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INDORE SIMULATION AND PERFORMANCE EVALUATION OF SOLAR PHOTOVOLTAIC CELL

Bhushan Sanjay Sonawane

Abstract

This paper's focus is on improving photovoltaic (PV) panel electrical efficiency in tests conducted indoors. Solar radiation and operating temperature are two environmental parameters that affect how well a PV panel performs. Due to an increase in operating temperature, these climatic conditions will decrease the electrical efficiency of PV panels. To elevate bulbs, a steel frame with a solar simulator is employed. The lights mimic natural sunshine. Tests of solar collectors conducted indoors are crucial because they may be repeated under controlled conditions, allowing for the optimization of the collectors using the same input energy and losses.

In the study and advancement of solar photovoltaic, solar thermal, and built environments, solar simulators are essential tools. The main criteria for creating a solar simulator are producing uniformity in the spatial, temporal, and spectral radiation distribution in order to match solar radiation as nearly as feasible in the laboratory setting.The development of a solar simulator for use in research and education is discussed in this study. By adjusting the temperature and irradiance, simulation analysis of solar modules is performed under various environmental circumstances. Photovoltaic cell output power efficiency is determined by the simulation model. This research's findings can be applied in the future to forecast the needed output power and to recommend the best photovoltaic cell connections for India's various climates.

1.Introduction

Systems using renewable energy have a big edge when it comes to the world's politics, economy, and ecology [1]. By the middle of the twenty-first century, it is predicted that renewable energy sources would make up two fifths of the global fuel market and three fifths of the global electricity industry. Additionally, the transition to a renewable energy economy will have important environmental and other benefits that cannot be measured in terms of money. By 2050, carbon dioxide (CO_2) emissions are expected to be 75% lower than they were in 1985, thanks to widespread adoption of renewable energy sources and efficient energy use [2].

According to the International Energy Agency (IEA), 2019 there were around 509.3 GW of solar PV installations worldwide in 2018. For the past ten years, it has grown steadily in the upward direction. The ability to estimate solar power performance is more crucial than ever because it facilitates speedy system design and ongoing dissemination (Shen et al., 2018; Arefifar et al., 2017). The power production of a PV system is significantly influenced by the solar resource of the installation location as well as other factors like temperature and wind speed (Gokmen et al., 2016; Bana and Saini, 2016).

Very poor electrical efficiency of PV cell conversion is one of the primary challenges that the PV panel must overcome to operate. This is a significant impediment to scientists' and researchers' efforts to improve PV cell electrical efficiency. The PV system's power output yield is influenced by a number of climatic variables, including solar radiation, operational temperature, and the condition of the PV panels (age, cell type, cleanliness, etc.) [4]. Solar radiation has a significant impact on PV plant efficiency, but so does the temperature at which the panels are working [5]. Low electrical efficiency of PV cell conversion is a result of overheating brought on by high operating temperatures and intense solar radiation. This is due to the PV panel only converting 15% of the solar energy into electricity and the remaining 85% into heat. In terms of producing electricity, solar renewable energy technologies are more environmentally benign than traditional energy sources. The primary factor affecting a PV cell's output characteristic is solar insolation. The current voltage and power-voltage characteristics of a PV module will be nonlinearly affected by changes in solar irradiation and cell operating temperature [6].

The study reported in this paper set out to analyse the various PV-powered lighting system components, estimate the overall system efficiency, comprehend what influences system efficiencies, and pinpoint the best system configurations for diverse applications. The last few decades have seen a significant amount of research efforts aimed at increasing the output of PV modules because solar energy is mostly dependent on changes in temperature, irradiance, and defects in the PV module [7]. The major defects in PV diagnostics are classified as O.C. and S.C. faults in the bypass and blocking diodes, impedance faults, and partial shading faults. Prediction and diagnosis of PV panel failures can improve performance, lower maintenance costs, and guarantee reliability [8]. Prediction of P-V and I-V characteristics under various fault conditions is a prerequisite for the efficient usage of PV panels and to boost system efficiency.

