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PERFORMANCE ANALYSIS AND SEASONAL MODULATION OF LOAD GRID CONNECTED PHOTO-VOLTAIC SYSTEM USING PVSYST

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Abstract: Photo Voltaic systems are presenting an alternative source for production of electricity in a sustainable way. Photo voltaic systems present an optimal solution to growing green house emissions which are depleting ozone layer, one of the major concerns in today's world. Photo voltaic system in the form of grid connected system reduces carbon emission by 13.33%. The analysis of grid connected system of 15 kW includes total energy output, detailed losses, seasonal load variation, efficiency, total irradiance, transposition factor and performance ratio. Its performance depends on orientation of PV array, horizon, irradiance, shading, the local climate, and inverter performance.

Keywords—grid, photo voltaic system, seasonal load variation, performance.

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INTRODUCTION

Photovoltaic systems convert solar energy which is derived from radiant light and heat from the Sun, into Direct Current Electricity by Photo Voltaic Effect. PV systems consist of solar panels which are composed of solar cells electrically connected and mounted on a supporting structure. The grid connected photo voltaic system consist of solar panels, one or several inverters, power conditioning unit and load in the form of grid. The solar energy collected by the solar panel is converted and regulated, and then given to inverter which is connected to the power grid. This inverter is placed between the solar array and the grid, draws energy from each, and monitors grid voltage, waveform, and frequency. Grid connected photo voltaic systems are being used as residential and commercial rooftop systems with capacity ranging from 5kW to 20 kW. The grid connected PV system supplies power as per consumer requirement and excess power is fed to the grid which can be used by other users. The daily loads such as lamps, computers, fans, domestic appliances and standby power are a part of a small commercial building. The energy consumed can be calculated on the basis of usage in hours per day. The maximum consumption is during summer whereas minimum during winter.

I. Solar potential assessment

The characteristics of grid connected PV system can be analyzed using PVsyst software which predicts the energy production taking into account the amount of irradiance and shading effects. PVsyst software gives quick evaluation of potentials and possible constraints of a project.

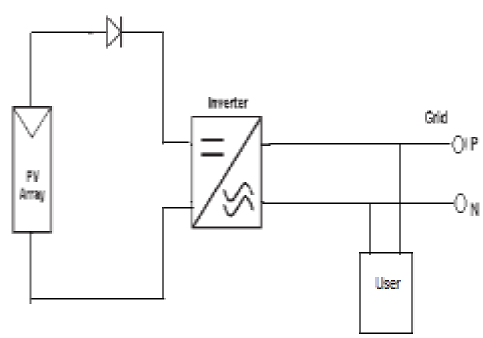

Figure 1. Grid Connected PV system

The PVsyst software provides full analysis of project, accurate System yield computed using detailed hourly simulation. Different simulation variants such as orientation i.e., tilt angle, azimuth angle, sizing of PV array, inverters with number of MPPT features and number of strings and modules can be performed and compared. Horizon analysis for different places can be analysed. Additionally economic evaluation with real component pricing can be done. Carbon balance is calculated on the basis of life cycle emissions of components being used in photo voltaic system. The simulation of grid connected system for residential building at New Delhi is presented in this paper. The meteorological details of the plant are generated from the pre-set data in the software. The above details are to be given to get the amount of irradiance at the solar photo voltaic plant.

TABLE I. GEOGRAPHICAL PARAMETERS OF NEW DELHI

Place	Latitude	Longitude	Altitude
New Delhi	77° 12’	28° 32’	219 m

Fig. 2 shows the tilt angle and orientation for the grid connected solar PV plant at New Delhi. The PV panel is of fixed tilt plane type. To get maximum solar irradiation the tilt angle should be kept equal to the longitude of the corresponding location. So the optimum tilt angle for this site is 30°. The azimuth angle indicates the orientation of the panel with respect to southern direction. The azimuth angle for this site is 180°. By reducing the tilt angle the performance ratio and energy output increases further.

