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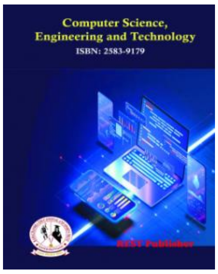

Empowering the Future: Harnessing Renewable Energy Resources for Sustainable Power Generation

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Abstract: *Sustainable energy sources like solar, wind, hydropower, biomass, geothermal, tidal, and wave energy can take the place of fossil fuels. They replenish organically and aid in the fight against climate change. Solar energy harvests the sun's energy using photovoltaic panels or concentrated solar power plants. Wind energy converts the kinetic energy of the wind into electricity by using turbines. Hydropower uses water that is either flowing or falling to generate electricity. You may generate energy from organic material using biomass. Geothermal energy harnesses the heat of the Earth to produce heat or electricity. Utilising the strength of tides and ocean waves to produce electricity is known as tidal and wave energy. These tools aid in the development of a cleaner, greener future by lowering emissions and enhancing air quality. Our energy mix needs to be more diverse in order to lessen our dependency on fossil fuels, and renewable energy sources are essential for this. Solar power is widely available and can be used in rooftop installations or massive solar farms. Building wind farms in windy areas has significantly increased the use of wind energy. An established technology called hydropower uses water sources to make electricity, whereas biomass uses organic waste to produce both heat and power. Geothermal energy uses the Earth's interior heat as a source of power, making it dependable and continuous. With the ability to harness the energy of the ocean to produce electricity, tidal and wave energy offer tremendous promise. Adopting renewable energy sources contributes to the development of a resilient and sustainable energy system for a cleaner and better future. Hydropower is a well-known technique that uses water to generate electricity, whereas biomass uses organic waste to generate both heat and power. Geothermal energy is dependable and continuous because it harnesses the heat from deep inside the Earth. Tidal and wave energy hold great potential since they can use ocean energy to generate electricity. Utilising renewable energy sources helps build a robust and sustainable energy system for a better and cleaner future.Due to our reliance on diminishing fossil fuel reserves, we are susceptible to price swings and geopolitical unrest. By varying our energy mix and lowering our dependency on foreign fuels, research into renewable energy sources fosters greater energy independence and thereby supports energy security. Environmental Protection: The exploitation and burning of fossil fuels have negative consequences on ecosystems, causing pollution of the air and water, the destruction of habitats, and the extinction of species. We can reduce environmental damage and safeguard natural resources by investigating and implementing renewable energy sources. The renewable energy industry has the ability to stimulate economic growth and employment creation. Research in this area paves the way for the creation of cutting-edge technology, lowers costs, and boosts productivity, making renewable energy more competitive with fossil fuels and economically viable. Energy Access in Developing Regions: Many areas, particularly in developing nations, do not have consistent access to energy. Researching renewable energy sources, especially decentralised ones like solar energy, can produce clean and economical energy solutions, enhancing socioeconomic development and quality of life.Technological Advancements: Ongoing research into renewable energy has made it possible to make strides in energy storage, solar panel efficiency, and wind turbine design. These developments improve the overall efficiency and dependability of renewable energy systems, increasing their viability and efficiency. Research offers insightful analysis into the policy and regulatory frameworks required to facilitate the integration of renewable energy into current power systems. It aids in identifying obstacles, evaluating the results of the deployment of renewable energy, and creating efficient policies to encourage the use of renewable energy. Conduct resource assessments to determine a region's potential for renewable energy. Decide on the appropriate renewable energy technology based on the needs of the location and the available resources. Utilise the technical, environmental, and economic factors to analyse the viability. Consider the system's size, capacity, and necessary infrastructure when designing it. It is necessary to buy and install the necessary infrastructure* *and machinery for the renewable energy system. Integrate the system into the existing electrical grid to ensure that it is compatible and compliant. Establish operational, maintenance, and performance-enhancing routines. Follow up on problems with and inefficiencies in the system. Continue your research and development efforts to advance technologies. Work with research organisations and stakeholders to advance the production of renewable energy.*