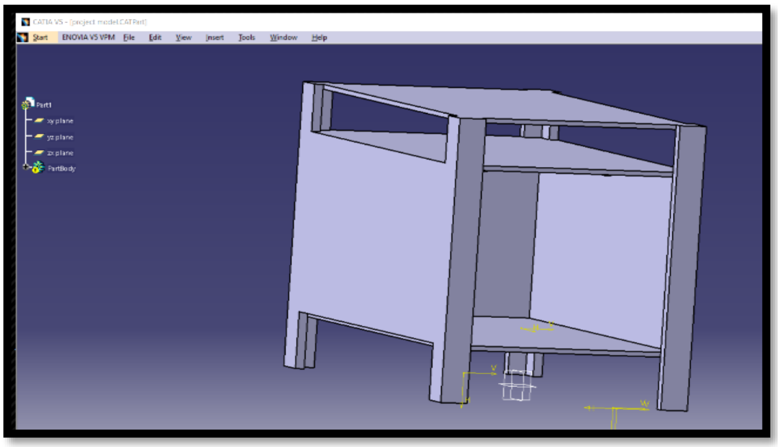
We describe an experimental investigation of a specific solar panel in this work. The primary feature of this solar system is its open design, which enables natural ventilation for cooling solar cells. Angles of inclination and two different ways are measured. To evaluate the effectiveness of this photovoltaic system and to contrast it with natural sunshine.

2. Methodology

The arrangement incandescent bulbs with the solar simulator is displayed . The solar simulator is set up on a steel frame is used to lift all the bulbs. Four units of bulbs with built in reflector is attached on the solar simulator. All the lamps can be controlled separately or in groups, to various total amounts of solar radiation. The solar radiation can be regulated via a combination of amounts of lamp bulbs and height above the target.For more efficient, we attached an aluminium foil inside the structure that's traps the more temperature and intensity.

From the exiting researches, several kinds of lamps were frequently used as the light source of the solar simulator, such as halogen lamps, metal halide lamp, mercury vapor lamps, incandescent spot, argon arc lamp and xenon arc lamps. incandescent bulbs are inexpensive, uncomplicated and convenient to operate and require only easy power supply units. The halogen lamp bulb is widely used in solar beam experiments (SBE) for solar simulator applications because it provides a very stable and smooth spectraloutput as

One unit of 200W Monocrystalline PV panels were used to convert solar energy into electrical energy in this investigation in Fig. 1 (b)



(a) (b)

Fig. 1. (a) Schematic of experimental set-up of solar simulator and (b) 200w Solar Panel

