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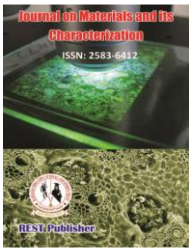

A study on the assessment of renewable energy resources for power generation using the MCDM approach

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Abstract: *The development and survival of contemporary economies are fundamentally dependent on energy. Practically every aspect of human well-being depends on it, encompassing "sustainability, employment, connectivity to necessities, and the economy, health care, employment, and education". Energy is regarded as being essential to the economic system and a key factor in a nation's prosperity. Developing markets must diversify their energy sources to ensure energy independence, supply options, employment generation, and sustainable development. A comprehensive energy development strategy is essential to meet supply and demand since population growth and modernization are two major drivers of rising energy needs."The multicriteria decision making (MCDM) method" is used to decide amongst many renewable power sources when numerous criteria are present. Using the COPRAS rating system, the report examines five alternative energy sources "PV, solar thermal, hydro, wind, and biomass"—against five components. "Solar PV ranks fifth, solar thermal is third, hydro is first, the wind is fourth, and biomass is second" in the COPRAS ranking of alternatives. Hydro recorded the largest significance compared to biomass, trailed by "solar thermal, wind, and solar PV", as per the COPRAS ranking. "Hydro > Biomass > Solar Thermal > Wind > Solar PV" sums up the order. The most potential renewable source for economic development, according to this, is hydro.*

Keywords:*Renewable energy**,** solar thermal, hydro, wind, biomass and COPRAS*

1. INTRODUCTION

Global climate change harms both the environment and humanity in the current situation. Nearly 75% of all "CO2 emissions" worldwide are produced by the energy industry for power systems, which also contributes to "greenhouse gas (GHG) emissions and global warming". As a result, the "Sustainable Development Goals (SDGs)" are being urged by "the United Nations" [1].They suggest using renewable energy alternatives to meet energy needs and lowering per capita usage to mitigate the consequences of climatic change. To comply with the SDGs, various nations have established their national policies for the generation of renewable energy (RE), as well as a structure for the acceptance of renewables [2].A non-statutory and consultative body in India called "National Institution for Transforming India (NITI) Aayog" has been given the task of developing a comprehensive index that will give a unified and combined perspective of the diverse socioeconomic and substantive statuses of the nation. Additionally, it has tracked India's and its government's progress in achieving the SDGs [3].Several of the factors expected to drive up requirements are the country's anticipated population growth, rapid urbanization, growth in the agricultural and customer care sectors, use of modern amenities, and little or no consciousness of energy efficiency or conservation. Another is the government's dedication to extending power to the country's leftover regions [4,5].

When non-renewable power sources are used in developing nations with low tiers of technological literacy, it not only pollutes the environment but also puts us in a precarious position because these priceless resources are depleting quickly, whereas renewable power sources can last us forever with much less of an influence on the environment than nuclear and fossil power sources. Because of this, the progressive substitution of non-renewable power sources with sustainable ones has drawn significant attention from the majority of nations and is one of the most crucial concerns of our day [6, 7].One of the primary issues facing academics and engineers working to provide power and heat for billions of people on the planet is the creation of new, green technologies. Iran, a country in the Region, is rich in clean energy source materials of energy and has made particular efforts to find and improve clean energy resources as well as embrace pertaining technical expertise [8,9]. Fossil fuel usage, a nonrenewable power source, results in several environmental issues such as air contamination and environmental degradation, which motivates the assessment and selection of desired renewable energy options. Therefore, choosing the best energy resources based on chosen competing criteria may be useful to energy choice experts in several countries for protracted planning of their power generation, usage, and production [10,11].The "multicriteria decision-making (MCDM) method" can be used to decide amongst many renewable power sources when numerous criteria are present. Using the COPRAS rating system, the report examines five alternative energy sources "PV, solar thermal, hydro, wind, and biomass"—against five components.

