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Simulation Optimization and Parametric Study of a Grid Connected Solar Power Plant for Commercial Rooftop as well as on Utility Scale

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Abstract: As the nonrenewable energy sources is about to end, future of human energy needs is in renewable energy (solar, wind, hydro etc). Solar energy are using all over the globe at micro as well as utility scale. A wide variety of tools exist for the analysis and dimensioning of both Grid connected and stand-alone photovoltaic systems. System designers and installers use simpler tools for sizing the PV system. Mostly scientists and engineers typically use more involved simulation tools for optimization. In present study design, optimization of a grid connected solar power plant at commercial rooftop as well as on utility scale in INDIA is to be discussed. Design, simulation, Optimization is going on simulation facility like PVSYST.

Keywords: PVSYST, panel, tilt, field type.

I. INTRODUCTION

Renewable energy is the future of human. Due to the high consumption and the reducing availability of fossil fuel resource renewable energy (solar, wind, hydro etc) is subject to great interest over decades. Solar energy is an emerging renewable energy source using all over the globe at micro as well as utility scale. The power of sun intercepted by earth is greater than the present consumption rate on earth of all energy sources. So solar energy can provide solutions of all the present and future problems related to electricity. Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Photovoltaic's convert light into an electric current using the photovoltaic. A rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity generating solar panels mounted on the rooftop of a residential or commercial building or structure. A photovoltaic (PV) system consists of a PV array, battery and elements for power conditioning. The PV system converts solar energy into dc power. If ac loads are used means, the system requires inverter to convert dc into ac.

There are two types in PV system such as grid connected and standalone. Grid connected photovoltaic systems feed electricity directly to the electrical network, operating parallel to the conventional energy source. Grid-connected systems generate clean electricity near the point of use, without the transmission and distribution losses or the need for the batteries. Its performance depends on the local climate, orientation and inclination of the PV array, and inverter performance. Whereas, a stand-alone system involves no interaction with a utility grid, the generated power is directly connected to the load. In case the PV array does not directly supply a load, a storage device is needed. Mostly this is a battery, the battery bank stores energy when the power supplied by the PV modules exceeds load demand and releases it backs when the PV supply is insufficient. This standalone PV power generation will be used in the home for the electrification purpose. A wide variety of tools exist for the analysis and dimensioning of both Grid connected and stand-alone photovoltaic systems. System designers and installers use simpler tools for sizing the PV system. Mostly scientists and engineers typically use more involved simulation tools for optimization. Software tools related to photovoltaic systems can be classified into pre-feasibility analysis, sizing, and simulation.

PVsyst is a dedicated PC software package for PV systems. The software was developed by the University of Geneva. It integrates pre-feasibility, sizing and simulation support for PV systems. After defined the location and loads, the user selects the different components from a product database and the software automatically calculates the size of the system. In present study design, optimization and cost analysis of a solar power plant at residential, commercial rooftop as well as on utility scale in INDIA is to be discussed. Design, simulation, Optimization and cost analysis is going on simulation facility like PVSYST.

II. LITERATURE REVIEW AND PROBLEM FORMULATION

Various investigations have done on residential, commercial rooftop, Chen Zhang 2011Designed technical shelter for storing electronic and technical equipments has high indoor heat dissipation rate, and cooling load exists almost all year around. Both experimental measurements and computer simulation are carried out to analyze the indoor. T.M. Iftakharet al 2012 shown grid connected

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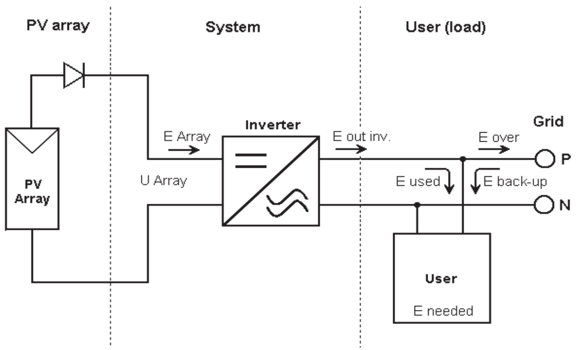
systems generate clean electricity near the point of use, without the transmission and distribution losses or the need for the batteries. Stand-alone system involves no interaction with a utility grid. Climate and energy performance of technical shelter in different conditions. C.P. Kandalama et al 2013 presented the simulation of a grid-connected solar photovoltaic system with the use of the computer software package Pvsyst and their performance was evaluated. Sangeetha. S 2014 has investigated the sizing of 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. Sébastin Jacques Et al 2014 described a new, highly modular simulation tool named "PVLab" and developed by the GREMAN laboratory. It is designed to assist the designer in the sizing of PV (photovoltaic) installations Jaydeep V. Ramoliya et al 2015 presented the simulation of a grid-connected solar photovoltaic system using of the computer software package Pvsyst and their performance was evaluated. Jones K. Chacko 2015 investigated the major factors which affect the performance of the solar PV module three different arrangements of solar PV modules are taken on a standalone system and Compared different panel arrangement that will minimize the floor area and maximize power generation through tracking the sun. By literature review it is clear that a comparative study of residential and utility scale PV system needed for efficient use of PV systems. Cost comparison will also give a better insight to efficient use a PV system.

