Turkish Online Journal of Qualitative Inquiry (TOJQI)

Volume 12, Issue 3, June 2021: 4517 - 4531

Research Article

Multi-criteria DEA approach for finding performance of dust accumulation and reflector influence on the PV module

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Abstract

This paper evaluates the relative performance of twenty-two cases on the photovoltaic (PV) module under different environmental conditions with dust accumulation and reflector influence, through the application of Data Envelopment Analysis (DEA) and Multi-Criteria Data Envelopment Analysis (MCDEA). In the DEA method, more than one unit is identified as an efficient operation. Therefore, this study provides a method for ranking the more efficient case by their importance. It notifies the inefficient cases through measurement. For obtaining the efficient case, the MCDEA method is used that has three conditions: minimizing d_0, minimizing the sum of the deviations, and minimizing the maximum deviation. It is observed that only the MDU rated are more efficient under the three criteria ($Ir_1R_4W_0T_0$, $Ir_1R_4W_1T_2$, $Ir_1W_2T_2$) based on the combination of dust weight, irradiation, etc. combinations.

Keywords: *Data Envelopment analysis (DEA), multi-objective linear programming model (MOLP)*

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1. Introduction

Solar energy is the most common renewable energy source for power generation due to its multiple advantages, including atmospheric friendliness and easily available. The authors have [1] investigated the impact of dust on Photovoltaic modules decay in a given climate area Dust deposition on PV modules is caused by the weather elements described previously, which alter depending on the season. As a consequence, the effect of dust on PV output varies seasonally. The authors have [2] aimed of this experiment is seeing how dust settlement influenced the power output of photovoltaic modules. In this paper, collecting dust properties are examined with the help of a (SEM). In the case of special coating on the PV glass, it has a Dust settlement can lead to a decrease in power loss. The authors have [3] concentrated this paper on the result of a study on the effect of dust accumulation on the power output of solar PV modules. The study indicated that PV module power is reduced just half of the real power. The authors have [4] investigated the several effects in terms of electrical parameters and PV characteristics of dust deposited on the glazing of photovoltaic panels. They have considered several types of dust for investigating the effect of dust. The authors [5] investigated the impact of different parameters on the efficiency and performance of PV cells. The dust deposition and settlement on the surface of the PV module can reduce the power and efficiency. The authors have [6] reviewed the current state of the experiments to find the impact of dust deposition on the performance of solar PV systems, particularly PV modules. Other dependable factors arise in the verification of the system's performance efficiency and output. The authors [7] investigated real-time monitoring of PV module temperature, output power, solar irradiance, and other environmental parameters. PV module output is seriously impacted by dust deposition. The authors have [8] studied the effect of dust on the performance of the PV modules. Reduced PV performance due to deposition of different pollutant types and accumulation has been identified. Due to this, there is more effect on the PV module voltage as compared to other used dust. In [9], the study has been aimed at identifying the seasonal dust deposition on a large area. Preventing the dust deposition on the PV module plant improves the frequency level of the plant, and provides good efficiency. The effect of dust fouling on the PV module glass cover, as well as the effect of inclination angle and glass cover, as well as anti-reflective coating on dust mitigation, was investigated by the authors [10]. The results can conclude these effects of the reduction in the efficiency and required power output. In [11], the authors have studied the impact of dust on the transmittance of light on PV modules. Investigate the effect of dry cleaning on the removal of dust particles that have settled on the glass, as well as the influence of brushing on the glass's transmission. The authors have studied that [12] accumulated dust can reduce the performance of the solar panel. Due to the accumulation of dust on the surface of solar panels, the performance of the panels is diminished. In [13], the authors studied using both sides of external and internal reflectors. Reflectors are good modifications to increase solar irradiation and efficiency. The authors have studied [14] that, using the bifacial solar panel with the reflector has optimized the maximum power and efficiency. Solar panel characteristics curve obtain good performance in current and voltage. The authors have observed that [15], accumulated dust and soil reduce the reflectance radiation, solar field efficiency and it optimizes the price of cleanliness. This paper has [16] analyzed the comparison of a solar panel that does not have a reflector, solar radiation, and different angle of reflector. When the angle of the reflector is adjusted, helpful to enhance the PV system efficiency. The authors [17] studied and investigated mono-crystalline performance using a concentrator and reflector, as well as evaluating the power output. In this paper, the aim is to improve and prevent the fluctuating intensity of sunlight due to different conditions of cloud and other factors such as temperature and humidity. The authors have [18] studied with the use of tools of (MCDEA). This tool plays an important role in determining the true efficiency of the considered case. The authors have [19] studied the PV performance in different environmental conditions and different irradiation levels. Experimental analysis has been carried out for the different types of air pollution. For more efficient performance evaluation of the system under diverse atmospheric conditions, DEA is used. The authors [20] have studied the biogas plants to investigate the performance in the expression of economic, environmental, and social criteria and corresponding indicators. DEA is used for calculating radial efficiency. The authors [21] have studied that the market supply and calculated according to multiple criteria such as quality and services. DEA tools have identified and the overall capabilities of suppliers are calculated.

