FOTOVOLTAICO CAVA RIANO

COMUNI DI RIANO (RM) e ROMA

PROGETTO DEFINITIVO

Autorizzazione Unica ai sensi del D.Lgs. 387/2003 per un impianto fotovoltaico di superficie pari a 48,6 ha costituito da tracker monoassiali, strutture fisse e strutture su parete (37,6 MWp) presso la ex cava di tufo in località "Quadro" nel Comune di Riano (RM) con cavidotto e SEU nel Comune di Roma

CODICE ELABORATO:	TITOLO ELABORATO:
R.7	Relazione tecnica producibilità impianti fotovoltaici
SCALA: - / FORMATO: A4	

PROPONENTE:

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AMMINISTRATORE UNICO

Lopez Francesch Jordi

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Jordi Lopez Francesch
Data: 16/04/2024 12:09:13

PROGETTISTA:

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We support the Sustainable Development Goals
CERTIFIED ISO 9001, ISO 14001, ISO 50001

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Valido dal 16/05/2023 al 15/05/2025
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REV.	DATA	STATO	PREPARATO	RIESAMINATO	APPROVATO
00	28-03-2024	PRIMA EMISSIONE	Fra. CASTELLANI	Fra. CASTELLANI	F. SANTI

Sommario

1 PREMESSA

La presente relazione tecnica descrive la producibilità dell'impianto fotovoltaico da realizzare presso la ex cava di tufo nel Comune di Riano (RM) con connessione a 150 kV alla CP Flaminia ARETI nel Comune di Roma di cui si attende STMG da ARETI come previsto da prot. TERNA/A20230108514-25/10/2023 (Codice Pratica 202203388).
Prima della connessione a 150 kV si realizzerà un cavidotto a 30 kV dall'impianto fotovoltaico fino alla SEU 30/150 kV da realizzarsi nelle immediate vicinanze di CP Flaminia nel Comune di Roma.
La titolarità dell'impianto è della CAVA SOLAR s.r.l.s., società con sede in Via Salari, 12, Montalto di Castro (VT), 01014, C.F. e P.Iva 02417800568 .

2 DESCRIZIONE DELL'IMPIANTO

L'impianto sarà costituito da n. 54.479 moduli fotovoltaici con potenza nominale 690 Wp installati:

- su inseguitori monoassiali che ospiteranno 1/2, 1 stringa, composta da 28 moduli
- su rack con tilt fisso 2V14 che ospiteranno 1 stringa, composta da 28 moduli
- su strutture a parete installati su pareti verticali

L'impianto avrà potenza complessiva installata di 37,6 MWp con potenza massima di immissione di 34,45 MWp.

L'impianto è composto da 3 sottocampi principali, raccordati ad una cabina di parallelo unica situata nel lotto 13. Il collegamento a stella è definito da linee a 30kV. Ogni sottocampo è associabile ad una delle tre cabine di parallelo secondarie, a sua volta suddiviso in linee secondarie a 30 kV collegate o a Powerstation o a Trasformatori 0,8/30 KV centralizzati. Nel totale saranno installate 11 cabine di campo con trasformatore e 10 Powerstation.

L'impianto sarà realizzato a terra e localizzato nel Comune di Riano (RM) alle seguenti coordinate.

Latitudine	42° 4'31.09" N
Longitudine	12°30'32.52" E
Quota media s.l.m.	100 m

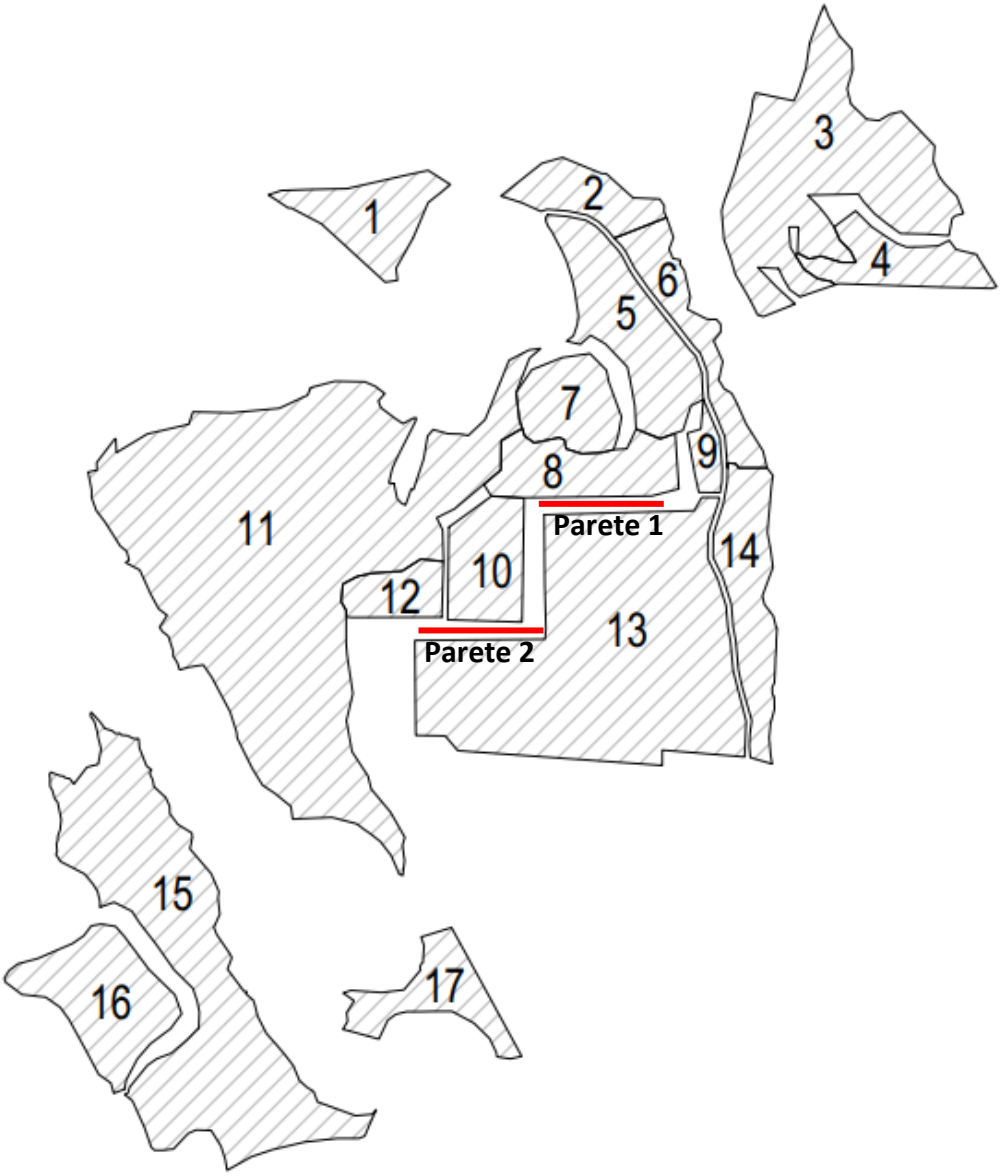
L'impianto sarà collegato a 30 KV alla SEU 30/150 KV localizzata nelle immediate vicinanze della CP Flaminia ARETI con un cavidotto di 13.520m.