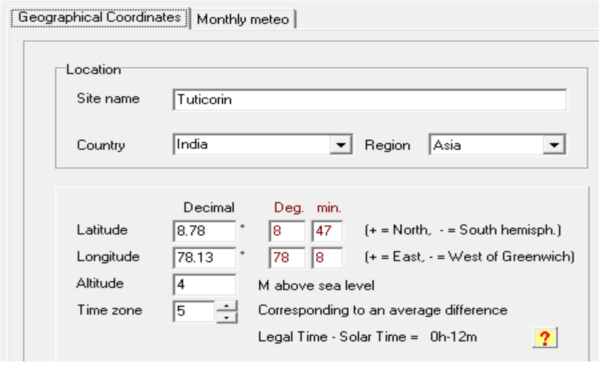
III. RESEARCH METHODOLOGY

It is a computational study using Pvsyst software facility. PVsyst is simulation software able to simulate both stand alone and grid connected PV systems. Location of system is taken Delhi ncr region. Validation will conduct on the basis of previous investigation.

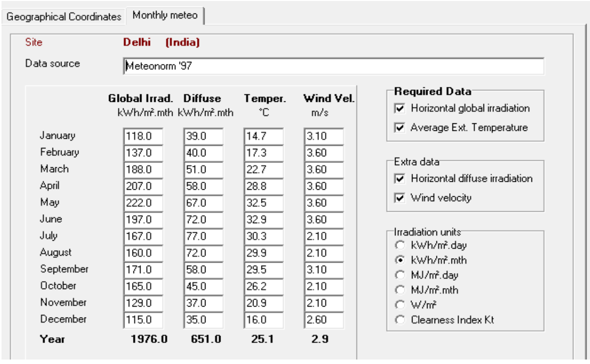
GRID CONNECTED SOLAR PV SYSTEM - A grid connected solar PV power plant is installing by compare the energy production, economic feasibility of some of the places in NORTH INDIA in DELHI using PVsyst Software. Proposed model of the grid connected PV system shown in figure. Tuticorin site is used for validation.



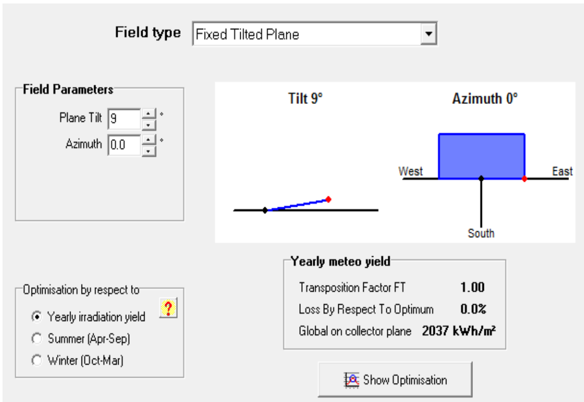
IV. VALIDATION



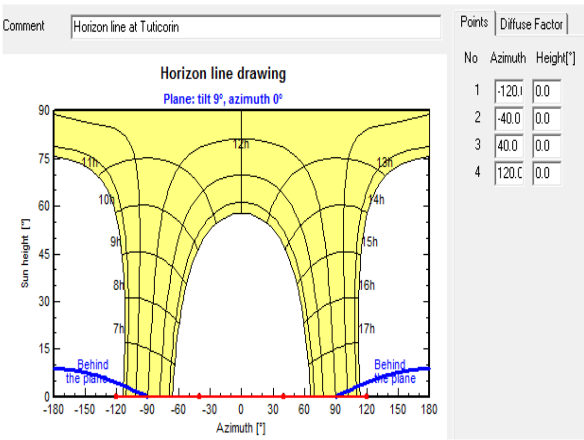
Geographical Location and Meteorology



Meteo data



Plane tilt and Azimuth



Horizon

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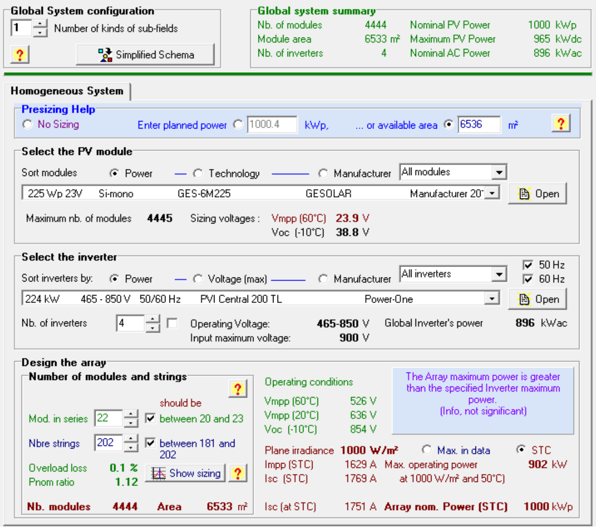


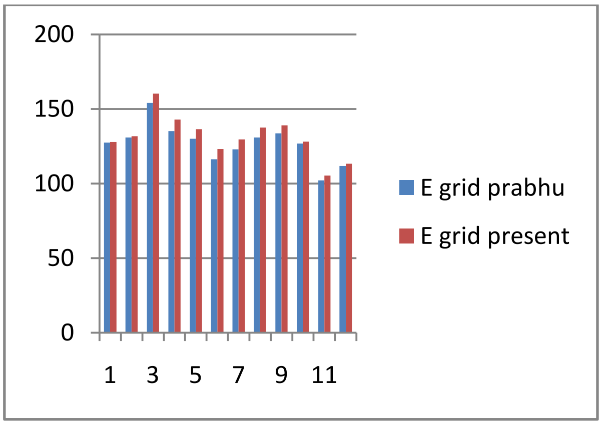
Module and Inverter

V. VALIDATION RESULTS

Simulation variant : tuticorin

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	9°	azimuth	0°
PV modules	Model	GES-6M225	Pnom	225 Wp
PV Array	Nb. of modules	4444	Pnom total	**1000 kWp**
Inverter	Model	PVI Central 200 TL	Pnom	224 kW ac
Inverter pack	Nb. of units	4.0	Pnom total	**896 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**1576 MWh/year**	Specific prod.	1576 kWh/kWp/year
	Performance Ratio PR	77.4 %		