2. Experimental Setup

Experimental set up designed for this study consists of 16 mono-crystalline cells connected in series–parallel (SP) configuration, self-assembled on a plywood board, simulated light for irradiance source, a rheostat for simulation load varied on the PV panel, Arduino (ATmega328P, ATmega16U2), Current (5A range ACS712) & Voltage (KG045) sensor for recording the electrical parameters of PV panel. The PV cell surface area is 0.316m^2. The experimental set up of the layout of the setup is shown in Fig. 1 as,

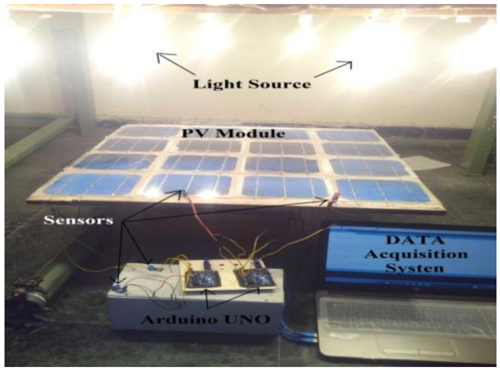

Fig 1. Experimental setup

3. Methodology

3.1 DEA

Data envelopment analysis (DEA) is a method of analyzing data tools, conceived by Charnes, et al. in 1978 [22], and basically used to obtain the relative effectiveness of (DMUs) with aggregate variable input and output, without the need to pre-specify the dependence between the performance measure. This tool is usually categories between parametric and non-parametric methods. In the parametric methods, a cost production function is considered while it is a non-parametric method for determining relative efficiencies for a given collection of DMUs that use linear programming. The DEA resulting in many ways, models are more versatile and efficient, basically in discrimination investigate and weight limit. Three benefits are shown: Firstly, in classical DEA, if a DMU is efficient, its prime (weights) approximately explanation certainly non-unique. Secondly (MOLP) solutions contain not only the solutions that separately maximizing the aims, but also provide alternatives for the associated DMUs. Thirdly, the total number of solutions is not dominated with DMUs. The stability of DMUs efficiency scores comparative to the modification in performance situation. The relative efficiencies of DMUs (where m denotes outputs and n denotes inputs) are calculated using fractional programming as shown below.

For any dth DMU $(d \in D)$,

$$\text{Max.}\,\eta_d = \left(\sum_{j=1}^{m} y_j^d u_j\right) / \left(\sum_{i=1}^{n} x_j^d v_j\right) \tag{1}$$

Subject to:

$$\left(\sum_{j=1}^{m} y_j^d u_j\right) / \left(\sum_{i=1}^{n} x_j^d v_j\right) <=1;\ d=1,2,\ldots\ldots.D \tag{2}$$

$$u_j\ v_j >=0; \quad j=1,2,\ldots\ldots..m\ \&\ I = 1,2,\ldots.n \tag{3}$$

3.2 MCDEA

Multi-criteria data envelopment analysis (MCDEA) model progress in selective power of DEA method, and also efficiently produce weights for inputs and outputs that are more appropriate. In this paper, the MCDEA technique as proposed by Li and reeves [23] depending on the performance requirements is applied. For a MCDEA issue, the three ensuing conditions are used: minimizing d_0, minimizing the sum of the deviations, and minimizing the maximum deviation. The MCDEA model can be expressed in the following way:

