A Computational Study on the Effect of Different Parameters on Performance of Standalone Solar Photovoltaic Panel

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Abstract: ***The photovoltaic solar power is a form of renewable energy which one of the most promising energy in the world. It is also the cleanest form of energy. But the implementation of a PV system has shown that their reliability and efficiency depend upon many factors. Effect of different factors like tilt, type of panel, irradiance etc., on output of PV plant is investigated in this study. PVSYST simulation facility is to be used for design and optimization. A computation has been conducted to verify the change in i-v and p-v characteristics of the system. PV plant at the location of Delhi NCER is designed and effect of factors is studied. Result shows PV plant at location of Thiruvanantpuram without shading will give more inverter output than with shading.***

Keywords: Grid-connected solar PV system, PVsyst software, Irradiance, Electricity, New Delhi

1. Introduction

Energy is a vital requirement to sustain and improve the standard of our daily lives. With the exponential growth in population, rapid spread of technology and advancement of globalization, energy consumption in the developing countries like India, is rising at a very fast pace. Like many of the developing countries, India is also facing an immense shortage of energy. The photovoltaic solar is a form of solar energy also the cleanest form of energy use all over the Globe But the implementation of a PV system has shown that their reliability and efficiency depend upon many factors. The output of solar PV system is mainly affected by different environmental factors like panel, tilt, irradiance, shading, etc, because in all the cases, the output power and efficiency are more rather than affected condition, because in all the cases, the output power and efficiency are more rather than affected condition.

Various studies have done on design of solar power plant on different location over the globe. Mona Al Ali et al 2013 presented the results obtained from simulated performance monitoring of seven different roof mounted PV systems in Abu Dhabi, the largest of UAE's emirate. Data were analyzed to evaluate the suitability of PV systems for installations in different types of buildings in the UAE. The PV systems consisted of amorphous silicon (a-Si) and polycrystalline silicon (p-Si) PV technologies. Different performance evaluation parameters are presented. Deepali Sharma et al 2014 gives design idea of optimized grid connected solar PV plant proposed at Bhopal. And a comparison has been made among results obtained after using three technologies available for modules poly crystalline silicon, mono crystalline silicon and a-siH thin film. Thus using actual data for both loads and irradiance is used for simulation of grid connected PV, done with the use of computer software package PVsyst 5.53. Analysis of results goes in favor of polycrystalline silicon technology. Petros J. et al 2014 presented the calculative accuracy of TRNSYS, Archelios, Polysun, PVSyst, PV*SOL and PVGIS and examined in comparison to the real electrical energy generated by a grid-connected 19.8 kWp photovoltaic installation. The assessment has been performed by using the climatic data which have been recorded at the site of the real PV Park over the same calendar year. Jaydeep V. Ramoliya et al 2015 presented the simulation of a grid-connected solar photovoltaic system with the use of the computer software package Pvsyst and their performance was evaluated. The maximum solar irradiation is achieved at a tilt angle of 22degree (for shapur) which is nearly equal to the latitude of that location (21degree28minute) and no shading effect is considered. For 1MW Grid connected solar PV system Energy injected to grid is 1416980kWh and the performance ratio is 0.764 and the various power losses are calculated. Elieser Tariga et al 2015 simulated the feasibility of installing a grid-connected photovoltaic (PV) system in a typical residential in Surabaya, Indonesia. The study was conducted to evaluate the technical, economic and environmental aspects of PV system for supplying of household electricity energy needs. A 1 kWp grid-connected PV system simulation is carried out with PVsyt and RET Screen software. The simulation expected to help in demonstrating the advantages and challenges of installing of a grid-connected PV system for residential in Surabaya. Sangeetha. S 2014 investigated the sizing the solar power plant in standalone mode of operation. Based on the load survey and the utilization factor, the capacity of the plant is determined for battery sizing and PV sizing. PVSYST and C programming are used for the sizing of the solar PV power plant. The total load is 14 kW. The total energy consumption is 66.196kW-hour. Considering the utilization factor 0.7, the effective load is 9.8kW. In the girls hostel mess the total load is 11kW. Jones K. Chacko2015 compared different panel arrangement that will minimize the floor area and maximize power generation through tracking the sun. The maximum generation was obtained from a three layer solar PV System with dual axis tracking system. By this arrangement we can reduce the space requirement to 58% to generate maximum energy. C.P. Kandasamy et al 2013 presented the simulation of a grid-connected solar photovoltaic system with the use of the computer software package Pvsyst and their performance was evaluated. Result shows For 1MW Grid connected solar PV system, the energy production is maximum in Tuticorin