2. MATERIALS AND METHODS

A rating approach called "Complex Proportional Assessment (COPRAS)" was created in 1994 by "Zavadskas, Kaklauskas, and Sarka". This approach takes into account both the highest and minimum results separately. Identifying “both the optimal best solution and the ideal worst solution” allows for the selection of the best alternative value. For evaluating and choosing different projects, this is frequently utilised in engineering field challenges. The primary goal of the COPRAS technique is to rank each alternative by taking the corresponding weights of every criterion into account [12,13]. While having a few small drawbacks, "COPRAS MCDM" has a lot of strong good traits that more than make up for them. The capacity of "COPRAS" to treat advantageous and non-beneficial factors individually is the primary and most important benefit [14].According to COPRAS, a collection of criteria that effectively specifies the possibilities, as well as the weights and amounts of the criterion, determines the significance and utility level of the versions under investigation. The COPRAS strategy is an essential MCDM technique and a useful decision-making tool, as shown by these guiding principles [15].With a single evaluation approach that takes into account the effects of both the cost and advantage type factors, COPRAS rates options. The fact that COPRAS considers “the utility degree of options", which denotes a portion and indicates the amount to which one solution is greater or inferior to the different options utilized for evaluation, sets it apart from other MCDM techniques [16].Additionally, according to recent studies, judgements embedded with COPRAS are more accurate and less biased than outcomes with "TOPSIS and WSM", and COPRAS is more stable than WSM in the involvement of data changes. Additionally, COPRAS has a lot of benefits over other MCDM tools like "PROMETHEE, DEA, VIKOR, AHP, and ELECTRE", including a highly straightforward and visible MCDM method that takes a lot less computing effort and a high likelihood of pictorial understanding [17,18].

Step 1: The decision matrix X, which displays how various options perform about certain criteria, is created.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: Weights for the criteria are expressed as

$$w_j = [w_1 \cdots w_n], \quad (2)$$

$$\sum_{j=1}^{n}(w_1 \cdots w_n) = 1$$

the sum of the weight distributed among the evaluation parameters must be one.

Step 3: The matrix x_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}} \quad (3)$$

Step 4: Weighted normalized matrix N_{ij} is calculated by the following formula

$$N_{ij} = w_j \times n_{ij} \quad (4)$$

Step 5: sum of benefit criteria and the sum of cost criteria are calculated by following equations 5 and 6 respectively.

$$B_i = \sum_{j=1}^{k} N_{ij} \quad (5)$$

$$C_i = \sum_{j=k+1}^{m} N_{ij} \quad (6)$$

Step 6: The relative importance of the choices should be determined. Calculations of alternative significance are based on Q_i. Higher the value of Q_i, the better the response. Alternatives with the highest Q_i value are $Q_{(max)}$. The following is a Qi equation:

$$Q_i = B_i + \frac{\min(C_i) \times \sum_{i=1}^{n} C_i}{C_i \times \sum_{i=1}^{n}\left(\frac{\min(C_i)}{C_i}\right)} \quad (7)$$

Step 7: Next U_i is calculated.

$$U_i = \frac{Q_i}{max(Q_i)} \times 100\% \qquad (8)$$

the highest relative level of significance is C_{max}. An alternative's utility function rises or falls as the relative importance value for that option does. From 0% to 100%, the utility value is possible. In a decision-making dilemma where multiple criteria are present, this method permits the assessment of operational qualities, utility stages of weight, and instantaneous and relative importance [19,20].

"The multicriteria decision making (MCDM) method" is used to decide amongst many renewable power sources when numerous criteria are present. Utilizing the COPRAS ranking system, the study compares five sustainable energy supplies ("solar PV, solar thermal, hydro, wind, and biomass") based on five criteria: "capacity factor (%), efficiency (%), economic development, CO2 emission levels, and operating and maintenance costs".The capacity factor (percent) is a crucial indicator of how frequently the plant will operate over a certain length of time. The better, the larger the "capacity factor".Efficiency (percent): The ratio of energy intake to result is an important metric. The stronger the plant, the greater its efficiency.Investments in such renewable resources should encourage significant economic growth.CO2 emission levels: The technique should emit very little or none at all. This is a crucial requirement for the implementation of any power system. " Operation and maintenance expenses": The project's generating and administration expenses should be at a minimum. Lower O & M is beneficial for a project [21].