Keywords: *MCDM, Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission, Operating cost and maintenance cost.*

1. INTRODUCTION

Energy is essentially necessary for the growth and continuation of modern economies. Almost all aspects of human pleasure are dependent on it, including sustainability, employment, availability to necessities, healthcare, agriculture, and other industries. The importance of energy to the economy and to a country's success is well acknowledged. Pakistan is a developing country that requires a lot of energy to satisfy its home and industrial needs and to maintain its economic growth. However, the country is struggling to maintain a consistent supply of electricity and is currently experiencing its worst energy crisis ever. Energy is essentially necessary for the growth and continuation of modern economies. It is crucial to almost every aspect of human welfare. Modern economies depend heavily on energy for both life and expansion. Practically every facet of human enjoyment depends on it, including sustainability, employment, access to necessities, healthcare, agriculture, and other sectors of the economy. Energy is regarded as being essential to the economy and a key factor in a nation's development. Pakistan is a developing nation with high energy needs to meet its domestic and industrial demands as well as to sustain economic growth. The country is currently going through its greatest energy crisis ever and is struggling to guarantee a steady supply of electricity. Modern economies depend heavily on energy for both life and expansion. Nearly every facet of human welfare depends on it.By 2020, Serbia must have used RESs for 27% of its entire final energy consumption (RS2, 2016). Serbia now falls short of the goal in each of the three industries (transport, heating, and cooling) (Eni, 2020). Both the Serbian Energy Sector Development Strategy and the National Action Plan for Use of Renewable Energy Sources suggest a plan for raising the share of RES in gross final energy consumption (RS2, 2016, 2013). Serbia must reach a 27% gross domestic product by 2020.

2. WASPAS METHOD

The Weighted Sum Model for Preference System (WASPAS) is a system for making decisions that is used to evaluate and rank possibilities based on a number of criteria. It helps decision-makers choose the best alternative using weighted scores by assisting them in assessing the relative weights of various elements. The following gives a brief explanation of the WASPAS method: Identification of Requirements Determine the elements that are crucial to the current decision. These criteria ought to encompass the important traits or components that must be considered while contrasting the choices. To reflect each criterion's relative weight or priority, it should be assigned a number. The weights demonstrate how significant each element was in the decision-making process. Each weight ought to equal one. Rating and Normalisation: The rating indicates how well each alternative performs or fits the requirements of a particular criterion. Normalise the ratings to a shared scale to guarantee that they are similar across criterion. Multiply the normalised ratings of each option by the weights given to each criterion to arrive at the weighted aggregate. Total the weighted scores for each alternative's various criteria. Selection and Assessment: Sort the options in ascending order based on their weighted average scores. The choice considered to be optimal or advised is the one with the highest score. evaluation of sensitization Analyse the decision's sensitivity to determine its soundness. Inquire about the results of altering the weights or ratings of the When making judgements that call for the simultaneous consideration of numerous factors, WASPAS is a great tool. It helps decision-makers to fully evaluate options while taking a variety of issue-related factors into account. Criteria Weight Flexibility: The WASPAS criteria weights may be changed to reflect the decision-maker's preferences or altering priorities. The decision-making process can be customised based on specific circumstances or stakeholder requirements thanks to this versatility. Supports Complex choice challenges: Using a range of criteria and options, WASPAS is able to manage complex choice challenges. It provides a clear framework for organising and assessing the data, which makes it simpler to evaluate and compare various possibilities. Reproducibility and openness The step-by-step process used by WASPAS ensures decision-making is open and transparent. By explicitly putting weights and ratings on things, clear results can be obtained.