(1523MWh/Year) as compared to other locations such as Madurai (1414 MWh/year), Sivagangai (1335 MWh/year) and Sivakasi (1398 MWh/year.By literature review it is clear that study the effect of environmental factors on different PV arrangements is needed in India. To investigate the effect of environmental factors like, irradiance, shading, on different PV system arrangements for standalone system in New Delhi region, India. To investigate the performance on the basis of change in i-v and p-v characteristics of the PV system. PVsyst is a simulation program able to simulate both stand alone and grid connected PV systems [7]. It provides the design proposals (Area required, module size, inverter size etc.). PVsyst performs the simulation on the basis of power required or available area[1]. It consists of input radiation meteo files of many locations in itself and can be import from NASA-SSE Worldwide [1,3,5].

2. Research Procedure

The efficiency of a solar PV plant is highly depends on the azimuth angle and tilt angle of PV modules. So these are adjusted in such a manner to get maximum irradiance from the sun and albedo factor taken for this study is 0.2.To validate the paper location at thiruvanantpuram has been taken. Validation is done on the basis of ‘Techno-Economic Simulation of a Grid-Connected PV System Design as Specifically Applied to Residential in Surabaya, Indonesia’ Elieser Tarigana 2015.

Geographical Location and Meteorology: Geographical location provides the (x,y,z) co-ordinates of a site that is latitude, longitude and altitude which defines the position of a point on the earth and time zone [1,3,8].

Table 1: Location Details

Country	Indonesia
City	surabaya
Latitude	7.19 S
Longitude	112.5 E
Altitude	3 m.
Time Zone	7 hr.

Meteo file consists complete information of geographical site parameters that is horizontal global, beam and diffusive irradiations, ambient temperature and wind velocity (If available).General parameter for pvsyst simulation

Parameter	*Paper Input Values*	*My Input Values*
Site	Surabaya	Surabaya
Field Type	Fixed tilted plane	Fixed tilted plane
Field parameter	Plane tilt 15°, azimuth0.0 (facing south)	Plane tilt 15°, azimuth0.0 (facing south)
Simulation(data)	Generic meteo data	Generic meteo data
PV modules	Gepv-100	Gepv-100
Number of modules	10 unit	10 unit
Unit power(one module)	100 w_p	100 w_p
Nominal power	1KW_p	1KW_p
Mpp Voltage	15.7v	15.7v
Mpp current	6.4a	6.4a
Inverter	BBS-1000	BBS-1000
Inverter unit power	1.0 KW	1.0 KW
Number of inverter	1unit	1unit
Pnom AC of inverter	1.00 KW	1.00 KW

Orientation of solar panels: In order to get maximum irradiance or to generate maximum power from PV system, PV panels should be in a specific direction. The PV panels may be fixed, sun tracking with one axis of rotation or sun tracking with two axis of rotation. Here we are assuming a fixed PV panel system. The tilt angle for a fixed solar panel is the angle of inclination from horizontal (It varies from 0^0 to 90^0)[4] .Azimuth angle is the angle between the direction in which panels are facing and south direction. The default Azimuth angle for the northern hemisphere countries is 0° (south-facing).So here azimuth angle is taken 0° and tilt angle is taken 30° to maximize the irradiance or to minimize the losses (set by using PVsyst).Fig 3 shows that transportation factor is 1.11.Transportation factor defines as the ratio of incident global irradiation to the horizontal globalirradiation.