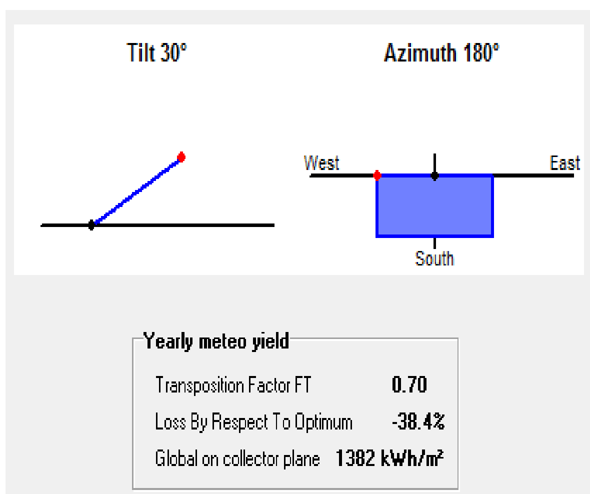

Fig. 2. Orientation of PV array

The transposition factor is defined as the ratio of the incident irradiation to the horizontal irradiation on the collector plane. The transposition factor with respect to summer season(Apr-Sep) is 0.87 and with respect to winter season (Oct-Mar) is 0.48, loss at optimum point is -13.6% and -66.8%, global incident energy is 975 kWh/m^2 and 406 kWh/m^2 respectively. In summer season the transposition factor and losses are increased whereas in winter season both are reduced.

The system specifications include the type of module that is used, definition of PV array, operating conditions and system parameters. The PV panel is of Poly-crystalline type with peak power rating of 120 Wp, 14V. This determines the size of the module by the PVsyst software. The determined size of module and strings is in the form of 16x8, in series that is 128 modules covering an area of 128 m^2. To eliminate overload loss the ratio of power rating of PV array and inverter should be greater than 1.The number of inverters is 4 with a rating of 3 kW and an operating voltage of 125-440 V. The inverter selected should neither make the system oversized nor undersized. The minimum peak current of inverter should be slightly less than array. The maximum irradiance obtained is around 1000 W/m^2. The Global System Summary can be explained in table II:

TABLE II. GLOBAL SYSTEM SUMMARY

GLOBAL SYSTEMS	SPECIFICATION
Module Type	Poly-crystalline
No. of Modules	128
Module Area	128 m^2
No. of Inverters	4
Nominal PV Power	15.4 kW_p
Maximum PV Power	12.3 kW_{dc}
Nominal AC Power	12 kW_{ac}
MPP Voltage	273 V
MPP Current	58.9A

The inverter is of generic type with 2 MPPT inputs. The optimum nominal power of inverter/array should be approximately 1.25 for maximum efficiency. In PVsyst, the inverter sizing is based on an acceptable overload loss during operation, and therefore involves estimations or simulations in the real conditions of the system (meteo, orientation, losses).

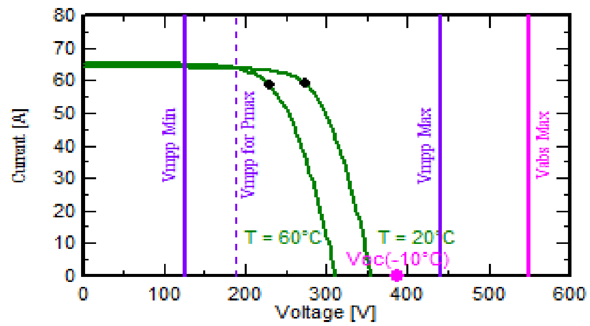

Fig. 3. Array and inverter voltage sizing

The number of modules in series should be set in a PV panel such that the minimum array operating voltage should be above the minimum inverter's operating voltage and the maximum array operating voltage should be below the maximum inverter's operating voltage. The peak power rating of inverter is slightly less than the PV array panel to reduce power losses, DC limit, and the inverter will stay at its safe nominal power. Therefore it will not undertake any overpower and there is no power to dissipate, no overheating and therefore no supplementary ageing.

