IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9764

Evaluation of solar panels for improved competency: a comparative study and appraisement with TOPSIS

Richa Sahu[1] and Ruchi Pandey[2]

Gyan Ganga Institute of Technology and Sciences, Jabalpur, Madhya Pradesh, India[1]

Department of Electrical & Electronics Engineering, Gyan Ganga Institute of Technology and Sciences, Jabalpur, Madhya Pradesh, India[2]

Abstract: Solar energy holds enormous potential, where solar panels are used to transform solar radiation into electricity for the benefit of the society. But, huge variants of solar panels are available in the market and thus it is very difficult, confusing and challenging to determine, which panels posses' immense potential, appropriate utility and can competently satisfy the desirability of the customers with efficient energy generation and cost reduction. The present paper aims to present an inventive approach, which can be used as decision making tool for solving the problem of selecting solar panels. Multiple criteria's are identified for evaluation.Ddata are collected under scrutinized multiple criteria's named as open circuit voltage, short circuit current, peak power, cost, module efficiency, weight and area in relation to the solar panels. In present study, TOPSIS methodology is adapted to determine the most influential alternative for solar panel. Final rankings of the alternatives are presented.

Keywords: Alternatives, TOPSIS, appraisement, Solar Energy, Assessment.

I. INTRODUCTION

Solar energy generation are nowadays drawing attention and is started implementing by the societal peoples due to its significant benefits under the origins of less maintenance, low environmental effect, and a longer service life (Ahmad and Razman (2014; Gnanasekaran and Venkatachalama, 2019). But, the best advantage from the solar energy can be attained by evading inherent environmental factors, parameters and obstacles. The solar energy sources are nowadays gaining attention due to the requirement of finding appropriate alternative resources for energy, which is environmentally caring and renewable (Asakereh et al. (2014; Bączkiewicz et al., 2021). The sinking of greenhouse gases is an imperative requirement in today's scenario, which can be achieve by using solar energies. Conventionally, the society is keenly dependent on non-renewable energy resource like fossil fuels, where; the usage of fossil fuels usage is resulting in omission of harmful gas, which renders damaging effect on society (Baniasad et al.; 2015; Lak Kamari et al.; 2020). Thus, renewable energy is found as an imperative alternative for society's long-term growth. The appropriate selection of solar technology and location of implementation has a significant impact on the cost and generation of power. Solar energy is a critical component of the energy development strategy. Solar energy source is gaining attention under the marks of cost-effective and continuous source of energy (Kahraman et al., 2009; Cavallaro, 2009). The solar energy outputs estimates are required to be developed appreciably in the near future for satisfying the demands of the economy. The best utility from solar energy can be gained by evaluating many criteria's. Solar technology is the need of today scenario and important relies on the evaluation of site location, numerous criteria's and limitations (Gnanasekaran and Venkatachalama, 2019).

Choosing suitable locations for the implementation of solar energy panels is noteworthy to attain a significant influence on the amount and quality of electric energy generated. The same will profit implementers economically and socially. The selection of a favourable geographic location for the implementation of solar panels is paramount from the aspects of economic, technological, social, geographical, and environmental. The solar energies have many compensations and their importance is rising drastically due to mounting concerns for environmental issues and less utility of fossil fuels in the future (Cavallaro, 2010; Luthra et al., 2016). Solar energy sources are well recognized inexhaustible source of energy and the same are utilizing by the concerns dramatically for electricity generation and transportations (Ghasempour et al., 2019; Ahammed and Abdullahil, 2013). The need to develop a more systematic approach to solar plant site selection, which can consider major characteristics i.e. economic, technological, social, geographical, and environmental is understand by the authors. The need of a constructive decision making provisions that would result in noteworthy cost savings and amplified electricity generation is needed in today's scenario (Luthra et al., 2016). Thus, the present study is conducted to report below mentioned two Research questions (RQ):

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9764

RQ1- What are the possible alternatives available in the market place for implementing solar panels?
RQ2- How one can evaluate number of available alternatives available in the market place in corresponding to the criteria?