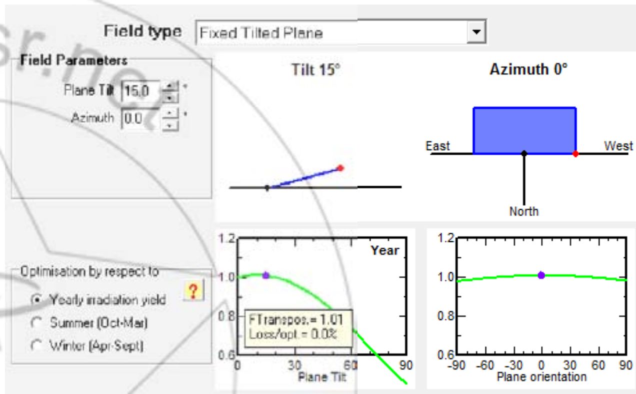

Figure 2: Tilt Angle and Optimization

Horizon and Near Shading: These two steps in the simulation are to calculate the shading effect but we are not assuming any shading in our project. Fig 4 shows the horizon line diagram for New Delhi region without shadings [2].

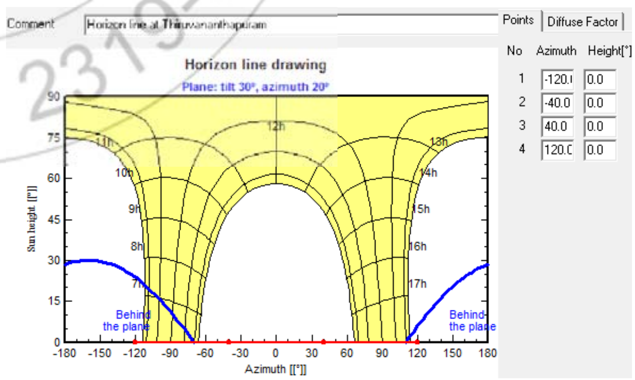

Figure 4: Horizon line Diagram

3. Results

Simulation of grid connected PV system consists of a large technical data i.e. balances, optical factors, system losses, inverter losses, normalized performance coefficients, normalized production etc.

System Balances: It includes horizontal global radiation, ambient temperature, incident global radiation, effective global radiation, and effective energy into grid, effective energy and efficiency at the output of array. All these data shown in table 5 on monthly as well as yearly basis.

Table 5: System Balances

New simulation variant

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	147.9	25.10	136.7	131.6	95.6	90.6	7.17	6.79
February	135.0	25.10	128.3	123.7	90.2	85.5	7.20	6.83
March	153.1	25.40	151.7	146.6	107.4	102.4	7.25	6.91
April	149.4	25.40	155.0	150.3	111.1	106.0	7.34	7.01
May	152.5	25.10	166.5	161.8	120.2	114.9	7.39	7.07
June	141.9	24.50	158.4	153.9	114.6	109.5	7.41	7.08
July	155.9	24.20	172.7	168.0	125.7	120.3	7.46	7.14
August	171.7	24.60	183.6	178.8	133.8	128.2	7.46	7.15
September	181.5	25.30	183.1	177.9	132.4	127.0	7.40	7.10
October	184.1	25.80	176.7	170.9	125.7	120.2	7.28	6.97
November	159.0	25.50	146.8	141.5	103.5	98.5	7.22	6.87
December	154.7	25.20	141.1	135.7	98.6	93.6	7.16	6.79
Year	1886.7	25.10	1900.6	1840.8	1358.7	1296.7	7.32	6.99

Energy Use: The detailed values of energy injected into grid on monthly as well as yearly basis are given in table 10. So the total energy production in a year is 3211.7 KWh.

