

# PVsyst - Simulation report

## Grid-Connected System

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Project: Bhadla MiniGrid Solar 1

Variant: New simulation variant

Sheds, single array

System power: 17.74 MWp

Ghator - India

**Author**

AVENGERS RAYS SOLAR PRIVATE LIMITED (India)



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### Project summary

#### Geographical Site

##### Ghator

India

#### Situation

Latitude 27.40 °N

Longitude 72.28 °E

Altitude 183 m

Time zone UTC+5.5

#### Project settings

Albedo 0.20

#### Weather data

Ghator

SolarGIS Monthly aver. , period not spec. - Synthetic

### System summary

#### Grid-Connected System

##### PV Field Orientation

Fixed plane

Tilt/Azimuth 22 / 0 °

#### Sheds, single array

##### Near Shadings

Linear shadings : Fast (table)

#### User's needs

Unlimited load (grid)

#### System information

##### PV Array

Nb. of modules

30856 units

Pnom total

17.74 MWp

##### Inverters

Nb. of units

8 units

Pnom total

19.45 MWac

Pnom ratio

0.912

### Results summary

Produced Energy 32751369 kWh/year Specific production 1846 kWh/kWp/year Perf. Ratio PR 82.96 %

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### General parameters

#### Grid-Connected System

#### PV Field Orientation

##### Orientation

Fixed plane  
Tilt/Azimuth 22 / 0 °

#### Horizon

Free Horizon

#### Bifacial system

Model 2D Calculation  
unlimited sheds

#### Bifacial model geometry

Sheds spacing 7.75 m  
Sheds width 4.62 m  
Limit profile angle 26.3 °  
GCR 59.6 %  
Height above ground 0.75 m

#### Sheds, single array

##### Sheds configuration

Nb. of sheds 150 units  
Single array

##### Sizes

Sheds spacing 7.75 m  
Collector width 4.58 m  
Ground Cov. Ratio (GCR) 59.0 %  
Top inactive band 0.02 m  
Bottom inactive band 0.02 m

##### Shading limit angle

Limit profile angle 26.3 °

#### Near Shadings

Linear shadings : Fast (table)

##### Models used

Transposition Perez  
Diffuse Perez, Meteonorm  
Circumsolar separate

#### User's needs

Unlimited load (grid)

### PV Array Characteristics

#### PV module

Manufacturer Waaree Energies Ltd.  
Model BiN-08-575  
(Custom parameters definition)

Unit Nom. Power 575 Wp  
Number of PV modules 6216 units  
Nominal (STC) 3574 kWp

#### Array #1 - PV Array

Number of PV modules 4928 units  
Nominal (STC) 2834 kWp  
Modules 176 string x 28 In series

#### At operating cond. (50°C)

Pmpp 2619 kWp  
U mpp 1097 V  
I mpp 2387 A

#### Array #5 - Sub-array #5

Number of PV modules 1288 units  
Nominal (STC) 741 kWp  
Modules 46 string x 28 In series

#### At operating cond. (50°C)

Pmpp 685 kWp  
U mpp 1097 V  
I mpp 624 A

#### Inverter

Manufacturer FIMER  
Model PVS980-58-1250-L prelim rev. A  
(Custom parameters definition)

Unit Nom. Power 1215 kWac  
Number of inverters 3 units  
Total power 3645 kWac

Number of inverters 2 units  
Total power 2430 kWac

Operating voltage 978-1500 V  
Max. power (=>25°C) 1250 kWac  
Pnom ratio (DC:AC) 1.17

Number of inverters 1 unit  
Total power 1215 kWac

Operating voltage 978-1500 V  
Max. power (=>25°C) 1250 kWac  
Pnom ratio (DC:AC) 0.61



## PV Array Characteristics

## Array #2 - Sub-array #2

## PV module

Manufacturer Waaree Energies Ltd.  
Model BiN-08-575

(Custom parameters definition)

Unit Nom. Power 575 Wp  
Number of PV modules 6160 units  
Nominal (STC) 3542 kWp  
Modules 220 string x 28 In series

## At operating cond. (50°C)

Pmpp 3274 kWp  
U mpp 1097 V  
I mpp 2984 A

## PV module

Manufacturer Waaree Energies Ltd.  
Model BiN-08-575

(Custom parameters definition)

Unit Nom. Power 575 Wp  
Number of PV modules 18480 units  
Nominal (STC) 10.63 MWp

