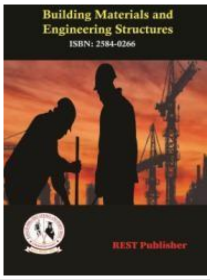
Building Materials and Engineering Structures
Vol: 2(4), December 2024
REST Publisher; ISSN: 2584-0266 (Online)
Website: https://restpublisher.com/journals/bmes/
DOI: http://doi.org/10.46632/bmes/2/4/1



Evaluation of Solar Energy Utilization Using the MOORA Method

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Abstract: *Solar energy is a renewable and sustainable source of power that generates environmentally friendly electricity and heat. It is primarily harnessed through photovoltaic (PV) cells, commonly known as solar panels, which convert sunlight into electricity by stimulating electrons within silicon cells. The adoption of solar energy reduces dependence on fossil fuels, lowers greenhouse gas emissions, and minimizes air pollution. With minimal maintenance requirements and long-term durability, solar panels are widely used in residential, commercial, and large-scale photovoltaic parks. Distributed energy solutions enable individuals and communities to produce their own electricity, reducing reliance on traditional power grids, while integration with existing infrastructure, such as rooftops and solar-powered streetlights, optimizes space utilization. Advancements in technology and declining costs have made solar energy more accessible, with governments and businesses investing in incentives like tax credits and feed-in tariffs to promote its adoption. Research in solar energy focuses on enhancing efficiency, affordability, and scalability through innovations in materials such as perovskite and thin-film solar cells, as well as developing energy storage solutions to address the intermittent nature of solar power. The Multi-Objective Optimization Based on Ratio Analysis (MOORA) method helps evaluate and rank solar energy exploitation alternatives based on multiple criteria, providing a systematic framework for decision-making. In a comparative analysis, "Solar-Energy Exploitation 4" ranked highest, while "Solar-Energy Exploitation 3" ranked lowest, based on benefit and non-benefit parameters. Continued research and investment in solar energy will drive its widespread adoption, contributing to a cleaner and more sustainable future.*

Keywords: *Properties, Solar Energy Exploitation.*

1. INTRODUCTION

The sun is a vital and abundant source of renewable energy, particularly in the form of solar power. Technological advancements have enabled the effective harnessing of solar energy for electricity generation, positioning innovative solar technologies as a key solution to meeting the rising global energy demand. The photovoltaic (PV) industry is rapidly expanding; however, challenges such as low efficiency, system imbalances, and economic constraints still hinder progress. Researchers are actively working on developing advanced PV systems that enhance charge movement, improve photovoltaic composites, and maximize solar radiation absorption for optimal energy harvesting. Additionally, extensive research over the past decades has focused on energy-efficient passive building designs, aiming to improve thermal energy storage, increase thermal mass, enhance insulation, and minimize heat loss. Since buildings consume a significant share of global energy and contribute to environmental pollution, energy retrofits are crucial for reducing their environmental impact, with government subsidies and regulations playing a vital role in promoting energy efficiency worldwide. Research is also being conducted on integrating solar energy with reverse osmosis (RO) desalination plants, particularly through hybrid solar-assisted steam cycles that generate the necessary power for high-pressure pumps in RO systems. This research addresses critical concerns related to energy consumption and sustainability in water desalination. The excessive reliance on fossil fuels has led to severe environmental consequences, including global warming, the greenhouse effect, climate change, ozone layer depletion, and acid rain, all of which are extensively documented in the literature. As a sustainable alternative, solar energy offers a viable solution for powering various desalination processes and mitigating the harmful effects of fossil fuel dependence.

Solar energy can heat brine, enhance filtration, power compressors, and directly desalinate seawater, providing versatile solutions for clean water scarcity. **[7].** A major direction of technological progress is focused on the integration of green energy practices. This is a perfect example that is the use of photovoltaic panels on the roofs of electric vehicles. Combining solar panels with advanced control systems will make it possible to extend the range of these vehicles **[8].** Even in ancient times, before fire was invented, people used solar energy. It was used for drying, cooking, draining materials such as salt and bricks, and for many other purposes. Animal power and human power were used first, then other energy sources such as fuels, fossil fuels, hydroelectric power, and nuclear power. Solar energy is plentiful but often overlooked as a viable alternative to these traditional forms of energy production **[9].** Instead of using thermal energy from sea water or power plant effluent, solar energy can be utilized for LNG regasification, preserving its physical exergy **[10].** The sun holds the key to our future energy needs, as it provides abundant, clean, and secure energy that surpasses our annual consumption and is free from pollution and geopolitical limitations **[11].** The power sector continues to evolve, with solar energy technology emerging as a significant and promising contributor in the rapidly expanding global renewable energy market **[12].** Solar thermal integration offers the opportunity to generate both heat and electricity by combining photovoltaic (PV) and related components into a hyper state unit. The less-cost design of these cells can attract a great deal of interest and attention from researchers in this field **[13].** As the proportion of Renewable Energy Sources (RES) which is an energy consumption, there is a need to expand the utilization of renewables not just in the form of electricity but also in the realm of thermal energy **[14].** Compared to conventional energy sources, solar energy technology (SET) offers clear advantages to the environment and thus makes a valuable contribution to sustainable development. Apart from being rich in inexhaustible natural resources, its main advantage is its ability to significantly reduce CO2 emissions. In addition, SET emits no air pollutants and produces no waste, further enhancing environmental benefits **[15].**