The present study has done decision making, which deals with the process to achieve the target or goal in the context of making right decisions (Sahu et al., 2020b; He et al. 2021). In today's era, it is required that productive resources should be managed with limited assets in a given time to maximum benefit (Sahu et al., 2018a; Sahu et al., 2019b). Today studies are needed to be conducted for optimizing natural resources (Guo et al. 2022; Sahu et al., 2020c).

II. LITERATURE SURVEY:

Miguel Sánchez-Lozano et al. (2013) declare that the solar energy is arousing considerable interest amongst competitors because of its free availability and economic aspects. Mohsen and Bilal (1997) found that the solar plants are supremely suitable for locations having low humidity, dust and other agents, which may prevent absorption of solar irradiation. They found the location of solar plant and sunlight hours as a very imperative reason for gaining efficiency by solar energy. Nixon and Davies (2010) found installation of solar power plants, solar panels, awareness etc., as few significant aspects, which are needed for its successfully implementation and retention. Nixon et al. (2013) stated that the households consume approximately one third of all energy produced, thus studies on the evaluation of solar energy production technologies in households are very important. Pohekar and Ramachandran (2004) investigated the need of critical studies to be conducted, which can provide an overview and in-depth analysis of solar utility and their selection components. They found that the utility of solar energy has started tending to decline the greenhouse gas emissions from households in many regions of the world. Sánchez-Lozano et al. (2015) stressed on the identification of many contradictory aspects, when are needed to be considered by the experts and required to conclude, which energy production system can be the most appropriate for a household. Shiue and Lin (2012) highlighted that the cost effectiveness does not always mean convenience or the most environmentally friendly technology. They, additionally highlighted that the cheap and reliable power supply does not always directly compare with installation costs and payback. Singh et al. (2016) declared that the conflicting criteria should be evaluated for the perspective of system efficiency, where Multi-criteria decision-making (MCDM) methods provide a possibility to evaluate these and other contradictory factors. MCDM is found effective to determine the optimum solution of problems, where many (contradictory) criteria's are to be attained concurrently. In MCDM contradictory objectives under the domain of conflicting criteria's are evaluated. MCDM techniques are being functional for problems with contrary and diverse objectives.

Vafaeipour et al. (2014) examined that the electricity demand is one of the main imperative requirements of every economy and the same is growing constantly. Hence the developments of solar or other renewable energy sources are required for coping industrial and economic activities as well as to fulfil the aspirations of the population growth. Toghi et al. (2015) stated that today, it is required to replace conventional electricity generation methods with renewable energies. Selection of renewable alternatives is a multi criteria decision making problem due to the existence of a range of inconsistent criteria's. Uyan (2013) declare that solar energy sources grants an opportunity to solve the climate change and economic decarbonization issues that are so pertinent today. Watson and Malcolm (2015) highlighted the need to analyze and evaluate solar energy sources, which are receiving rising interest in the politics of diverse countries and the scientific literatures. Tarwidi et al. (2016) highlighted the need of appropriate selection of solar power sources and their mediums are very important for evident power generation effectively under low cost and other constraints. It is found evident that MCDM framework or model can assist in better envisaging the plan for the acquisition of system performance and allow them to expand more speedily by rationalizing the right thing (Wang et al. 2019; Sahu et al., 2020a). In MCDM, the decision-making procedure uses the decision criterions, which are rated by each judgment maker or decision group (Kang et al., 2022; Sahu et al., 2019a). Today, Quality measures are today needed to be for benchmarked for evaluating substitute for industrial applications (Sahu et al., 2017; Bag et al., 2021a).

III. RESEARCH GAPS:

After conducting the literature survey in the field of solar energy and solar panels implementation field, it is observed that many energy related materials are developing by the researchers for reinforcing solar energy capacities, but less attention is paid in relation to its implementation under various criteria's. After understanding vast literatures, the following Research Gaps (RG) has been identified:

RG1- Little attention is paid in the literatures towards disclosing number of criteria's for evaluating solar panels.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9764

RG2- A very less degree of research of research is done towards disclosing the available number of alternatives for implementing solar panels.

RG3- Less research is done to report the methodological procedure, which will help in evaluating number of solar panel alternatives in relation to the criteria's.