## Array #3 - Sub-array #3

Number of PV modules 12320 units  
Nominal (STC) 7084 kWp  
Modules 440 string x 28 In series

## At operating cond. (50°C)

Pmpp 6548 kWp  
U mpp 1097 V  
I mpp 5967 A

## Array #4 - Sub-array #4

Number of PV modules 6160 units  
Nominal (STC) 3542 kWp  
Modules 220 string x 28 In series

## At operating cond. (50°C)

Pmpp 3274 kWp  
U mpp 1097 V  
I mpp 2984 A

## Total PV power

Nominal (STC) 17742 kWp  
Total 30856 modules  
Module area 79709 m<sup>2</sup>

## Inverter

Manufacturer FIMER  
Model PVS980-58-2500-L prelim rev. A

(Custom parameters definition)

Unit Nom. Power 2431 kWac  
Number of inverters 2 units  
Total power 4862 kWac  
Operating voltage 978-1500 V  
Max. power (=>25°C) 2500 kWac  
Pnom ratio (DC:AC) 0.73

## Inverter

Manufacturer FIMER  
Model PVS980-58-3750-L prelim rev. A

(Custom parameters definition)

Unit Nom. Power 3647 kWac  
Number of inverters 3 units  
Total power 10941 kWac

Number of inverters 2 units  
Total power 7294 kWac

Operating voltage 978-1500 V  
Max. power (=>25°C) 3750 kWac  
Pnom ratio (DC:AC) 0.97

Number of inverters 1 unit  
Total power 3647 kWac

Operating voltage 978-1500 V  
Max. power (=>25°C) 3750 kWac  
Pnom ratio (DC:AC) 0.97

## Total inverter power

Total power 19448 kWac  
Max. power 20000 kWac  
Number of inverters 8 units  
Pnom ratio 0.91

## Array losses

## Array Soiling Losses

Loss Fraction 1.0 %

## Thermal Loss factor

Module temperature according to irradiance  
Uc (const) 20.0 W/m<sup>2</sup>K  
Uv (wind) 0.0 W/m<sup>2</sup>K/m/s

## Serie Diode Loss

Voltage drop 0.7 V  
Loss Fraction 0.1 % at STC

## LID - Light Induced Degradation

Loss Fraction 0.3 %

## Module Quality Loss

Loss Fraction 0.5 %

## Module mismatch losses

Loss Fraction 2.0 % at MPP

## Strings Mismatch loss

Loss Fraction 0.2 %



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## Array losses

### IAM loss factor

Incidence effect (IAM): User defined profile

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	1.000	0.999	0.993	0.979	0.946	0.855	0.615	0.000

## DC wiring losses

Global wiring resistance 1.2 mΩ  
Loss Fraction 1.5 % at STC

### Array #1 - PV Array

Global array res. 7.5 mΩ  
Loss Fraction 1.5 % at STC

### Array #3 - Sub-array #3

Global array res. 3.0 mΩ  
Loss Fraction 1.5 % at STC

### Array #5 - Sub-array #5

Global array res. 29 mΩ  
Loss Fraction 1.5 % at STC

### Array #2 - Sub-array #2

Global array res. 6.0 mΩ  
Loss Fraction 1.5 % at STC

### Array #4 - Sub-array #4

Global array res. 6.0 mΩ  
Loss Fraction 1.5 % at STC

## System losses

### Unavailability of the system

Time fraction 1.0 %  
3.7 days,  
3 periods

### Auxiliaries loss

Proportionnal to Power 5.0 W/kW  
0.0 kW from Power thresh.  
Night aux. cons. 5.00 kW

## AC wiring losses

### Inv. output line up to MV transfo

Inverter voltage 690 Vac tri  
Loss Fraction 0.36 % at STC

Inverters: PVS980-58-1250-L prelim rev. A, PVS980-58-2500-L prelim rev. A, PVS980-58-3750-L prelim rev. A

Wire section (7 Inv.) Alu 7 x 3 x 1000 mm<sup>2</sup>  
Average wires length 25 m

### Inverter: PVS980-58-1250-L prelim rev. A

Wire section (1 Inv.) Alu 1 x 3 x 500 mm<sup>2</sup>  
Wires length 0 m

### MV line up to HV Transfo

MV Voltage 20 kV  
Wires Alu 3 x 500 mm<sup>2</sup>  
Length 900 m  
Loss Fraction 0.25 % at STC

### HV line up to Injection

HV line voltage 33 kV  
Wires Alu 3 x 240 mm<sup>2</sup>  
Length 500 m  
Loss Fraction 0.10 % at STC