3. ANALYSIS AND DISCUSSION

TABLE 1. Energy source

Energy source	Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
Solar Pv	16	20	5	4	4
Solar Thermal	42	35	4	2	5
Hydro	46	90	9	3	9
Wind	38	30	3	3	6
Biomass	70	42	8	6	7

Table 1 shows the data set of the Main parameters of each energy source. The study optimizes five renewable power sources ("solar PV, solar thermal, hydro, wind and biomass") against five options (Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission and Operating cost and maintenance cost) using COPRAS ranking algorithm.

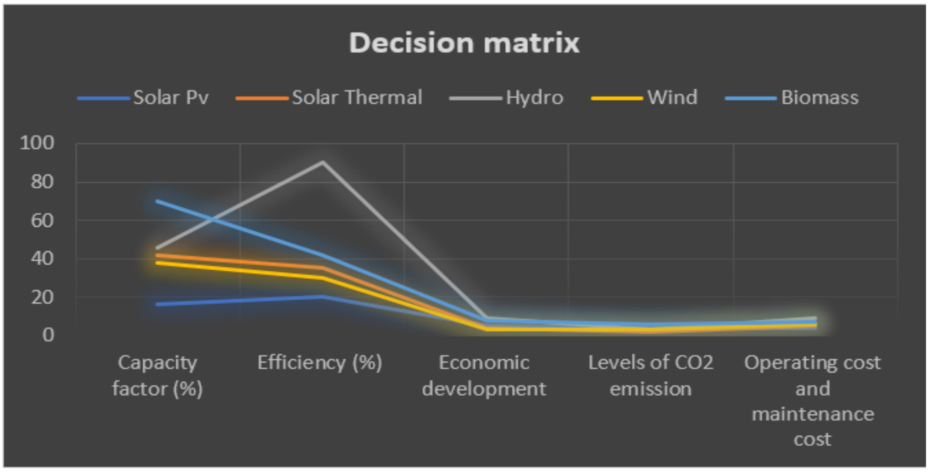

FIGURE 1. parameters of Energy source

The figure illustrates the data set of the Main parameters of each energy source. The study optimizes five renewable power sources ("solar PV, solar thermal, hydro, wind and biomass") against five options (Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission and Operating cost and maintenance cost) using COPRAS ranking algorithm.

TABLE 2. Normalized matrix

0.0755	0.0922	0.1724	0.2222	0.1290
0.1981	0.1613	0.1379	0.1111	0.1613
0.2170	0.4147	0.3103	0.1667	0.2903
0.1792	0.1382	0.1034	0.1667	0.1935
0.3302	0.1935	0.2759	0.3333	0.2258

The normalized matrix of Performance Ratings of parameters of each base station is displayed in Table 2 above. Equation 3 was used to create this matrix.

TABLE 3. Weight Distribution

0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20
0.20	0.20	0.20	0.20	0.20

The preferred weight for the evaluation parameters is shown in Table 3. In this case, weight is equally distributed among evaluation criteria and the sum of weight distributed is one.

TABLE 4. Weighted normalized decision matrix

0.01509	0.01843	0.03448	0.04444	0.02581
0.03962	0.03226	0.02759	0.02222	0.03226
0.04340	0.08295	0.06207	0.03333	0.05806
0.03585	0.02765	0.02069	0.03333	0.03871
0.06604	0.03871	0.05517	0.06667	0.04516

The Performance Ratings of the parameters of each base station are shown in Table 4 as a normalized matrix. Equation 4 was used to calculate this matrix, which was produced by multiplying tables 2 and 3.