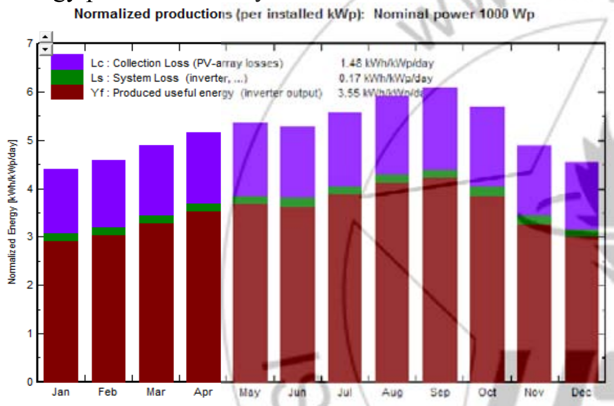

Figure 9: Total Energy Production

Normalized performance Coefficients: Table 11 contains reference incident energy in coll. Plane, normalized array losses, normalized array production, normalized system losses, normalized system production, array loss/incident energy ratio, system loss/incident energy ratio and performance ratio.

Table 11: Normalizes performance coefficient

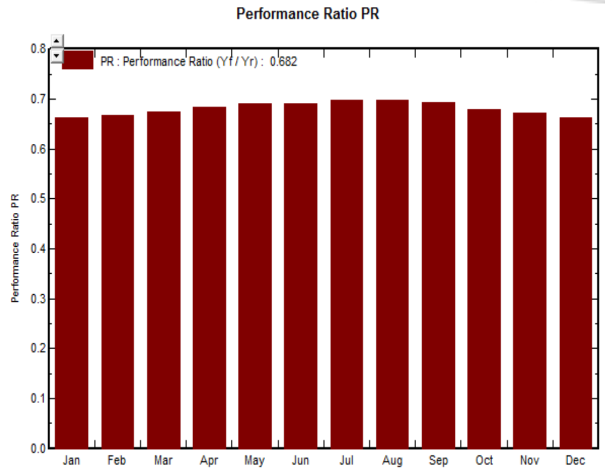

Figure 11: Performance coefficients

Comparison

Parameter	*Paper values*	*present*	*% Error*
Horizontal global Radiation	1886.8	1886.7	0.005
Ambient Temperature	27.72	25.10	9.45
Global incident in coll. plane	1884.7	1900.6	0.84
Effective global, coll. For IAM and shading	1826.2	1840.8	0.79
Array virtual energy at MPP	1428.2	1358.7	4.866
Effective energy at the output of the array	1366.0	1296.7	5.07
Energy supplied to the user	7.76%	7.32%	5.67

Effect of tilt angle: Location and Orientation

Project : Stand Alone Project at New Delhi

Geographical Site New Delhi Country India

Situation Latitude 28.6°N Longitude 77.2°E
Time defined as Legal Time Time zone UT+5.5 Altitude 219 m
Albedo 0.20

Meteo data: New Delhi MeteoNorm 7.1 station - Synthetic

Simulation parameters
Collector Plane Orientation Tilt 5° Azimuth 0°
Models used Transposition Perez Diffuse Perez, Meteonorm

PV Module

PV Array Characteristics
PV module Si-poly Model **Poly 190 Wp 54 cells**
Original PVsyst database Manufacturer Generic
Number of PV modules In series 1 modules In parallel 4 strings
Total number of PV modules Nb. modules 4 Unit Nom. Power 190 Wp
Array global power Nominal (STC) **760 Wp** At operating cond. 676 Wp (50°C)
Array operating characteristics(50°C) U mpp 23 V I mpp 29 A
Total area Module area **5.9 m²** Cell area 5.2 m²

PV Array loss factors
Thermal Loss factor Uc (const) 20.0 W/m²K Uv (wind) 0.0 W/m²K / m/s
Wiring Ohmic Loss Global array res. 13 mOhm Loss Fraction 1.5 % at STC
Serie Diode Loss Voltage Drop 0.7 V Loss Fraction 2.7 % at STC
Module Quality Loss Loss Fraction 1.5 %
Module Mismatch Losses Loss Fraction 2.5 % (fixed voltage)
Incidence effect, ASHRAE parametrization IAM = 1 - bo (1/cos i - 1) bo Param. 0.05

Battery and Controller
Battery Model **Open 12V / 100 Ah**
Manufacturer Generic
Battery Pack Characteristics Voltage 24 V Nominal Capacity 500 Ah
Nb. of units 2 in series x 5 in parallel
Temperature Fixed (20°C)