Today, there is an evident requirement of right resources in society as the same not only saves money, escalates production, improves profit margins (Bag et al., 2021b; Sahu et al., 2022). Right selection of resources will also gratifies the consumption of scarce natural resources (He et al. 2021; Sahu et al., 2018b).

IV. TOPSIS TECHNIQUE:

TOPSIS abbreviated for Technique for Order of Preference by Similarity to Ideal Solution technique (Bianchini, 2018; Sahu et al., 2016). It is found that a multi objective optimization tools lays down the synergy between multiple conflicting criteria's and helps in efficiently transforming multiple responses into the single objective optimization problem (Sudhagar et al., 2017; Saha and Mondal, 2017). Consequently; TOPSIS technique is adapted in present paper for transform the multiple responses into single response for analysis (Khan and Maity, 2017; Chitnis and Vaidya, 2018). The TOPSIS technique was proposed by Hwang and Yoon (1981) and defines Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) to generate decision results. The PIS minimizes the cost criteria and maximizes the benefit criteria; whereas, the NIS maximizes the cost criteria and minimizes the benefit criteria in TOPSIS. The below mentioned procedures is adopted for implicating the TOPSIS methodology in this study (Sahu et al., 2016; Chitnis and Vaidya, 2018)

V. MODELLING:

Following a comprehensive review of the relevant literature, it is found that the cost effectiveness does not always mean convenience or the most environmentally friendly technology. Additionally, cheap and reliable power supply does not always directly compare with installation costs and payback. Thus, the motivation has been received by the candidate and candidate started searching for the appropriate criteria's, which will assists in selection of solar panels. Accordingly, six criteria's and thirty alternatives are selected for building the decision making model. Literature review is performed in the principal stage to understand critical criteria that need to be importantly incorporated for the selection of solar panels. The model for the present paper is built by the candidate, which are presented in Tables 1-5, where, the related to the alternative solar panels pertaining to Open Circuit Voltage (Volts) cand short circuit current (ampere) can be identified in Tables 1 & 2.

TABLE 1: DATA ASSOCIATED WITH AVAILABLE ALTERNATIVES OBTAINED FROM WEBSITES UNDER CRITERIA OPEN CIRCUIT VOLTAGE (V)

Alternative	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
Open Circuit Voltage (V)	42.80	40.93	40.20	40.60	41.20	43.30	41.67	40.56	40.60	40.50
Alternative	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**
Open Circuit Voltage (V)	43.30	45.04	44.00	44.30	44.20	40.66	45.40	41.00	48.00	49.86
Alternative	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A27**	**A28**	**A29**	**A30**
Open Circuit Voltage (V)	48.30	47.62	49.60	46.80	51.20	48.91	48.91	49.14	49.00	49.33

TABLE 2: DATA ASSOCIATED WITH AVAILABLE ALTERNATIVES OBTAINED FROM WEBSITES UNDER CRITERIA SHORT CIRCUIT CURRENT (A)

Alternative	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
Short Circuit Current (A)	10.82	9.82	9.98	10.40	10.35	10.50	10.08	9.94	10.00	10.20
Alternative	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**
Short Circuit Current (A)	9.51	10.50	10.37	10.26	10.58	10.52	10.20	10.92	10.83	10.39
Alternative	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A27**	**A28**	**A29**	**A30**
Short Circuit Current (A)	9.60	9.66	10.66	9.59	10.29	10.22	10.79	11.05	10.24	10.83

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 7, July 2022

DOI: 10.17148/IARJSET.2022.9764

VI. ANALYTICAL PROCEDURE:

The paper selected six criteria's units for modelling the selection model of solar panels. The paper utilized TOPSIS methodology to determine the most influential alternative for solar panel. TOPSIS methodology is used for evaluation and to determine the most appropriate alternative amongst available in the market. In the primary stage, literature review is conducted to understand critical criteria's that need to be importantly incorporated for the selection of solar panels. After, understanding the literature, six criteria's are selected to define possible alternatives. Afterwards, the available variants of solar panels are identified from the sources of literatures, internet and web support. Here, thirty variants of solar panels are identified, presented, and data are collected in terms of selected criteria's for the identified solar variants named as alternatives. Normalized decision making matrix, PIS (Table 3), NIS (Table 4) and performance score (Table 5) of the alternatives are generated to report significant alterative.