## AC losses in transformers



### AC losses in transformers

#### MV transfo

Medium voltage 20 kV

#### Transformer parameters

Nominal power at STC	17.39 MVA
Iron Loss (24/24 Connexion)	17.39 kVA
Iron loss fraction	0.10 % at STC
Copper loss	156.52 kVA
Copper loss fraction	0.90 % at STC
Coils equivalent resistance	3 x 0.25 mΩ

#### HV transfo

Grid voltage 33 kV

#### Transformer from Datasheets

Nominal power	17390 kVA
Iron Loss (24/24 Connexion)	17.00 kVA
Iron loss fraction	0.10 % of PNom
Copper loss	170.00 kVA
Copper loss fraction	0.98 % at PNom
Coils equivalent resistance	3 x 224.86 mΩ



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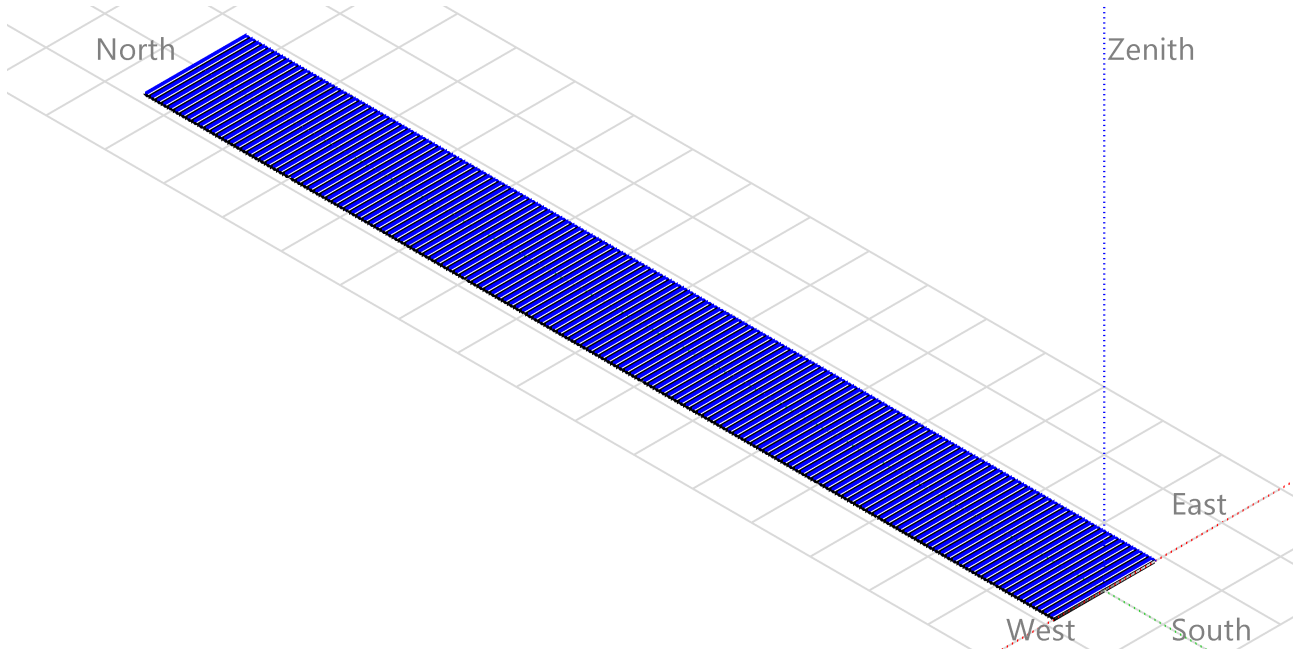
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## Near shadings parameter