Electricity injected into grid

PV plant on New Delhi Location:

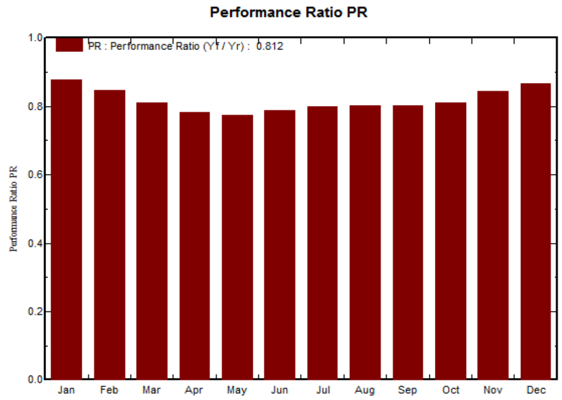
Geographical Site	New Delhi		Country	India
Situation	Latitude	28.6°N	Longitude	77.2°E
Time defined as	Legal Time	Time zone UT+5.5	Altitude	219 m
	Albedo	0.20		
Meteo data:	New Delhi	Synthetic - MeteoNorm 7.1 station		
Simulation parameters				
Collector Plane Orientation	Tilt	9°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Erbs, Meteonorm
Horizon	Free Horizon			

System Parameter

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	9°	azimuth	0°
PV modules	Model	GES-6M225	Pnom	225 Wp
PV Array	Nb. of modules	4444	Pnom total	**1000 kWp**
Inverter	Model	PVI Central 200 TL	Pnom	224 kW ac
Inverter pack	Nb. of units	4.0	Pnom total	**896 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**1707 MWh/year**	Specific prod.	1707 kWh/kWp/year
	Performance Ratio PR	81.2 %		

Results:



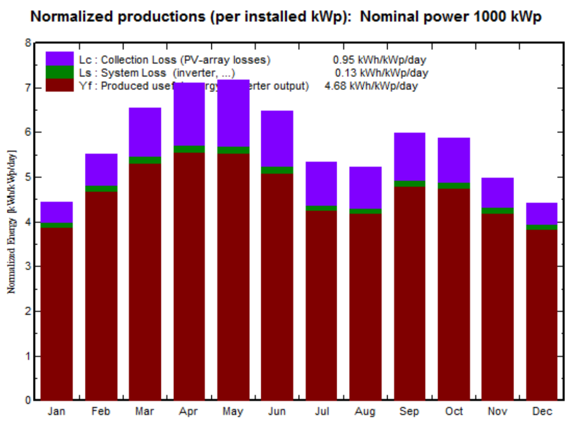
Performance Ratio

New simulation variant

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	118.2	13.23	137.8	132.7	124136	120719	13.79	13.41
February	137.0	17.24	154.6	149.8	134830	131104	13.35	12.98
March	188.2	23.29	203.0	197.2	169336	164711	12.77	12.42
April	206.5	29.22	213.4	207.7	171580	166805	12.31	11.96
May	222.1	32.61	222.7	216.3	176938	172066	12.16	11.82
June	196.5	32.14	194.6	188.3	157336	153023	12.38	12.04
July	166.4	31.42	165.5	159.9	135993	132197	12.58	12.23
August	159.9	30.36	161.8	156.3	133661	129892	12.65	12.29
September	170.6	28.58	179.5	174.0	148067	143955	12.63	12.27
October	164.5	25.49	182.2	176.7	151512	147366	12.73	12.38
November	128.5	19.32	149.7	144.4	129667	126155	13.26	12.90
December	115.1	14.85	137.4	132.2	122467	119091	13.64	13.27
Year	1973.5	24.85	2102.2	2035.4	1755523	1707085	12.78	12.43

Electricity Production at New Delhi:



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Comparison b/w Thiruvanantpuram and New Delhi

- Energy production per year at new Delhi location is 1707 Mwh.
- Energy production per year at Thiruvanantpuram location is 1707 Mwh.

Grid connected Plant at Delhi location;
Location and Orientation

Project :	**Grid-Connected 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
Horizon	Free Horizon		

PV Array Characteristics

PV Array Characteristics					
PV module	Si-mono	Model	**Mono 250 Wp 60 cells**		
Original PVsyst database		Manufacturer	Generic		
Number of PV modules		In series	10 modules	In parallel	4 strings
Total number of PV modules		Nb. modules	40	Unit Nom. Power	250 Wp
Array global power		Nominal (STC)	**10.00 kWp**	At operating cond.	8.87 kWp (50°C)
Array operating characteristics (50°C)		U mpp	271 V	I mpp	33 A
Total area		Module area	**65.1 m²**	Cell area	56.9 m²

