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Yield Analysis of 20kW Grid-Tie Roof-top Solar Photovoltaic Unit in Tamilnadu

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Abstract

India, as part of its international commitments on climate change, is in rapid pace in the renewable energy segment. India has set a goal to attain 100GW solar energy generation all the way through grid-tie solar PV system but out of which 40GW is planned to attain from roof-top solar PV systems by 2022. Roof-top solar PV system attain the familiarity due to different rewards like low development period, island mode operation and grid stability. This paper presents the study on the yield analysis of the 20kW on-grid roof-top solar photovoltaic unit installed at AMET Deemed to be University, Chennai, India. The data collected from this plant is used to calculate the annual energy generation and capacity factor. The study proves that, this 20kW grid-connected solar PV system achieve better performance record of energy generation over a year as 29.7MWh and the capacity factor of 17%.

Keywords: *Yield analysis, Performance, On-Grid, Roof-top PV system*

Introduction:

Power is one of the leading components for the growth and upkeep of an up to date society with profits of its socio-economic conditions and technical improvements. The greatest obstacle for humanity is providing energy in a sustainable fashion for various customers and at the identical time promising wealth for future populations. Discharges from fossil fuels due to the GHG emissions, their deterioration in raw materials and subsequent rising price and probable effects on climate change, several countries are now re-examining their policies on energy with the view of changing on the way to low-carbon and renewable resources. Among the several forms of renewable sources photovoltaic energy inhabits a major place due to much distinctiveness.

Economic encouragements, decrease in rate, and the fast-technological advances allow us to use the grid tie photovoltaic systems in a simple, competent and lucrative way [1].Government of India has fixed the goal of 100GW capacity through on-gird rooftop solar PV system but out of which 40GW is planned to attain from roof-top PV systems by 2022. This is a massive job to be done achieved by diverse businesses and other agencies. The most important states include a rise in solar status are Gujarat, Tamilnadu, Kerala, Karnataka, Madhya Pradesh, Rajasthan and Uttar Pradesh. Sustainable Development is the necessity of India. Not just in the PV solar generation arena, concentrated solar power also plays a key role in increasing market demand for solar power. Many solar companies took part to discover India's maximum solar potential.

Now-a-days, India's main demand for electricity is based on thermal power plants. Due to diverse Government inventiveness, individuals are participating in solar roof-top PV systems. It's economical and a improved choice as most part of India obtains 300 days of insolation from sun [2]. So Solar roof-top PV system can show a vibrant task as by using roof of the buildings, hilly areas and waste land to set up PV system. With modern idea of a self-sustaining smart city that means cites creating

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its own electricity by the obtainable resources within the city. This paper explains about yield analysis of roof-top grid-tie photovoltaic system.

The Grid Connected PV System:

The complete unit for the on-grid PV system contains PV arrays, protection devices, grid-tie inverter and energy meter. The grid-tie PV system considered in this study is commissioned at AMET Deemed to be University, Chennai, Tamilnadu, India, as exposed in the Fig.1. The system installed and started its operation on October, 2017. This system is located on the latitude12.85°N and longitude 80.24°E. This PV system comprises of 64 PV modules covering 151sq.m of total area with a total installed capacity of 20kW$_p$. It consists of 64 numbers of Goldi Green's GOLDI315PM of 315W$_p$ modules. The PV array is connected to a Fronius Symo 20.0-3-M three-phase grid connected inverter with input voltages of 200-1000V and three-phase output voltage of 400V, 50Hz via DC and AC Combiner boxes (DCCB and ACCB).

(a)

(b)

Fig. 1. 20kWp Grid-Tie Roof-top Solar PV System (a) PV array arrangement (b) Control room

Table 1 Parameters of the PV module

S. No	Parameters	Ratings
1	Maximum Power, P_{max}	315 W
2	Max. Voltage, V_{max}	37 V
3	Max. Current, I_{max}	8.52 A
4	Open circuit voltage, V_{oc}	46 V
5	Short circuit current, I_{sc}	8.9 A
6	Max. System Voltage	1000 V
7	Solar Irradiance (STC)	1000 W/m^2
8	No. of Cells	60 Cells

Table 2: Specifications of Solar Power Plant

S. No	Parameters	Ratings
1	Maximum Power of Solar Module, P_{max}	315 W
2	No. of Solar Modules	64
3	Solar PV Inverter	400 V / 20kVA
4	Plant capacity	20kW$_p$ (approx.)

Performance Factors:

Quality of an on-grid solar PV system is regularly measured using IEC 61724 Standard. The performance factors are: generation of energy, reference yields, array yields and final yields, losses in array and the converter system, performance ratio, system outputs and capacity factor [3-9]. In this study, the energy generation and the capacity factor are considered from the available data.

