Performance Analysis of Grid Connected Solar Captive Power Plant

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Abstract: The Indian government introduced different schemes and programmes for promotion of solar power plant across the country for domestic and commercial purposes as a part of green energy program. In this case study we are considering 75kWp grid connected solar power plant in odisha for analysing the performance of solar power plant. The performance of solar power plant depends on different parameters like location of plant, type of load, load demand, integrated other sources etc. In this paper we are analyzing the performance of 75kWp solar power plant in grid connected plant is compare with the simulation analysis.

Keywords : Solar power plant, Grid connected , performance ,simulation

I. Introduction: Solar Energy is a transformative solution to meet energy demand in present and future India. As government of India has main concern about global warming and environmental pollution from conventional sources [1]. The Government have introduce many programme for fulfil the electricity demand through clean energy sources like solar, Wind, Hydro, biomass at substitute of coal. Under same path for implement more solar power to fulfil the demand government introduces different schemes to benefit the domestic and commercial consumers. Solar Energy is considered as one of the most auspicious solutions to fulfil the electricity demand in present and future through ON-Grid or OFF-Grid mode.
In India, captive uses of solar power plant are playing major role in the development of the country as a back bone. Government of India introduces different schemes for implementation of solar power on roof tops of the captive use to fulfil the electricity demand . Under captive use programme across the country many Educational intuitions have come forward to set up the Solar Power plants on rooftops for their electricity demand[2][3].
In this case study, we are considering the educational intuition with 75kWp solar power plant in , Odisha, India. The solar power plant is working in grid connected mode through Net-meter. In this paper, we are discussing System model and Geographical location in section-II, , Simulation analysis in Section-III and in section-iv Performance analysis of 75kWp Grid Connected solar captive power plant & at final we are concluding the paper[2][4].

II. Geographical location and System Model

a) Geographical location: Solar Power Plants utilize the maximum solar radiations throughout the year for power generation. Odisha have around 280-300 sunny days with solar radiations of 4.5-6kWh every day. The electrical power generation of solar power plant depends on the geographical location, temperature, solar radiations etc. The geographical location of considered educational institution is 21°55`N, 86°95`E. The solar Power plant is installed on Flat roof with Tilt angle 19° for captive use. The solar power generation analysis is carried out based on RET Screen Expert Software [2][5]. The analysis carries out the study of Daily solar radiations, wind speed and temperature on given site throughout the year as given in Table-1.

Table-1: Geographical parameters of educational intuitions ,Odisha, India *(source RET Screen Expert)*

Month	Air Temperature (°C)	Relative Humidity %	Daily Solar Radiation Horizontal kWh/m²/d	Atmospheric pressure kPa	Wind Speed m/s	Earth Temperature (°C)
January	20.0	67.0%	4.40	99.8	1.2	21.9
February	23.4	66.6%	5.03	99.6	1.4	26.0
March	27.3	66.0%	5.63	99.3	1.8	30.6
April	29.7	68.2%	6.11	99.0	2.2	31.4
May	30.5	71.7%	5.95	98.6	2.0	30.8
June	29.8	77.7%	4.45	98.3	1.8	29.5
July	28.9	81.4%	3.92	98.4	1.6	28.2
August	28.6	82.9%	3.77	98.5	1.5	27.9
September	28.5	82.5%	3.95	98.8	1.2	27.6
October	27.4	78.0%	4.44	99.3	1.1	26.0
November	23.8	69.4%	4.31	99.7	1.1	23.8
December	20.3	65.2%	4.25	99.9	1.2	21.7
Annual	26.5	73.1%	4.68	99.1	1.5	27.1

b) System Architecture: Solar Power Plant 75kWp at educational intuition are connected to common Bus-Bar for captive utilization by Integration with Utility Grid through Net-Metering policy as shows in Figure 1.