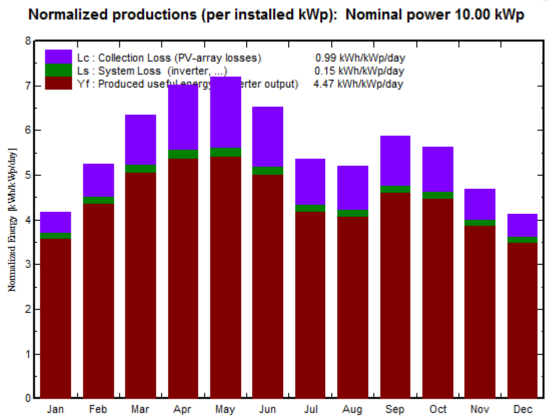
System Parameters

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.	141 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	-0.8 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Param.	0.05
Inverter	Model	**4.2 kWac inverter with 2 MPPT**		
Original PVsyst database	Manufacturer	Generic		
Characteristics	Operating Voltage	125-500 V	Unit Nom. Power	4.20 kWac
Inverter pack	Nb. of inverters	4 * MPPT 50 %	Total Power	8.4 kWac

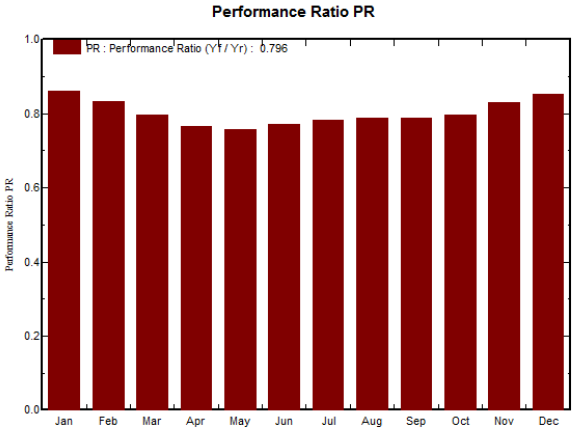
Results

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	Mono 250 Wp 60 cells	Pnom	250 Wp
PV Array	Nb. of modules	40	Pnom total	**10.00 kWp**
Inverter	Model	4.2 kWac inverter with 2 MPPT		4200 W ac
Inverter pack	Nb. of units	2.0	Pnom total	**8.40 kW ac**
User's needs	Unlimited load (grid)			
Main simulation results				
System Production	**Produced Energy**	**16.32 MWh/year**	Specific prod.	1632 kWh/kWp/year
	Performance Ratio PR	79.6 %		

Production



PR



Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	129.4	124.0	1.153	1.115	13.69	13.24
February	137.0	17.24	147.2	142.1	1.270	1.227	13.26	12.81
March	188.2	23.29	196.9	190.9	1.624	1.570	12.67	12.25
April	206.5	29.22	210.9	205.0	1.672	1.616	12.19	11.78
May	222.1	32.61	223.0	216.5	1.745	1.686	12.02	11.62
June	196.5	32.14	195.9	189.5	1.560	1.509	12.24	11.83
July	166.4	31.42	166.3	160.5	1.347	1.301	12.45	12.02
August	159.9	30.36	161.3	155.7	1.315	1.269	12.53	12.09
September	170.6	28.58	176.0	170.3	1.433	1.385	12.52	12.10
October	164.5	25.49	174.8	169.0	1.438	1.390	12.64	12.22
November	128.5	19.32	140.6	135.0	1.205	1.165	13.16	12.73
December	115.1	14.85	127.8	122.3	1.126	1.089	13.54	13.09
Year	1973.5	24.85	2050.0	1980.8	16.888	16.323	12.66	12.24

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

Effect of Tilt and Location

Project :	**Grid-Connected 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 10°	Azimuth	0°
Models used	Transposition Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon		

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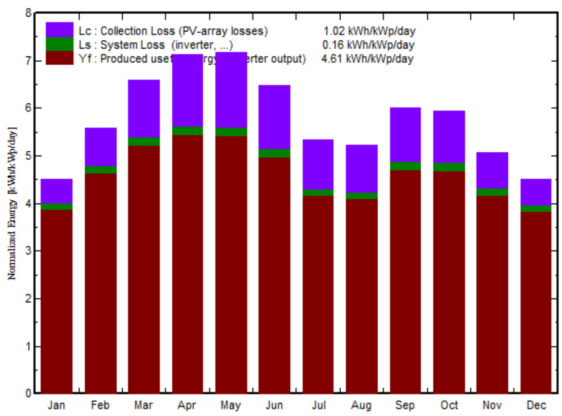
VI. RESULTS

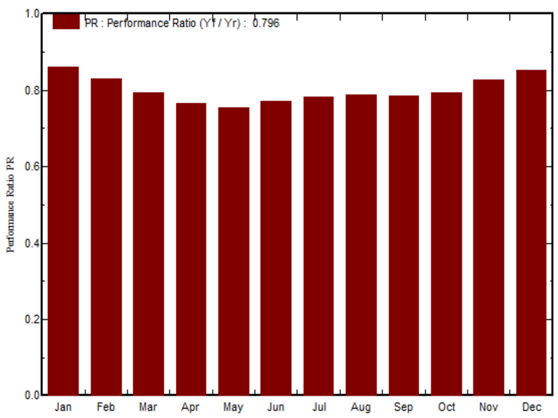
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	10°	azimuth	0°
PV modules	Model	Mono 250 Wp 60 cells	Pnom	250 Wp
PV Array	Nb. of modules	40	Pnom total	**10.00 kWp**
Inverter	Model	4.2 kWac inverter with 2 MPPT		4200 W ac
Inverter pack	Nb. of units	2.0	Pnom total	**8.40 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**16.82 MWh/year**	Specific prod.	1682 kWh/kWp/year
	Performance Ratio PR	79.6 %		