The data available on actual generation and projected generation are analysed in this part. The generation of the PV system vary with the variations in the temperature, and solar irradiance at the location and at the environments to the PV modules. Also, there are several other decisive aspects like the density of accumulated dust, wind velocity at that location and measure of convective temperature current flow disturb the power generation of the plant. The presence of dust particles in the atmosphere diminishes the irradiance at ground level

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due to the reflective spatial state of the field. In addition to this wave-length smatter due to dirt and particulates, the incidence of the required wave-length may be reduced. The average direct normal irradiance per month for Chennai [10] is shown in Table 3. The projected power generation with the above data for a month can be calculated by [11],

$$G_p = \frac{[No.of\ Modules \times P_{out} \times No.of\ Days]}{1000}$$

Where, G_p is projected power generation in kWh, P_{out} is the output power and it is equal to the product of peak power and irradiance.

The generation data of the 20kWp rooftop on-grid solar PV system are revealed in Table 4. The average generation per month is determined by the number of days the plant is in operations. (The data is collected from the 20kW on-grid PV system situated at AMET). The highest yield was detected in March month and minimum yield was detected in June month due to climatic circumstances eroticisms which obtained from the Table 4 and Fig.2. The sample monthly actual generation yield data is shown in Fig.2. The data used in these graphs are provided in the APPEXDIX. Dust accrual and other climatic properties have also an influence ultimately in the irradiance level [9].

Table 3: Average Direct Normal Irradiance for Chennai

S. No	Month	Direct Normal Irradiance in kWh/m^2/day
1	January	5.76
2	February	6.60
3	March	6.05
4	April	5.91
5	May	5.78
6	June	4.85
7	July	4.39
8	August	4.22
9	September	4.86
10	October	3.68
11	November	4.12
12	December	4.92

Table 4: Expected and Actual Generation of AMET 20kW$_p$ Solar Plant

Month	Expected Generation in kWh	Actual Generation in kWh
January	3599.77	2517.77
February	3725.57	2477.11
March	3781.01	3070.21
April	3574.37	2597.66
May	3612.27	2463.74
June	2933.28	2052.82
July	2743.57	2327.17
August	2637.33	2545.39
September	2939.33	2498.41
October	2299.85	2473.20
November	2491.78	2355.04
December	3074.80	2335.53

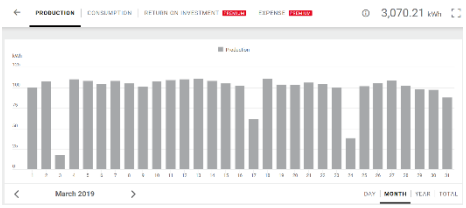

Fig.2. Day-wise Monthly Generation Data of 20kW Grid Connected PV System

The predicted output is more than the actual generation, as illustrated in the beginning of the paper, due to the datum there is a transformation in irradiance, temperature, dust accrual and other climatic conditions. During the calculation of the expected energy the average daily value of the insolation is taken into account, but is reflected in the actual energy output based on the insolation variation over each day.

Results and Discussions:

In order to study the performance of rooftop PVsystem high power crystalline silicon solar cell module is used. The interline row spacing of solar array is set at 0.7 m while the tilt angle is set 13°. According to the PV module self-shading is a single shading factor included in this study, i.e. it does not include the effects of nearby physical structures, self-shading effect was insignificant.

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The annual energyoutput of 20 kW rooftop PV systemis listed in Annexure. From the annual energy generation, the capacity factor for the rooftop PV system is 17 per cent, which is quite strong. The study was conducted for a duration of one year and it generated the total energy of 29.7MWh. that is an average of 2.48MWh per month. The monthly energy production varied between the value of 3.1MWh in March 2019 and 2.1MWh in June 2019. The peak power output measured to 16.34kW from the total installed capacity of 20kW. The annual power generated throughout the period divided by the system's rated power is 1485.7 kWh/kWp. This energy output is better than the value (1372 kWh/kWp) cited in [5].

Conclusions:

Aperformance analysis of 20kWp grid connected solarphotovoltaic system installed at AMET Deemed to be University was evaluated for the period of December 2018 to November 2019. The following conclusions are drawn from thestudy.

- A peak power output of 16.34kW was observed during the year-roundoperation.
- Maximum total generation of 3.07MWh was observed March, and lowest total generation of 2.05MWh was observed in June.
- The yearly energy generation as 29.7MWh and the capacity factor of 17%.
- Average daily energy generation over a period was observed as 81.41kWh.
- The maximum monthly average generation of99.04kWh and minimum average monthly generation of 68.43kWh was observed over a period of study.
- The power output of the solar power plant varies with the variation in irradiance, operating temperature and the input AC supply oscillations.
- The observed data and working knowledge of PV system can be applied for future expansion projects.