For any dth DMU $(d \in D)$

$$\text{Minimize } \delta_d \text{, Minimize } \sum_{k=1}^{D} \delta_k \text{, and Minimize M} \tag{4}$$

Subject to,

$$\sum_{i=1}^{n} x_i^d v_i = 1 \tag{5}$$

$$\sum_{J=1}^{M} y_j^d u_j - \sum_{i=1}^{n} x_i^d v_i + \delta_k = 0; k = 1,2,\ldots D \tag{6}$$

$$\text{M-}\delta_k >=0; \qquad k= 1.2\ldots\ldots..D \tag{7}$$

$$u_j, v_j, \delta_k >=0;\ j=1,2,\ldots m; \qquad i=1,2\ldots.n\ \&\ k= 1,2,\ldots..D \tag{8}$$

The ratings of relative performance of separate DMUs may be acquired. as follows,

$$\eta_d = 1 - \delta_d.$$

Model (4) – (5) is a MOLP model, which results in non-dominant solutions and thereby helps us to choose the much more desired DMUs. The issue is overcome by focusing on one goal at a time. The most effective DMUs are those that achieve higher efficiency scores throughout the condition..

4. Result and discussion

4.1 Input-Output Selection

The choice of input and outputs play a most important part of the assessment of the PV performance using DEA. Differentiation has been used to plot the parameters, for highly classified as input and outputs variables obtained during the experiment procedure. The irradiation levels, the concentration of dust, and reflector deployment on the PV panel precisely influence on the current (I) versus voltage (V) and Power (W) versus voltage (V) curve and maximum power output. These two variables are taken into consideration as input irradiation and weight of dust in this study. However, the irradiation level and weight of dust have both positive correlations with the specifications of the PV performance.

For this project, the MCDEA model was used and evaluation of the effectiveness of 22 cases is considered through PV performance under different conditions. Considered cases nominate with different prefix names and are evaluated. The analysis of input and output data are used and shown in the table below. Table1: (a)-(b), are defined as follows,

Table-1(a). Input-output variable

Inputs	
x_1	Irradiation level (W/m^2)
x_2	Weight of dust particles (gm.)
Outputs	
y_1	Short circuit current (A)
y_2	Fill factors
y_3	Open voltage (Volt)
y_4	Power loss (Watt)

*It suggests that an increase of any input should not reduce any of the outputs.

The result of the classical DEA method is shown in table 2. Tables 3-5 demonstrate the results obtained for each of the three results parameters (minimizing d_0, minimizing the maximum deviation, and minimizing the sum of the deviations). Show accurate effective performance tables 2 and 3, it can be distinguished because they were collected using the same parameters. As we can shows from all nominated DMU cases, D_1 to D_{22} are efficient. However, the differences between the solutions in both tables are immediately recognizable.

Table 1(b)- Correlation between input and output variables

	Inputs variables	
Output variables	x_1 : Irradiation level	x_2 : Concentration of TSP
y_1 : Short circuit current (I_{sc})	0.3136	0.3171
y_2 : Fill factor (FF)	0.0055	0.1949
y_3 : Open circuit voltage (V_{oc})	0.0820	0.2446
y_4 : Power loss	0.0131	0.3628