TABLE 5. the sum of benefit criteria and the sum of cost criterion

Energy source	Bi	Ci
Solar Pv	0.068	0.070
Solar Thermal	0.099	0.054
Hydro	0.188	0.091
Wind	0.084	0.072
Biomass	0.160	0.112

Table 5 displays the total cost and total benefit criteria that were determined using equations 5 and 6. "Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission and Operating cost and maintenance cost" are used to optimize the Comprehensive Performance of power sources**.**

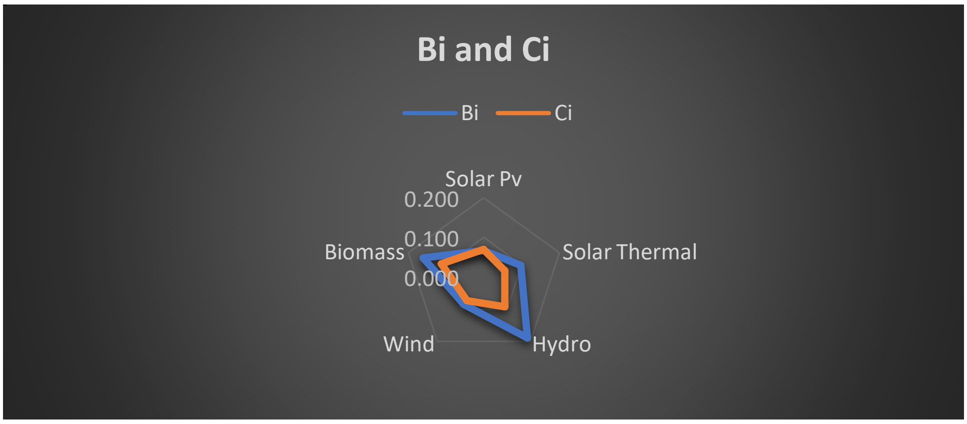

FIGURE 2. Bi and Ci

Equations 5 and 6 were used to calculate the total beneficial criteria and total cost criterion shown in Figure 2. "Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission and Operating cost and maintenance cost" are used to evaluate the Comprehensive Performance of energy sources**.**

TABLE 6. Relative significance and Utility degree

Energy source	Qi	Ui
Solar Pv	0.154	60.4711
Solar Thermal	0.210	82.6028
Hydro	0.254	100.0000
Wind	0.168	65.9920
Biomass	0.214	84.0609

Using equations 7 and 8, Table 6 displays the relative relevance and utility degree. Here utility degree value for solar PV is 60.4711, solar thermal is 82.6028, hydro is 100, the wind is 65.9920 and biomass is 84.609.

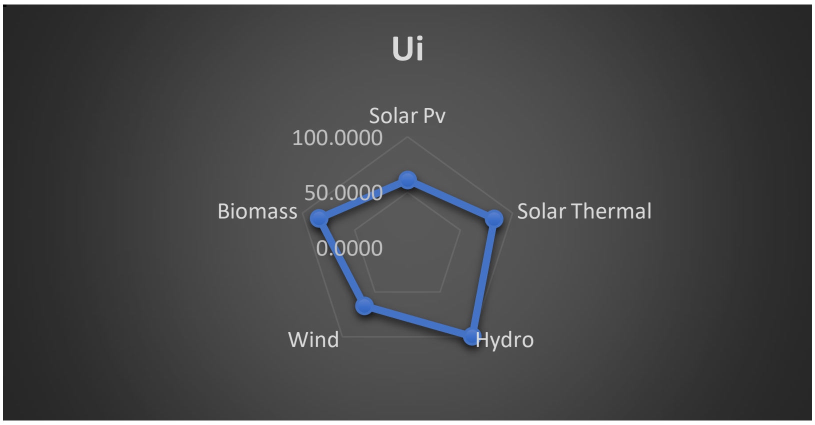

FIGURE 3. Utility Degree

Figure 3 shows the illustration of the Relative significance and Utility degree calculated by using equations 7 and 8. Here utility degree value for solar PV is 60.4711, solar thermal is 82.6028, hydro is 100, the wind is 65.9920 and biomass is 84.609.