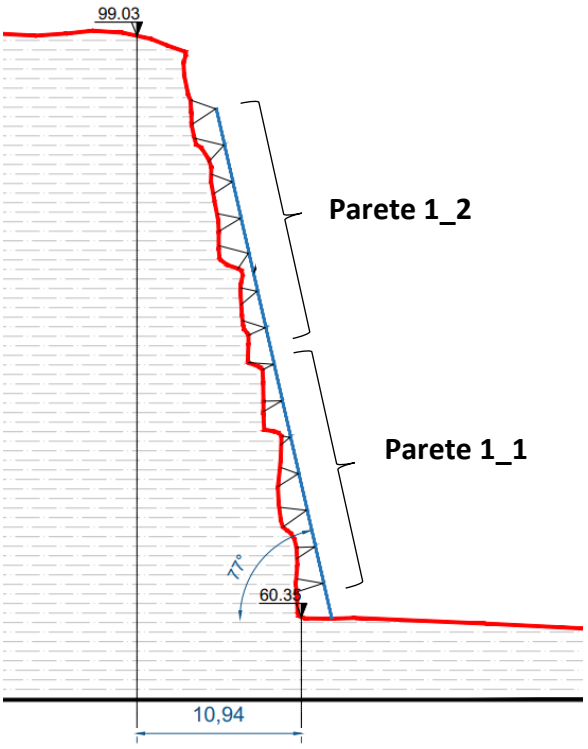
L'impianto sarà collegato alla RTN tramite la CP Flaminia ARETI a 150 kV tramite un cavidotto di 420m.

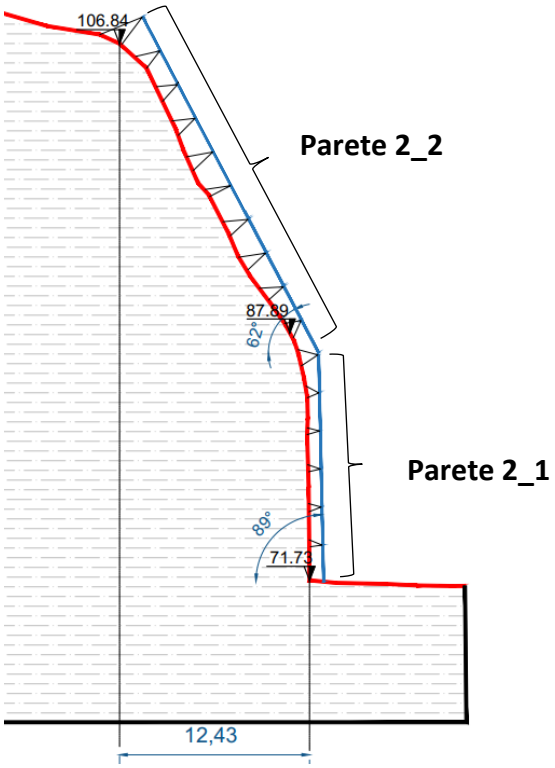
3 REPORT PVSYST

L'area di impianto prevede l'installazione di tecnologie differenti in funzione dell'orografia e dell'esposizione dei lotti. Per questo è stato necessario suddividere i report in funzione delle strutture utilizzate.
Si riportano brevemente le tecnologie installate e i lotti sulle quali giacciono:

- Rack ad asse fisso con tilt 20° e disposizione dei pannelli 2V lungo le aree più scoscese esposte a sud, installato nei lotti 8 e 4;
- Tracker monoassiali orientamento EST/OVEST e tilt variabile nelle aree a minor pendenza, installati nei lotti 1, 3, 7, 9,10, 11, 12, 13, 14, 15, 16 e 17;
- Tracker monoassiali ad orientamento misto nelle zone più scoscese, seguendo con terrazzamenti le curve di livello, installati nei lotti 5,2 e 6;
- Pareti verticali su strutture verticali a ridosso delle pareti in tufo esposte a sud suddivisi nei report in funzione delle altezze e inclinazioni in: Parete 1_1 ,1_2 e Parete 2_1, 2_2.




99.03
Parete 1_2
Parete 1_1
77°
60.35
10,94


106.84
Parete 2_2
87.89
62°
Parete 2_1
89°
71.73
12,43

Lotto	Tecnologia	Capacità (kWp)	Capacità kWac	Energia prodotta P50 kWh/yr	SP (kWh/kWp/yr)
Lotto 1	Tracker				
Lotto 3	Tracker				
Lotto 7	Tracker				
Lotto 11	Tracker				
Lotto 9	Tracker				
Lotto 10	Tracker				
Lotto 12	Tracker				
Lotto 13	Tracker				
Lotto 14	Tracker				
Lotto 13	Tracker				
Lotto 13	Tracker				
Lotto 15	Tracker				
Lotto 16	Tracker				
Lotto 17	Tracker				
	TOTALE Tracker	29.680	29.450	47.349.502	1.596
Lotto 8	Rack				
Lotto 4	Rack				
	TOTALE RACK	2.125	2.000	2.844.576	1.338
Lotto 5	Tracker rotate azimuth	1.758	1.500	2.421.779	1.377
Lotto 2	Tracker rotate azimuth	580	500	724.438	1.250
Lotto 6	Tracker rotate azimuth	792	750	1.125.784	1.421
Parete_1_2	Wall	773	700	1.075.647	1392
Parete_1_1	Wall	464	444	446.454	963
Parete_2_1	Wall	449	350	547.453	1221
Parete_2_2	Wall	897	700	993.309	1107
		37.518	**36.394**	**57.528.942**	**-**