Table 2: Input - output data of classical DEA method

DMU	Efficiency	Input weights		Output weights			
		v_1	v_2	u_1 **(I_{sc})**	u_2 **(FF)**	u_3 **(V_{oc})**	u_4 **(P_{loss})**
$Ir_1R_4W_0T_0$	1.0	300.0	1.0	5.58	0.789	2.07	0.5
$Ir_1R_0W_0T_0$	1.0	300.0	1.0	3.68	0.77	2.03	3.34
$Ir_1W_1T_1$	1.0	300.0	1.0	3.7	0.75	2.02	3.5
$Ir_1W_3T_1$	1.0	300.0	5.0	3.07	0.73	2.14	4.21
$Ir_1W_1T_2$	1.0	300.0	1.0	3.51	0.73	2.05	3.83
$Ir_1W_2T_2$	1.0	300.0	2.0	3.31	0.76	2.03	3.95
$Ir_1W_1T_3$	1.0	300.0	1.0	3.1	0.766	2.1	4.07
$Ir_1W_2T_3$	1.0	300.0	2.0	2.9	0.77	2.08	4.41
$Ir_1W_3T_3$	1.0	300.0	5.0	2.61	0.74	2.08	5.07
$Ir_1R_4W_1T_1$	1.0	300.0	1.0	5.25	0.776	2.15	0.34
$Ir_1R_4W_1T_2$	1.0	300.0	1.0	5.2	0.676	2.08	1.79
$Ir_1R_4W_2T_2$	1.0	300.0	2.0	4.5	0.674	2.1	2.74
$Ir_1R_4W_1T_3$	1.0	300.0	1.0	5.35	0.82	2.02	0.22
$Ir_1R_4W_2T_3$	1.0	300.0	2.0	5.29	0.782	2.12	1.11
$Ir_2R_4W_0T_0$	1.0	500.0	1.0	6.76	0.76	2.02	1
$Ir_2R_0W_0T_0$	1.0	500.0	1.0	4.27	0.736	2.03	4.11
$Ir_2W_1T_1$	1.0	500.0	1.0	4.07	0.79	2.1	3.8

$Ir_2W_1T_2$	1.0	500.0	1.0	4	0.79	2.03	4.03
$Ir_2W_1T_3$	1.0	500.0	1.0	3.9	0.76	2.03	4.47
$Ir_2R_4W_1T_1$	1.0	500.0	1.0	6.02	0.796	2.06	0.61
$Ir_2R_4W_1T_2$	1.0	500.0	1.0	5.88	0.66	2.1	2.24
$Ir_2R_4W_1T_3$	1.0	500.0	1.0	6.5	0.71	2.1	0.68

Table 3: Minimizing d_0 results

DMU	Efficiency	Input weights		Output weights			
		v_1	v_2	u_1	u_2	u_3	u_4
$Ir_1R_1W_0T_0$	1.0	0.0033	0.0074	0.1124	0.4276	0.0	0.0705
$Ir_1R_0W_0T_0$	0.9964	0.0033	0.0006	0.0525	0.8654	0.0	0.0412
$Ir_1W_1T_1$	1.0	0.0033	0.0002	0.1065	0.4486	0.0	0.0769
$Ir_1W_3T_1$	1.0	0.0033	0.0	0.0310	0.0	0.3838	0.0197
$Ir_1W_1T_2$	1.0	0.0033	0.0053	0.0901	0.0	0.1791	0.0815
$Ir_1W_2T_2$	1.0	0.0032	0.0052	0.0897	0.0	0.1781	0.0810
$Ir_1W_1T_3$	1.0	0.0031	0.0052	0.0611	0.0	0.2710	0.0586
$Ir_1W_2T_3$	1.0	0.0032	0.0101	0.0	0.0733	0.3485	0.0495
$Ir_1W_3T_3$	1.0	0.0031	0.0098	0.0	0.0712	0.3382	0.0480
$Ir_1R_4W_1T_1$	1.0	0.0033	0.0058	0.0	0.6702	0.2224	0.0047
$Ir_1R_4W_1T_2$	1.0	0.0033	0.0077	0.0306	0.0523	0.3677	0.0224
$Ir_1R_4W_2T_2$	1.0	0.0032	0.0072	0.0298	0.0445	0.3693	0.0219
$Ir_1R_4W_1T_3$	1.0	0.0033	0.0052	0.0090	0.6338	0.2125	0.0096
$Ir_1R_4W_2T_3$	1.0	0.0032	0.0052	0.0090	0.6305	0.2119	0.0096
$Ir_2R_4W_0T_0$	0.7686	0.0018	0.0860	0.1136	0.0	0.0	0.0
$Ir_2R_0W_0T_0$	0.6868	0.0019	0.0042	0.0895	0.0	0.0	0.0740
$Ir_2W_1T_1$	0.6488	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2W_1T_2$	0.6567	0.0019	0.0042	0.0895	0.0	0.0	0.0742
$Ir_2W_1T_3$	0.6808	0.0019	.0038	0.0854	0.0	0.0	0.0
$Ir_2R_4W_1T_1$	0.6845	0.0018	0.0860	01136	0.0	0.0	0
$Ir_2R_4W_1T_2$	0.7058	0.7058	0.0019	0.0450	0.0	0.0	0.0137