TABLE 7. Rank

Energy source	Rank
Solar Pv	5
Solar Thermal	3
Hydro	1
Wind	4
Biomass	2

Table 7 shows the rank of alternatives "solar PV, solar thermal, hydro, wind and biomass" using utility degree values in table 6. Here rank of alternatives using the COPRAS method for solar PV is fifth, solar thermal is third, hydro is first, the wind is fourth and biomass is second.

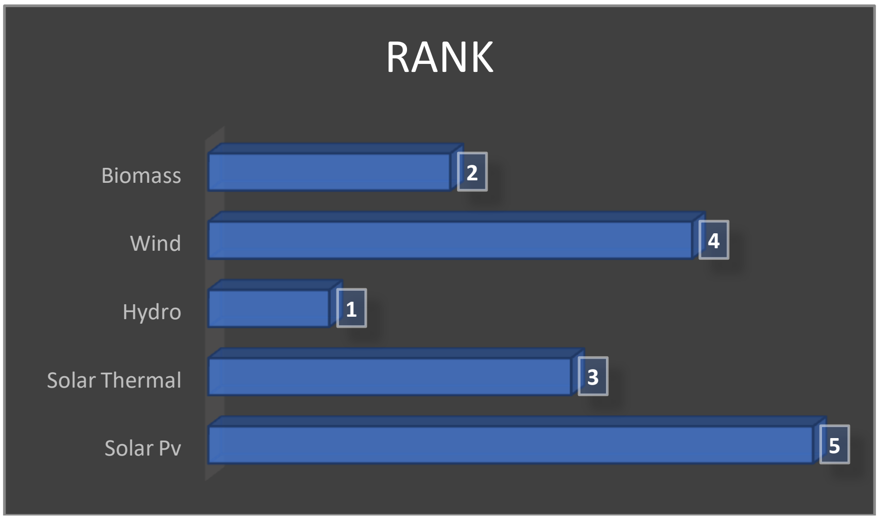

FIGURE 4. Rank

Figure 4 illustrates the ranking of Ui from Table 6. Here rank of alternatives using the COPRAS method for solar PV is fifth, solar thermal is third, hydro is first, the wind is fourth and biomass is second. "Solar PV ranks fifth, solar thermal is third, hydro is first, the wind is fourth, and biomass is second" in the COPRAS ranking of alternatives. Hydro recorded the largest significance compared to biomass, trailed by "solar thermal, wind, and solar PV", as per the COPRAS ranking. "Hydro > Biomass > Solar Thermal > Wind > Solar PV" sums up the order. The most potential renewable source for economic development, according to this, is hydro.

4. CONCLUSION

Renewable energy has had an impact on nation-state "environmental, social, and economic development", since the dawn of civilization. Recently, some academics and professionals have concentrated their research on finding the greatest renewable energy options. It has been said that this kind of energy comes from local products that have the necessary ability to provide energy with little or no emissions of "greenhouse gases and other pollutants".In comparison to conventional source materials, sustainable source materials of energy including "solar, wind, biomass, geothermal, and hydraulic energy" are almost limitless and simultaneously offer a wide range of financial and ecological benefits. Each green energy resource has a special advantage that makes it particularly suitable for specific uses in specific locations.The availability of energy has become a crucial global concern in recent years as civilization has dramatically advanced. Diverse nations are currently using renewable energy sources as a main replacement for cutting back on the utilization of fossil fuels. Alternative energy options significantly influence human development in both the economic and social spheres. Renewable energy sources may lower manufacturing costs, and greenhouse gas emissions, and possibly save non-renewable energy sources."Solar PV ranks fifth, solar thermal is third, hydro is first, the wind is fourth, and biomass is second" in the COPRAS ranking of alternatives. Hydro recorded the largest significance compared to biomass, trailed by “solar thermal, wind, and solar PV”, as per the COPRAS ranking. "Hydro > Biomass > Solar Thermal > Wind > Solar PV" sums up the order. The most potential renewable source for economic development, according to this, is hydro.

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