II. Performance Analysis

The PVsyst software analyzes all the input data given and on simulation, results are generated with the computation model of grid connected PV panel. The annual global irradiation is 1973.5 kWh/m^2. The global incident energy on collector plane is 1374.8 kWh/m^2. The energy at output of the array is 17.509 MWh and the efficiency of the PV system is 12.40. The performance ratio of the PV system placed at New Delhi is 0.8. The average ambient temperature is 24.66°. The transposition factor which indicates the energy on collector plane is 0.70. The annual losses in the form of ohmic losses, module quality losses, and module mismatch losses, Incident angle Modifier (IAM) is 33.6%.

The power versus voltage at different temperature and irradiance values can be plotted. The curve is a parabola with decreasing magnitude as the irradiance decreases. As the voltage increases the power of array also increases until an optimum point is reached, and then decreases as the voltage further increases. This can be depicted in fig. 4. Graphs of current versus voltage, efficiency versus incident global energy can also be plotted for varying temperature and irradiance values.

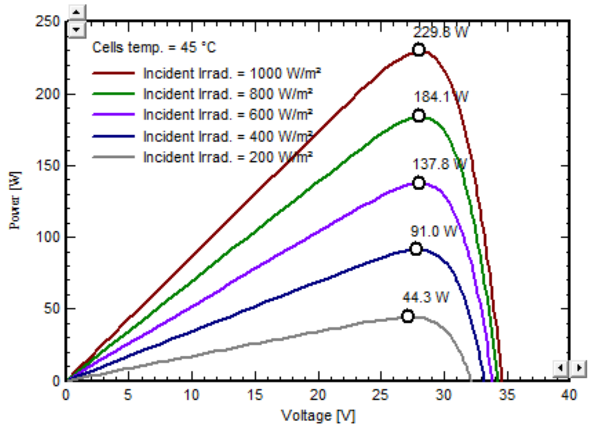

Fig. 4. Power versus voltage

The seasonal modulation of a commercial building having fixed load can be calculated using PVsyst software. A commercial building having 12 fluorescent lamps, 12 fans, 20 personal computers can be simulated over different seasons in the year 2014 according to usage with respective power ratings as represented in the following table III.

TABLE III LOAD USAGE OVER DIFFERENT SEASONS Summer (Jun-Aug)

Use 5 days a week	Number	Power	Use	Energy Wh/day
Fluorescent lamps	12	18 W/lamp	4 h/day	864
PC		75W		
Fans Fridge	20	40 W	8 h/day	12000
Stand by consumers	12		8 h/day	3840
	1		600 Wh/day	600
		100W	24 h/day	
				2400
Total daily energy				19704 Wh/day

Autumn (Sep-Nov)

Use 5 days a week	Number	Power	Use	Energy Wh/day
Fluorescent lamps	12	18 W/lamp	4 h/day	864
PC		75W		
Fans	20	40	8 h/day	12000
Fridge	12		6 h/day	2880

Stand by consumers	1		600 Wh/day	600
		100W	24 h/day	
				2400
Total daily energy				18744 Wh/day

Winter (Dec-Feb)

Use 5 days a week	Number	Power	Use	Energy Wh/day
Fluorescent lamps	12	18 W/lamp	8 h/day	1728
PC		75W		
Fans	20	40 W	8 h/day	12000
Fridge	12		1 h/day	480
Stand by consumers	1		600 Wh/day	600
		100W	24	
				2400
Total daily energy				14808

Spring (Mar-May)

Use 5 days a week	Number	Power	Use	Energy Wh/day
Fluorescent lamps	12	18 W/lamp	4 h/day	864
PC		75+		
Fans	20	40	8 h/day	12000
Fridge	12		6 h/day	2880
Stand by consumers	1		600 Wh/day	600
		100W	24 h/day	
				2400
Total daily energy				18744 Wh/day

