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Performance Evaluation of Maximum Power Generation of A Rooftop Solar Photovoltaic System

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Abstract: ***Rooftop solar photovoltaic (SPV) system has vast scope in India as the commercial buildings are huge in number. At the national level, the rooftops of commercial buildings would be an alternate of unused and suitable area to make distributed solar power generation viable. Due to high energy demand and climate change, the SPV has attracted the attention of government towards it in recent years and this has vast future scope of energy generation. The actual performance parameter has been identified by filtering and normalization of the solar power plant data installed on the rooftop. This paper presents 15-minute data of 2nd September 2015 to evaluate performance of the solar plant comprises of 20 numbers of solar panel, of cumulative capacity of 2 kW and a weather station. The solar plant comprises the panels of monocrystal, polycrystal and thin film technology installed on the rooftop of faculty of Engineering and Technology building. The performance ratio (PR) of the solar plant has been evaluated by reporting the effect of average temperature, time of hour (TOH), solar irradiance on the power generation and efficiency of the plant.***

Keywords: high-potential, monocrystal, polycrystalline, solar irradiance, thin film

1.Introduction

The power generation and efficiency of the plant depends on the global irradiance, ambient temperature and soiling loss. The objective of this work is to observe the performance of the PV system with respect to global irradiance, average temperature, TOH for 24 hours. The performances of SPV with respect to different climatic parameters and geographical conditions have been reported in many technical papers [1-3]. As compared to crystalline cells, the thin film solar cells were more flexible [4-5]. Monocrystalline silicon with a glass surface, polycrystalline with an epoxy surface and an amorphous silicon panel with glass performances were examined in dry climatic condition in India under dust accumulation. Researchers conducted the test for nearly 1.1 hour and found that the reduction in performance in amorphous module is less and greater reduction in polycrystalline [6].Various studies have been done to assess factors that influence PV performance; dust deposition or soiling is the most impactful factor. It is clear that any change in intensity of irradiance or quality, changes the performance of PV output; therefore whenever dust of organic or non organic in nature deposited on the surface of module ,changes the solar irradiance characteristics incident on PV module. The cleaning frequency and the method of cleaning is highly site specific. Several studies have been done; one study strongly advised that cleaning must be done within 2-3 weeks in the absence of cleaning rain. It was recommended that a cost/benefit analysis be performed for any system to determine its specific needs in terms of a cleaning schedule [7]. The fast growing world energy has already raised problem over supply of fossil fuel, depletion of crude energy reservoirs, huge environmental issues, such as ozone layer depletion, global warming, climate change etc. The global contribution of energy consumption from both residential and commercial has been continuously increased to between 20% to 40% in developed countries [8-10]. A large spread and expansion of renewable energy is essentially required due to rapidly growing demand of electricity. For sustainable widespread energy production and carbon –neutral energy, the solar power generation is highly attractive. The global solar electricity market is currently more than $10 billion/year, and the industry is growing at more than 30% per annum [11-12].In a report published by the Environment Canada (2012), the performance ratio for rooftop PV systems was 0.75 and 0.8 for ground-mounted [13-15]. Over the last 20 years, the statistical average performance ratio of a new PV installation in moderate climates has improved from 0.65 to approximately 0.85 [16].In order to obtain data specific to New Delhi, this study investigates the performance of rooftop solar photovoltaic system installed on the roof of Engineering building of Jamia Millia Islamia University.

2. Photovoltaic plant's description and methodology

The photovoltaic system installed on the roof top of Engineering building, jamia Millia Islamia University, New Delhi. The SPV generating plant consist of mono, poly and thin film solar panels . The weather station is also installed on the roof to record and save the meteorological data. Pyranometer (Kipp & Zonen, CMP11) has been installed to measure the solar radiation of wave length 285-2800nm. The data logger has 455B/24 Channels manufactured by phonix. The uniline power conditioning unit (PCU) has 600 VA

capacities with 12 V DC input and 230 V AC single phases with 4 numbers. The Li-ion battery of 12V having 6AH capacity in 20 numbers manufactured by SBD, Ni-cad battery of 12 V, 6AH capacity with 20 numbers made by HBL India and Lead-acid battery of 12 V and 150 AH capacity with 20 numbers made by Maxwell has been installed to store DC power generated by the SPV plant and fed to the PCU. Wind sensor of 0.5 resolutions has been installed to measure the wind speed and direction. Humidity sensors also installed to measure the humidity from 0-100% at -500C to +500C manufactured by Met one USA. Data were collected over a twelve-month period and became the basis of this analysis. The tilt angle was chosen as a compromise between the optimum value, available roof area, and to reduce shading. The plant was mounted on roof on concrete blocks to prevent penetration into the existing structure. Here the data of 2nd September 2015 has been taken to analyze the performance of the plant. The details of the main components are tabulated in table 1.1

