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Feasibility Analysis of 100 kW Solar Plant for Chandigarh, India

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Feasibility Analysis of 100 kW Solar Plant for Chandigarh, India

Amit Rai[1,*]**, Ashish Shrivastava**[2]**, Kartick C. Jana**[1]**, Sandeep Tripathi**[1] **and Amit Agrawal**[3]

Indian Institute of Technology (ISM) Dhanbad[1]
Manipal University Jaipur[2],
ABES Engineering College Ghaziabad[3]
E-mail: *rai.amit21@gmail.com

Abstract. The electricity demand is increasing worldwide with a fast pace. Accomplishment of this growing demand with renewable energy sources is gaining importance globally due to it's negligible pollutant emission. In this work, solar power potential is analysed for Chandigarh. A 100-kW photovoltaic plant is analysed for selected area with different PV panel combination for finding optimal solution of power generation. This selected area is having a good solar radiation reception potential of 5.07 kWh/m²/day annually at annual 25.4°C temperature. The plant is designed with fixed axis orientation and has tilt of 31°. The plant has potential to export 156120 kWh of electricity to the grid with performance ratio of 76%.

1. Introduction

The growing demand of energy can be full field with renewable or non-renewable energy generation systems. The non- renewable generation systems have a major problem of greenhouse gas emission. However, the renewable energy sources are environmentally friendly and sustainable way to accommodate this supply this energy [1]. The geographical position of India has enormous solar based plant potential, as it receives solar radiation from 4 to 7 kWh [2]. The National Solar Mission of India has a massive target of 20,000 MW power generations through solar power by 2020 [3].

The solar panels have zero carbon emission because they use semiconductor device to generate electricity. Recent developments in manufacturing of these panels have reduced the production cost significantly and have provided, solar a competitive platform in energy generation systems. However, power output from solar depends on the varying climatic conditions which creates shading and also reduces the radiation [4]. To solve this problem of power fluctuation various dc-dc converters [5-6], maximum power point tracking algorithms are proposed. Different researchers in their work have analysed the PV plant feasibility in terms of cost and energy production for different areas of world [7-11].

In this work feasibility analysis of 100 kW solar power plant is analysed for Chandigarh, India. The technical performance is estimated on the basis of capacity factor, annual energy production, and energy production and performance ratio. Moreover, financial analysis is also presented in terms of Levelized COE, payback period and net present cost.

2. Another System Description

The location of the plant is 30.75°N latitude and 76.5°E longitude. At this location, the value of GHI is 5.07kWh/m²/day with the annual mean temperature of 25.4°C. The selected solar panel is Trina Solar TSM which has 16.76 % efficiency and other parameters are shown in table.1. The selected inverter is of SMA American with maximum ac power capacity of 3800 Wac and other parameters are shown in table.2. To generate 100 kW of power total system will need 306 solar panels in which 34 strings of 9 panels each string, shown in table.3.

Table. 1. Solar panel Specification

Panel	Value
Nominal efficiency	16.76%
Max. Power	325.2 Wdc
Voc	46 Vdc
Isc	9.2 Adc
Module Length	1.94 meter

Table.2 Inverter Specification

Inverter	Value
Max. AC Power	3800 Wac
Max. DC Power	3928.11 Wsc
Max. DC Voltage	600 Vdc
Nominal DC Voltage	398.4 Vdc

Table.3. System Configuration at reference condition

Configuration	Value
Nameplate Capacity	99.5 kWdc
Number of Modules	306
Modules/String	9
String in Parallel	34
Total Module Area	593.6 m2
String Voc	414 V

3. Methodology

The performance of PV plant is evaluated through System Advisor Model (SAM), a software for performance evaluation, developed by National Renewable Energy Laboratory, USA. Analysis of this plant includes:

A. Technical feasibility of the plant in terms of capacity, production and energy yield
B. The financial feasibility of the plant in terms of payback period, COE and net capital cost
C. The carbon emission reduction potential of the plant.