2. MATERIALS AND METHOD

MOORA METHOD: A Multi-objective optimization, where called as multi-criteria or multi-attribute optimization, aims in optimizing several conflicting attributes (or) objectives simultaneously under certain boundary conditions. Such optimization problems can arise in a variety of fields including "product and process design, finance, aerospace design, oil and gas, manufacturing, automotive design, and many others". Achieving optimal results in these areas requires a skilful use of trade-offs and compromises.
The MOOR method allows decision makers to evaluate and rank alternatives against multiple criteria and objectives. By considering different factors and considering different weightings, MOORA supports well-founded decision-making in different areas **[16].** In the real-time of decision making, manufacturing environment is challenging due to the diversity of interests and values of different stakeholders. In such decision problems, goals or measurable criteria are necessary and the performance of each alternative can be evaluated accordingly. There are conflicting goals, some of which are beneficial and prioritize maximum values, while others are considered irrelevant and require at least a certain scaling value. Balancing these competing criteria in decision making presents a significant problem **[17].** The MOORA method optimizes welding parameters by considering multiple objectives. It simplifies decision-making, enabling the selection of the most suitable option while eliminating poor choices. It offers an alternative to existing selection procedures, enhancing the decision-making process **[18].** In MOORA, overall performance is determined by comparing the sum of normalized performances for favourable and unfavourable criteria, evaluating the effectiveness of alternatives considering both factors **[19].** The PPA selection process uses the MOORA system and merit-based criteria to choose recipients. My research focused on implementing a decision support system that effectively selects deserving students for scholarships using MOORA **[20].** Numerical tests confirm MOORA's efficiency in computation and problem definition. This study explores industrial engineering students' career choices and the criteria influencing them, filling a research gap in this area **[21].** Integrating MOORA and Taguchi methods converts multi-response optimization problems into single-answer questions, minimizing mathematical calculations and saving time and costs **[22].**
The pricing system approach normalizes output data, resulting in a dimensionless matrix for fair comparison of all elements. This normalization process enables easy comparison within the result matrix **[23].** Determining the best supply chain strategy is critical for companies to improve efficiency and reduce costs. A supply chain consists of interconnected organizations that create value through various processes and ultimately deliver products and services that satisfy customers. The goal is to maximize the value created and match it with supply chain profitability **[24].** As technology and industry progress, new challenges arise in health, safety, and the environment **[25].**

Solar Energy Exploitation 1, 2, 3, 4, 5: Solar energy utilization datasets consist of valuable information pertaining to solar radiation, weather patterns, panel efficiency, energy generation, and other pertinent variables. These datasets enable researchers and professionals to thoroughly analyse solar energy systems and make well-informed decisions regarding sustainable energy solutions. By examining the data, insights that optimize the performance & effectiveness of 'solar energy systems', contributing to a greener and more sustainable future.

Permeation Characteristics: Exchange properties study how one substance allows other substances to interact. The goal is to understand factors such as pore size, surface properties, and molecular structure to design materials with desirable permeability. This knowledge is important for industries that need to control material flow to improve process and product quality.

Geometrical Properties: Geometrical properties involve the shape, size, and dimensions of an object. They include parameters like length, width, area, and angles. Understanding these properties is crucial for modelling, analysis, and design in various fields.

Climatological Characteristics: Climatological characteristics study long-term weather patterns and conditions in an area, including temperature, precipitation, humidity, wind, and atmospheric pressure. They provide insights for agriculture, infrastructure planning, and environmental management.