Controller Model Universal controller with DCDC converter
Technology DC-DC converter Temp coeff. -5.0 mV/°C/elem
Converter Maxi and EURO efficiencies 97.0/95.0 % DC Input voltage 0.0V
Battery management control Treshold commands as SOC calculation
Charging SOC = 0.92/0.75 i.e. approx. 27.9/25.1 V
Discharging SOC = 0.20/0.45 i.e. approx. 23.6/24.4 V

Loads

Annual values

	Number	Power	Use	Energy
Lamps (LED or fluo)	5	15 W/lamp	12 h/day	900 Wh/day
TV / PC / Mobile	1	100 W/app	5 h/day	500 Wh/day
Domestic appliances	2	2 W/app	2 h/day	8 Wh/day
Fridge / Deep-freeze	1		24 Wh/day	1000 Wh/day
Dish- & Cloth-washers	1		4 Wh/day	9 Wh/day
Other uses	1	1 W tot	1 h/day	1 Wh/day
Other uses	1	1 W tot	1 h/day	1 Wh/day
Stand-by consumers			24 h/day	24 Wh/day
Total daily energy				2443 Wh/day

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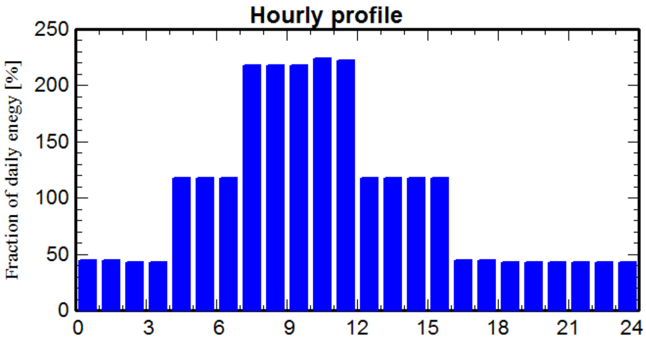
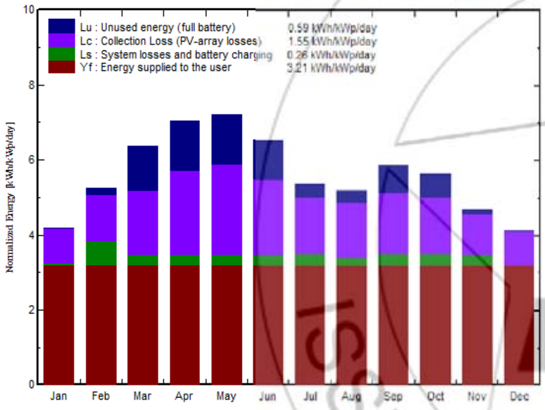


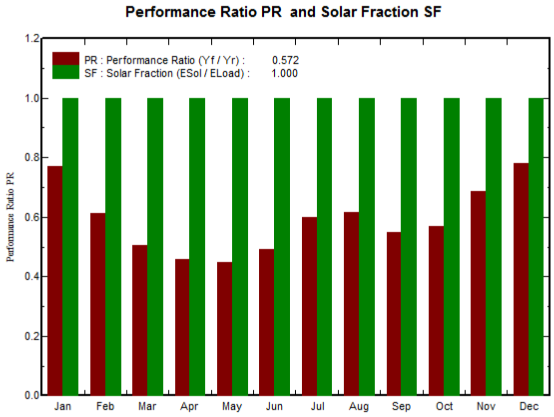
4. Results

Main system parameters	System type	**Stand alone**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	Poly 190 Wp 54 cells	Pnom	190 Wp
PV Array	Nb. of modules	4	Pnom total	**760 Wp**
Battery	Model	Open 12V / 100 Ah	Technology	vented, plates
battery Pack	Nb. of units	10	Voltage / Capacity	**24 V / 500 Ah**
User's needs	Daily household consumers	Constant over the year	global	892 kWh/year

Main simulation results				
System Production	**Available Energy**	**1091 kWh/year**	Specific prod.	1436 kWh/kWp/year
	Used Energy	892 kWh/year	Excess (unused)	165 kWh/year
	Performance Ratio PR	57.2 %	Solar Fraction SF	100.0 %
Loss of Load	Time Fraction	0.0 %	Missing Energy	0 kWh/year