Version 7.3.1

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry_Final Update

Variant: Rack_fixed

Ground system (tables) on a hill

System power: 2125 kWp

Riano - Italy

Author

Signature

PVsyst V7.3.1
VC0, Simulation date:
03/27/24 11:47
with v7.3.1

Project summary

Geographical Site
Riano
Italy

Situation
Latitude 42.09 °N
Longitude 12.51 °E
Altitude 126 m
Time zone UTC+1

Project settings
Albedo 0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015); Sat=57% - Synthetic

System summary

Grid-Connected System

Ground system (tables) on a hill

PV Field Orientation
Fixed planes 2 orientations
Tilts/azimuths 22.3 / 21.2 °
24.7 / -27.4 °

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

System information

PV Array
Nb. of modules 3080 units
Pnom total 2125 kWp

Inverters
Nb. of units 8 units
Pnom total 2000 kWac
Pnom ratio 1.063

Results summary

Produced Energy 2844576 kWh/year
Specific production 1338 kWh/kWp/year
Perf. Ratio PR 78.37 %

Table of contents

PVsyst V7.3.1
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with v7.3.1

General parameters

Grid-Connected System — **Ground system (tables) on a hill**

PV Field Orientation

Orientation		Sheds configuration		Models used	
Fixed planes	2 orientations	Nb. of sheds	108 units	Transposition	Perez
Tilts/azimuths	22.3 / 21.2 °	Several orientations		Diffuse	Perez, Meteonorm
	24.7 / -27.4 °			Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	3080 units
Nominal (STC)	2125 kWp

Inverter

Manufacturer	Sungrow
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	8 units
Total power	2000 kWac

Array #1 - Transformer_TX1

Orientation	#1		
Tilt/Azimuth	22/21 °		
Number of PV modules	1820 units	Number of inverters	5 units
Nominal (STC)	1256 kWp	Total power	1250 kWac
Modules	65 Strings x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	1150 kWp	Pnom ratio (DC:AC)	1.00
U mpp	1017 V	Power sharing within this inverter	
I mpp	1131 A		

Array #2 - Transformer_TX2

Orientation	#2		
Tilt/Azimuth	25/-27 °		
Number of PV modules	1260 units	Number of inverters	3 units
Nominal (STC)	869 kWp	Total power	750 kWac
Modules	45 Strings x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	796 kWp	Pnom ratio (DC:AC)	1.16
U mpp	1017 V	Power sharing within this inverter	
I mpp	783 A		

Total PV power

Nominal (STC)	2125 kWp
Total	3080 modules
Module area	9568 m²

Total inverter power

Total power	2000 kWac
Number of inverters	8 units
Pnom ratio	1.06

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Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 29.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

DC wiring losses

Global wiring resistance 0.91 mΩ
Loss Fraction 0.2 % at STC

Array #1 - Transformer_TX1
Global array res. 1.5 mΩ
Loss Fraction 0.2 % at STC

Array #2 - Transformer_TX2
Global array res. 2.2 mΩ
Loss Fraction 0.2 % at STC

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 0.45 % at STC

Inverter: SG250-HX
Wire section (8 Inv.) Copper 8 x 3 x 95 mm²
Average wires length 63 m

MV line up to Injection
MV Voltage 36 kV
Average each inverter
Wires Copper 3 x 2.5 mm²
Length 1000 m
Loss Fraction 0.61 % at STC

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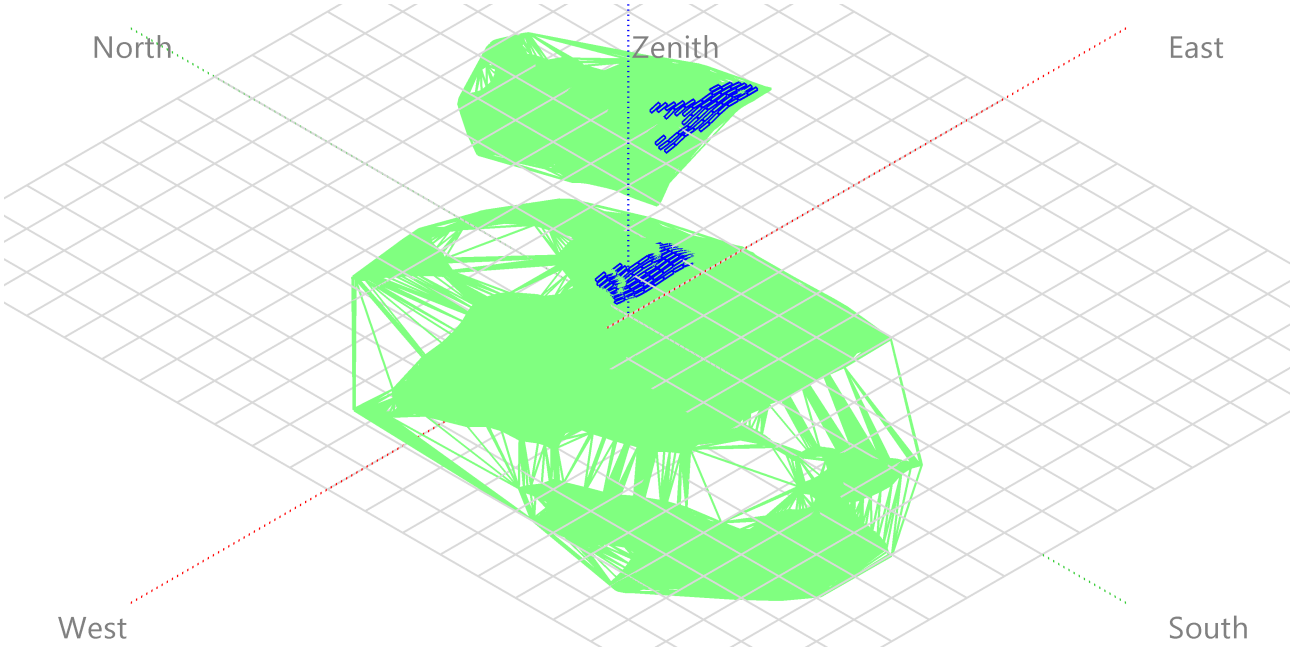
AC losses in transformers