Systems Characteristics: System characteristics include system-specific attributes and properties. They reveal its components, structures, interactions, behaviours, and functions. Analysing these characteristics provides a comprehensive understanding of system behaviour and helps optimize performance. Guide decisions to improve efficiency and effectiveness in managing complex systems.

3. RESULT AND DISCUSSION

Table 1. Solar Energy Exploitation

Alternatives	Permeation characteristics	Geometrical properties	Climatological characteristics	Systems characteristics
Solar Energy Exploitation 1	46.36	150.63	35.63	48.96
Solar Energy Exploitation 2	36.45	142.97	33.69	36.45
Solar Energy Exploitation 3	30.15	130.46	38.65	43.78
Solar Energy Exploitation 4	37.63	145.46	40.32	35.63
Solar Energy Exploitation 5	35.63	186.41	46.56	33.48

Table 1 contains the Dataset of "Solar-Energy Exploitation 1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar-Energy Exploitation 4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics.

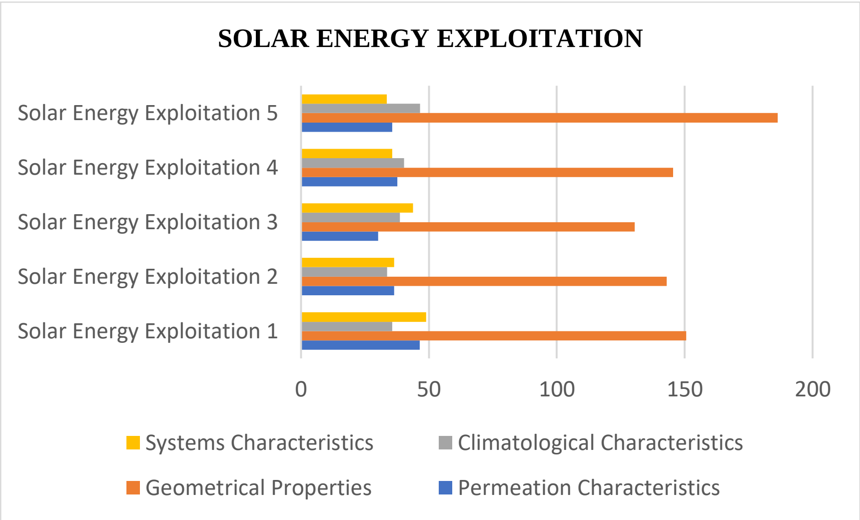

FIGURE 1. Values of "Solar Energy Exploitation"

Figure 1 implies that the statistics of individual solar Energy Exploitation and from this we understand that the Solar energy Exploitation 4 has the high benefit and the lowest non-benefit of all other solar Energy Exploitations.

Table 2. Normalized Data for Solar Energy Exploitation

Alternatives	Permeation characteristics	Geometrical properties	Climatological characteristics	Systems characteristics
Solar Energy Exploitation 1	0.551265	0.442156	0.406256	0.546271
Solar Energy Exploitation 2	0.433426	0.419671	0.384136	0.406691
Solar Energy Exploitation 3	0.358512	0.38295	0.44069	0.488476
Solar Energy Exploitation 4	0.447457	0.426981	0.459732	0.397542
Solar Energy Exploitation 5	0.423675	0.547184	0.530881	0.373553

Table 2 shows the Normalized Data for "Solar-Energy Exploitation 1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar-Energy Exploitation 4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics.

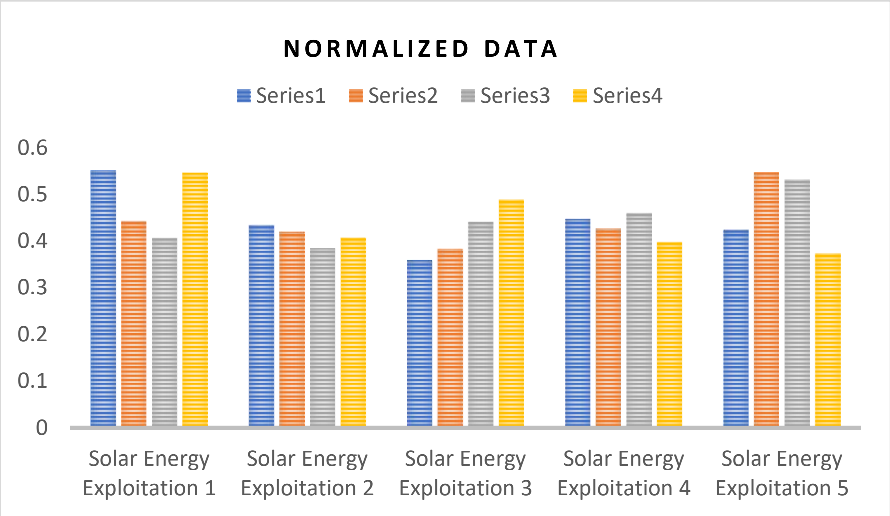

FIGURE 2. Normalized data for Automotive brake disc material selection

Figure 2 shows the Normalized data for MOORA Method Alternative: "Solar-Energy Exploitation 1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar Energy Exploitation-4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics (i.e.) which shows which has better advantages.