3. MATERIALS

Capacity factor (%): This flexibility allows the decision-making process to be tailored based on particular situations or stakeholder requirements. strengthens issues with complex decision-making WASPAS uses a variety of criteria and alternatives to tackle complex decision-making issues. It offers a clear structure for structuring and evaluating the data, making it easier to examine and contrast various options. Replicability and transparency The methodical approach taken by WASPAS guarantees openness and transparency in decision-making. Clear outcomes can be attained by openly assigning weights and ratings to various factors.
Efficiency (%): Natural resources that replenish more fast than they are depleted provide renewable energy.
Economic development: Economic development is not hampered by the use of renewable energy, on the contrary, it is hampered significantly by it. Thus, income development has both good and negative effects on the consumption of renewable and no renewable energy, according to Islam et al. (2022).
Levels of CO2 emission: When fossil fuels are used to create energy, they emit dangerous greenhouse gases like carbon dioxide.
Operating cost and maintenance cost: The "marginal cost," which includes fuel, labour, and maintenance costs, is the price to create each MWh of electricity.

3. RESULT AND DISCUSSION

TABLE 1. WSM Weighted Sum Model,

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 WSM the alternative parameter Energy source, Solar PV, Solar Thermal, Hydro, Wind, Biomass. The evaluation parameter Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission, Operating cost and maintenance cost.

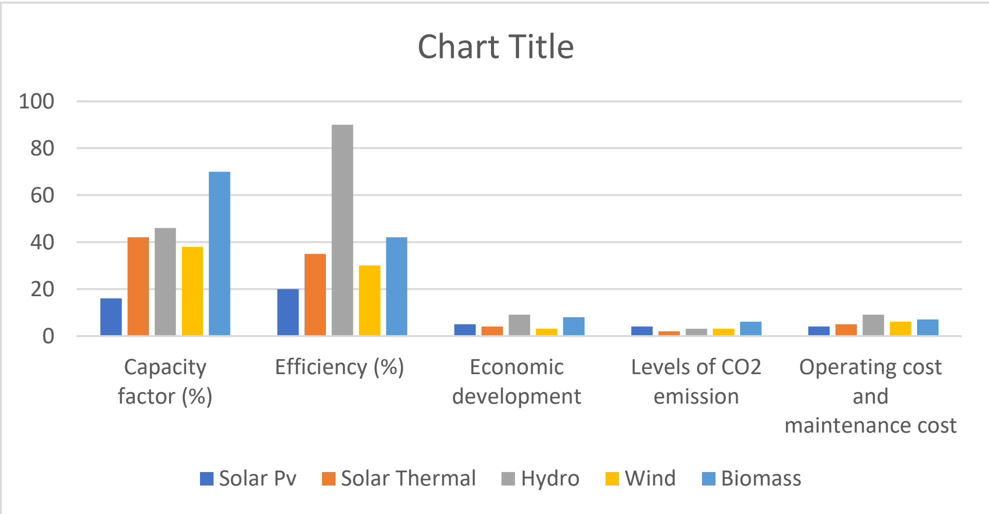

FIGURE 1. WSM Weighted Sum Model

FIGURE 1 shows WSM alternative parameter Energy source, Solar PV, Solar Thermal, Hydro, Wind, Biomass. The evaluation parameter Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission, Operating cost and maintenance cost.

FIGURE 2 shows WPM the alternative parameter Energy source, Solar PV, Solar Thermal, Hydro, Wind, Biomass. The evaluation parameter Capacity factor (%), Efficiency (%), Economic development, Levels of CO2 emission, Operating cost and maintenance cost.

TABLE 2. Performance value of WSM

Energy source	Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
Solar Pv	0.22857	0.22222	0.55556	0.50000	1.00000
Solar Thermal	0.60000	0.38889	0.44444	1.00000	0.80000
Hydro	0.65714	1.00000	1.00000	0.66667	0.44444
Wind	0.54286	0.33333	0.33333	0.66667	0.66667
Biomass	1.00000	0.46667	0.88889	0.33333	0.57143