Inside view **During Reading** **Real view**

Fig. 2. (a) Inside view (b) During Reading (c) Real View

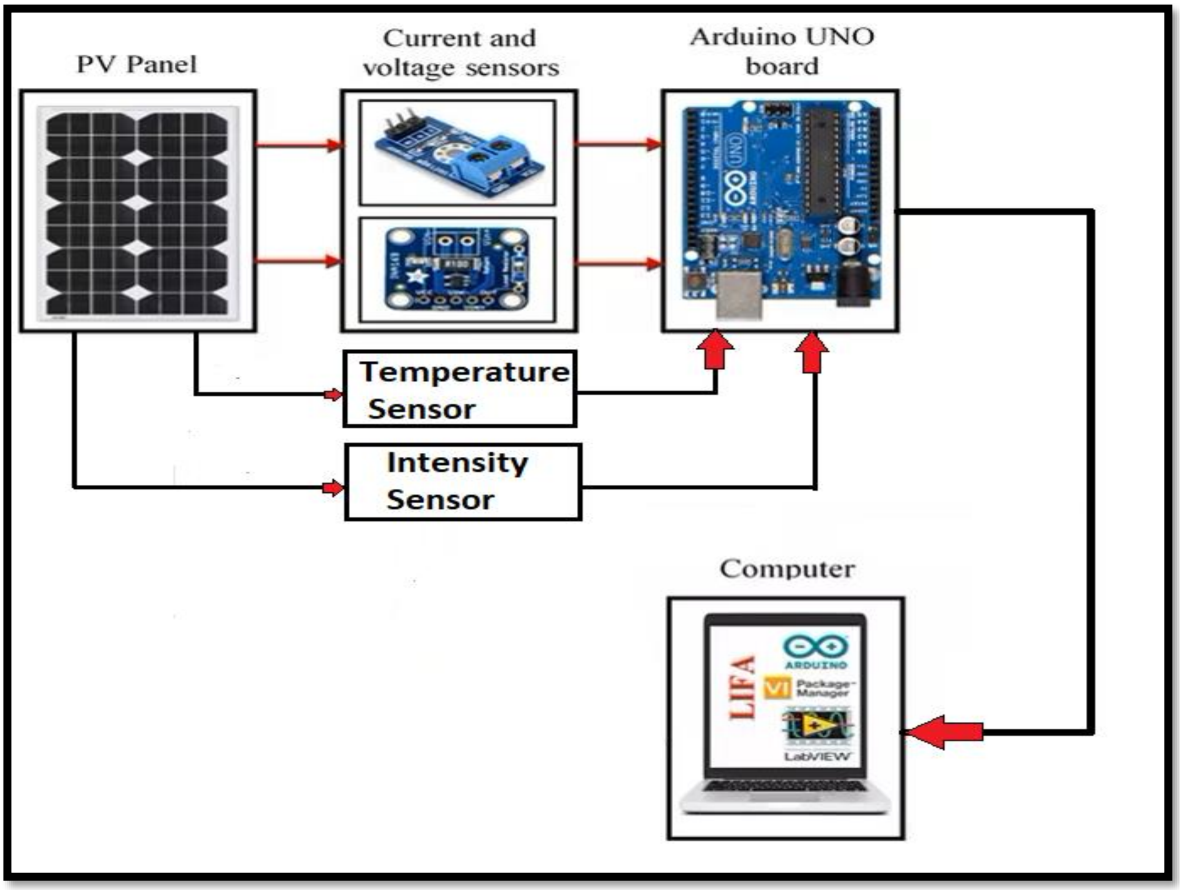


Fig. 3. Connectios Diagram

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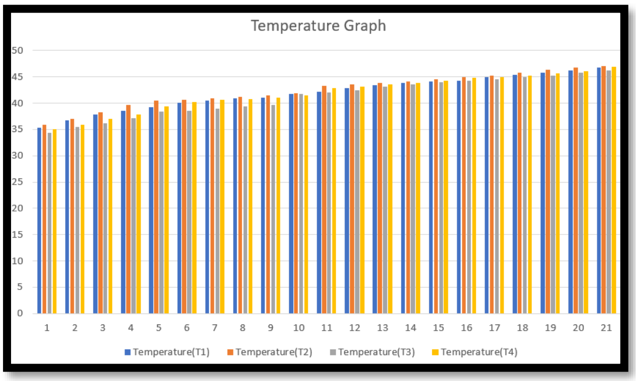
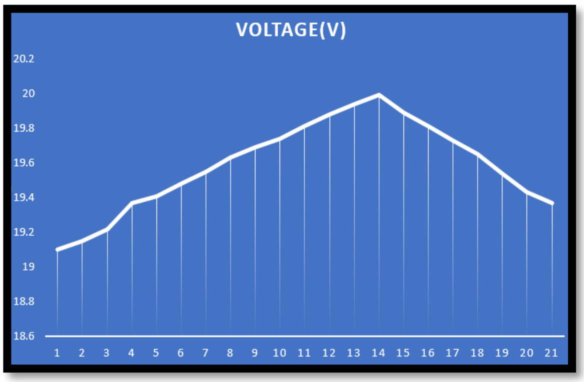
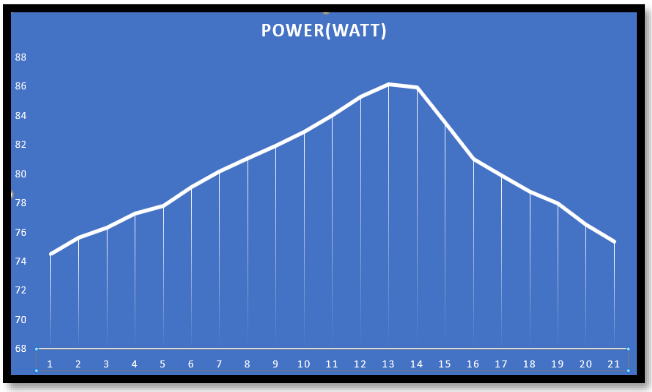
3. Results

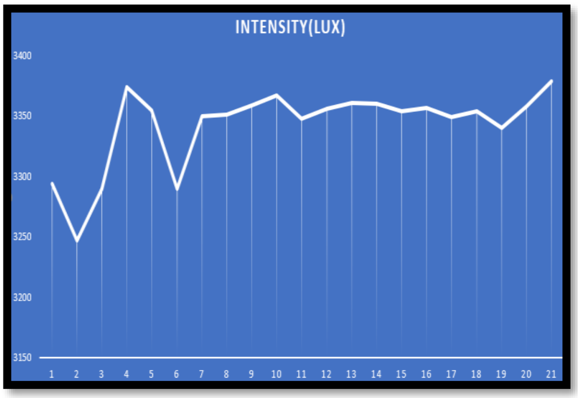
Case 1: Using 100Watt bulbs(4 Bulbs)