TABLE 3: DISTANCE FROM PIS UNDER TOPSIS TECHNIQUE FOR EACH OF THE ALTERNATIVES

Alternative	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
PIS	0.2923	0.0455	0.0709	0.0344	0.1587	0.2777	0.0475	0.0996	0.0600	0.0850
Alternative	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**
PIS	0.0720	0.0843	0.1568	0.0983	0.1214	0.0677	0.0664	0.0683	0.1790	0.0491
Alternative	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A27**	**A28**	**A29**	**A30**
PIS	0.1524	0.0786	0.0479	0.0623	0.0615	0.0816	0.0734	0.0713	0.1117	0.0578

TABLE 4: DISTANCE FROM NIS UNDER TOPSIS TECHNIQUE FOR EACH OF THE ALTERNATIVES

Alternative	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
NIS	0.0664	0.2712	0.2365	0.2770	0.1457	0.0585	0.2680	0.2066	0.2511	0.2217
Alternative	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**
NIS	0.2397	0.2179	0.1462	0.2042	0.1826	0.2404	0.2398	0.2409	0.1279	0.2734
Alternative	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A27**	**A28**	**A29**	**A30**
NIS	0.1523	0.2383	0.2736	0.2927	0.2622	0.2288	0.2367	0.2421	0.1946	0.2633

TABLE 5: COMPUTED PERFORMANCE SCORE UNDER TOPSIS FOR ALTERNATIVE RANKING

Alternative	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
Performance score	0.1851	0.8564	0.7693	0.8895	0.4787	0.1739	0.8494	0.6748	0.8072	0.7228
Alternative	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**
Performance score	0.7690	0.7211	0.4824	0.6750	0.6007	0.7803	0.7831	0.7792	0.4167	0.8479
Alternative	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**	**A27**	**A28**	**A29**	**A30**
Performance score	0.4998	0.7520	0.8511	0.8244	0.8100	0.7372	0.7634	0.7725	0.6353	0.8201

VII. CONCLUSIONS:

It is presented that the households consume approximately one third of all energy produced, thus studies on the evaluation of solar energy production technologies in households are found important. The need of critical studies, which can provide an overview and in-depth analysis of solar utility and their selection components are found significant. Thus, in present paper solar panel criteria's are evaluated. The study is framed with the intension to increase the efficiency of solar energy to decline the greenhouse gas emissions from the society. The paper presented that the electricity demand is one of the main imperative requirements of every economy and the same is growing constantly. Hence, the developments of solar or other renewable energy sources are required for coping industrial and economic activities as well as to fulfil the aspirations of the population growth. Today, it is required to replace conventional electricity generation methods with renewable energies. Thus, the paper highlighted the need of appropriate selection of solar power sources and their mediums are very important for evident power generation effectively under low cost and other constraints. The results of the study can assist in understanding critical choice of solar panel for implementation

DOI: 10.17148/IARJSET.2022.9764

by the societal people. The paper admirably reported six criteria's named as Open Circuit Voltage (Volts), short circuit current (ampere), module efficiency (%), Peak Power per m^2 (W/m^2), Cost per m^2 ($Rs./m^2$) and Weight per m^2 (Kg/m^2) that are found significant to be considered before purchasing a solar panel from the market from the insights of competency. The procedure for determining the optimal selection of solar panel is presented in present paper by the implication of MCDM technique. In present thesis, the procedural steps of TOPSIS an MCDM technique is presented to help the evaluated in selection an optimum choice.

REFERENCES

[1] Gnanasekaran, S. and Venkatachalama, N. (2019). A review on applications of multi-criteria decision making (MCDM) for solar panel selection. International Journal of Mechanical and Production Engineering Research and Development, Volume 9, Page 11–20.

[2] Ahammed, F. and Abdullahil, A. (2013). Selection of the most appropriate package of Solar Home System using Analytic Hierarchy Process model in rural areas of Bangladesh. Renewable Energy, Volume 55, Page 6–11.