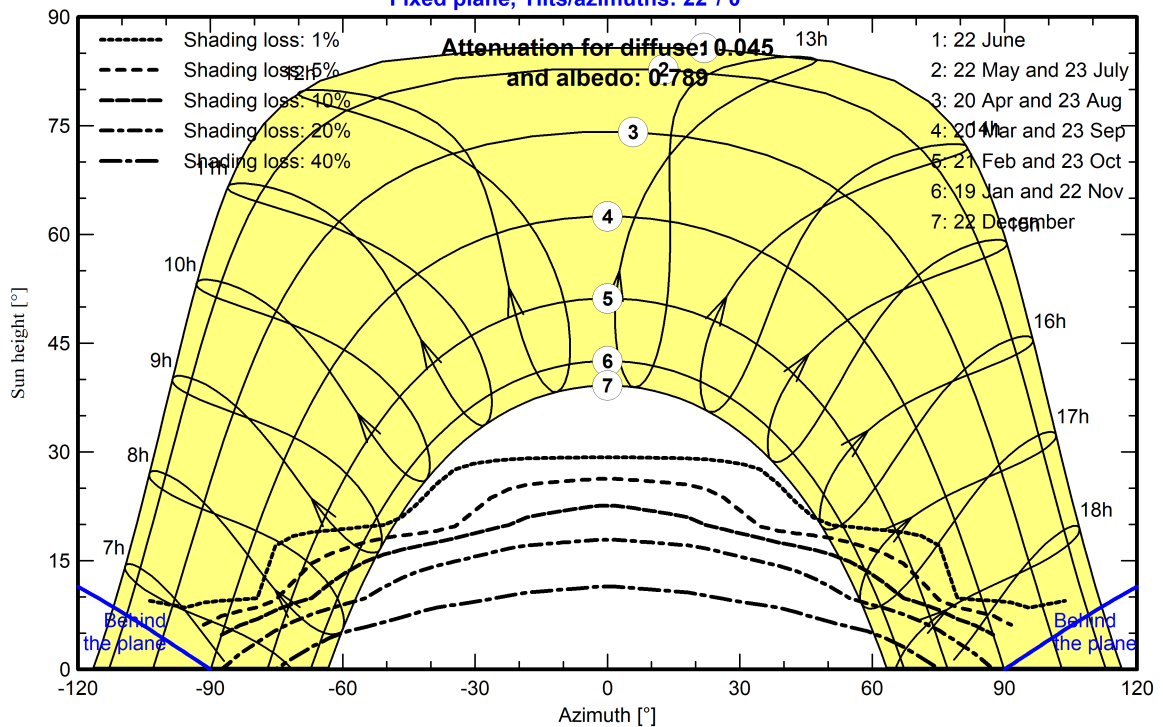
Perspective of the PV-field and surrounding shading scene



## Iso-shadings diagram

Orientation #1

Fixed plane, Tilts/azimuths: 22°/ 0°





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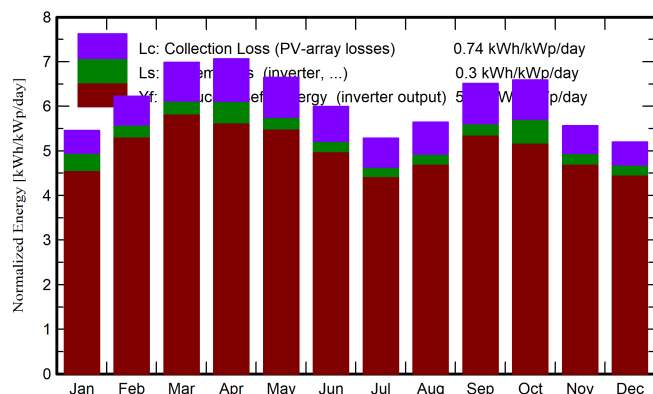
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## Main results

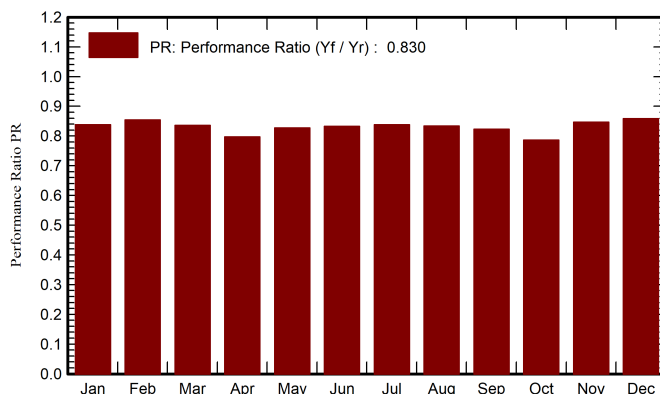
### System Production

Produced Energy (P50) 32751369 kWh/year	Specific production (P50) 1846 kWh/kWp/year	Perf. Ratio PR	82.96 %
Produced Energy (P90) 31994262 kWh/year	Specific production (P90) 1803 kWh/kWp/year		
Produced Energy (P95) 31781242 kWh/year	Specific production (P95) 1791 kWh/kWp/year		