MV transfo		
Grid voltage	36	kV
One transfo in each sub-array		
Array #1 - Transformer_TX1		
Transformer parameters		
Nominal power at STC	1.24	MVA
Iron Loss (24/24 Connexion)	1.24	kVA
Iron loss fraction	0.10	% at STC
Copper loss	12.43	kVA
Copper loss fraction	1.00	% at STC
Coils equivalent resistance	3 x 5.15	mΩ
Array #2 - Transformer_TX2		
Transformer parameters		
Nominal power at STC	861	kVA
Iron Loss (24/24 Connexion)	0.86	kVA
Iron loss fraction	0.10	% at STC
Copper loss	8.61	kVA
Copper loss fraction	1.00	% at STC
Coils equivalent resistance	3 x 7.44	mΩ

Near shadings parameter

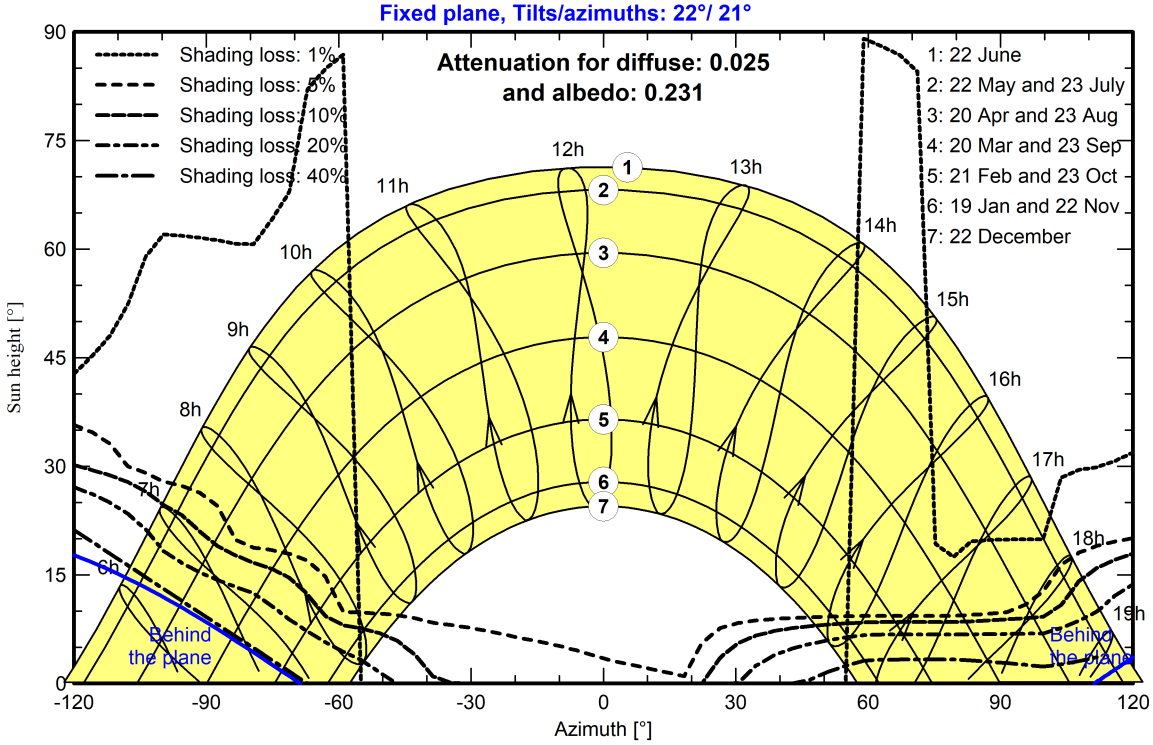
Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