Table 1.1: Main components and their specification

S. No.	Name of components	Specification	Model & Make
1	Pyranometer	285-2800nm,7-14 μV/W/m^2,-40 to +80 ^{0}C	CMP11,Kipp & Zonen
2	Wind Sensor	0-75 m/s, 0.5 resolution	034B,Metone ,USA
3	RH/T Sensor	0-100%H,-50 to +50 ^{0}C	083-X-35,593A, Met one ,USA
4	PV modules (Multicrystalline)	2 PV arrays of 500 Wp each	Photon energy system, Hyderabad India
5	PV modules (Monocrystalline)	1 PV array of 500 Wp	Photon energy system, Hyderabad India
6	PV modules (Thin film)	1 PV array of 500 Wp	Moser Baer
7	Power conditioning unit (PCU)	600 VA,input 12 V DC,output 230 V,AC single phase,4 Nos.	Uniline
8	Li-Ion Battery	12V,6AH,20Nos.	SBD
9	Ni-Cad Battery	12V,6AH,6Nos.	HBL India
10	Lead-acid Battery	12V,150AH,20Nos.	Okaya
11	Capacitor Bank	12V,60F	Maxwell
12	Data Logger	455B/24 channels	Phonix

Table1.2: Technical Specification of Solar PV Modules installed on roof of Electrical Engineering Department, JMI building

Type	Maximum Power(Wp)	Voltage at Maximum Power (V)	Current at Maximum Power (A)	Open Circuit Voltage(V)	Short Circuit Current(A)	Tolerance
Mono crystalline	100	17.7	5.7	21.6	6.3	2%
Poly Crystalline	100	17.7	5.7	21.6	6.3	2%
Thin plate	100	17.7	5.7	21.6	6.3	2%

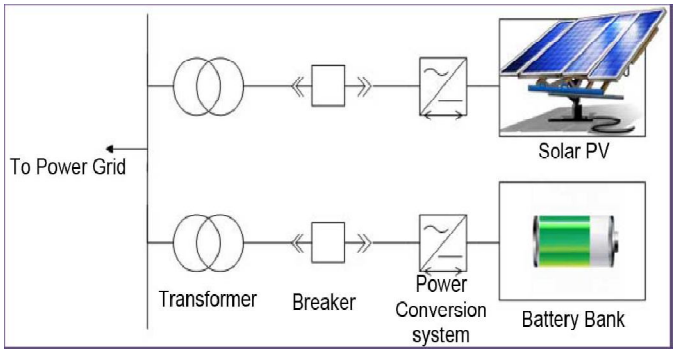

Figure1.Schematic model of Grid connected SPV power system with energy storage device

Figure 2.Polycrystalline, monocrystalline and thin film solar modules are connected on roof top of Electrical engineering building of JMI

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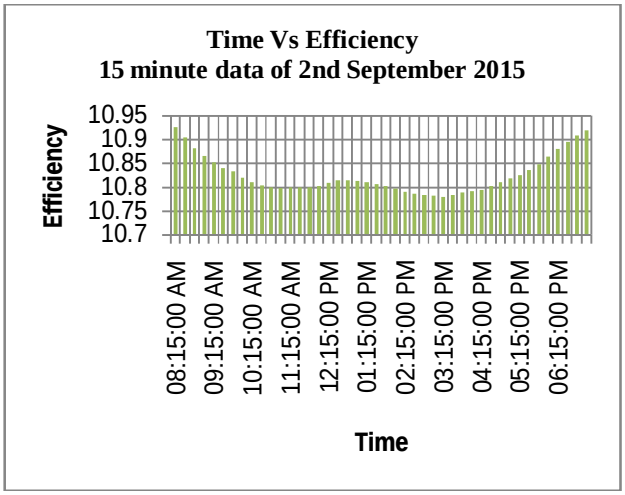
Table1.3 Solar power system 15-minute data of 2nd September 2015