The yearly load curve can be depicted in fig. 5

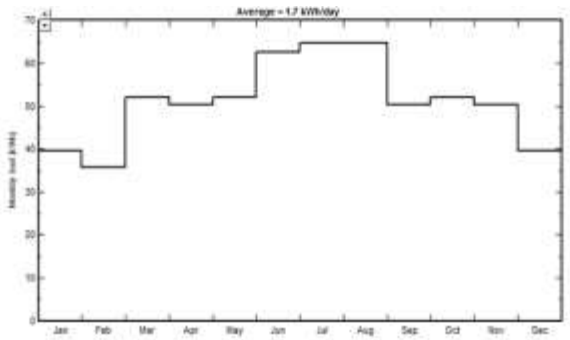

Fig. 5. Load curve for yearly yield

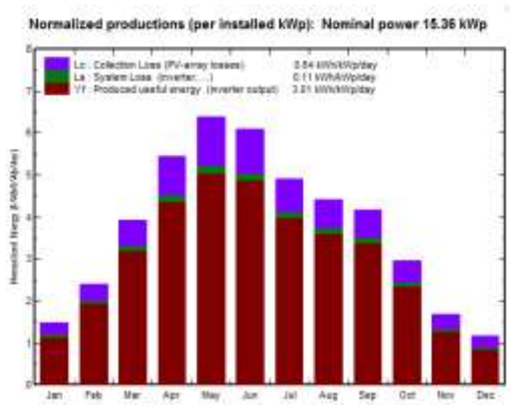

Fig. 6. Energy Output throughout year

Fig. 6 represents the total energy output throughout the year which is 3.01 kWh/day, collection loss which is 0.64 kWh/day and system or inverter loss which is 0.11 kWh/day. The Solar Potential Assessment of grid connected solar Photo Voltaic system located at New Delhi can be summarized in table V.

Location	New Delhi
Energy Production (MWh/year)	17.509 MWh
Performance Ratio	0.8
Transposition Factor	0.70
Annual losses (%)	33.6
Global Incident Energy on collector plane	1374.8 kWh/m^2
Efficiency of PV array (%)	12.40

The maximum load consumption is in summer and minimum in winter. The average load consumed is 5409 kW in a year. The rest of the energy can be supplied to the grid which is available for other users. The maximum usage is 19704 W/day and minimum is 14808 W/day.

Conclusion

The PVsyst software helps in modelling an efficient grid connected PV system by reducing the effects of shading. It also provides an optimal orientation angle to maximize the total energy output. The maximum solar irradiation is obtained at an angle of 30°, which is nearly equal to the longitude of the site at New Delhi. The efficiency of the solar panel of 15kW at New Delhi is 12.40% and total energy output is 17.509 MWh/year. The performance ratio gives the amount of efficiency of conversion which is 0.8 for this site. The load consumed by the commercial building is supplied by the PV system and the excess load is supplied to the grid for other uses. The overall losses can be reduced by maintaining nominal power ratio of inverter and array below 1.25.The efficiency of grid connected PV system can be improved by varying irradiance and temperature of modules of a PV panel. The irradiance can be improved by optimizing tilt angle of PV array and proper sizing of array and the temperature dependence of modules can be improved by using more efficient semi conductor material.

REFERENCES

1. T.M. Iftakhar Uddin, Md. Zakaria Mahbub, "Computational Modelling of a grid connected system using PVsyst software", Int. J. of Scientific and Engineering Research, vol. 3, 2012.
2. Ashok Kumar, N.S. Thakur, Rahul Makade, Maneesh Kumar Shivhare, " Optimization of Tilt Angle for Photo Voltaic Array", Int. J. of Engineering Science and Technology, vol. 3, 2011, pp. 3153- 3161.
3. Husnain-Al-Bustam, Md.Zakaria Mahbub, M. M. Shuvro Shahriar,T.M. Iftakhar Uddin and Md.Abrar Saad, "Analysis of a Standalone Photovoltaic Power Generation System Using PVSyst Software", Global J. Inc. , vol. 12, 2012.
4. C.W Sauer, K.J. Yingli Roessler, T. Hansen., "Modeling the Irradiance and Temperature Dependence of Photovoltaic Modules in PVsyst", IEEE J. of Photovoltaics, vol. 5, 2014.
5. Sara M. MacAlpine, Robert W Erickson and Michael J. Brandemuehl, "Characterization of Power Optimizer Potential to Increase Energy Capture in Photovoltaic Systems Operating Under Non uniform Conditions", IEEE Trans. on Power Electronics, vol. 28, 2013.
6. www.pvsyst.com version 6.3.8.