority of hydropower utilization of each according to the scores obtained.

Cities	(Score 100-0) Φ '	Φ	$Φ^+$	$Φ^-$	Utilization	Ranking
Ardabil	66.21372	0.324274	0.34181	0.017535	relatively appropriate	1
Khalkhal	62.3228	0.246456	0.305826	0.05937	moderate	8
Sarein	65.19595	0.303919	0.319498	0.015579	relatively appropriate	4
Meshkinshahr	66.10059	0.322012	0.33167	0.009658	relatively appropriate	3
Namin	64.31611	0.286322	0.315931	0.029609	relatively appropriate	6
Germi	63.49857	0.269971	0.312957	0.042986	relatively appropriate	7
ParsAbad	66.15818	0.323164	0.329404	0.00624	relatively appropriate	2
Bilehsavar	65.0576	0.301152	0.319664	0.018512	relatively appropriate	5

The utilization of solar energy is in relatively good condition for all these cities. Also the cities of ParsAbad, Bilehsavar, Khalkhal, Germi, Namin, Sarein, Meshkinshahr, and Ardabil have the highest scores in solar energy utilization, respectively.

The use of wind energy for all these cities is in relatively good condition. Also the cities of Namin, Sarein, Germi, ParsAbad, Bilehssvar, Khalkhal, Ardabil, and Meshkinshahr have the highest points in the use of wind energy, respectively.

The utilization of hydropower for all these cities is in relatively good condition. Also the cities of Sarein, Bilehsavar, Namin, Germi, Ardabil, Khalkhal, and Meshkinshahr have the highest points in the use of hydropower, respectively.

The utilization of geothermal energy for the three cities studied is in relatively good condition. Also the cities of Meshkinshahr, Khalkhal, and Sarein have the highest score in geothermal energy utilization, respectively.

The utilization of biomass energy for all these cities is in relatively good condition. Also, the cities of Ardabil, ParsAbad, Meshkinshahr, Sarein, Bilehsavar, Namin, Germi, and Khalkhal have the highest points in biomass energy utilization, respectively.

4. Conclusions

Energy is a vital resource for the social and economic development of any nation.

Environmental pollution and the energy crisis are two important problems in controlling the sustainable development of modern society.

Evaluation and selection decisions related to the prioritization of renewable energy sources for long-term development is a complex process. This is mainly because the nature of decision problems is multifaceted. The development of energy projects requires the recognition of social, environmental, and economic criteria in decision-making models including stakeholder participation. Choosing which renewable energy needs to be prioritized and invested in is inherently a multidimensional decision-making process. First, the potential of the five renewable energies was estimated. Then economic and environmental indicators were calculated based on data and field information. Economic and environmental indicators were evaluated and prioritized for the use of renewable energy in the cities of Ardabil province. The utilization of solar energy is in relatively good condition for all these cities. The cities of ParsAbad, Bilehsavar, Khalkhal, Germi,

Namin, Sarein, Meshkinshahr, and Ardabil have the highest scores in the use of solar energy, respectively.

Wind energy utilization is relatively good for all these cities. The cities of Namin, Sarein, Germi, ParsAbad, Bilehsavar, Khalkhal, Ardabil, and Meshkinshahr have the highest points in the use of wind energy, respectively. The utilization of hydropower for all these cities is in relatively good condition. The cities of Sarein, Bilehsavar, Namin, Germi, Ardabil, Khalkhal, and Meshkinshahr have the highest points in the utilization of hydropower, respectively.
The utilization of biomass energy is relatively good for all these cities. The cities of Ardabil, ParsAbad, Meshkinshahr, Sarein, Bilehsavar, Namin, Germi, and Khalkhal have the highest scores in biomass energy utilization, respectively. The exploitation of geothermal energy for the three cities studied is in relatively good condition. The cities of Meshkinshahr, Khalkhal, and Sarein have the highest points in exploiting geothermal energy, respectively.

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