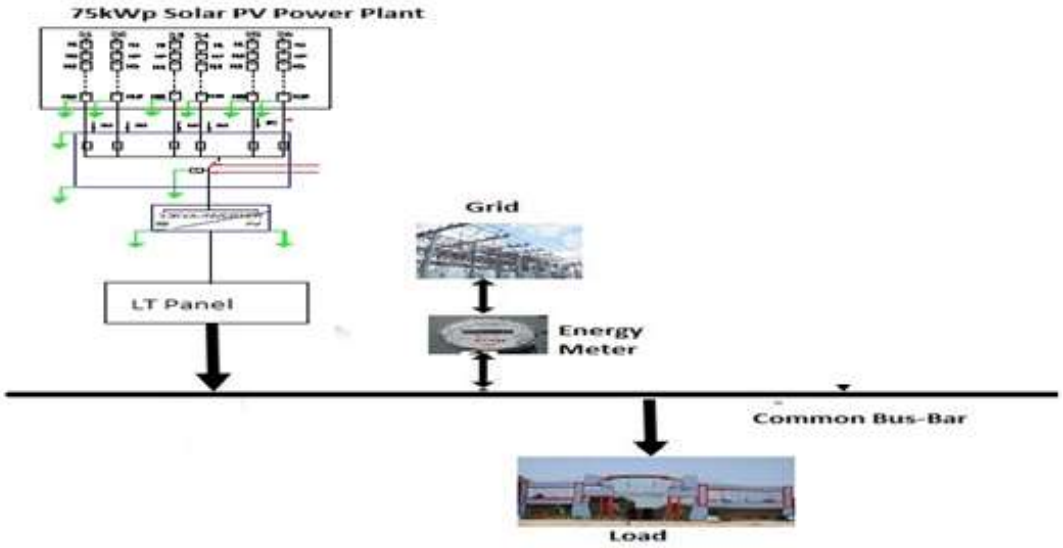

Figure-1 System architecture of grid connected captive solar power plant

The captive Solar Power Plant generates the direct DC Power from with sun's radiations through PV modules. The PV Modules are feeding DC to string-inverter for converting the DC Power into AC, which is feeding to common captive distribution panel [2].

ii. Simulation analysis for 75kWp captive solar power plant

The 75kWp captive solar power plant generation analysis for given educational intuition based on the based on predictive models from NREL, USA is given in table-2

Table 1: Predicted energy output of 2MW solar power plant:

Station Identification		PVWatts Monthly Performance Estimate		
Location:	Odisha	Month	Solar Energy on ground (kWh/m^2/day)	AC Energy (kWh)
Latitude:	21.55 °N	1	5.67	9,595
Longitude:	86.95 °E	2	5.98	8,769
		3	6.35	10,047
		4	6.53	10,211
PV System Specifications		5	6.01	9,883
DC Rating:	75kW	6	4.99	8,157
Derate Factor:	0.86	7	4.64	7,934
AC Rating	64.5 kVA	8	4.94	8,405
Slope type:	Fixed tilt	9	4.98	8,165
		10	5.56	9,311
		11	5.77	9,300
		12	5.09	8,726
		Annual	5.54	108,503

III. Performance analysis of 75kWp Grid Connected solar captive power plant

As discussed in above section the captive solar power plant generation depends on the solar radiations on plant location, which may not constant throughout the day or month or year. Due to uncertainty in solar power generation, load needs to integrate with grid to fulfil the demand and other side, we are using Grid Inverter for converting DC to AC. In case of grid-inverter, reference voltage and frequency is required for inverter operation. In Educational institute, which normally runs from morning 9.00AM to 5.00PM daily, this time is the maximum load demand period. The institutions have Maximum contract Demand of 110kVA from utility through 200kva transformer. From 5.00PM to 9.00AM maximum load demand is only for Hostels. This is around 15kWh. The maximum number of working days in one year is 278 days. Other 87, days the maximum average load is around 20kW. The load duration curve for is shown in Figure-2[2][3][6].

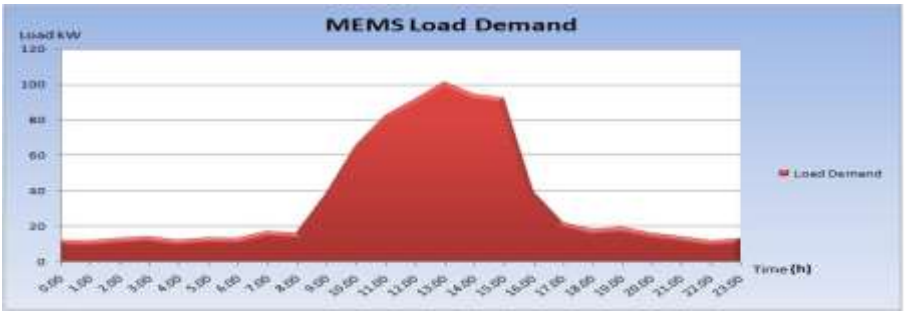

Figure-2 Daily Load duration curve

From above graph the peak load demand from 11.00AM to 4.00PM and average load is:

$$Daily\ Average\ Laod = \frac{kWh\ in\ one\ day}{24} \quad (1)$$

$$\boldsymbol{Daily\ Average\ Laod = 20.05\ kW}$$

$$Load\ Factor(LF) = \frac{Average\ Demand}{Maximum\ Demand} \quad (2)$$

$$\boldsymbol{Load\ Factor(LF) = 15.66\%}$$

Total load demand is sharing on captive solar PV plant and grid through 200kVA transformer. The Figure-3 is shows the daily generation of solar power plant and Figure-4 shows import/Export of Electrical power from grid in case if load demand is higher or less that of PV generation. Figure-5 shows total load sharing with PV Solar power plant with grid.

Total Power demand $P_D = P_V + P_{Grid}$ (3)

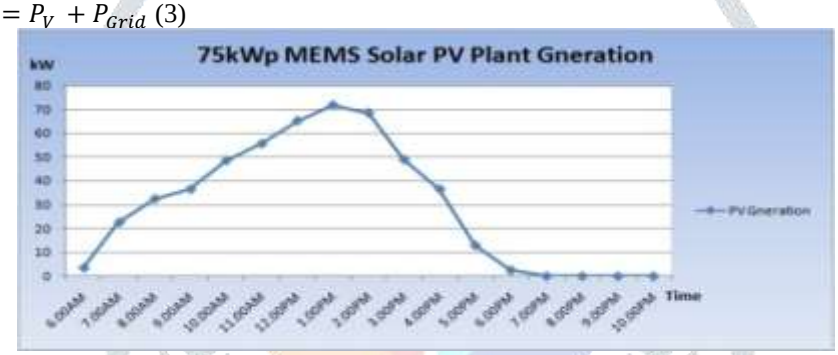

Figure-3 Daily Captive solar PV Plant Generation

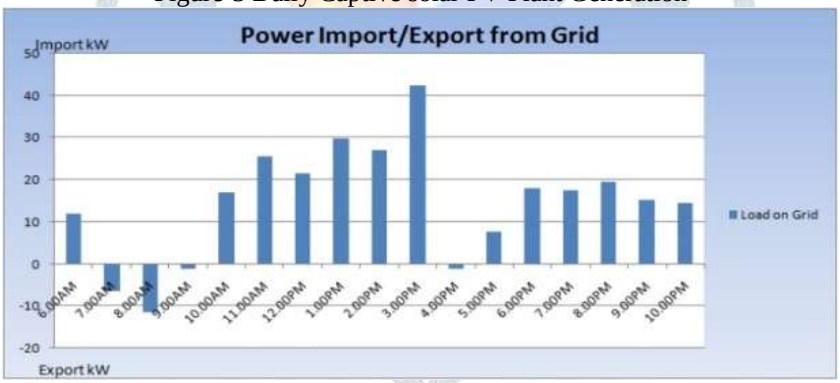

Figure-4 import/Export From grid

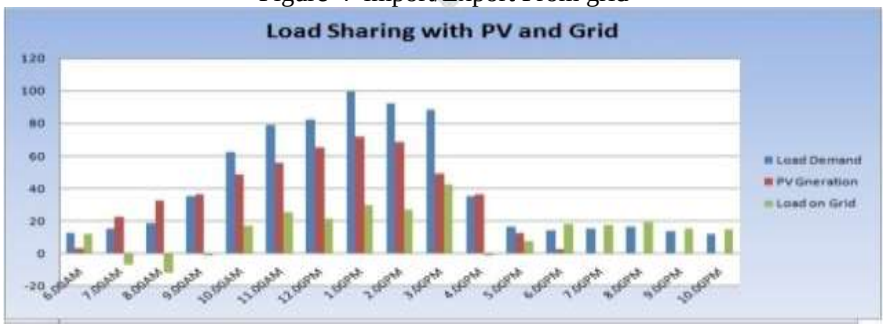

Figure-5 Load Sharing with captive PV solar plant and Grid

IV. Conclusion

This paper analyses the performance of captive 75kWp solar PV power plant in grid connected mode for educational intuitions in Odisha . The study explains different geographical location parameters for captive solar power generation and system model architecture of 75kWp solar plant on grid mode. The study explains the simulation study for given location and prediction generation of captive power plant at given location and it is also explain the load sharing on captive solar power plant and Grid in

grid based on the load demand . The Captive Solar PV plant is contributing for green energy source for domestic and commercial user for fulfil the electrical demand.

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