Normalized productions (per installed kWp): Nominal power 10.00 kWp



Performance Ratio PR

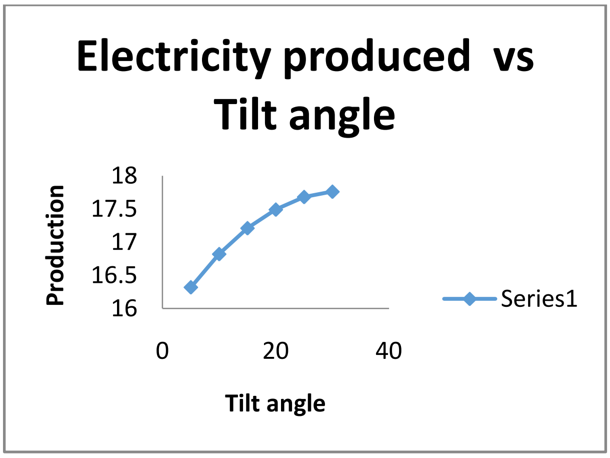


Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	139.8	134.8	1.244	1.203	13.67	13.22
February	137.0	17.24	156.4	151.6	1.345	1.300	13.22	12.77
March	188.2	23.29	204.4	198.6	1.679	1.624	12.63	12.21
April	206.5	29.22	213.9	208.2	1.692	1.635	12.15	11.74
May	222.1	32.61	222.5	216.1	1.739	1.681	12.01	11.61
June	196.5	32.14	194.1	187.9	1.546	1.495	12.24	11.83
July	166.4	31.42	165.2	159.6	1.339	1.293	12.45	12.02
August	159.9	30.36	161.8	156.3	1.318	1.273	12.52	12.09
September	170.6	28.58	180.3	174.8	1.465	1.416	12.49	12.07
October	164.5	25.49	183.9	178.5	1.507	1.457	12.59	12.17
November	128.5	19.32	151.9	146.6	1.298	1.256	13.13	12.70
December	115.1	14.85	139.7	134.6	1.229	1.189	13.52	13.08
Year	1973.5	24.85	2114.0	2047.8	17.402	16.819	12.65	12.23

Legends: GlobHor Horizontal global irradiation; T Amb Ambient Temperature; GlobInc Global incident in coll. plane; EArray Effective energy at the output of the array; E_Grid Energy injected into grid; EffArrR Effic. Eout array / rough area

Production for different Tilt
Tilt is taken 5, 10,15,20,25 and 30 degree



Effect of plane type
Si-MONO Type Plane

Geographical Site		**New Delhi**	Country	**India**
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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	30°	Azimuth	0°
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			

PV Array Characteristics				
PV module Si-mono	Model	**Mono 250 Wp 60 cells**		
Original PVsyst database	Manufacturer	Generic		
Number of PV modules	In series	10 modules	In parallel	4 strings
Total number of PV modules	Nb. modules	40	Unit Nom. Power	250 Wp
Array global power	Nominal (STC)	10.00 kWp	At operating cond.	8.87 kWp (50°C)
Array operating characteristics (50°C)	U mpp	271 V	I mpp	33 A
Total area	Module area	65.1 m²	Cell area	56.9 m²

Inverter

Inverter	Model	**4.2 kWac inverter with 2 MPPT**		
Original PVsyst database	Manufacturer	Generic		
Characteristics	Operating Voltage	125-500 V	Unit Nom. Power	4.20 kWac
Inverter pack	Nb. of inverters	4 * MPPT 50 %	Total Power	8.4 kWac

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.	141 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	-0.8 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Param.	0.05

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Results

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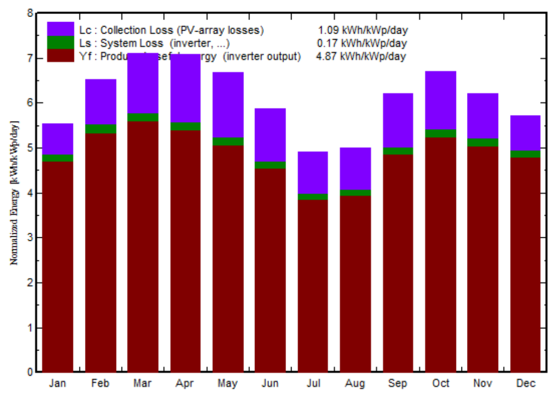
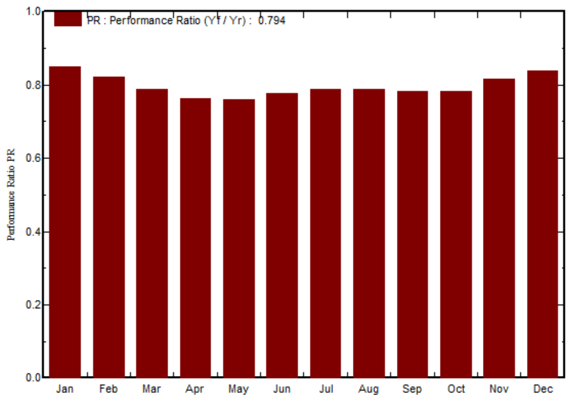
PV modules	Model	Mono 250 Wp 60 cells	Pnom	250 Wp
PV Array	Nb. of modules	40	Pnom total	10.00 kWp
Inverter	Model	4.2 kWac inverter with 2 MPPT		4200 W ac
Inverter pack	Nb. of units	2.0	Pnom total	8.40 kW ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	Produced Energy	17.76 MWh/year	Specific prod.	1776 kWh/kWp/year
	Performance Ratio PR	79.4 %		