[3] Ahmad, S. and Razman, M.T. (2014). Selection of renewable energy sources for sustainable development of electricity generation system using analytic hierarchy process: A case of Malaysia. Renewable Energy, Volume 63, Page, 458–466.

[4] Shiue, Y.-C. and Lin. C-Y. (2012). Applying analytic network process to evaluate the optimal recycling strategy in upstream of solar energy industry. Energy and Building, Volume 34, Page 266–277.

[5] Asakereh, A., Omid, M., Alimardani, R and Sarmadian, F. (2014). Developing a GIS-based Fuzzy AHP Model for Selecting Solar Energy Sites in Shodirwan Region in Iran. International Journal of Advanced Science and Technology, Volume 68, Page 37-48.

[6] Sahu, A. K., Sahu, N. K., Sahu, A. K., Rajput, M. S., & Narang, H. K. (2020a). An Investigation Tool for Mounting Sustainable Practice: Modeling Using GIVTFNs in an Indian Context. International Journal of Decision Support System Technology (IJDSST), 12(2), 25-49.

[7] Sahu, A.K., Sharma, M., Raut, R.D., Sahu, A.K., Sahu, N.K., Antony, J. and Tortorella, G.L. (2022), "Decision-making framework for supplier selection using an integrated MCDM approach in a lean-agile-resilient-green environment: evidence from Indian automotive sector", https://doi.org/10.1108/TQM-12-2021-0372.

[8] Nixon, J.D., Dey, P.K. and Davies. P.A. (2010). Which is the best solar thermal collection technology for electricity generation in north-west India? Evaluation of options using the analytical hierarchy process. Energy, Volume 35, Issue 12, Page 5230–5240.

[9] Baniasad A, I., Sadegh, M.O and Ameri, M. (2015). Energy management and economics of a trigeneration system considering the effect of solar PV, solar collector and fuel price. Energy for Sustainable Development, Volume 26, Page 43-55.

[10] Cavallaro, F. (2009). Multi-criteria decision aid to assess concentrated solar thermal technologies. Renewable Energy, Volume 37, Issue 7, Page 1678–1685.

[11] Saha, A. & Mondal, S.C. (2017). Multi-objective optimization of manual metal arc welding process parameters for nano-structured hardfacing material using hybrid approach. Measurement, 102, 80-89.

[12] Hwang, C. L. & Yoon, K. (1981). Multiple Attribute Decision Making Methods and Applications. Berlin Heidelberg, Springer.

[13] Cavallaro, F. (2010). Fuzzy TOPSIS approach for assessing thermal-energy storage in concentrated solar power (CSP) systems. Applied Energy, Volume 87, Issue 2, Page 496–503.

[14] Bianchini, A. (2018). 3PL provider selection by AHP and TOPSIS methodology. Benchmarking: An International Journal, 25(1), 235-252.

[15] Kang, D., Prabhu, M., Ahmed, R.R., Zhang, Z. and Sahu, A. K. (2022), "Digital-IIoTs spheres approach toward public development: an exploiting fuzzy-grey mathematical modeling of IIoTs spheres", Grey Systems: Theory and Application, Vol. 12 No. 2, pp. 389-416.

[16] Sahu A. K., Sahu, N. K., Sahu, A. K., Narang, H. K. and Rajput, M. S.(2018a) "Grey-based scorecard model for opting fruit supply bazaar locality under advanced chain of macro-micro parameter", British Food Journal, Vol. 120 Issue: 1, pp.59-79.

[17] Sahu A. K., Sahu, N. K., and Sahu, A. K. (2018b) "Knowledge based decision support system for appraisement of sustainable partner under fuzzy cum non-fuzzy information", Kybernetes, Vol. 47 No. 6, pp. 1090-1121.

[18] Khan, A. & Maity, K. (2017). Application of MCDM-based TOPSIS method for the selection of optimal process parameter in turning of pure titanium. Benchmarking: An International Journal, 24(7), 2009-2021.