Normalized productions (per installed kWp): Nominal power 760 Wp





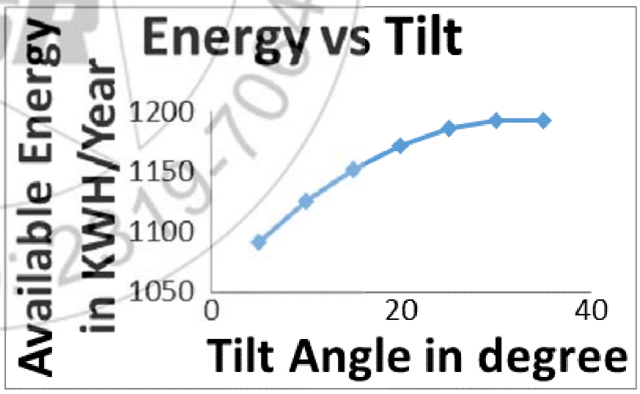
Balances and main results

	GlobHor	GlobEff	E Avail	EUnused	E Miss	E User	E Load	SolFrac
	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh	
January	118.2	124.0	73.7	0.00	0.000	75.73	75.73	1.000
February	137.0	142.1	82.7	3.89	0.000	68.40	68.40	1.000
March	188.2	190.9	106.6	27.30	0.000	75.73	75.73	1.000
April	206.5	205.0	106.7	29.97	0.000	73.28	73.28	1.000
May	222.1	216.5	109.9	30.68	0.000	75.73	75.73	1.000
June	196.5	189.5	100.3	23.68	0.000	73.28	73.28	1.000
July	166.4	160.5	86.9	8.10	0.000	75.73	75.73	1.000
August	159.9	155.7	85.1	7.81	0.000	75.73	75.73	1.000
September	170.6	170.3	93.7	16.36	0.000	73.28	73.28	1.000
October	164.5	169.0	94.5	14.79	0.000	75.73	75.73	1.000
November	128.5	135.0	78.8	2.41	0.000	73.28	73.28	1.000
December	115.1	122.3	72.4	0.01	0.000	75.73	75.73	1.000
Year	1973.5	1980.8	1091.3	164.99	0.000	891.62	891.62	1.000

Legends:

GlobHor	Horizontal global irradiation	E Miss	Missing energy
GlobEff	Effective Global, corr. for IAM and shadings	E User	Energy supplied to the user
E Avail	Available Solar Energy	E Load	Energy need of the user (Load)
EUnused	Unused energy (full battery) loss	SolFrac	Solar fraction (EUsed / ELoad)

Energy Production for different tilt angles



Effect of Field Type

Results

Sessional tilt summer/winter

Main system parameters	System type	**Stand alone**		
PV Field Orientation	Seasonal tilt: summer/winter	20°/50°	azimuth	0°
PV modules	Model	Poly 190 Wp 54 cells	Pnom	190 Wp
PV Array	Nb. of modules	3	Pnom total	**570 Wp**
Battery	Model	Open 12V / 100 Ah	Technology	vented, plates
battery Pack	Nb. of units	10	Voltage / Capacity	**24 V / 500 Ah**
User's needs	Daily household consumers	Constant over the year	global	890 kWh/year
Main simulation results				
System Production	**Available Energy**	**915.1 kWh/year**	Specific prod.	1605 kWh/kWp/year
	Used Energy	863.5 kWh/year	Excess (unused)	18.6 kWh/year
	Performance Ratio PR	65.2 %	Solar Fraction SF	97.0 %
Loss of Load	Time Fraction	2.7 %	Missing Energy	26.4 kWh/year