Time	STC Temp(0C)	Isc (Amp)	Im (Imp)	Voc (V)	Vm (V)	Fill Factor	Avg Temp (0C)	Pmax	% Efficiency at Actual Temp.
08:15:00 AM	25	6.3	2.144	21.6	17.34	0.273235	31.82	37.18178	10.591
08:30:00 AM	25	6.3	2.404	21.6	17.31	0.305814	33.25	41.61523	10.501
08:45:00 AM	25	6.3	2.698	21.6	17.27	0.342426	34.86	46.59727	10.399
09:00:00 AM	25	6.3	2.961	21.6	17.25	0.375307	35.95	51.07177	10.331
09:15:00 AM	25	6.3	3.234	21.6	17.23	0.409444	36.9	55.71709	10.271
09:30:00 AM	25	6.3	3.545	21.6	17.21	0.448336	37.52	61.00952	10.227
09:45:00 AM	25	6.3	3.851	21.6	17.2	0.486588	38.21	66.21488	10.19
10:00:00 AM	25	6.3	4.09	21.6	17.18	0.516218	39.11	70.24699	10.133
10:15:00 AM	25	6.3	4.31	21.6	17.16	0.543496	39.76	73.95892	10.093
10:30:00 AM	25	6.3	4.558	21.6	17.15	0.574459	40.2	78.17238	10.066
10:45:00 AM	25	6.3	4.714	21.6	17.14	0.593872	40.45	80.81405	10.05
11:00:00 AM	25	6.3	4.916	21.6	17.14	0.619251	40.57	84.26765	10.043
11:15:00 AM	25	6.3	5.097	21.6	17.14	0.642105	40.48	87.37762	10.048
11:30:00 AM	25	6.3	5.267	21.6	17.15	0.663579	40.43	90.29987	10.051
11:45:00 AM	25	6.3	5.355	21.6	17.15	0.674692	40.43	91.81206	10.051
12:00:00 PM	25	6.3	5.405	21.6	17.15	0.68117	40.29	92.69358	10.06
12:15:00 PM	25	6.3	5.399	21.6	17.16	0.680768	39.86	92.63895	10.087
12:30:00 PM	25	6.3	5.374	21.6	17.17	0.677918	39.5	92.25105	10.109
12:45:00 PM	25	6.3	5.292	21.6	17.17	0.667568	39.52	90.84268	10.108

01:00:00 PM	25	6.3	5.179	21.6	17.16	0.653211	39.58	88.88891	10.104
01:15:00 PM	25	6.3	5.179	21.6	17.16	0.653062	39.75	88.86866	10.094
01:30:00 PM	25	6.3	4.836	21.6	17.15	0.609613	40.03	82.95618	10.076
01:45:00 PM	25	6.3	4.839	21.6	17.15	0.609773	40.32	82.97794	10.058
02:00:00 PM	25	6.3	5.065	21.6	17.14	0.637991	40.65	86.81778	10.038
02:15:00 PM	25	6.3	5.038	21.6	17.13	0.634161	41.14	86.29668	10.007
02:30:00 PM	25	6.3	4.619	21.6	17.12	0.581247	41.37	79.09614	9.993
02:45:00 PM	25	6.3	4.486	21.6	17.12	0.564244	41.63	76.7823	9.977
03:00:00 PM	25	6.3	4.171	21.6	17.11	0.524579	41.8	71.38476	9.966
03:15:00 PM	25	6.3	4.048	21.6	17.11	0.509047	41.92	69.27118	9.959
03:30:00 PM	25	6.3	3.67	21.6	17.12	0.461691	41.64	62.82692	9.976

03:45:00 PM	25	6.3	3.183	21.6	17.13	0.400564	41.25	54.50874	10.001
04:00:00 PM	25	6.3	2.938	21.6	17.13	0.369909	41.03	50.33727	10.014
04:15:00 PM	25	6.3	2.58	21.6	17.14	0.324894	40.77	44.21164	10.03
04:30:00 PM	25	6.3	2.231	21.6	17.15	0.281182	40.34	38.26325	10.057
04:45:00 PM	25	6.3	1.891	21.6	17.16	0.238503	39.75	32.45544	10.094
05:00:00 PM	25	6.3	1.511	21.6	17.17	0.190644	39.25	25.9428	10.125
05:15:00 PM	25	6.3	1.12	21.6	17.18	0.14137	38.74	19.23764	10.157
05:30:00 PM	25	6.3	0.788	21.6	17.2	0.099624	37.99	13.55681	10.203
05:45:00 PM	25	6.3	0.487	21.6	17.22	0.061653	37.13	8.389714	10.257
06:00:00 PM	25	6.3	0.294	21.6	17.25	0.037269	36.07	5.071593	10.323
06:15:00 PM	25	6.3	0.129	21.6	17.27	0.016392	34.94	2.230599	10.394