[19] Kahraman, C., İ Kaya,I and Cebi.S. (2009). A comparative analysis for multiattribute selection among renewable energy alternatives using fuzzy axiomatic design and fuzzy analytic hierarchy process. Energy, Volume 34, Issue 10, Page 1603– 1616.

DOI: 10.17148/IARJSET.2022.9764

[20] Ghasempour, R., Nazari, M.A., Ebrahimi, M., Ahmadi, M.H. and Hadiyanto, H. (2019). Multi-Criteria Decision Making (MCDM) Approach for Selecting Solar Plants Site and Technology: A Review. International Journal of Renewable Energy Development, Volume 8, Issue 1, Page 15-25.

[21] Luthra, S., Govindan, K., Ravinder K. K, and Mangla, S.K. (2016). Evaluating the enablers in solar power developments in the current scenario using fuzzy DEMATEL: An Indian perspective. Renewable and Sustainable Energy Review, Volume 63, Page 379–397.

[22] Miguel Sánchez-Lozano, J., Socorro García-Cascales, M. and Teresa Lamata. M. (2013). Decision Criteria for Optimal Location of Solar Plants: Photovoltaic and Thermoelectric. Assessment and Simulation Tools for Sustainable Energy Systems, Volume 129, Page 79-91.

[23] Bag, S., Viktorovich, D.A., Sahu, A.K. and Sahu, A.K. (2021b), "Barriers to adoption of blockchain technology in green supply chain management", Journal of Global Operations and Strategic Sourcing, Vol. 14 No. 1, pp. 104-133.

[24] Guo, X., Sahu, A. K., Sahu, N. K. and Sahu, A. K. (2022), "A novel integrated computational TRIFMRG approach with grey relational analysis toward parametric evaluation of weld bead geometry of ms-grade: IS 2062", Grey Systems: Theory and Application, Vol. 12 No. 1, pp. 117-141.

[25] Mohsen, Mousa S., and Bilal A. Akash (1997). Evaluation of domestic solar water heating system in Jordan using analytic hierarchy process. Energy Conversion and Management, Volume 38, Issue 18, Page 1815–1822.

[26] Nixon, J.D., Dey, P.K. and Davies. P.A. (2013). Design of a novel solar thermal collector using a multi-criteria decision making methodology. Journal of Cleaner Production, Volume 59, Page 150–159.

[27] Pohekar, S.D., and Ramachandran, M. (2004). Application of multi-criteria decision making to sustainable energy planning—A review. Renewable and Sustainable Energy Reviews, Volume 8, Issue 4, Page 365–381.

[28] Wang, W., Huang, L., Zhu, Y., Jiang, L., Sahu, A.K., Sahu, A.K. and Sahu, N.K. (2019), "Decision support system toward evaluation of resilient supplier: A novel fuzzy gain-loss computational approach", Kybernetes, Vol. 49 No. 6, pp. 1741-1765. https://doi.org/10.1108/K-05-2019-0345.

[29] Sahu A. K., Sahu, N. K. and Sahu, A. K. (2017), Appraise the Economic Values of Logistic Handling System under Mixed Information, Theoretical and Practical Advancements for Fuzzy System Integration, pp. 278-308.

[30] Sánchez-Lozano, J.M., García-Cascales, M.S. and Lamata M.T. (2015). Evaluation of suitable locations for the installation of solar thermoelectric power plant. Computers & Industrial Engineering, Volume 87, Page 343–355.

[31] Chitnis, A. & Vaidya, O.S. (2018). Efficiency ranking method using SFA and TOPSIS (ERM-ST): case of Indian banks. Benchmarking: An International Journal, 25(2), 471-488.

[32] Sahu A. K., Sahu, N. K. & Sahu, A. K. (2016). Application of Integrated TOPSIS in ASC index: Partners Benchmarking perspective, Benchmarking: An International Journal, 23(3), 540-563.

[33] Singh, A., Vats, G and Khanduja. D. (2016). Exploring tapping potential of solar energy: Prioritization of Indian states. Renewable and Sustainable Energy Reviews, Volume 58, Page 397–406.