### Normalized productions (per installed kWp)



### Performance Ratio PR



## Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m <sup>2</sup>	kWh/m <sup>2</sup>	°C	kWh/m <sup>2</sup>	kWh/m <sup>2</sup>	kWh	kWh	ratio
January	127.0	48.0	13.90	169.1	163.6	2724748	2514295	0.838
February	141.0	50.0	17.70	174.3	169.7	2774789	2643266	0.855
March	192.0	69.0	24.00	216.5	211.0	3367792	3209582	0.835
April	205.0	86.0	29.90	212.0	206.1	3257324	3000230	0.798
May	213.0	108.0	34.40	206.1	199.6	3166088	3027007	0.828
June	191.0	104.0	36.00	179.8	173.6	2778320	2657552	0.833
July	172.0	103.0	34.50	163.9	157.8	2550616	2436530	0.838
August	175.0	92.0	33.40	175.0	169.2	2712225	2590349	0.834
September	180.0	74.0	32.20	195.5	190.1	2990937	2855934	0.823
October	171.0	60.0	27.10	204.3	199.0	3145181	2850819	0.786
November	130.0	53.0	20.20	167.0	161.9	2635789	2509427	0.847
December	119.0	46.0	15.09	161.3	155.8	2580791	2456378	0.859
Year	2016.0	893.0	26.57	2225.0	2157.4	34684599	32751369	0.830

### Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		





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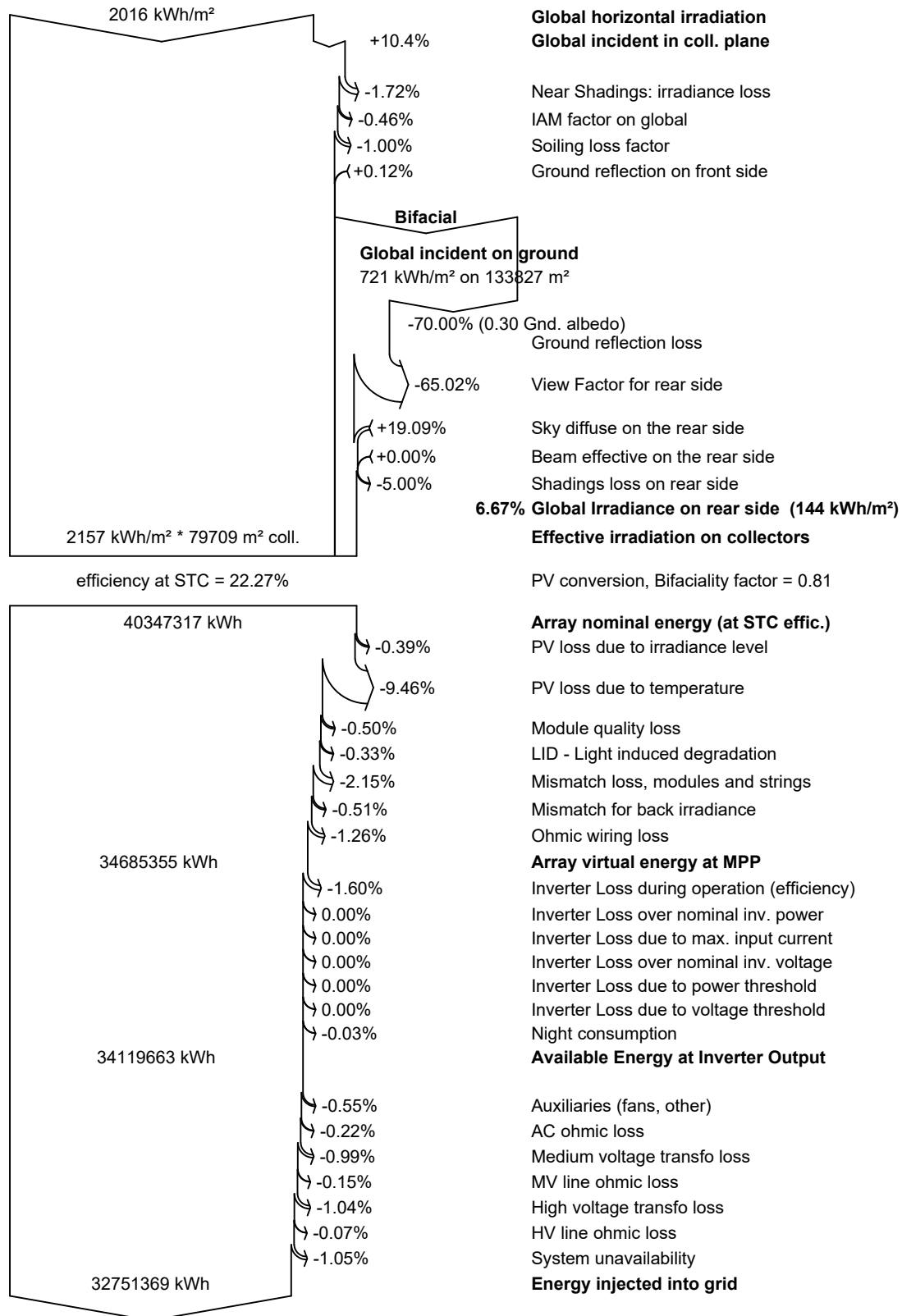
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## Loss diagram