Normalized productions (per installed kWp): Nominal power 10.00 kWp

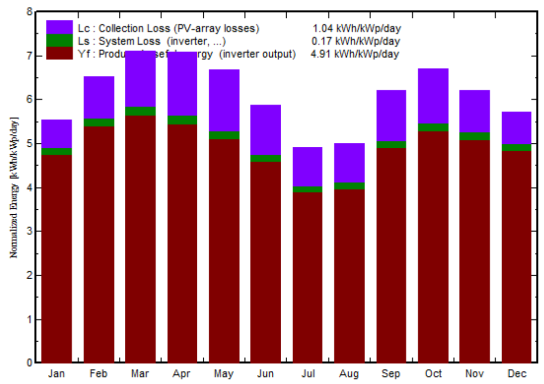


Performance Ratio PR

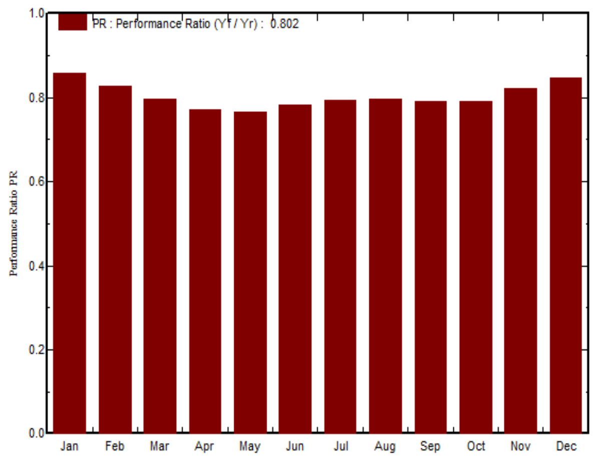


Si-Poly type

Normalized productions (per installed kWp): Nominal power 10.00 kWp



Performance Ratio PR



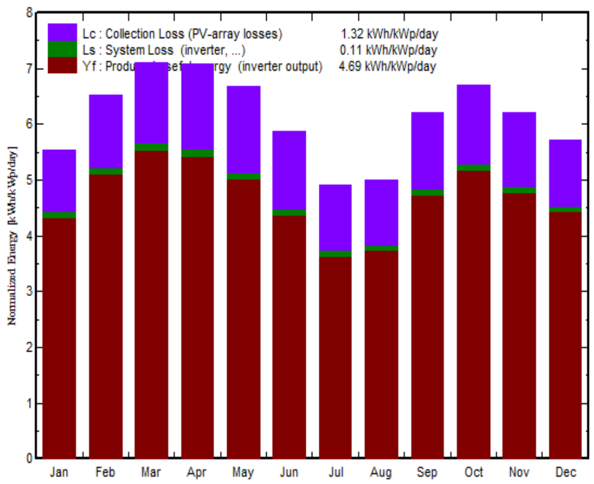
Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	171.7	167.9	1.523	1.472	13.63	13.17
February	137.0	17.24	182.6	178.8	1.564	1.511	13.16	12.71
March	188.2	23.29	220.6	215.4	1.814	1.753	12.64	12.22
April	206.5	29.22	212.4	206.8	1.695	1.637	12.26	11.84
May	222.1	32.61	207.3	200.9	1.644	1.588	12.19	11.78
June	196.5	32.14	176.2	170.3	1.427	1.379	12.44	12.02
July	166.4	31.42	152.1	147.0	1.251	1.208	12.64	12.20
August	159.9	30.36	155.0	150.1	1.278	1.234	12.67	12.23
September	170.6	28.58	186.4	181.3	1.523	1.471	12.56	12.13
October	164.5	25.49	208.1	203.6	1.699	1.642	12.55	12.13
November	128.5	19.32	186.2	182.2	1.584	1.531	13.07	12.64
December	115.1	14.85	177.4	173.7	1.553	1.501	13.45	13.00
Year	1973.5	24.85	2236.0	2178.2	18.555	17.927	12.75	12.32

Legends:
GlobHor Horizontal global irradiation
T Amb Ambient Temperature
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
EffArrR Effic. Eout array / rough area
EffSysR Effic. Eout system / rough area

A-Si:H single type

Normalized productions (per installed kWp): Nominal power 9.98 kWp



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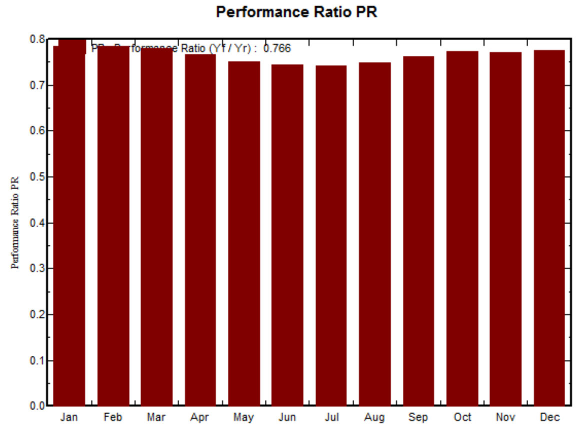
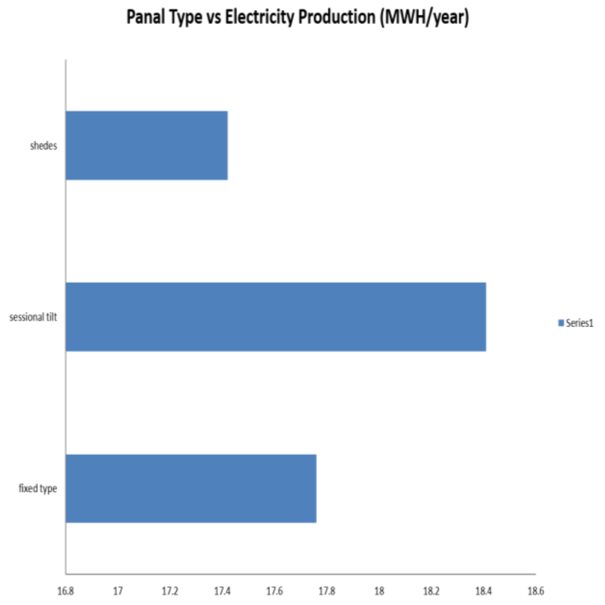


Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	171.7	167.9	1.373	1.343	4.77	4.66
February	137.0	17.24	182.6	178.8	1.461	1.428	4.77	4.66
March	188.2	23.29	220.6	215.4	1.754	1.715	4.74	4.64
April	206.5	29.22	212.4	206.8	1.662	1.624	4.67	4.56
May	222.1	32.61	207.3	200.9	1.591	1.553	4.58	4.47
June	196.5	32.14	176.2	170.3	1.342	1.309	4.54	4.43
July	166.4	31.42	152.1	147.0	1.157	1.126	4.53	4.41
August	159.9	30.36	155.0	150.1	1.188	1.157	4.57	4.45
September	170.6	28.58	186.4	181.3	1.452	1.418	4.65	4.54
October	164.5	25.49	208.1	203.6	1.640	1.604	4.70	4.59
November	128.5	19.32	186.2	182.2	1.464	1.431	4.69	4.58
December	115.1	14.85	177.4	173.7	1.403	1.372	4.72	4.61
Year	1973.5	24.85	2236.0	2178.2	17.487	17.079	4.66	4.55

Legends:
- GlobHor: Horizontal global irradiation
- T Amb: Ambient Temperature
- GlobInc: Global incident in coll. plane
- GlobEff: Effective Global, corr. for IAM and shadings
- EArray: Effective energy at the output of the array
- E_Grid: Energy injected into grid
- EffArrR: Effic. Eout array / rough area
- EffSysR: Effic. Eout system / rough area

Results of plane type



Effect of Type of field
Fixed plane type field

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		

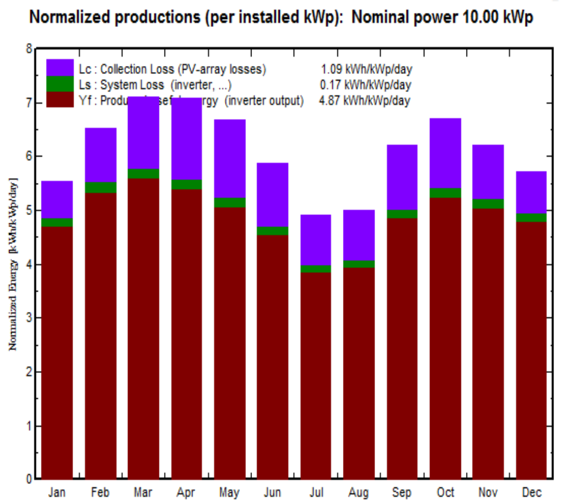
Simulation parameters

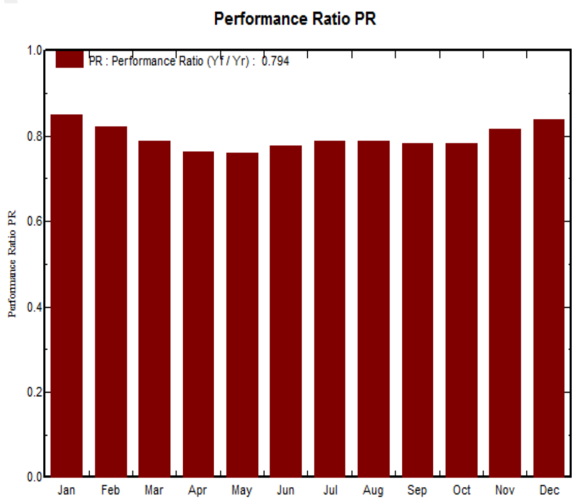
Collector Plane Orientation	Tilt 30°	Azimuth 0°
Models used	Transposition Perez	Diffuse Perez, Meteonorm
Horizon	Free Horizon	

Results

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	Mono 250 Wp 60 cells	Pnom	250 Wp
PV Array	Nb. of modules	40	Pnom total	**10.00 kWp**
Inverter	Model	4.2 kWac inverter with 2 MPPT		4200 W ac
Inverter pack	Nb. of units	2.0	Pnom total	**8.40 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**17.76 MWh/year**	Specific prod.	1776 kWh/kWp/year
	Performance Ratio PR	79.4 %		