$Ir_2R_4W_1T_3$	0.7391	0.0018	0.0860	0.1136	0.0	0.0	0.0

Both approaches are shown in the tables, the input and outputs weights obtained by the multi-objective linear programming (MOLP) Table 3 shows that the results from the classical DEA procedure are more uniformly distributed than those from Table 2. The efficiency ratings for each DMU using the Min sum criteria are listed in Table 4. Only the most effective DMUs are graded as efficient under the criterion. D5, D6, D11, and D14.

Table 4: Min sum DEA results

DMU	Efficiency	Input variable		Output variable			
		v_1	v_2	u_1	u_2	u_3	u_3
$Ir_1R_1W_0T_0$	0.9879	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1R_0W_0T_0$	0.9907	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1W_1T_1$	0.9995	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1W_3T_1$	0.9742	0.0033	0.0007	0.1104	0.4173	0.0	0.0784
$Ir_1W_1T_2$	1.0	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1W_2T_2$	1.0	0.0033	0.0008	0.1106	0.4183	0.0	0.0786
$Ir_1W_1T_3$	0.9891	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1W_2T_3$	0.9902	0.0033	0.0008	0.1106	0.4183	0.0	0.0786
$Ir_1W_3T_3$	0.9951	0.0033	0.0007	0.1104	0.4173	0.0	0.0787
$Ir_1R_4W_1T_1$	0.9333	0.0033	0.0008	0.1107	0.4187	0.0	0.0784
$Ir_1R_4W_1T_2$	1.0	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1R_4W_2T_2$	0.9957	0.0033	0.0008	0.1106	0.4187	0.0	0.0787
$Ir_1R_4W_1T_3$	0.9533	0.0033	0.0008	0.1107	0.4187	0.0	0.0787
$Ir_1R_4W_2T_3$	1.0	0.0033	0.0008	0.1106	0.4183	0.0	0.0787
$Ir_2R_4W_0T_0$	0.6817	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2R_0W_0T_0$	0.6631	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2W_1T_1$	0.6488	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2W_1T_2$	0.6549	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2W_1T_3$	0.6616	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2R_4W_1T_1$	0.6291	0.0019	0.0004	0.0664	0.2513	0.0	0.0472
$Ir_2R_4W_1T_2$	0.6627	0.0019	0.0004	0.0664	0.2513	0.0	0.0472

$Ir_2R_4W_1T_3$	0.6427	0.0019	0.0004	0.0664	0.2513	0.0	0.0472

The efficiency scores for each DMU under the Mini-max criterion are listed in Table-5. Only D1, D6, and D11 are considered to be effective. The rest of the DMUs that were graded as useful by Classical DEA and Min sum necessity are no longer efficient by Mini-max necessity. As we can see the only DMUs according to the three necessities, it is effective are D1, D6, and D11, and it is also the only solution that is not-dominated.

Table 5: Mini-max DEA results

DMU	**Efficiency**	**Input weights**		**Output weights**			
		v_1	v_2	u_1	u_2	u_3	u_3
$Ir_1R_1W_0T_0$	1.0	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1R_0W_0T_0$	0.9736	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1W_1T_1$	0.09808	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1W_3T_1$	0.5826	0.0023	0.0569	0.1351	0.0	0.0	0.0398
$Ir_1W_1T_2$	0.9775	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1W_2T_2$	1.0	0.0033	0.0086	0.1126	0.4160	0.0	0.0696
$Ir_1W_1T_3$	0.9639	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1W_2T_3$	0.9540	0.0032	0.0086	0.1126	0.4160	0.0	0.0696
$Ir_1W_3T_3$	0.5547	0.0023	.0564	0.1351	0.0	0.0	0.0398
$Ir_1R_4W_1T_1$	0.9459	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1R_4W_1T_2$	1.0	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1R_4W_2T_2$	0.9779	0.0033	0.0086	0.1126	0.4160	0.0	0.0696
$Ir_1R_4W_1T_3$	0.9673	0.0033	0.0086	0.1135	0.4196	0.0	0.0702
$Ir_1R_4W_2T_3$	0.9983	0.0032	0.0086	0.1126	0.4160	0.0	0.0696
$Ir_2R_4W_0T_0$	0.6966	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2R_0W_0T_0$	0.6518	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2W_1T_1$	0.6387	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2W_1T_2$	0.6436	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2W_1T_3$	0.6478	0.0119	0.0052	0.0683	0.2526	0.0	0.0422