Table 3 shows performance value of WSM Weighted Sum Model

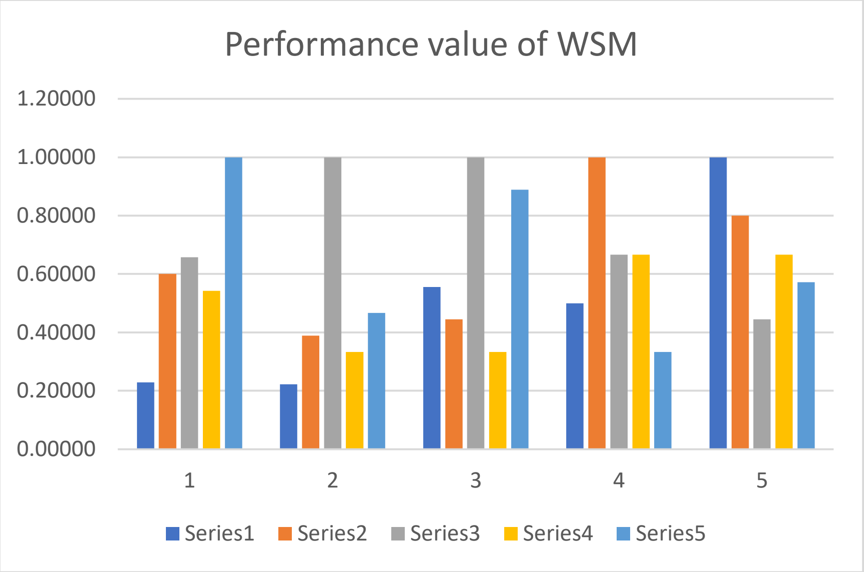

FIGURE 2. Performance value of WSM

Figure 3 Shows performance value of WSM Weighted Sum Model

TABLE 3. Performance value of WPM

Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
0.22857	0.22222	0.55556	0.50000	1.00000
0.60000	0.38889	0.44444	1.00000	0.80000
0.65714	1.00000	1.00000	0.66667	0.44444
0.54286	0.33333	0.33333	0.66667	0.66667
1.00000	0.46667	0.88889	0.33333	0.57143

Table 4 shows performance value of wpm weighted product model

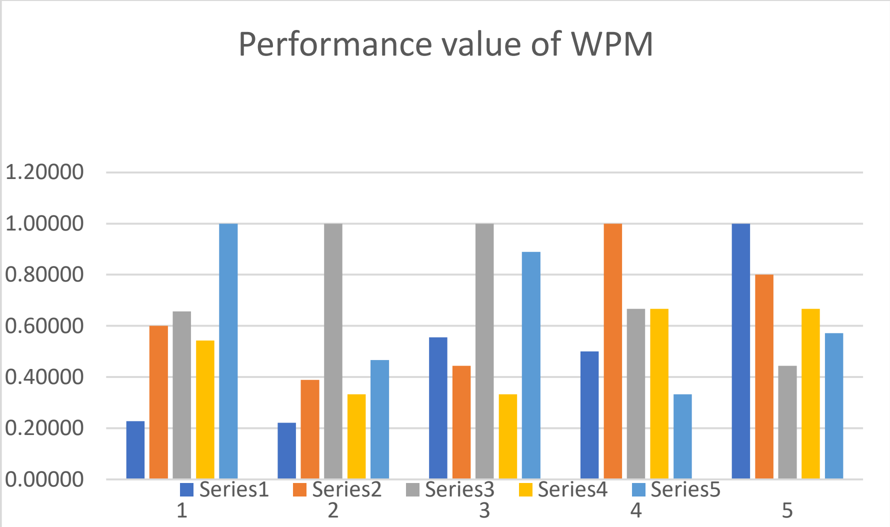

FIGURE 3. Performance value of WPM

Figure 4 shows performance value of WPM Weighted Product Model

TABLE 4. WEIGHT of WSM Weighted Sum Model

Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
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