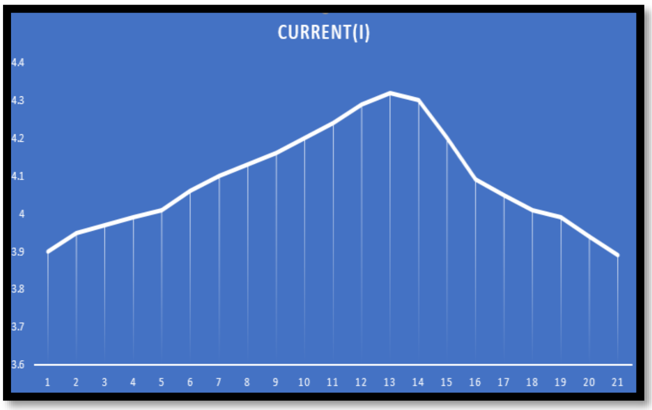
	A	B	C	D	E	F	G	H	I
1	Date And Time(IST)	Temperature(T1)	Temperature(T2)	Temperature(T3)	Temperature(T4)	Voltage(V)	Intensity(Lux)	Current(I)	Power(watt)
2	[2022-06-25 17:40:25.946]	35.3	35.9	34.3	35	19.1	3294	3.9	74.49
3	[2022-06-25 17:43:28.406]	36.7	37	35.4	35.9	19.15	3247	3.95	75.6425
4	[2022-06-25 17:46:30.865]	37.8	38.3	36.2	37	19.22	3290	3.97	76.3034
5	[2022-06-25 17:49:33.324]	38.5	39.6	37.1	37.9	19.37	3374	3.99	77.2863
6	[2022-06-25 17:52:35.787]	39.3	40.5	38.4	39.4	19.41	3355	4.01	77.8341
7	[2022-06-25 17:55:30.573]	40.1	40.6	38.6	40.2	19.48	3290	4.06	79.0888
8	[2022-06-25 17:58:39.734]	40.5	40.9	39	40.6	19.55	3350	4.1	80.155
9	[2022-06-25 18:01:35.780]	40.9	41.2	39.4	40.8	19.63	3351	4.13	81.0719
10	[2022-06-25 18:04:56.590]	41.1	41.5	39.7	41	19.69	3359	4.16	81.9104
11	[2022-06-25 18:07:50.550]	41.7	41.9	41.7	41.4	19.74	3367	4.2	82.908
12	[2022-06-25 18:10:10.990]	42.2	43.3	42	42.9	19.81	3348	4.24	83.9944
13	[2022-06-25 18:13:56.560]	42.8	43.6	42.5	43.1	19.88	3356	4.29	85.2852
14	[2022-06-25 18:16:10.400]	43.4	43.9	43.1	43.5	19.94	3361	4.32	86.1408
15	[2022-06-25 18:19:51.600]	43.8	44.1	43.6	43.9	19.99	3360	4.3	85.957
16	[2022-06-25 18:22:56.679]	44.1	44.5	44	44.3	19.89	3354	4.2	83.538
17	[2022-06-25 18:25:30.450]	44.3	44.9	44.2	44.8	19.81	3357	4.09	81.0229
18	[2022-06-25 18:28:54.990]	44.9	45.3	44.6	45	19.73	3349	4.05	79.9065
19	[2022-06-25 18:31:26.987]	45.4	45.8	45	45.3	19.65	3354	4.01	78.7965
20	[2022-06-25 18:34:43.654]	45.8	46.4	45.3	45.7	19.54	3340	3.99	77.9646
21	[2022-06-25 18:37:33.894]	46.2	46.8	45.8	46.1	19.43	3358	3.94	76.5542
22	[2022-06-25 18:40:22.854]	46.7	47.1	46.2	46.9	19.37	3379	3.89	75.3493
23									
24	Average	41.97619048	42.52857143	41.24285714	41.93809524	19.58952381	3342.52381	4.085238095	80.05713333