$Ir_2R_4W_1T_1$	0.6387	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2R_4W_1T_2$	0.6636	0.0119	0.0052	0.0683	0.2526	0.0	0.0422
$Ir_2R_4W_1T_3$	0.6527	0.0119	0.0052	0.0683	0.2526	0.0	0.0422

4.2 Investigate of initial experimental data

The open-circuit voltage(V_{OC}), short circuit current (I_{SC}), peak power loss and fill factor (FF) are the effects of alteration in the irradiance level and weight of dust. For analysis of the performance of PV modules, the Power (W) versus Voltage (V) and Current (A) versus Voltage (V) curves are drawn at an irradiation level of 500W/m^2, as shown in Fig. 2 and 3.

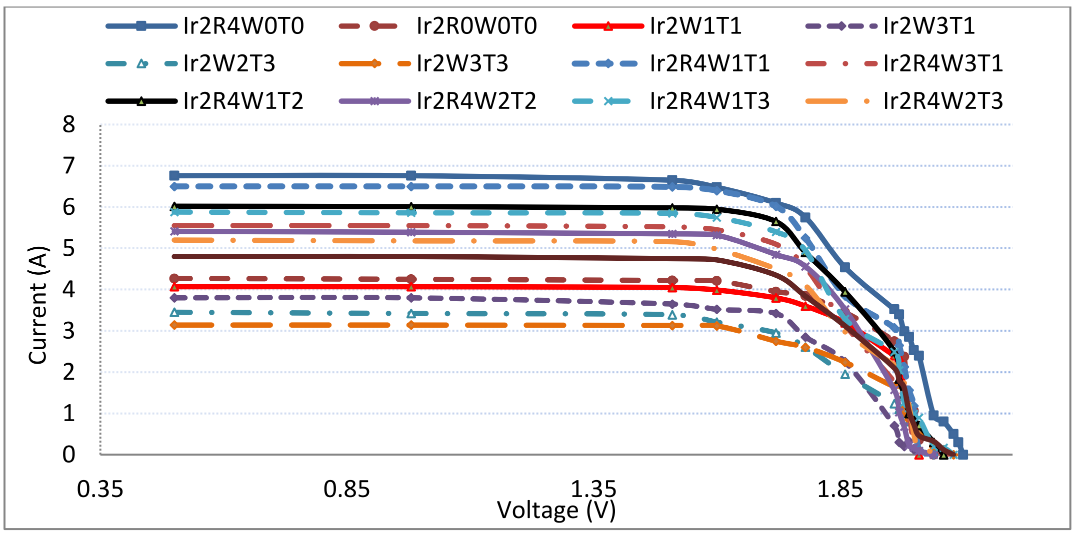

Fig 2. I- V characteristics at 500W/m^2

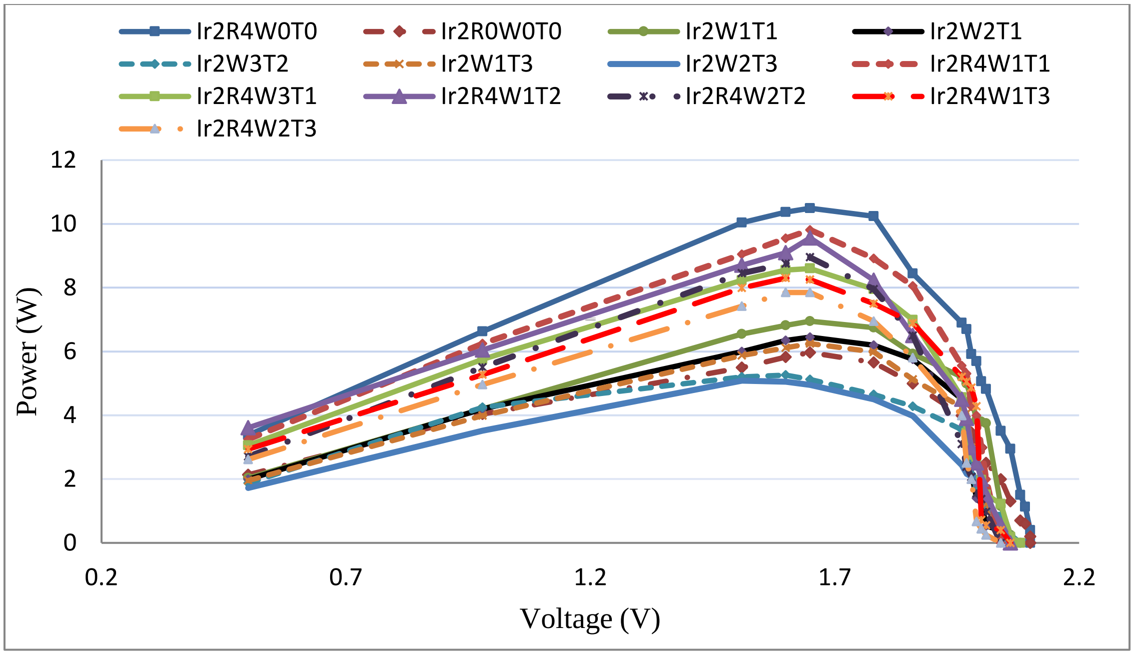

Fig 3. P- V characteristics at 500W/m^2

The above Current (A) versus Voltage (V) and Power (W) versus Voltage (V) characteristics is drawn and analyzed for twenty distinguish cases, keeping in mind the consideration of clean panel, dust, and reflector. For PV module performance consideration, some of the cases ($Ir_2W_2T_1$, $Ir_2W_1T_2$, $Ir_2W_2T_2$, $Ir_2W_3T_2$, $Ir_2W_1T_3$, $Ir_2R_4W_2T_1$, and $Ir_2R_4W_3T_2$) are avoided due to minute variation in their values.

For analysis of the performance of the PV modules, analyzed the Power (W) versus Voltage (V) and Current (A) versus Voltage (V) characteristics at the irradiation level of 500W/m^2 and shown in figures 4 and 5.