Table 5 shows Weight of WSM Weighted Sum Model

TABLE 5. WSM OF weighted normalization decision matrix

Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
0.04571	0.04444	0.11111	0.10000	0.20000
0.12000	0.07778	0.08889	0.20000	0.16000
0.13143	0.20000	0.20000	0.13333	0.08889
0.10857	0.06667	0.06667	0.13333	0.13333
0.20000	0.09333	0.17778	0.06667	0.11429

Table 7 shows WSM OF weighted normalization decision matrix

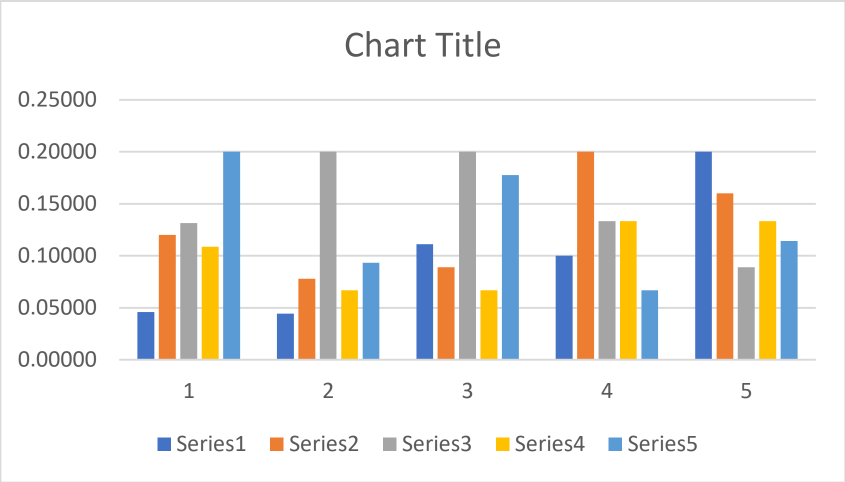

FIGURE 4. WSM of weighted normalization decision matrix

FIGURE 6 shows WSM OF weighted normalization decision matrix

TABLE 6. WPM of weighted normalization decision matrix

Capacity factor (%)	Efficiency (%)	Economic development	Levels of CO^2 emission	Operating cost and maintenance cost
0.69221	0.69932	0.40896	0.44721	0.20000
0.38073	0.53478	0.48904	0.20000	0.27595
0.34728	0.20000	0.20000	0.34200	0.48904
0.41741	0.58480	0.58480	0.34200	0.34200
0.20000	0.47186	0.23916	0.58480	0.39865

Table 8 shows WPM of weighted normalization decision matrix

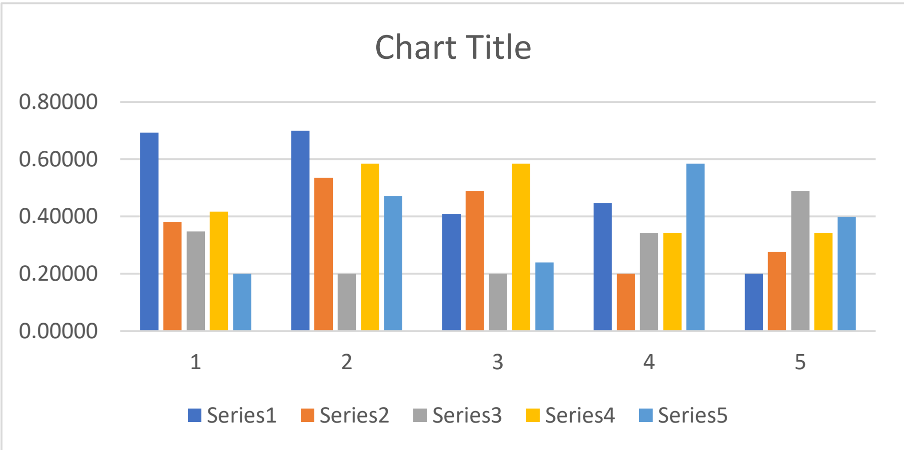

FIGURE 5. WPM of weighted normalization decision matrix

Figure 7 Shows WPM of weighted normalization decision matrix

TABLE 7. Preference score of WSM

Energy source	Preference Score
Solar Pv	0.50127
Solar Thermal	0.64667
Hydro	0.75365
Wind	0.50857
Biomass	0.65206