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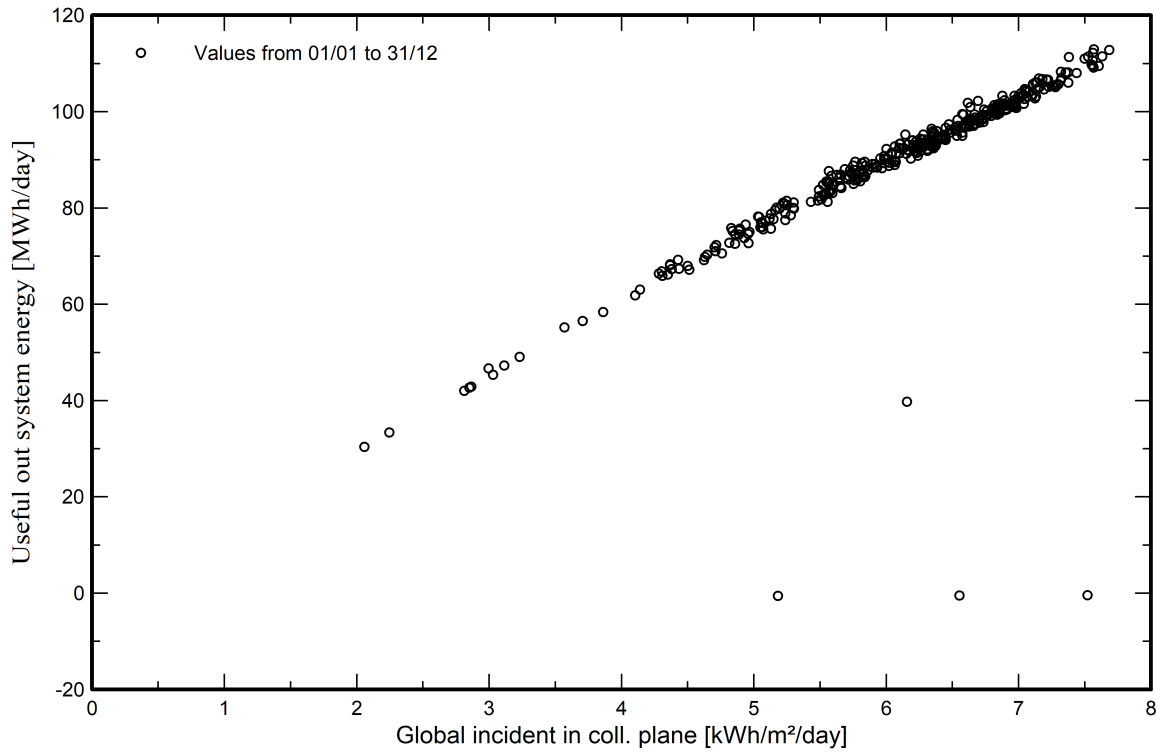
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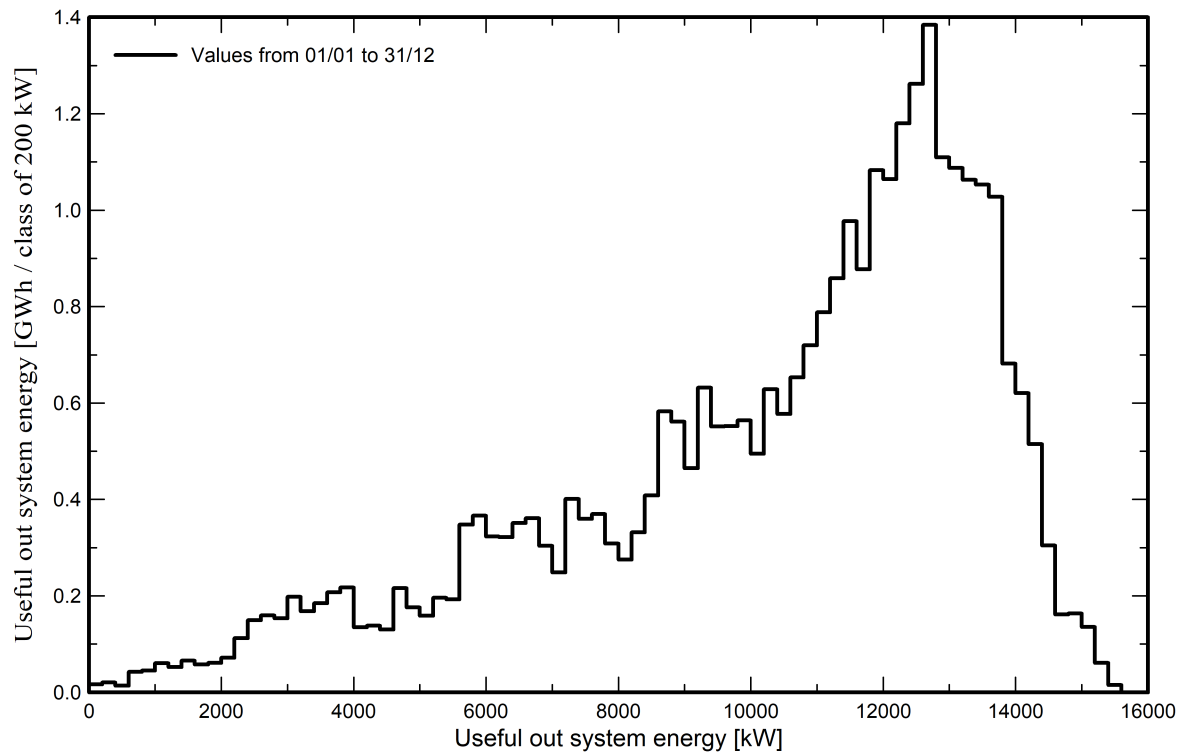
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## Predef. graphs

