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An exploratory investigation towards evaluating criteria's to solar panels: study under MCDM directory

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Abstract: Solar energy is one of the most capable and environmentally responsive energy source. The main purpose of present study is to evaluate a multi criteria decision making model to report the significant solar panels evaluation criteria's. The criteria's are identified for evaluation through literature review and identification of the most momentous criteria's, which can assist in achieving to high degree of performance is evaluated from DEMATEL Technique. The solar panels evaluation dimensions are extracted from the sources of literature review to persuade sustainability. The priority importance of the criteria's, which are originated from the dimensions of solar energy is done for locking sustainability. Eleven technical criterias i.e. Maintenance and handling, Installation cost, Availability of land, Technological drag, Payback period, Average temperature, Capital cost, Climate, Efficiency and reliability, Power factor and capacity factor, and Transmission problem are evaluated to define the crucial criteria's. 10 point linkert scale is used to understand the weights of the criteria's under DEMATEL method. It is found that a criteria named as "Climate" have received the weight vector of 0.1029 with first priority ranking, which is followed by "Availability of land" and "payback period" in the second and third state of priority ranking.

Keywords: Solar Panels, Evaluation, Selection, Criteria's, critical thinking.

I. INTRODUCTION

Today, solar plants are supremely suitable for locations having low humidity, dust and other agents, which may prevent absorption of solar irradiation (Vafaeipour et al., 2014; Miguel Sánchez-Lozano et al., 2013). The location of solar plant and sunlight hours are found as very imperative reason for gaining efficiency by solar energy. For the same, the many 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 criteria's are to be attained concurrently. In MCDM contradictory objectives under the domain of conflicting criteria's are evaluated. MCDM is a Decision making process to achieve the target or goal in the context of making right decisions (Sahu et al., 2020b; He et al. 2021). The decision-making procedure uses the decision criterion/factors/indicators/measures which are rated by each judgment maker or decision group (Kang et al., 2022; Sahu et al., 2019a).

It is 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 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). 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). Quality measures are today needed to be for benchmarked for evaluating substitute for industrial applications (Sahu et al., 2017; Bag et al., 2021a). It is evident that many contradictory aspects, when are needed to be considered by the experts and required to be evaluate to determine the most appropriate energy production system for a household. The installation of solar power plants, solar panels, awareness etc. are found as significant aspects, which are needed to be evaluated for its successfully implementation and retention (Nixon et al., 2013; Mohsen and Bilal, 1997).

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. MCDM techniques are being functional for problems with contrary and diverse objectives. It is found that the households consume approximately one third of all energy produced, thus studies on the evaluation of solar energy

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production technologies in households are very important. The solar energy is arousing considerable interest amongst competitors because of its free availability and economic aspects (Toghi et al., 2015; Pohekar and Ramachandran, 2004). Thus, the critical studies need to be conducted, which can provide an overview and in-depth analysis of solar utility and their selection components. The utility of solar energy has started tending to decline the greenhouse gas emissions from households in many regions of the world. The need to analyse and evaluate solar energy sources are receiving rising interest in the politics of diverse countries and the scientific literatures (Sánchez-Lozano et al., 2015; Singh et al., 2016). It is highlighted that the cost effectiveness does not always mean convenience or the most environmentally friendly technology. The cheap and reliable power supply does not always directly compare with installation costs and payback. Thus critical criteria's should be evaluated irrespective of costs. The same is attempted in this study.

Today, the electricity demand is one of the main imperative requirements of every economy and the same is growing constantly (Shiue and Lin, 2012; Nixon and Davies, 2010). 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 (Uyan, 2013; Toghi et al., 2015). Solar energy sources grants an opportunity to solve the climate change and economic decarbonization issues that are so pertinent today. 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 (Watson and Malcolm, 2015; Tarwidi et al., 2016). Thus, the present study is conducted to report below mentioned two Research questions (RQ):

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

II. LITERATURE REVIEW:

Bączkiewicz et al. (2021) highlighted that the appropriate selection of solar technology and location of implementation has a significant impact on the cost and generation of power. They declare solar energy is a critical component of the energy development strategy. They demanded the need of a constructive decision making provisions that would result in noteworthy cost savings and amplified electricity generation. Lak Kamari et al. (2020) found that traditionally, 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. Thus, they found renewable energy as an imperative alternative for society's long-term growth. Gnanasekaran and Venkatachalama, (2019) stressed towards 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. Ghasempour et al. (2019) stated that solar energy source is gaining attention under the marks of cost-effective and continuous source of energy. They additionally stated that the solar energy outputs estimates are required to be developed appreciably in the near future for satisfying the demands of the economy. Ahammed and Abdullahil (2013) investigated that 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) stressed towards choosing suitable locations for the implementation of solar energy panels to attain a significant influence on the amount and quality of electric energy generated. The same will profit implementers economically and socially. Asakereh et al. (2014) found that the selection of a favorable geographic location for the implementation of solar panels is paramount from the aspects of economic, technological, social, geographical, and environmental.