06:30:00 PM	25	6.3	0.029	21.6	17.3	0.003642	33.88	0.495565	10.461
06:45:00 PM	25	6.3	0	21.6	17.32	8.02E-06	32.98	0.001091	10.518
07:00:00 PM	25	6.3	0	21.6	17.33	8.02E-06	32.24	0.001092	10.564
08:15:00 AM	25	6.3	2.144	21.6	17.34	0.273235	31.82	37.18178	10.591

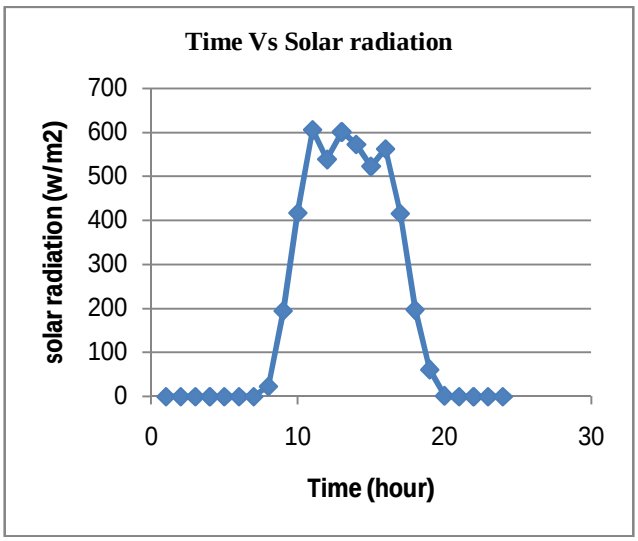


Performance Evaluation:

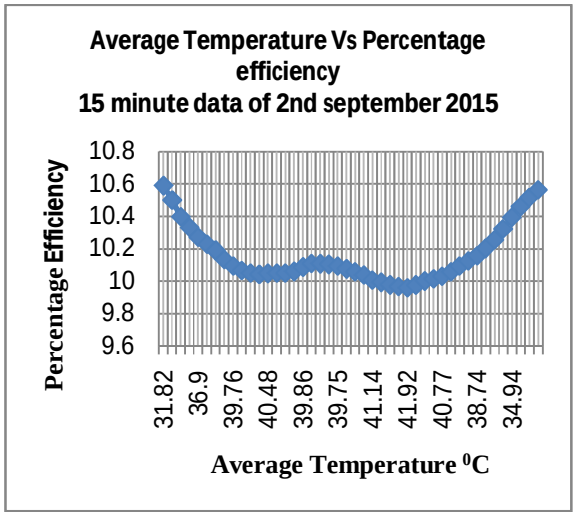
The performance ratio (PR) was calculated to evaluate the performance of the PV systems as follows:

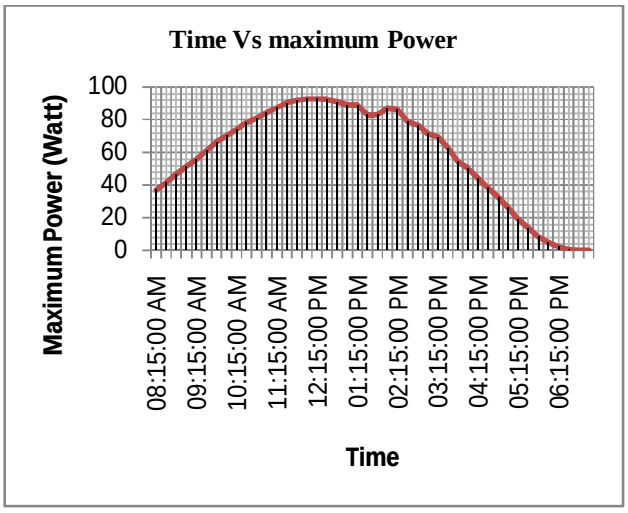
$$PR\% = \frac{Ps \times 100}{I \times A \times Es} \qquad (1)$$

Ps is the total output measured energy (kWh) of the system. I is the irradiance (kWh/m^2) A is the area of array; Es is the efficiency of the module. When normalizing with respect to irradiance, the influence of losses is quantified on the rated output. PR values are normally presented on a monthly or annual basis. It is common that the PR is higher in lower temperature months due to the fact that PV systems experience losses at higher temperatures.



3. Results and conclusion





The SPV plant data has been taken and performance of the plant evaluated. Following Results have been concluded.

(i) The performance ratio varies between 0.7 and 0.8.
(ii) The maximum power generation is at 12:00 noon.
(iii) Efficiency is maximum at the both end of the day and minimum at 41.92^{0}C
(iv) During high temperature the efficiency is lower.
(v) Solar radiation is highest in the mid day and power generation is also highest but the efficiency is lower in the fact that the power loss is more at high temperature.

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