Daily Input/Output diagram



System Output Power Distribution





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## P50 - P90 evaluation

### Weather data

Source SolarGIS Monthly aver. , period not spec.  
Kind Not defined  
Year-to-year variability(Variance) 0.0 %

### Specified Deviation

### Global variability (weather data + system)

Variability (Quadratic sum) 1.8 %

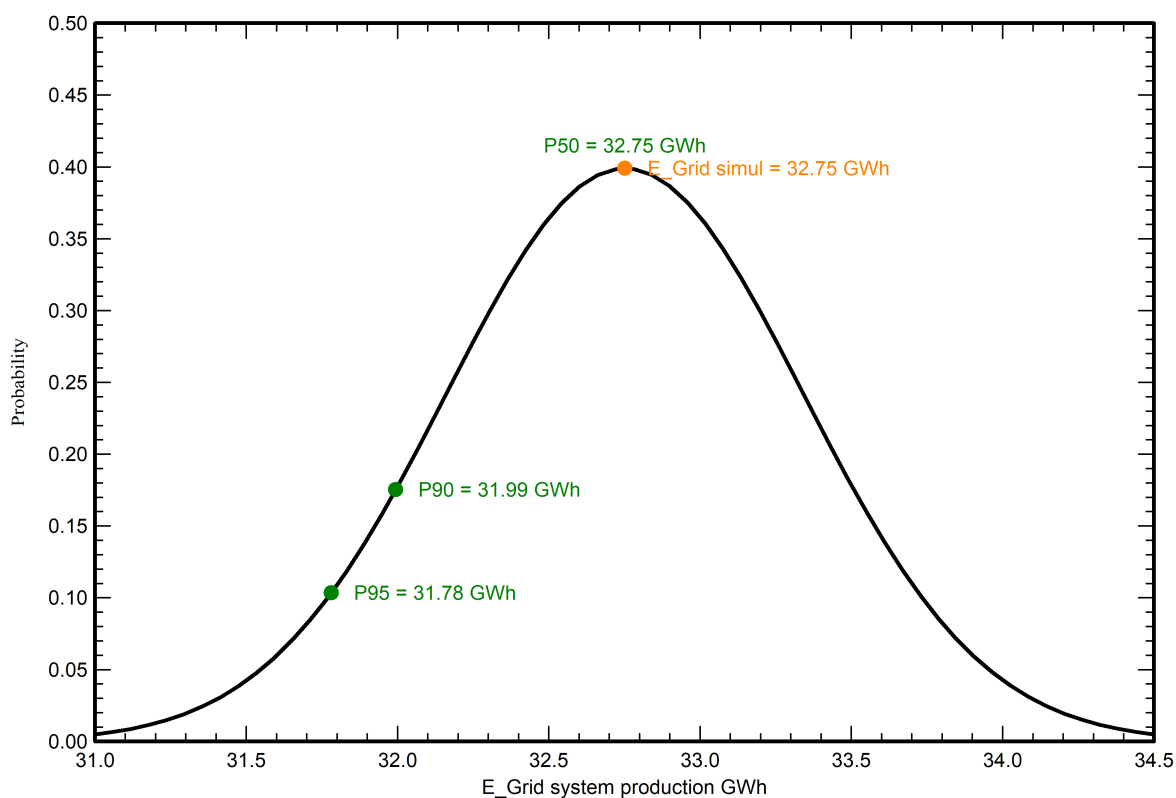
### Simulation and parameters uncertainties