Baniasad et al. (2015) found that the best advantage from the solar energy can be attained by evading inherent environmental factors, parameters and obstacles. Cavallaro (2009) found that 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) highlighted that solar energy sources are well recognized inexhaustible source of energy and the same are utilizing by the concerns dramatically for electricity generation and transportations. Kahraman et al. (2009) examined that the best utility from solar energy can be gained by evaluating many criteria's. They highlighted that the applied solar technology is the need of today scenario and important relies on the evaluation of site location, numerous criteria's and limitations. Luthra et al. (2016) stated that 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. They found that the sinking of greenhouse gases is an imperative requirement in today's scenario, which can be achieve by using solar energies.

III. METHODOLOGY:

The obligation to decrease greenhouse gas emissions needs the development of improved energy systems, which can deliver low emissions in comparison to the traditional fossil fuel based energy exploitation systems. Today,

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sustainable energy arrangements are needed to be designed to attain low discharge of toxics, pollutants, carbon dioxide, and greenhouse gases into the environment. In present study, DEMATEL technique is utilized, where DEMATEL stands for the decision making trial and evaluation Technique. This technique is in present study for understanding the priority weight of the solar panels criteria's under consideration. The DEMATEL is found as an effective technique for the identification of priority weight elements under an evaluated system (Sahu et al., 2022). The technique has been utilizes by a group of researchers to evaluate co-dependent associations among criteria's. This technique can assist in shaping and identifying the critical criteria's through a visual structural model. DEMATEL is used in this study to define the significant criteria's for the evaluation of solar panels.

IV. CRITERIA'S FOR EVALUATION:

These sustainable energy arrangements can be attained by the utilization of solar sources and that too may help in attaining low discharge of toxics, pollutants, carbon dioxide, and greenhouse gases into the environment. But, today, wide varieties of solar panels are available in the market place, whose selection is thereby difficult for the practitioners and exploiters. Solar energy is significant segment that can support in the sustainable development of the energy requirements due to its high availability, environmental harmlessness, and non-exhaustibility. Thus, the wide spectrum of criteria's for evaluating solar panels are identified from the sources of literature review and exposed in Table 1. A modelling of criteria's is done in this study to understand energy efficiency and cost reduction provisions. The same is done to unveil a proposal, which can be used to receive high performance for machinery assets. It is originated that the criteria's evaluation model is easier to appreciate and more insightful and thus inspiration is received by the authors for present doing present modelling under the zone of evaluation of solar panels. The present study will help in understanding the enablers that can drive a system for sustainability.

TABLE 1: SOLAR PANELS EVALUATION CRITERIA FOR MODELLING

S.N	Criteria's	Symbol
1	Maintenance and handling	MAHA
2	Installation cost	INCO
3	Availability of land	AVLA
4	Technological drag	TEDR
5	Payback period	PAPR
6	Average temperature	AVTE
7	Capital cost	CACO
8	Climate	CLMT
9	Efficiency and reliability	EFRE
10	Power factor and capacity factor	PFCF
11	Transmission problem	TRPR

V. EVALUATION AND DISCUSSION:

Solar energy is one of the most capable and environmentally responsive energy sources. The energy source holds enormous potential and thus with the help of solar panels, solar radiation is converted into electricity for the benefit of the society. The solar panels are used for converting solar energy into utility. Today, 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 ease energy generation and cost reduction. Modelling is done in present paper, where the normalized direct relation matrix as shown in Table 2, Total Relationship Matrix as shown in Table 3. Table 3 is determined for understanding the rank of the dimensions or indicators. Table 4 showed the determined values of prominence and relation vectors. Here the prominence and relation values are calculated to define the ranking of the construction sustainable dimensions.