4. Result and Discussion

4.1 Power Production and Capacity

The power generated from PV panel is directly proportional to the solar irradiance incident on it. However, shading and seasonal variation play a crucial role in the DC power output of the plant, and ac power supplied to the grid. In the month of April irradiance and power production both is maximum as there is a clear sky condition is in this month with irradiance of 115731 kWh and dc output is 15771.9 kWh. The minimum power and irradiance is in the month of January, shown in fig.1. The annual energy production of first year will be 156120 kWh and after this 0.5% degradation in power is taken in simulation to match practical limitation of the plant. The capacity factor of the plant is 17.90% and performance ratio is 76 %, which shows the feasibility of the plant is in acceptable limit and location of the PV plant is viable for the production, shown in table 4.
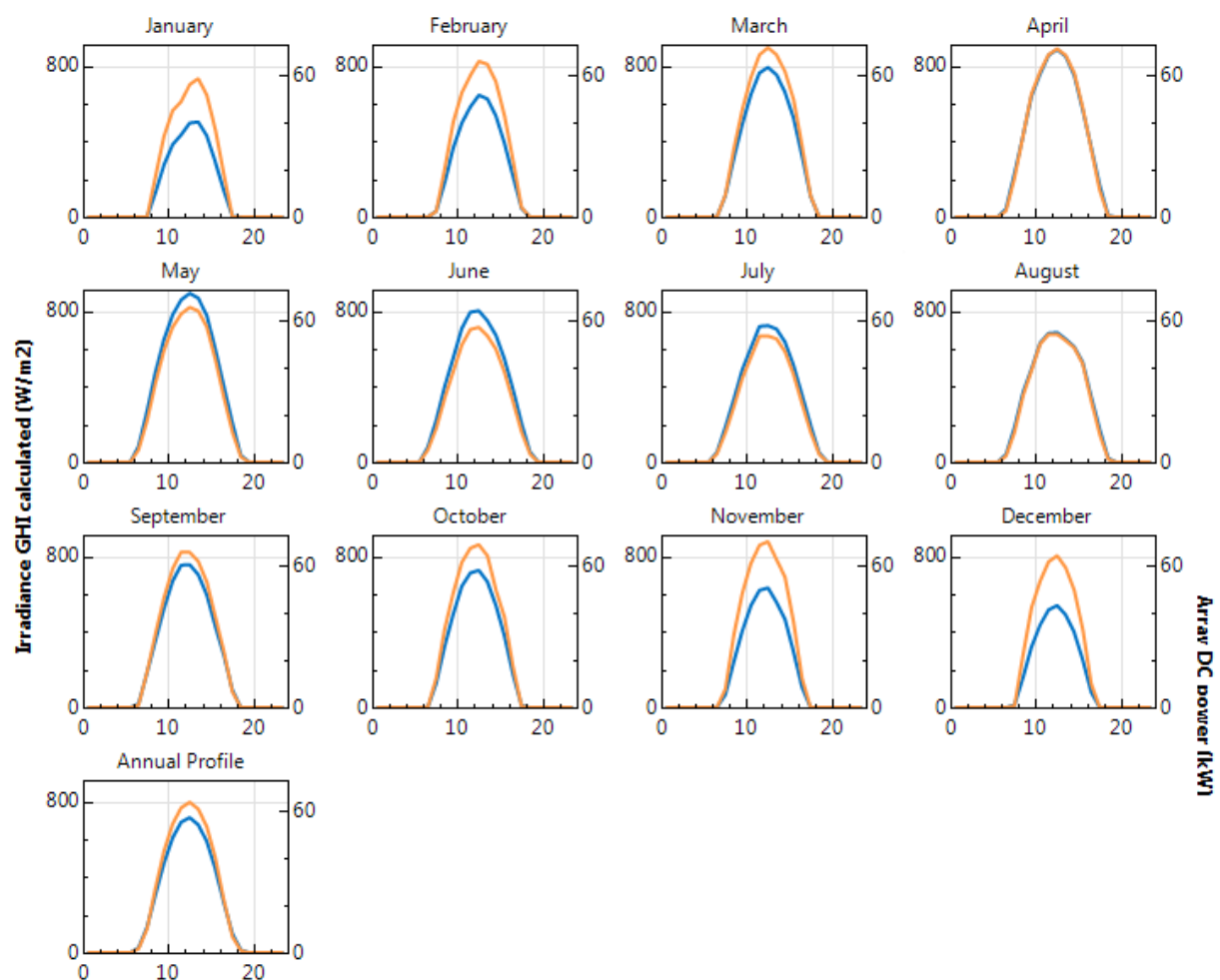

Fig.1. Solar Irradiance vs. Monthly Energy Production

Table.4. Technical outcomes

Metric	Value
Annual energy (year 1)	156,120 kWh
Capacity factor (year 1)	17.90%
Energy yield (year 1)	1,569 kWh/kW
Performance ratio (year 1)	0.76

4.2 Financial Viability of the Plant

The financial analysis is a key factor for decision making in any plant. In this section, for analysis various inputs and parameters are specified, like project life time is 25 years, loan term is 20 years with the rate of 2%, inflation rate is considered 1%. With this input parameter as shown in table.5, the COE of the solar plant is coming 2.57 cent per kWh which is a comparable COE. The payback period is 16.9 years, which shows with 100% loan, the project is financially viable.