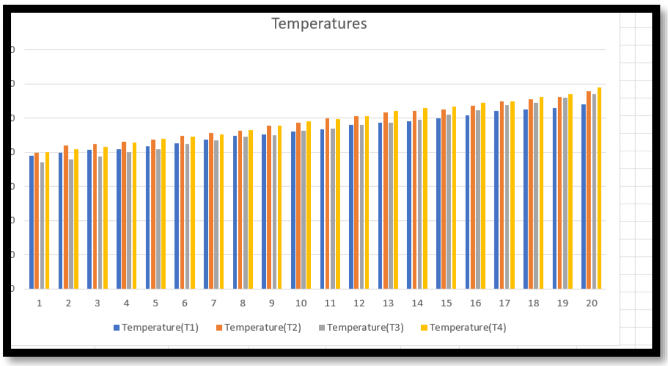


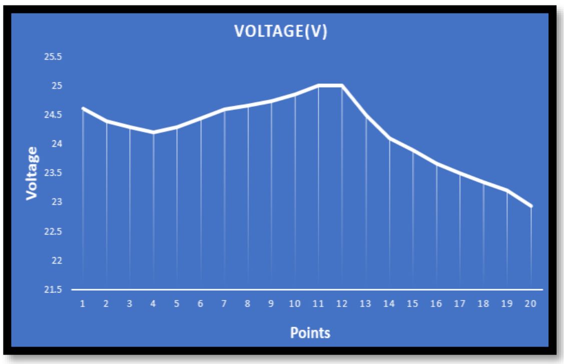


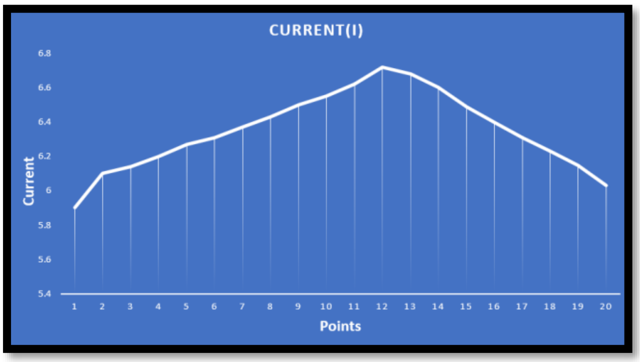


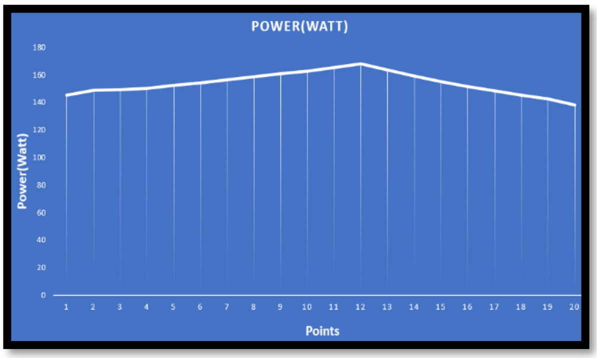
Case 2: Using 200Watt bulbs (4 Bulbs)