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Appendix

Table A-I: Daily Generation of 20kWp On-Grid Solar PV system

Dates	Generation in kWh											
	Dec-18	**Jan-19**	**Feb-19**	**Mar-19**	**Apr-19**	**May-19**	**Jun-19**	**Jul-19**	**Aug-19**	**Sep-19**	**Oct-19**	**Nov-19**
1	103.09	32.13	88.91	100.67	105.48	31.03	50	83.48	59.3	48.82	91.45	106.6
2	102.49	94.2	94.13	108.75	76.28	59.57	67.05	63.18	60.26	64.46	111.17	107.82
3	77.99	100.83	3.72	17.82	97.07	88.98	61.51	80.61	75.04	71.15	108.79	93.63
4	55.18	99.6	64.79	111.05	103.73	72.88	75.53	65.00	67.84	85.00	89.74	56.45
5	72.65	94.52	93.77	108.84	101.68	76.58	74.28	53.70	66.40	102.85	114.44	43.50
6	93.31	32.23	90.75	104.94	58.79	79.69	81.65	63.50	71.88	74.85	96.50	87.19
7	90.98	91.74	91.32	108.94	64.27	73.23	62.52	70.63	79.22	81.9	98.35	67.65
8	85.64	99.81	99.88	105.87	92.95	68.36	33.74	97.70	87.87	92.44	104.66	80.88
9	80.87	98.35	99.51	101.89	97.84	68.56	78.06	84.61	96.01	86.85	98.20	67.30
10	74.15	96.44	47.54	108.59	100.68	76.75	69.60	93.27	91.69	102.63	107.71	81.08
11	90.93	93.76	76.65	110.24	94.97	80.04	80.46	92.10	104.05	69.17	105.69	106.29
12	90.00	99.63	98.81	111.26	89.70	86.29	83.43	96.53	88.63	98.62	109.58	104.81
13	81.24	19.35	98.26	111.35	97.05	89.79	46.78	96.74	73.74	97.76	110.67	93.35
14	100.75	91.45	102.40	109.12	78.70	86.17	83.50	54.36	103.31	110.08	105.58	93.97
15	49.54	15.24	104.45	106.14	109.99	82.66	78.24	89.86	79.18	85.81	101.94	58.59
16	10.11	60.44	97.83	102.95	103.25	85.74	80.28	107.18	82.26	110.29	62.95	89.59
17	74.26	79.29	30.99	62.34	97.74	91.14	64.68	41.57	54.63	57.05	24.41	67.48
18	74.40	94.63	93.75	111.40	13.26	84.78	77.33	88.04	65.14	54.27	107.23	99.80
19	92.96	98.34	97.24	104.66	102.48	84.39	56.44	66.72	103.30	32.71	73.95	94.04
20	87.29	71.18	100.92	103.98	104.19	88.06	28.93	94.29	77.49	55.46	49.39	85.17
21	64.19	70.21	105.78	106.86	77.87	89.41	49.84	72.23	81.68	85.54	36.66	66.03
22	62.90	95.00	107.61	105.37	79.87	88.47	89.98	22.94	57.21	24.42	30.62	72.96
23	2.94	97.47	106.43	100.98	84.07	88.77	88.13	75.51	75.40	101.19	75.86	30.13
24	97.01	96.91	92.20	38.60	95.97	80.84	60.06	98.40	90.12	72.79	47.02	64.23
25	89.54	92.85	110.82	102.67	89.26	80.71	50.47	58.55	93.14	79.94	61.47	79.91
26	90.82	84.05	97.97	106.81	93.46	85.55	58.64	45.96	109.42	102.32	52.98	57.68
27	84.00	68.85	100.48	109.69	92.78	85.77	81.96	85.33	108.66	119.30	59.19	79.45
28	78.09	81.83	80.20	102.99	60.52	81.40	83.62	62.49	93.03	109.10	74.17	82.13
29	48.80	93.87	--	98.77	76.63	75.88	87.39	59.02	105.11	109.00	78.42	92.89
30	39.48	81.51	--	97.86	57.13	72.84	68.72	61.43	86.96	112.64	18.77	44.46
31	89.93	92.06	--	88.81	--	79.41	--	102.24	57.42	--	65.64	--
Total	2335.53	2517.77	2477.11	3070.21	2597.66	2463.74	2052.82	2327.17	2545.39	2498.41	2473.2	2355.04
Monthly Average	75.34	81.22	88.47	99.04	86.59	79.48	68.43	75.07	82.11	83.28	79.78	78.50
Annual Average	81.632											

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