Table.5. Financial Parameters and Outcome

LOAN PARAMETERS	
Debt fraction (% of total installed cost)	100.00
Loan term (years)	20
Loan rate (%/year)	2.00
ANALYSIS PARAMETERS	
Analysis period (years)	25
Inflation rate (%/year)	1.00
Real discount rate (%/year)	5.50
Nominal discount rate (%/year)	6.56
TAX AND INSURANCE RATES	
Federal income tax rate (%)	7.00
State income tax rate (%)	2.00
Sales tax (% of direct costs)	0.00
Insurance rate (%/year)	1.00
Property Tax (%/year)	
Assessed percentage (% of total installed cost)	100.00
Assessed value ($)	99,523
Metric	**Value**
Levelized COE (nominal)	2.57 ¢/kWh
Levelized COE (real)	2.33 ¢/kWh
Electricity bill without system (year 1)	$1,091
Net savings with system (year 1)	$5,043
Net present value	$17,786
Payback period	16.9 years
Net capital cost	$99,523
Debt	$99,523

5. Conclusion

The performance 100 kW PV plant is analysed for Chandigarh, India. The annual production and performance ratio of 156120kW and 76% respectively shows that the project is comparable to established PV plants in similar climatic condition. The COE of the plant is low and payback period is

ensuring the return on investment. With above outcome, it can be concluded that this project is suitable and will reduce the dependency on the conventional non-renewable plants.

References

[1] Goura, R., 2015. Analyzing the on-field performance of a 1-641 megawatt-grid –tied PV system in South India. Int. J. Sustainable Energy 34, 1–9.

[2] Sudhakar, K., Srivastava, T., Satpathy, G., Premalatha, M., 2013. Modelling and estimation of photosynthetically active incident radiation based on global irradiance in Indian latitudes. Int. J. Energy Environ. Eng. 4 (21), 2–8.

[3] Ministry of New and Renewable Energy, Solar energy in India. February 12, 2014.

[4] Makrides, G., Zinsser, B., Norton, M., Georghiou, G.E., Schubert, M., Werner, J.H., 2010. Potential of photovoltaic systems in Countries with high solar irradiation. Renewable Sustainable Energy Rev. 14, 754–762.

[5] Amit Agrawal, Ashish Shrivastava, Kartick C. Jana, "Uniform Model and Analysis of PWM DC-DC Converter for Discontinuous Conduction Mode", IETE journal of Research, Vol. 64, issue-4, 2018, pp. 569-581.

[6] Bhim Singh and Ashish Shrivastava, "Buck converter based power supply design for low power light emitting diode lamp lighting," IET Power Electronics, vol. 7, no. 4, pp. 946-956, 2014.

[7] Ayompe, L.M., Duffy, A., McCormack, S.J., Conlon, M., 2011. Measured performance of a 1.72 kW rooftop grid connected photovoltaic system in Ireland. Energy Convers. Manage. 52, 816–825.

[8] Besarati, S.M., Padilla, R.V., Goswami, D.Y., Stefanakos, E., 2013. The potential of harnessing solar radiation in Iran: generating solar maps and viability study of PV power plants. Renew. Energy 53, 193–199.

[9] Elhodeiby, A.S., Metwally, H.M.B., Farahat, M.A., 2011. Performance analysis of 3.6 kW Rooftop grid connected photovoltaic system Egypt. In: International Conference on Energy Systems and Technologies, Cairo, Egypt, CEST 2011, 11–14 March.

[10] IEA (International Energy agency) Country report on analytical monitoring of photovoltaic systems IEA PVPS Task13, 2014

[11] Labed, S., Lorenzo, E., 2004. The impact of solar radiation variability and data discrepancies on the design of PV systems. Renew. Energy 29, 1007–1022.