Shed deposition

Main system parameters	System type	**Stand alone**		
PV Field Orientation	Sheds disposition, tilt	30°	azimuth	0°
PV modules	Model	Poly 190 Wp 54 cells	Pnom	190 Wp
PV Array	Nb. of modules	3	Pnom total	**570 Wp**
Battery	Model	Open 12V / 100 Ah	Technology	vented, plates
battery Pack	Nb. of units	10	Voltage / Capacity	**24 V / 500 Ah**
User's needs	Daily household consumers	Constant over the year	global	890 kWh/year
Main simulation results				
System Production	**Available Energy**	**870.3 kWh/year**	Specific prod.	1527 kWh/kWp/year
	Used Energy	849.3 kWh/year	Excess (unused)	3.7 kWh/year
	Performance Ratio PR	66.6 %	Solar Fraction SF	95.4 %
Loss of Load	Time Fraction	4.2 %	Missing Energy	40.6 kWh/year

Sun Shield Deposition

Main system parameters	System type	**Stand alone**		
PV Field Orientation	Sun-shields disposition, tilt	30°	azimuth	0°
PV modules	Model	Poly 190 Wp 54 cells	Pnom	190 Wp
PV Array	Nb. of modules	3	Pnom total	**570 Wp**
Battery	Model	Open 12V / 100 Ah	Technology	vented, plates
battery Pack	Nb. of units	10	Voltage / Capacity	**24 V / 500 Ah**
User's needs	Daily household consumers	Constant over the year	global	890 kWh/year
Main simulation results				
System Production	**Available Energy**	**718.1 kWh/year**	Specific prod.	1260 kWh/kWp/year
	Used Energy	705.2 kWh/year	Excess (unused)	0.0 kWh/year
	Performance Ratio PR	55.3 %	Solar Fraction SF	79.3 %
Loss of Load	Time Fraction	19.3 %	Missing Energy	184.6 kWh/year

Comparison

Field Type	*Available electricity*	*Specific Production*
Fixed Tilted	1192	1568
Sessional Tilt	915	1605
Shed	870.3	1527
Sun Shield	718.08	1260

Effect of Panels

Panel	Available electricity	Specific Production
Si-MONO	858.4	1717
Poly-MONO	866.6	1733
a-Si H, Triple Junction	944.4	1736

5. Conclusion

1) Production of energy increases with increases of tilt angle up to 30 degree for above specification, maximum energy production is achieved at 30 degree.
2) Maximum electricity is available for fixed tilted type of field, and minimum electricity is available from sun shield type of field.
3) a-Si H, Triple Junction panel will give maximum production of energy.

References

[1] Elieser Tarigan, Djuwari, Fitri Dwi Kartikasari. Techno-Economic simulation of a Grid-Connected PV system

Design as specifically applied to Residential in Surabaya, Indonesia. Energy Procedia 2015;65: 90-99.

[2] Deepali Sharma, Anula Khare. Comparative Analysis of Solar PV modules. International Journal on Emerging Technologies 2014;5(2) 22-26.

[3] Jones K. Chacko, Prof. K. J Thomas. Analysis of Different Solar Panel Arrangements using PVSYST . International Journal of Engineering Research and Technology 2015;Volume 4,Issue 4.ISSN:2278-0181.

[4] Parvathy Suresh, Jaimol Thomas, Anu A.G. Performance analysis of a stand-alone PV systems using PVsyst. Proceedings of second IRF second International Conference on 10th August 2014, Cochin, India, ISBN:978-93-842-09-43-8.

[5] C.P. Kandasamy, P. Prabu, K.Niruba. Solar potential Assessment using PVsyst Software.International conference on Green Computing, Comunication and conservation of Energy(ICGCE) 2013, 978-1-4673-6126-2/13

[6] Maharaja .K, Sangeetha .S, Mareeswari. K. Sizing of Solar PV Power Plant in Stand-Alone Operation. . International Journal of Engineering Research and Technology 2014; Volume 3,Issue 6.ISSN:2278-0181.

[7] http://www.pvsyst.com/images/pdf/PVsyst_Tutorials.pdf

[8] Petros J Axaopoulos, Emmanouil D Fylladitakis, Konstantinos Gkarakis. Accuracy Analysis of Software for the estimation and planning of photovoltaic installations. International Journal of energy and environmental engineering 2014, 5:1.