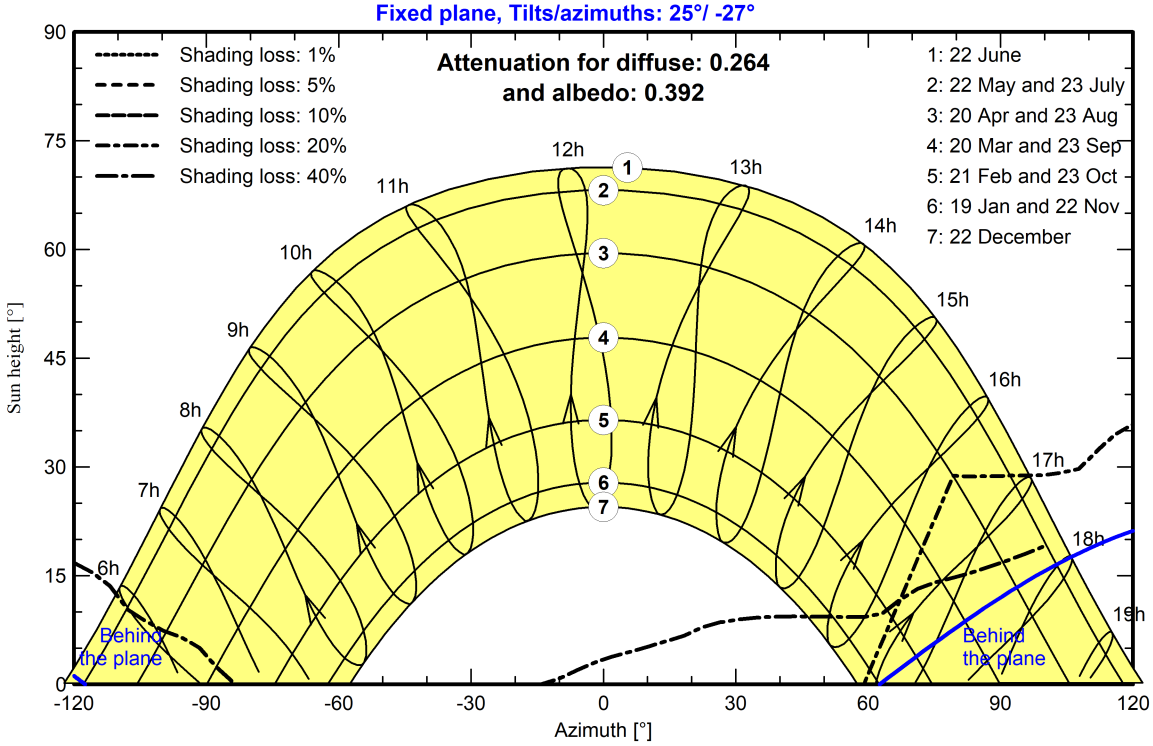
Orientation #1

Fixed plane, Tilts/azimuths: 22°/ 21°



Orientation #2

Fixed plane, Tilts/azimuths: 25°/ -27°

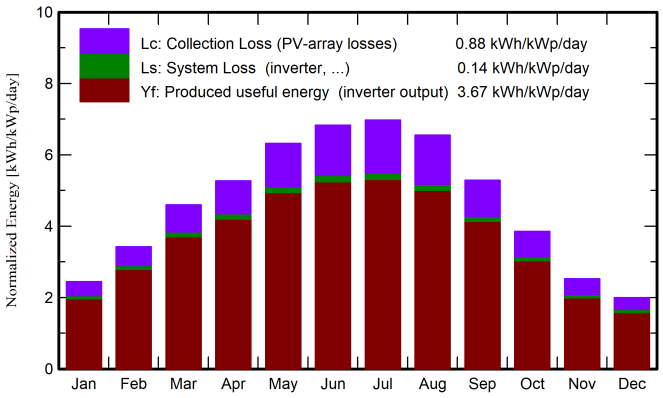


Main results

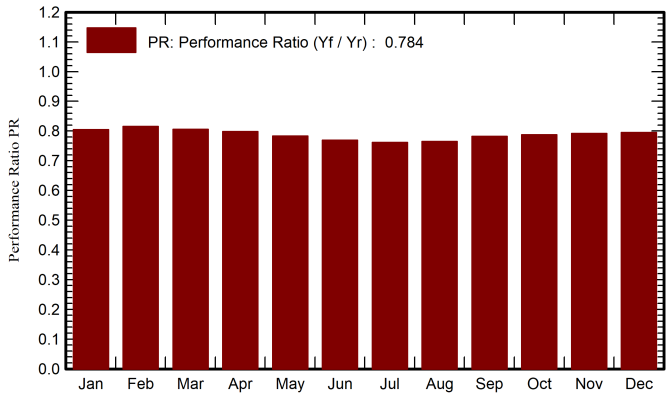
System Production

Produced Energy (P50)	2844576 kWh/year	Specific production (P50)	1338 kWh/kWp/year	Performance Ratio PR	78.37 %
Produced Energy (P90)	2778819 kWh/year	Produced Energy (P90)	1308 kWh/kWp/year		
Produced Energy (P95)	2760317 kWh/year	Produced Energy (P95)	1299 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.90	7.77	75.8	64.6	135726	129587	0.804
February	72.5	34.60	8.94	95.8	82.7	172689	166107	0.816
March	121.3	56.00	12.20	142.6	123.2	253209	244207	0.806
April	147.3	68.60	15.45	158.0	136.7	277714	268055	0.798
May	191.8	75.50	19.98	195.8	169.0	337238	325980	0.783
June	207.5	80.80	24.45	204.8	177.3	346613	335016	0.770
July	215.4	69.90	27.52	216.2	186.9	361788	350028	0.762
August	190.1	68.10	27.40	203.1	176.3	341243	330065	0.765
September	135.4	51.60	22.17	158.8	137.5	273061	263835	0.782
October	93.9	42.60	18.41	119.5	102.9	207866	200070	0.788
November	55.6	29.10	13.08	75.6	64.8	133440	127285	0.792
December	43.8	26.50	9.08	61.8	52.7	109965	104340	0.795
Year	1527.1	629.19	17.25	1707.9	1474.7	2950553	2844576	0.784