Table 9 shows preference score of WSM

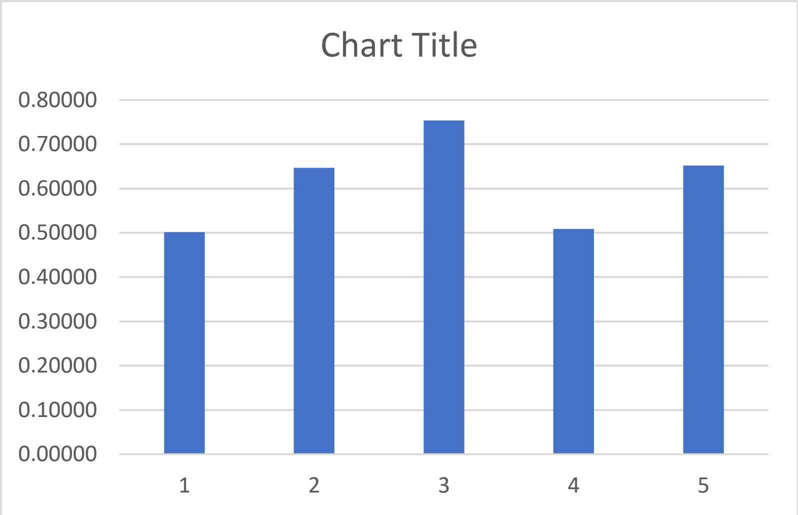

FIGURE 6. Preference score

FIGURE 8 shows preference score of WSM

TABLE 8. Preferance score of WPM

Energy source	**Preference Score**
Solar Pv	0.01771
Solar Thermal	0.00550
Hydro	0.00232
Wind	0.01670
Biomass	0.00526

TABLE 10 shows preference score of WPM

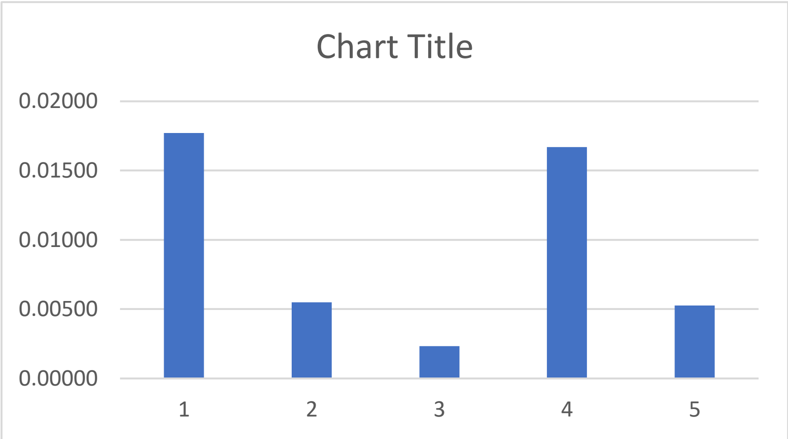

FIGURE 7. preference score

FIGURE 9 shows preference score of WPM

Table 9. WASPAS coefficient

Energy source	WASPAS Coefficient
Solar Pv	0.25949
Solar Thermal	0.32608
Hydro	0.37799
Wind	0.26263
Biomass	0.32866