TABLE 2: NORMALIZED DIRECT RELATIONSHIP MATRIX

Criteria's	MAHA	INCO	AVLA	TEDR	PAPR	AVTE	CACO	CLMT	EFRE	PFCF	TRPR
MAHA	0.000	0.096	0.060	0.042	0.087	0.065	0.074	0.087	0.051	0.054	0.058
INCO	0.087	0.000	0.089	0.067	0.049	0.045	0.062	0.114	0.065	0.058	0.071
AVLA	0.076	0.114	0.000	0.098	0.092	0.096	0.098	0.047	0.100	0.062	0.071
TEDR	0.094	0.038	0.065	0.000	0.067	0.100	0.047	0.083	0.042	0.080	0.065
PAPR	0.112	0.087	0.089	0.107	0.000	0.089	0.109	0.100	0.067	0.054	0.083
AVTE	0.067	0.080	0.089	0.076	0.112	0.000	0.112	0.071	0.103	0.058	0.042
CACO	0.067	0.042	0.065	0.058	0.060	0.092	0.000	0.107	0.080	0.107	0.069

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CLMT	0.096	0.103	0.085	0.116	0.098	0.098	0.121	0.000	0.096	0.089	0.098
EFRE	0.083	0.100	0.087	0.085	0.058	0.067	0.069	0.083	0.000	0.105	0.094
PFCF	0.067	0.103	0.098	0.087	0.085	0.058	0.062	0.065	0.067	0.000	0.105
TRPR	0.094	0.103	0.089	0.100	0.054	0.054	0.060	0.054	0.051	0.056	0.000

TABLE 3: TOTAL RELATION MATRIX

Criteria's	**MAHA**	**INCO**	**AVLA**	**TEDR**	**PAPR**	**AVTE**	**CACO**	**CLMT**	**EFRE**	**PFCF**	**TRPR**
MAHA	0.256	0.349	0.304	0.294	0.312	0.294	0.318	0.329	0.271	0.272	0.285
INCO	0.347	0.274	0.340	0.327	0.290	0.288	0.318	0.361	0.293	0.287	0.308
AVLA	0.384	0.421	0.303	0.398	0.368	0.374	0.392	0.351	0.363	0.331	0.348
TEDR	0.342	0.301	0.309	0.254	0.299	0.327	0.296	0.324	0.264	0.295	0.291
PAPR	0.431	0.415	0.399	0.422	0.300	0.385	0.419	0.412	0.348	0.337	0.372
AVTE	0.366	0.382	0.375	0.370	0.377	0.279	0.396	0.362	0.357	0.319	0.315
CACO	0.344	0.332	0.335	0.336	0.316	0.343	0.275	0.370	0.321	0.344	0.321
CLMT	0.451	0.463	0.430	0.464	0.420	0.422	0.460	0.353	0.402	0.398	0.417
EFRE	0.382	0.405	0.377	0.381	0.333	0.341	0.359	0.372	0.264	0.360	0.362
PFCF	0.358	0.395	0.375	0.372	0.345	0.324	0.343	0.345	0.317	0.254	0.361
TRPR	0.349	0.362	0.336	0.351	0.290	0.291	0.310	0.306	0.276	0.280	0.236

TABLE 4: DETERMINED VALUES OF PROMINENCE AND RELATION VECTORS

Criteria's	d_i	r_j	**Weight vector**	**Ranking**
MAHA	3.285	4.010	0.0876	8
INCO	3.433	4.097	0.0905	5
AVLA	4.032	3.882	0.0951	2
TEDR	3.303	3.969	0.0874	9
PAPR	4.238	3.648	0.0948	3
AVTE	3.897	3.668	0.0909	4
CACO	3.636	3.886	0.0904	6
CLMT	4.679	3.886	0.1029	1
EFRE	3.937	3.477	0.0891	7
PFCF	3.787	3.475	0.0873	10
TRPR	3.386	3.614	0.0841	11

VI. CONCLUSIONS:

Today, it is needed to choose appropriate solar system under multiple aspect, criteria's and parameters to reap maximum benefits and sustainability. Varieties of criteria's under the domain of economic, social, environmental, and technological are needed to be investigated for integration and right selection of the appropriate choice of solar panels for harnessing maximum benefits. Thus, present study is conducted by the candidate with the motivation to help the practitioners in choosing the right selection of solar panels. In present study, modelling of solar panels criteria's is carry out to expose the crucial facts related with the customers perceptions. Eleven technical factors i.e. Maintenance and handling, Installation cost, Availability of land, Technological drag, Payback period, Average temperature, Capital cost, Climate, Efficiency and reliability, Power factor and capacity factor, and Transmission problem are evaluated to define the crucial criteria'. Here, the weight vector of 0.1029 is reported with the criteria named as "Climate" and fix him in the first priority importance ranking. The next two ranking orders of the criteria's in chronological order are found as by "Availability of land" and "payback period". The same highlighting that the condition of climate plays a major role for influencing the customers in implementing solar panels. Additionally, Availability of land to the customers and the payback period of the solar installation costs are also influencing the attention of the customers.

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