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

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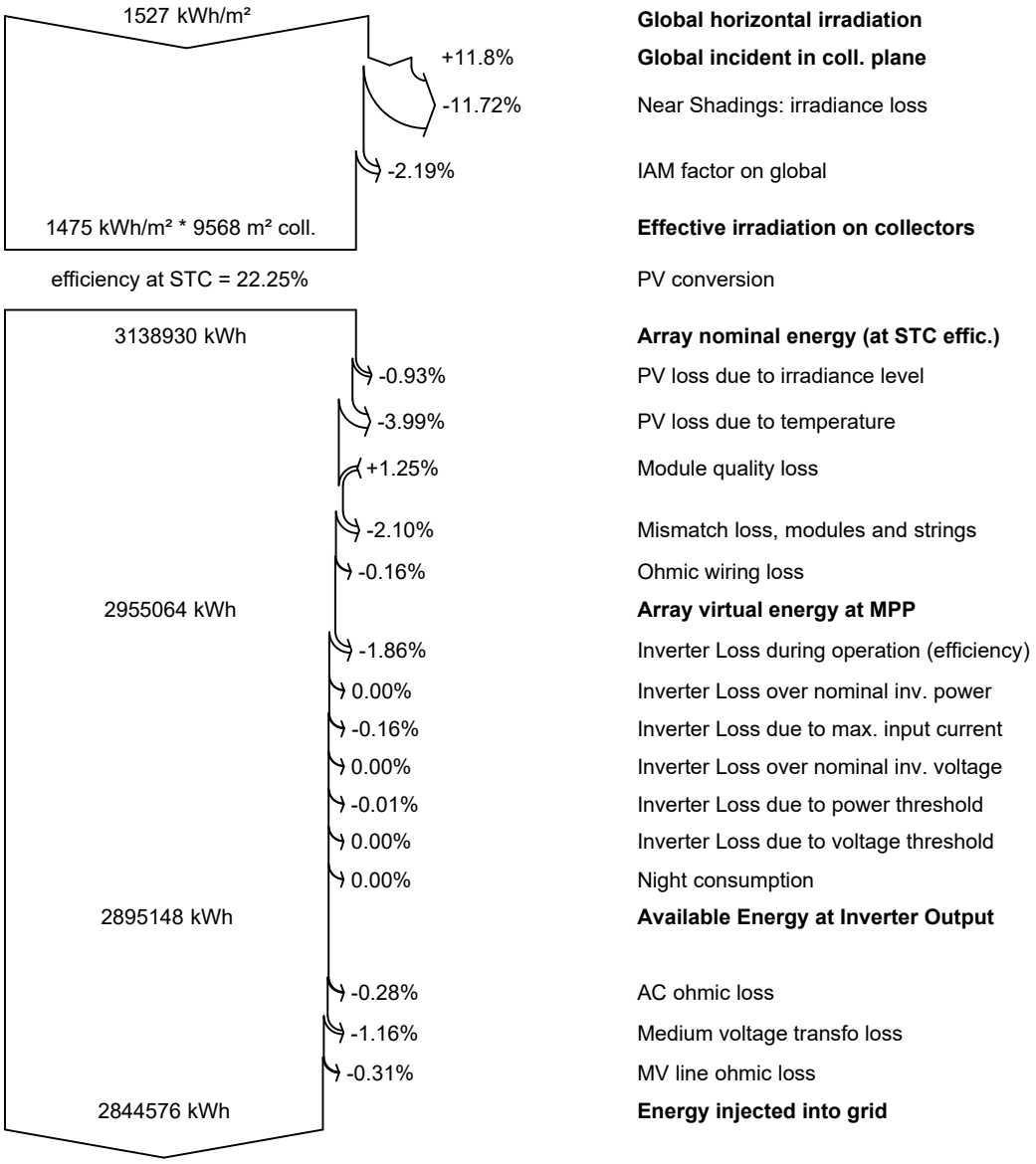
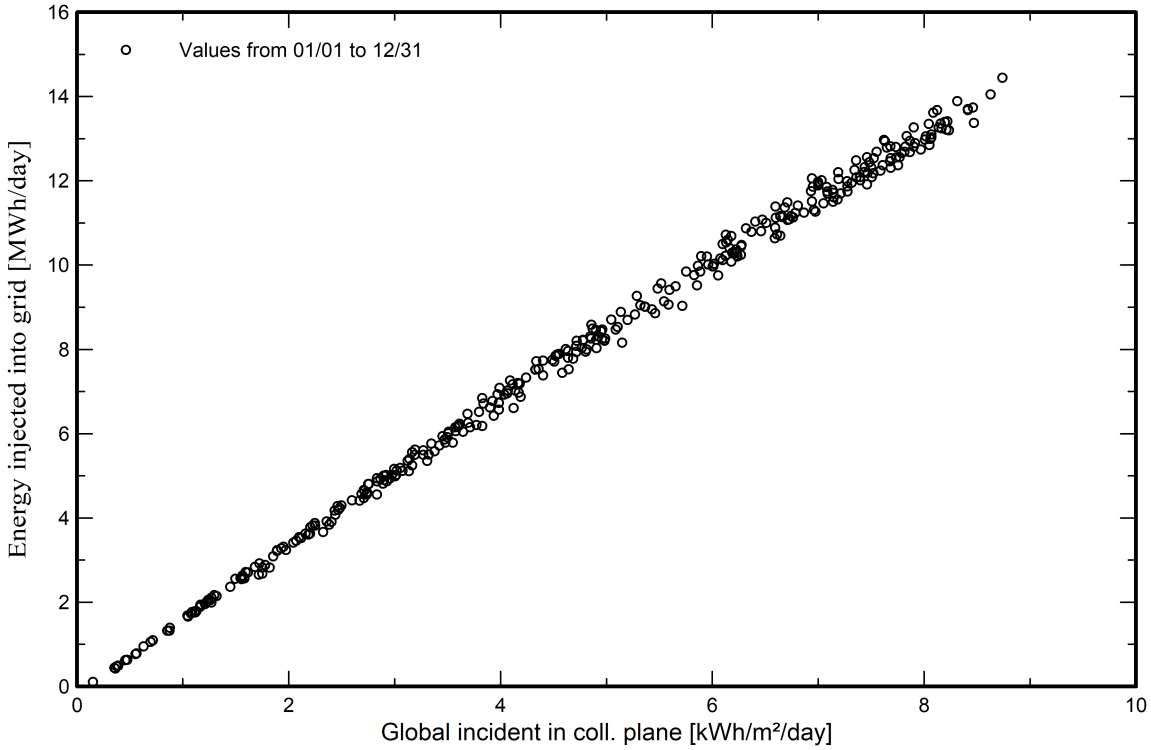
with v7.3.1