[34] Bączkiewicz, A., Kizielewicz, B., Shekhovtsov, A., Yelmikheiev, M., Kozlov, V. and Sałabun W. (2021). Comparative Analysis of Solar Panels with Determination of Local Significance Levels of Criteria Using the MCDM Methods Resistant to the Rank Reversal Phenomenon. Energies, Volume 14, Issue 18, Page 1-21.

[35] Lak Kamari, M., Isvand, H. and Alhuyi Nazari, M (2020). Applications of multi-criteria decision-making (MCDM) methods in renewable energy development: A review. Renewable Energy Research and Applications, Volume 1, Page 47–54.

[36] Sahu, A. K., Sahu, N. K., & Sahu, A. K. (2019a). Agile Supplier Assessment Using Generalized Interval-Valued Trapezoidal Fuzzy Numbers. In Dey, N. (Ed.), Technological Innovations in Knowledge Management and Decision Support (pp. 67-97).

[37] Sahu, A. K., Narang, H. K., Rajput, M. S., & Sahu, N. K. (2019b). Sustainability Appraisement of Industrial Robots by GRA for Real Automation Environment. International Journal of Social Ecology and Sustainable Development (IJSESD), 10(3), 53-68.

[38] Sahu, A.K., Kumar, A., Sahu, A.K. and Sahu, N.K. (2020b), "Evaluation of machine tool substitute under data-driven quality management system: a hybrid decision-making approach", The TQM Journal, https://doi.org/10.1108/TQM-07-2020-0153.

[39] Sahu A. K., Sahu, N. K., and Sahu, A. K. (2020c). "A Review on the Research Growth of Industry 4.0: IIoT Business Architectures Benchmarking." International Journal of Business Analytics, Vol. 7 Issue: 1, pp.77-97.

[40] Tarwidi, D., Murdiansyah, D.T. and Ginanjar.N (2016). Performance Evaluation of Various Phase Change Materials for Thermal Energy Storage of A Solar Cooker via Numerical Simulation. International Journal of Renewable Energy Development, Volume 1, Page 199-210.

[41] Toghi E., Amin, R. G., Fatemeh, R. and Fatollah, P. (2015). Evaluation of nanoparticle shape effect on a nanofluid based flat-plate solar collector efficiency. Energy, Exploration & Exploitation, Volume 33, Issue 5, Page 1-18.

[42] Uyan, M. (2013). GIS-based solar farms site selection using analytic hierarchy process (AHP) in Karapinar region, Konya/Turkey. Renewable and Sustainable Energy Reviews, Volume 28, Page 11–17.

DOI: 10.17148/IARJSET.2022.9764

[43] Vafaeipour, M., Sarfaraz, H. Z., Varzandeh, M.H.M, Derakhti, A. and Eshkalag,M.K. (2014). Assessment of regions priority for implementation of solar projects in Iran: New application of a hybrid multi-criteria decision-making approach. Energy Conversion and Management, Volume 86, Page 653– 663.

[44] Watson, J. and Malcolm D. H. (2015). Regional Scale wind farm and solar farm suitability assessment using GIS-assisted multi-criteria evaluation. Landscape and Urban Planning, Volume 138, Page 20–31.

[45] Bag, S., Sahu, A.K., Kilbourn, P., Pisa, N., Dhamija, P. and Sahu, A.K. (2021a), "Modeling barriers of digital manufacturing in a circular economy for enhancing sustainability", International Journal of Productivity and Performance Management, Vol. 71 No. 3, pp. 833-869 , https://doi.org/10.1108/IJPPM-12-2020-0637.

[46] He, Z., Ma, X., Luo, J., Sahu, A. K., Sahu, A. K. and Sahu, N. K. (2021), "Exploitation of the advanced manufacturing machine tool evaluation model under objective-grey information: a knowledge-based cluster with the grey relational analysis approach", Grey Systems: Theory and Application, Vol. 11 No. 3, pp. 394-417.

[47] Sudhagar, S., Sakthivel, M., Mathew, P.J. & Daniel, S.A.A. (2017). A multi criteria decision making approach for process improvement in friction stir welding of aluminium alloy. Measurement, 108, 1-8.