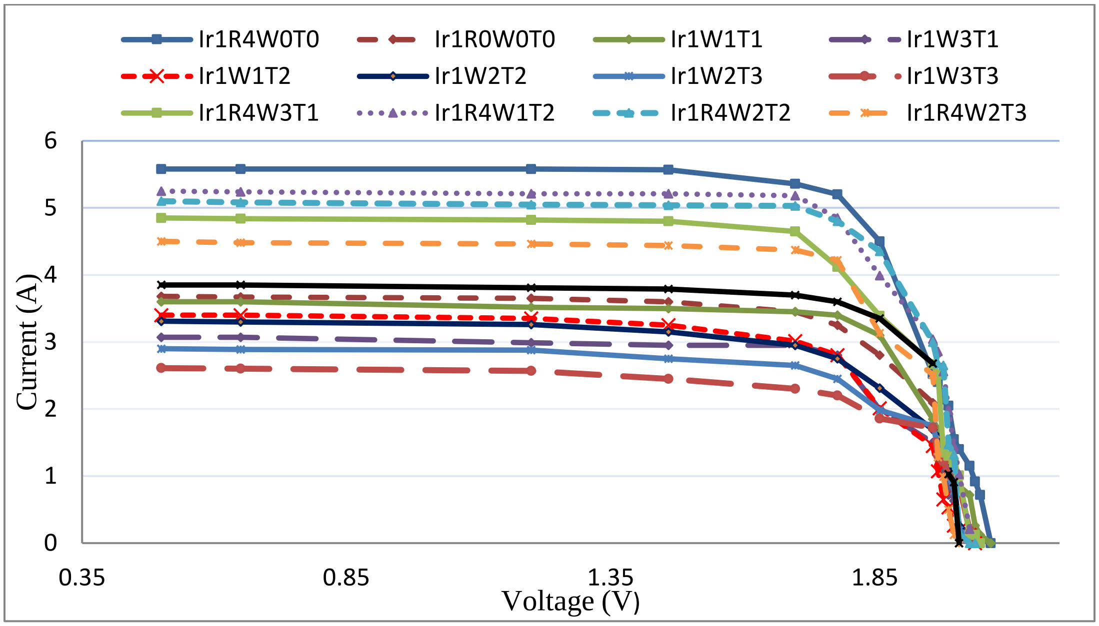

Fig-4: I- V characteristics at 300W/m^2

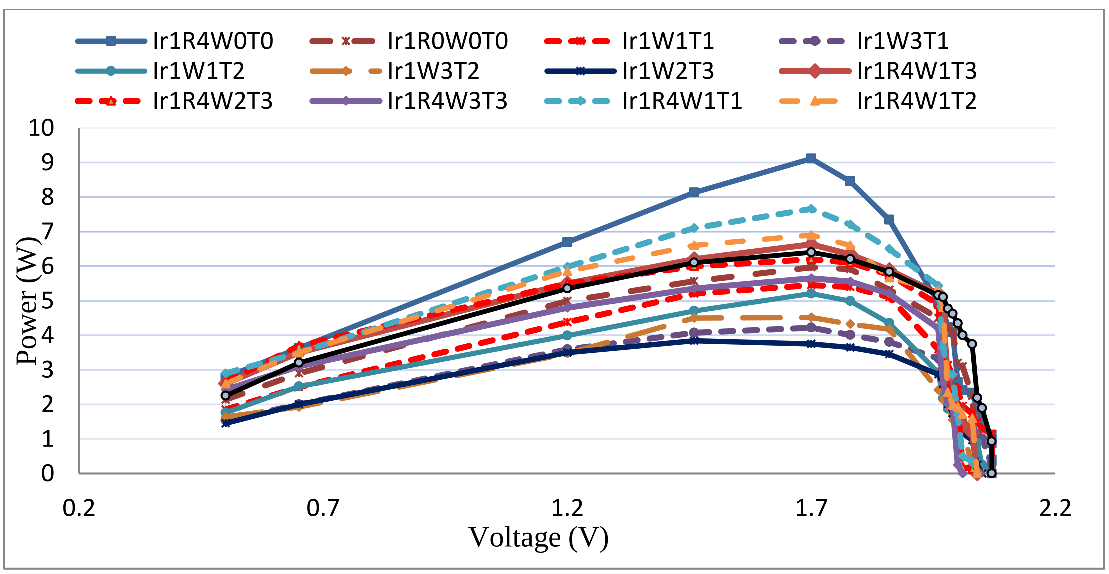

Fig-5: I- V characteristics at 300W/m^2

Current (A) versus Voltage (V) and Power (W) versus Voltage (V) characteristics are analyzed with 20 cases, keeping in mind the consideration of clean panel, dust, and reflector. As PV module performance has not been considered, some of the cases ($Ir_1W_2T_1$, $Ir_1W_3T_2$, $Ir_1W_2T_3$, $Ir_1R_4W_1T_1$, $Ir_1R_4W_2T_1$, $Ir_1R_4W_3T_2$, and $Ir_1R_4W_1T_3$) are skipped due to minute variation in their values.

5. Conclusion

An experimental study has been done on the three types of air pollutants, and the influence of reflector on the PV module. The common dust samples are taken as natural dust, brick furnace dust, and sugar mill bagasse dust, each of which can be correlated to environmental conditions. These are studied in terms of diameter, color, and weight. Further, the considered aluminum foil reflector, which can be correlated with the conditions of the intensity of light, is investigated with the area, optical property, and refractive index. MCDEA is applied under three different criteria (minimizing d_0, minimizing the maximum deviation, and minimizing the sum of the deviations), each one of which is presented with an independent objective function. It can be seen that the only DMUs rated are more efficient under the three criteria are $Ir_1R_4W_0T_0$, $Ir_1W_2T_2$, and $Ir_1R_4W_1T_2$. Finally, DEA models good with the right to discriminate may be accepted as a technique for investigate of the complex sets of employing data more efficiently, to have better and approaching achievement of PV modules under the various atmospheric, topographical and climatic conditions.

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