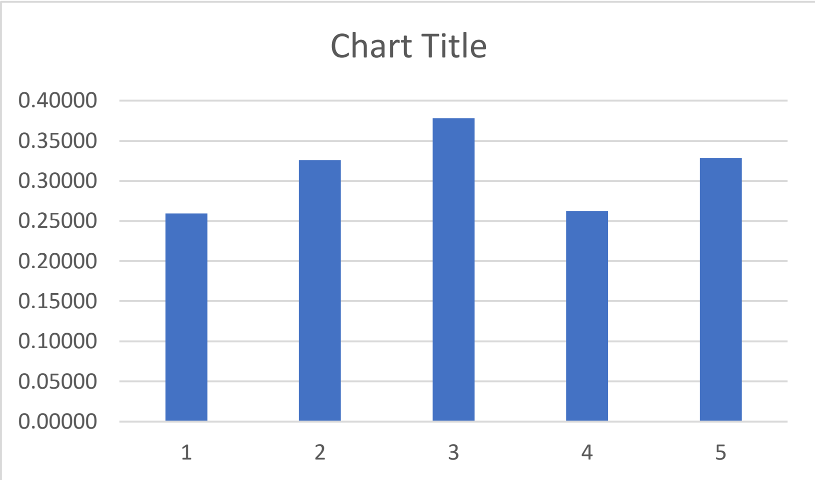

FIGURE 8. WASPAS coefficient

Figure 10 shows WASPAS coefficient

TABLE 10. Rank

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

Table 12 shows rank of WASPAS. Solar pv got fifth rank, solar thermal got third rank, hydro got first rank, wind got fourth rank and biomass is second rank.

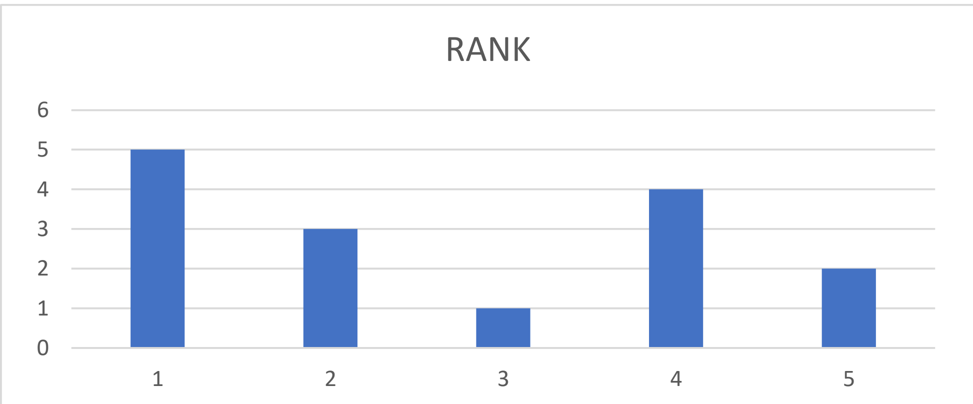

FIGURE 9. Rank of WASPAS

Figure 11 shows rank of WASPAS. Solar PV got fifth rank, Solar Thermal got third rank, Hydro got first rank, Wind got fourth rank and Biomass is second rank.

4. CONCLUSION

The current energy crisis is the result of poor planning, bad policies, bad judgments, and a lack of urgency on the part of the government to address the problem. Without adequate action and a solid commitment from the government, the problem cannot be fixed. The study included a thorough evaluation of the Pakistani energy industry and provided suggestions to decision- and policy-makers on how to go forward with the development of energy technology and resources. To address the primary problems, including energy supply, rising energy prices, electrification of rural regions, and the development of indigenous energy sources, a technology roadmap has been created. Poorly thought out actions, lousy policies, and poor planning are to blame for the current energy problem. Poor planning, terrible policies, poor judgments, and a lack of urgency on the side of the government to solve the issue are to blame for the current energy crisis. The issue cannot be solved without proper action and a strong commitment from the government. The report made recommendations to decision- and policy-makers on how to go forward with the development of energy technology and resources and included a complete examination of the Pakistani energy sector. A technology roadmap has been developed to solve the main issues, such as energy supply, growing energy prices, electrification of rural areas, and the development of indigenous energy sources. The current energy crisis is due to poorly planned acts, bad policies, and inadequate planning. To address the primary concerns, including energy supply, growing energy costs, electrification of rural regions, and the development of indigenous energy sources, a technology roadmap has been created.

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