Table 3. Weightages of the materials

WEIGHT				
Solar Energy Exploitation 1	0.25	0.25	0.25	0.25
Solar Energy Exploitation 2	0.25	0.25	0.25	0.25
Solar Energy Exploitation 3	0.25	0.25	0.25	0.25
Solar Energy Exploitation 4	0.25	0.25	0.25	0.25
Solar Energy Exploitation 5	0.25	0.25	0.25	0.25

Table 3 provides the weights utilized for the analysis, where equal weights are assigned to all parameters

Table 4. "Weighted normalized decision matrix"

WEIGHTED - NORMALIZED DECISION MATRIX				
Solar Energy Exploitation 1	0.137816	0.110539	0.101564	0.136568
Solar Energy Exploitation 2	0.108356	0.104918	0.096034	0.101673
Solar Energy Exploitation 3	0.089628	0.095737	0.110173	0.122119
Solar Energy Exploitation 4	0.111864	0.106745	0.114933	0.099385
Solar Energy Exploitation 5	0.105919	0.136796	0.13272	0.093388

Table 4 for MOORA Alternative: "Solar-Energy Exploitation 1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar-Energy Exploitation 4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics. It shows which is the comparison between others.

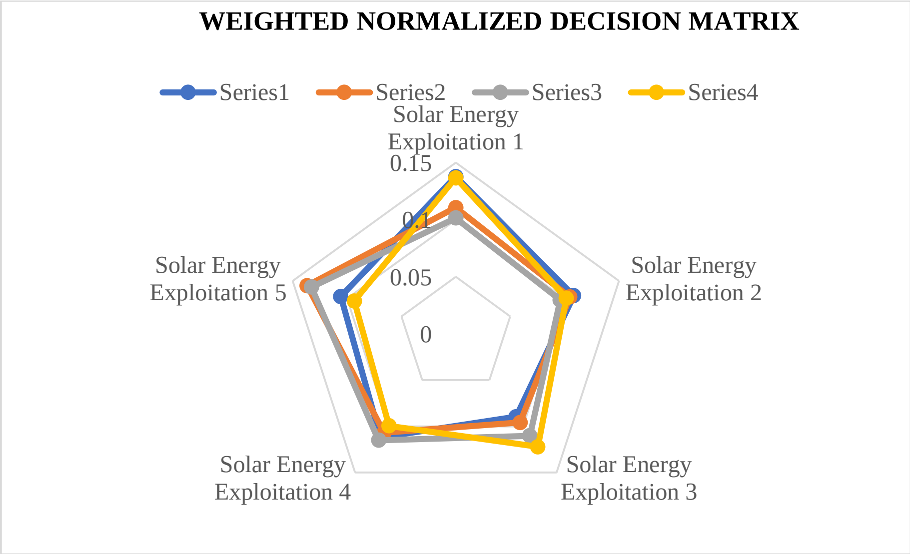

FIGURE 4. Weighted Normalized Decision Matrix for solar Energy Exploitation

Figure 4 shows that Weighted Normalized Decision Matrix for “Solar-Energy Exploitation 1”, “Solar-Energy Exploitation 2”, “Solar-Energy Exploitation 3”, “Solar-Energy Exploitation 4”, “Solar-Energy Exploitation 5”; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics.

TABLE 5. Assessment value of the Solar Energy Exploitation

Assessment value	
Solar-Energy Exploitation 1	0.0102
Solar-Energy Exploitation 2	0.0155
Solar-Energy Exploitation 3	-0.0469
Solar-Energy Exploitation 4	0.0042
Solar-Energy Exploitation 5	0.0166

Table 5. Assessment value of the “Solar Energy Exploitation” for “Solar-Energy Exploitation 1”, “Solar-Energy Exploitation 2”, “Solar-Energy Exploitation 3”, “Solar-Energy Exploitation 4”, “Solar -Energy Exploitation 5”; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics. It shows which is the comparison between others.