PV module modelling/parameters	1.0 %
Inverter efficiency uncertainty	0.5 %
Soiling and mismatch uncertainties	1.0 %
Degradation uncertainty	1.0 %

### Annual production probability

Variability	0.59 GWh
P50	32.75 GWh
P90	31.99 GWh
P95	31.78 GWh

## Probability distribution

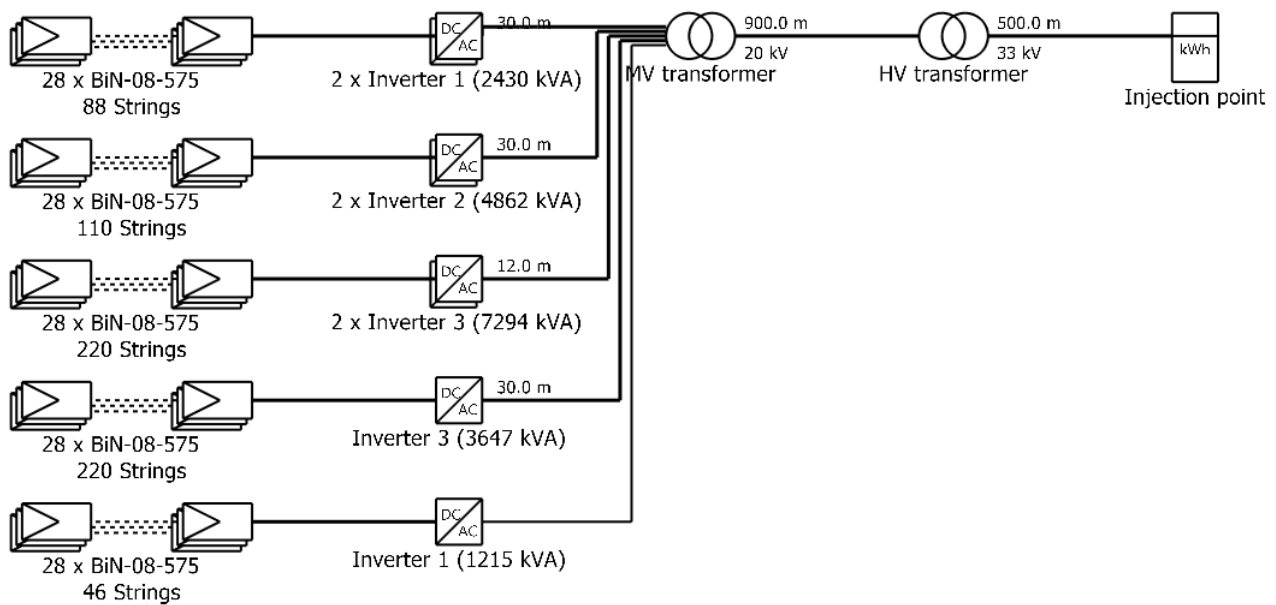




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# Single-line diagram



PV module	BiN-08-575
Inverter 1	PVS980-58-1250-L prelim rev. A
Inverter 2	PVS980-58-2500-L prelim rev. A
Inverter 3	PVS980-58-3750-L prelim rev. A
String	28 x BiN-08-575

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