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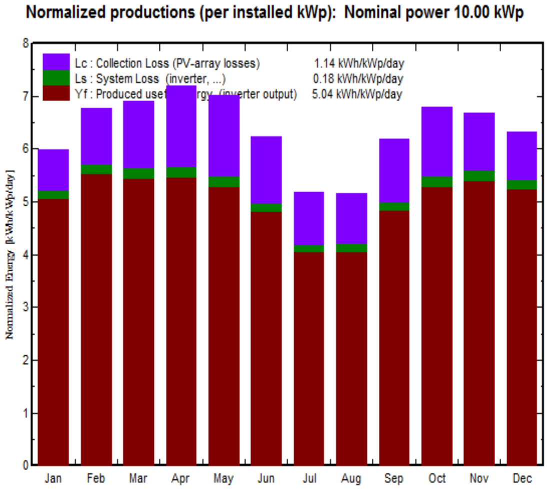
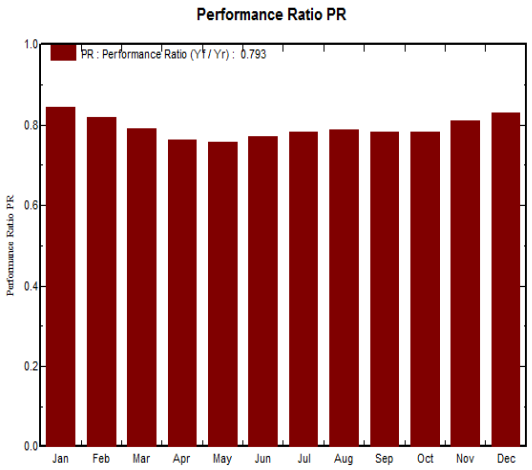
Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	171.7	167.9	1.511	1.461	13.52	13.07
February	137.0	17.24	182.6	178.8	1.550	1.498	13.05	12.60
March	188.2	23.29	220.6	215.4	1.796	1.736	12.51	12.10
April	206.5	29.22	212.4	206.8	1.677	1.620	12.13	11.71
May	222.1	32.61	207.3	200.9	1.627	1.572	12.06	11.66
June	196.5	32.14	176.2	170.3	1.414	1.366	12.33	11.91
July	166.4	31.42	152.1	147.0	1.240	1.197	12.53	12.09
August	159.9	30.36	155.0	150.1	1.267	1.223	12.56	12.12
September	170.6	28.58	186.4	181.3	1.508	1.457	12.44	12.02
October	164.5	25.49	208.1	203.6	1.682	1.626	12.42	12.01
November	128.5	19.32	186.2	182.2	1.570	1.518	12.96	12.53
December	115.1	14.85	177.4	173.7	1.540	1.489	13.34	12.90
Year	1973.5	24.85	2236.0	2178.2	18.383	17.762	12.63	12.21

Legends: GlobHor Horizontal global irradiation; T Amb Ambient Temperature; GlobInc Global incident in coll. plane; GlobEff Effective Global, corr. for IAM and shadings; EArray Effective energy at the output of the array; E_Grid Energy injected into grid; EffArrR Effic. Eout array / rough area; EffSysR Effic. Eout system / rough area

Sessional tilt type field



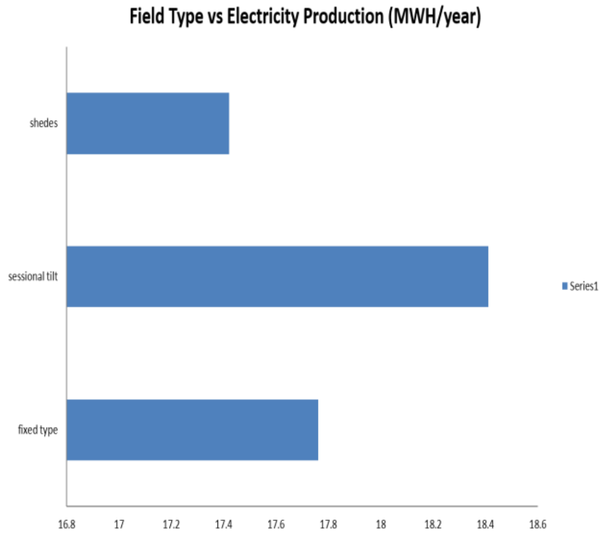


Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	118.2	13.23	185.7	182.4	1.623	1.569	13.43	12.98
February	137.0	17.24	189.5	185.9	1.605	1.550	13.01	12.57
March	188.2	23.29	213.8	208.4	1.750	1.691	12.57	12.16
April	206.5	29.22	215.9	210.4	1.703	1.645	12.12	11.71
May	222.1	32.61	217.5	211.2	1.701	1.644	12.02	11.62
June	196.5	32.14	187.2	181.1	1.494	1.444	12.27	11.86
July	166.4	31.42	160.4	155.0	1.301	1.256	12.47	12.04
August	159.9	30.36	160.1	155.0	1.305	1.260	12.53	12.09
September	170.6	28.58	185.6	180.4	1.503	1.453	12.45	12.03
October	164.5	25.49	210.6	206.1	1.701	1.645	12.42	12.00
November	128.5	19.32	200.6	197.2	1.681	1.625	12.87	12.44
December	115.1	14.85	196.0	193.0	1.685	1.629	13.21	12.77
Year	1973.5	24.85	2322.9	2265.9	19.052	18.409	12.60	12.18

Legends: GlobHor Horizontal global irradiation; T Amb Ambient Temperature; GlobInc Global incident in coll. plane; EArray Effective energy at the output of the array; E_Grid Energy injected into grid; EffArrR Effic. Eout array / rough area

Effect of field type on production



VII. CONCLUSION

Computational method is a effective one for analysis and design of a solar panel power plant. In present study analysis is done for grid connected solar system, a parametric analysis is presented in this study. Energy production from a grid connected solar panel system is increased with increasing tilt angle. Sessional tilt will give large production of energy in comparison to fixed type and shading type.

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