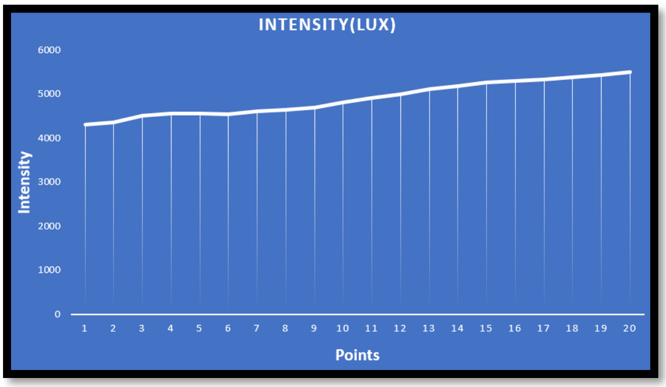
1	Date And Time(IST)	Temperature(T1)	Temperature(T2)	Temperature(T3)	Temperature(T4)	Voltage(V)	Intensity(Lux)	Current(I)	Power(watt)
2	[2022-06-25 15:03:25.946]	39	39.9	37	40	24.61	4303	5.9	145.199
3	[2022-06-25 15:06:26.676]	39.9	41.9	37.9	40.9	24.39	4363	6.1	148.779
4	[2022-06-25 15:09:20.356]	40.7	42.5	38.8	41.6	24.29	4515	6.14	149.1406
5	[2022-06-25 15:12:25.946]	41	43	40	42.8	24.2	4567	6.2	150.04
6	[2022-06-25 15:15:15.946]	41.8	43.7	41	44	24.29	4562	6.27	152.2983
7	[2022-06-25 15:18:45.946]	42.7	44.7	42.4	44.5	24.45	4550	6.31	154.2795
8	[2022-06-25 15:21:35.946]	43.7	45.6	43.6	45.2	24.6	4610	6.37	156.702
9	[2022-06-25 15:24:25.946]	44.8	46.4	44.5	46.6	24.66	4650	6.43	158.5638
10	[2022-06-25 15:27:56.946]	45.3	47.8	45	47.9	24.74	4700	6.5	160.81
11	[2022-06-25 15:30:25.946]	46	48.6	46.2	49	24.85	4810	6.55	162.7675
12	[2022-06-25 15:33:25.946]	46.7	49.9	47	49.8	25.01	4919	6.62	165.5662
13	[2022-06-25 15:36:16.946]	48	50.5	48	50.7	25	5000	6.72	168
14	[2022-06-25 15:39:25.946]	48.7	51.6	48.7	52	24.5	5110	6.68	163.66
15	[2022-06-25 15:42:25.946]	49.2	52	49.6	52.9	24.1	5190	6.6	159.06
16	[2022-06-25 15:45:25.946]	50	52.6	51	53.4	23.89	5270	6.49	155.0461
17	[2022-06-25 15:48:25.946]	50.9	53.7	52.3	54.4	23.67	5300	6.4	151.488
18	[2022-06-25 15:51:45.946]	52	54.8	53.8	55	23.5	5340	6.31	148.285
19	[2022-06-25 15:54:25.926]	52.5	55.6	54.5	56.3	23.35	5390	6.23	145.4705
20	[2022-06-25 15:57:25.946]	53	56.3	55.9	57.1	23.2	5440	6.15	142.68
21	[2022-06-25 16:00:59.976]	54	57.9	57.1	59	22.94	5500	6.03	138.3282
22	**Average**	**46.495**	**48.95**	**46.715**	**49.155**	**24.212**	**4904.45**	**6.35**	**153.808185**











4. Conclusion

Solar collectors are tested indoors, where the testing circumstances may be controlled and repeated, allowing for the optimization of the collectors using the same input energy and losses. In this experiment, the halogen lamp system used as the solar simulator was successfully built and constructed. PV panel performance tests can be run at any time, continuously, throughout the day, using a solar simulator.

5. Future Scope

When using the default test boundary , this procedure measures and analyses the energy output of a photovoltaic system in comparison to the output anticipated from weather data, such as horizontal irradiance, ambient temperature, and wind speed, or other data specified by the test's participants. This document does not include the process for anticipating production.Using this approach to test solar systems' long-term performance (energy generation) and assess how they function under all possible operating situations throughout the year will yield the best results. Such an assessment shows that long-term predictions of system energy generation are reliable.

The process assesses the effectiveness of the PV system performance, taking into account both the quality of the initial installation and the quality of the plant's ongoing operation, under the presumption that the model effectively captures the effectiveness of the system.

In this process, the actual energy generated by the solar system is measured and compared to the predicted energy output given the weather conditions. Using a model of the PV system that will serve as the guarantee or evaluation basis, expectations for energy production are generated. This model must be accepted by all stakeholders.

This standard's goal is to define a framework process for contrasting the measured energy generated with the energy that is anticipated from a PV system. The test duration, data filtering strategies, data collecting, and sensor selection are only a few of the topics covered by the framework technique. In case you missed it, the approach does not specify a way to come up with predictions of expected energy. The test's user is free to use their own prediction strategy. Documentation of the PV system's performance in comparison to the performance anticipated by the selected model for the measured weather is the end result.

This test method is expected to be used in medium- or large-scale projects and is intended for grid-connected solar systems that comprise at least one inverter and the related gear.

Concentrator (> 3X) photovoltaic systems are not the intended use of this procedure, but it will be investigated in the future.

This test procedure may be used to confirm the accuracy of a model, track performance (for example, degradation) of a system over a period of years, or to document system performance for any other purpose. It was designed with the primary objective of making it easier to document a performance guarantee.

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