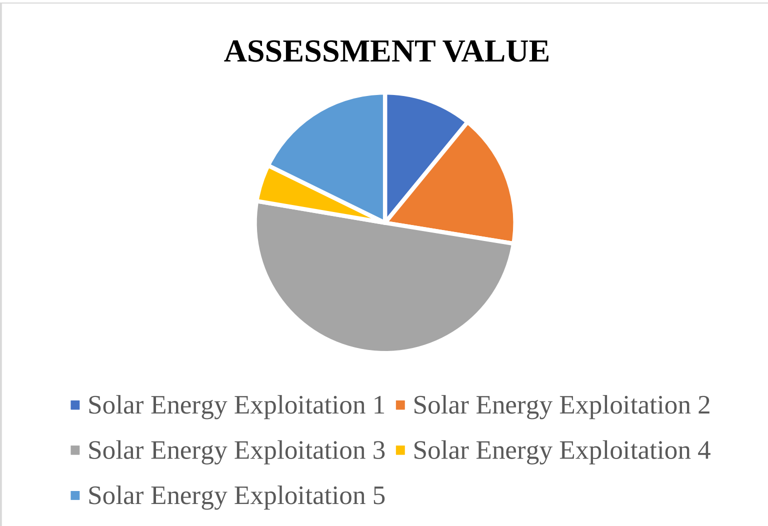

Figure 5. Assessment value for solar Energy Exploitation

Figure 4 shows the Assessment value for "Solar-Energy Exploitation1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar-Energy Exploitation-4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics.

Table 6. Rank of the Solar Exploitation

RANK	
Solar-Energy Exploitation - 1	3
Solar-Energy Exploitation - 2	2
Solar-Energy Exploitation - 3	5
Solar-Energy Exploitation - 4	4
Solar-Energy Exploitation - 5	1

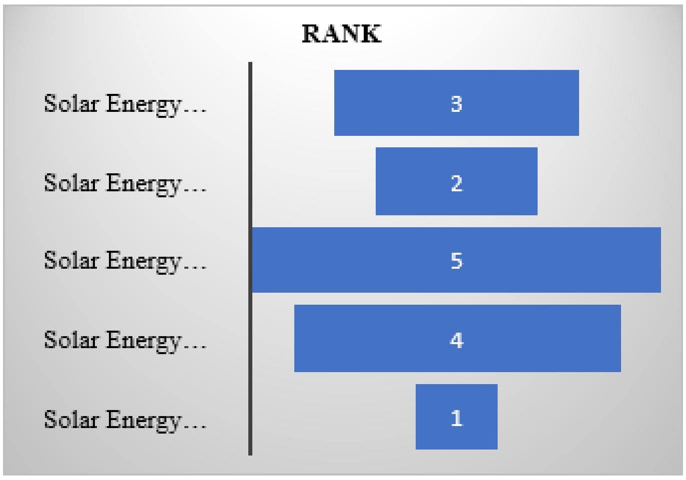

Figure 6. Rank of these solar Energy Exploitation

Figure 6 shows that the Rank of these "Solar-Energy Exploitation 1", "Solar-Energy Exploitation 2", "Solar-Energy Exploitation 3", "Solar-Energy Exploitation 4", "Solar-Energy Exploitation 5"; Permeation Characteristics, Geometrical Properties, Climatological Characteristics, Systems Characteristics. Here "the Solar-Energy Exploitation 5" is placed first and the Solar Energy Exploitation 3 placed at last. It is best to use "Solar-Energy Exploitation 5" everywhere.

4. CONCLUSION

Solar energy implementation of the solar energy to create environmentally friendly electricity and heat. It is a renewable and sustainable energy source with many benefits. One of the main approaches to harnessing solar energy is by photovoltaic cells (PV), commonly referred to as solar panels. solar energy research will accelerate the transition to renewable energy, mitigate climatic changes and promote the utilization of the sun as a reliable, affordable, and accessible energy solution for a sustainable future. It has great potential for energy production. Solar energy offers a sustainable and environmentally friendly solution to meet a variety of challenges such as energy demand, water scarcity, pollution, and dependence on fossil fuels. Its enormous potential and current developments are paving a promising path towards a cleaner and more sustainable future. Thus, from the dataset we can conclude that the "Solar-Energy Exploitation 5" is placed first and the Solar Energy Exploitation 3 placed at last. It is best to use "Solar-Energy Exploitation 5" everywhere. By using 'MOORA' approach, we got the result for the "Solar-Energy Exploitation.

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