Loss diagram

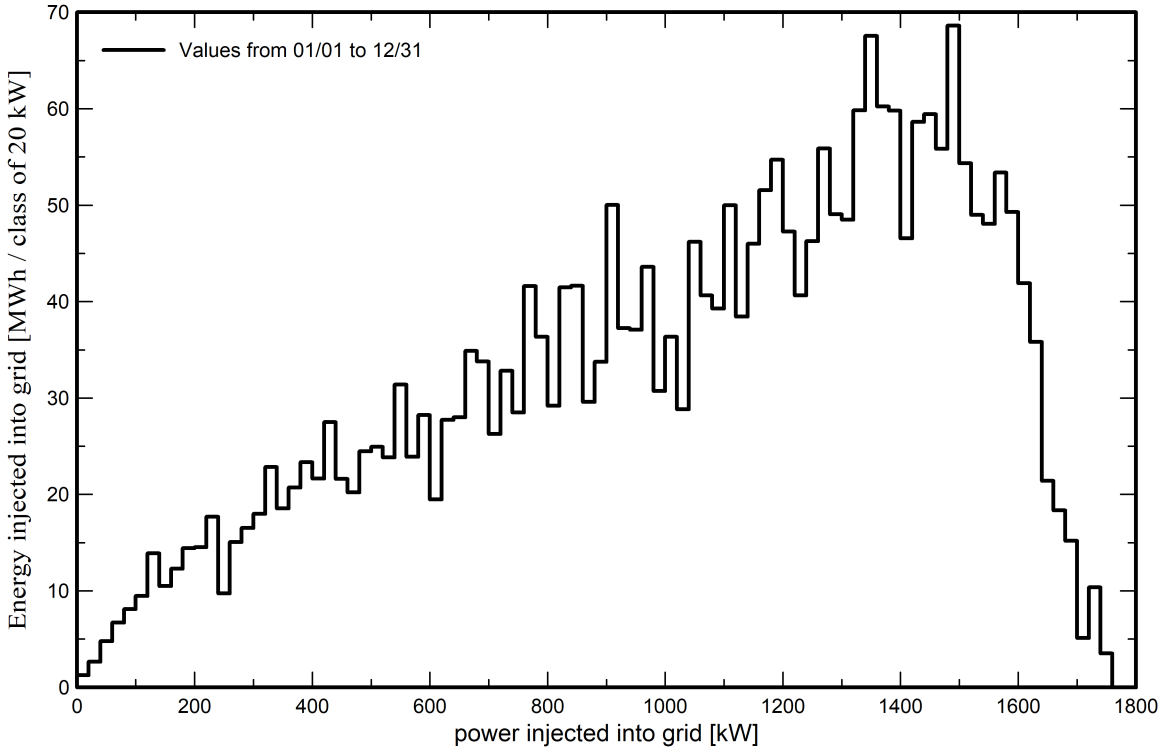


Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015); Sat=57%
Kind	Not defined
Year-to-year variability(Variance)	0.0 %
Specified Deviation	

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 %

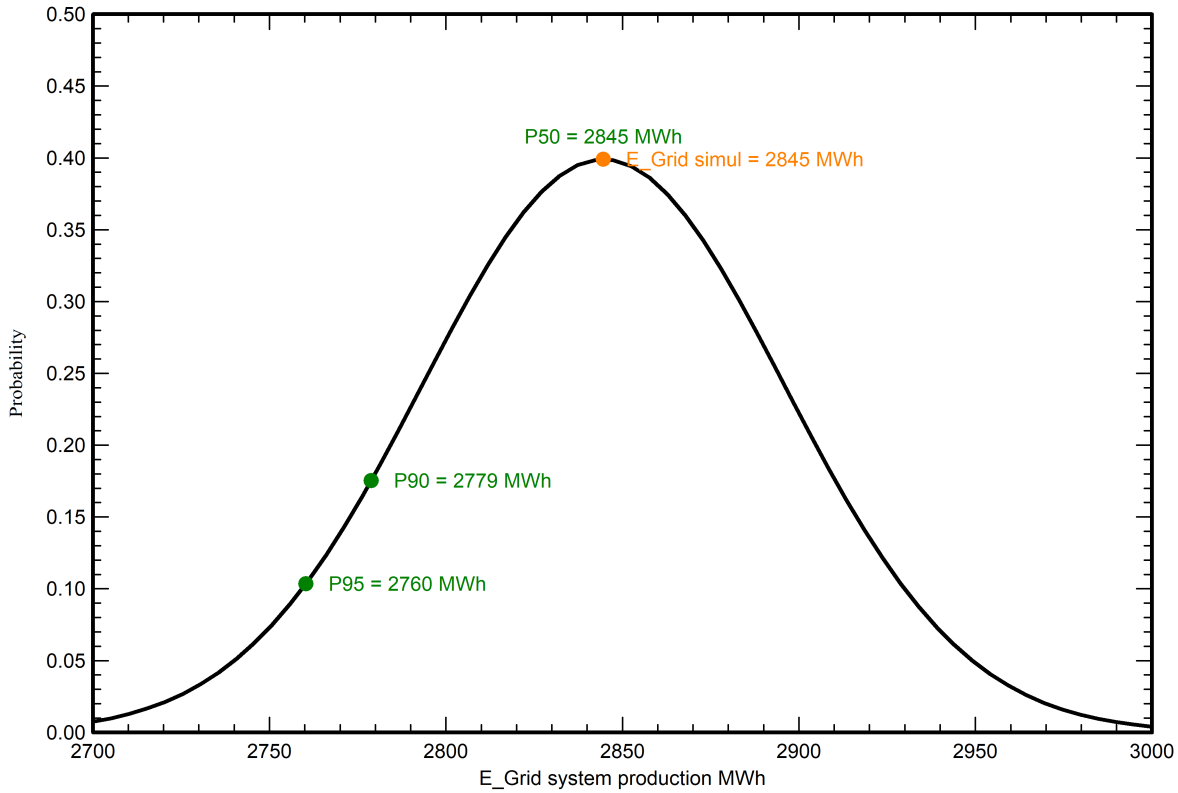
Global variability (meteo + system)

Variability (Quadratic sum)	1.8 %

Annual production probability

Variability	51 MWh
P50	2845 MWh
P90	2779 MWh
P95	2760 MWh

Probability distribution



Single-line diagram

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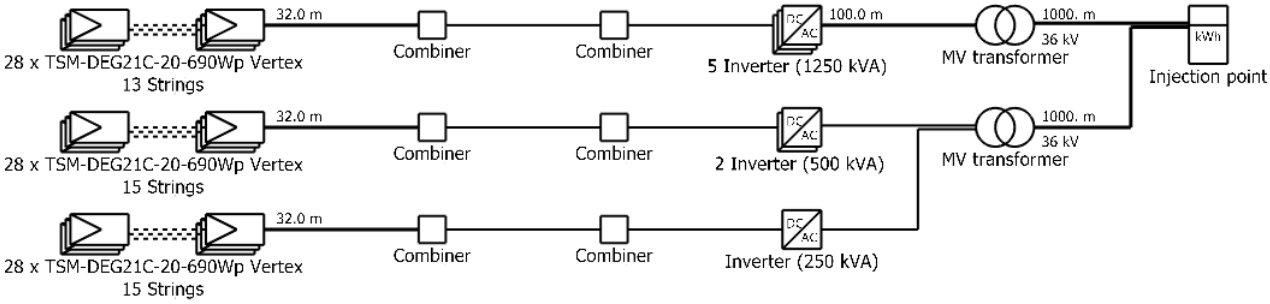

PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG250-HX
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry_Final Update	
	VC0 : Asse fisso_fixed	03/27/24

Version 7.4.6

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry Final

Variant: Tracker_EW

Tracking system with backtracking

System power: 29.68 MWp

Riano - Italy

Author

Studio Santi srl (Italy)

PVsyst V7.4.6
VC0, Simulation date:
03/27/24 15:19
with V7.4.6

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	186 m
Time zone	UTC+1

Project settings
Albedo 0.20

Weather data
Riano
Meteonorm 8.1 (1996-2015); Sat=57% - Synthetic

System summary

Grid-Connected System

Tracking system with backtracking

PV Field Orientation
Orientation
Tracking plane, tilted axis

Avg axis tilt	2.1 °
Avg axis azim.	0 °

Tracking algorithm
Astronomic calculation
Backtracking activated

Near Shadings
Linear shadings : Fast (table)
Diffuse shading Automatic

System information

PV Array

Nb. of modules	43008 units
Pnom total	29.68 MWp

Inverters

Nb. of units	43 units
Pnom total	29.45 MWac
Pnom ratio	1.008

User's needs
Unlimited load (grid)

Results summary

Produced Energy	47349502 kWh/year	Specific production	1596 kWh/kWp/year	Perf. Ratio PR	85.59 %

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General parameters

Grid-Connected System — **Tracking system with backtracking**

PV Field Orientation

Orientation

Tracking plane, tilted axis	
Avg axis tilt	2.1 °
Avg axis azim.	0 °

Tracking algorithm

Astronomic calculation	
Backtracking activated	

Backtracking array

Nb. of trackers	1703 units
Identical arrays	

Sizes

Tracker Spacing	4.10 m
Collector width	2.38 m
Ground Cov. Ratio (GCR)	58.1 %
Phi min / max.	-/+ 55.0 °

Backtracking strategy

Phi limits for BT	-/+ 54.2 °
Backtracking pitch	3.76 m
Backtracking width	2.38 m

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings : Fast (table)
Diffuse shading Automatic

User's needs
Unlimited load (grid)

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	4.10 m
Tracker width	2.38 m
GCR	58.1 %
Axis height above ground	1.50 m

Bifacial model definitions

Ground albedo	0.20
Bifaciality factor	72 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	7784 units
Nominal (STC)	5371 kWp

Inverter

Manufacturer	Sungrow
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	21 units
Total power	5250 kWac

Array #1 - Transformer TX1

Number of PV modules	1316 units
Nominal (STC)	908 kWp
Modules	47 string x 28 In series
At operating cond. (50°C)	
Pmpp	832 kWp
U mpp	1017 V
I mpp	818 A

Number of inverters	4 units
Total power	1000 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	0.91
Power sharing within this inverter	

PV Array Characteristics

Array #2 - Transformer TX2

Number of PV modules	2884 units	Number of inverters	8 units
Nominal (STC)	1990 kWp	Total power	2000 kWac
Modules	103 string x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	1823 kWp	Pnom ratio (DC:AC)	0.99
U mpp	1017 V	Power sharing within this inverter	
I mpp	1792 A		

Array #3 - Transformer TX3

Number of PV modules	1484 units	Number of inverters	4 units
Nominal (STC)	1024 kWp	Total power	1000 kWac
Modules	53 string x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	938 kWp	Pnom ratio (DC:AC)	1.02
U mpp	1017 V	Power sharing within this inverter	
I mpp	922 A		

Array #4 - Transformer TX4

Number of PV modules	280 units	Number of inverters	1 unit
Nominal (STC)	193 kWp	Total power	250 kWac
Modules	10 string x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	177 kWp	Pnom ratio (DC:AC)	0.77
U mpp	1017 V	Power sharing within this inverter	
I mpp	174 A		

Array #15 - Sub-array #15

Number of PV modules	1820 units	Number of inverters	4 units
Nominal (STC)	1256 kWp	Total power	1000 kWac
Modules	65 string x 28 In series		
At operating cond. (50°C)		Operating voltage	500-1450 V
Pmpp	1150 kWp	Pnom ratio (DC:AC)	1.26
U mpp	1017 V	Power sharing within this inverter	
I mpp	1131 A		

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	35224 units
Nominal (STC)	24.30 MWp

Inverter

Manufacturer	Sungrow
Model	SG1100UD-MV
(Custom parameters definition)	
Unit Nom. Power	1100 kWac
Number of inverters	22 units
Total power	24200 kWac

Array #5 - Transformer TX5

Number of PV modules	3444 units	Number of inverters	2 units
Nominal (STC)	2376 kWp	Total power	2200 kWac
Modules	123 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	2177 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	1.08
I mpp	2140 A		

PV Array Characteristics

Array #6 - Transformer T6

Number of PV modules	3136 units	Number of inverters	2 units
Nominal (STC)	2164 kWp	Total power	2200 kWac
Modules	112 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	1982 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.98
I mpp	1949 A		

Array #7 - Sub-array #7

Number of PV modules	3136 units	Number of inverters	2 units
Nominal (STC)	2164 kWp	Total power	2200 kWac
Modules	112 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	1982 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.98
I mpp	1949 A		

Array #8 - Sub-array #8

Number of PV modules	3136 units	Number of inverters	2 units
Nominal (STC)	2164 kWp	Total power	2200 kWac
Modules	112 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	1982 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.98
I mpp	1949 A		

Array #9 - Sub-array #9

Number of PV modules	3220 units	Number of inverters	2 units
Nominal (STC)	2222 kWp	Total power	2200 kWac
Modules	115 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	2035 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	1.01
I mpp	2001 A		

Array #10 - Sub-array #10

Number of PV modules	4704 units	Number of inverters	3 units
Nominal (STC)	3246 kWp	Total power	3300 kWac
Modules	168 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	2973 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.98
I mpp	2923 A		

Array #11 - Sub-array #11

Number of PV modules	5992 units	Number of inverters	4 units
Nominal (STC)	4134 kWp	Total power	4400 kWac
Modules	214 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	3788 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.94
I mpp	3723 A		

PV Array Characteristics

Array #12 - Sub-array #12

Number of PV modules	1568 units	Number of inverters	1 unit
Nominal (STC)	1082 kWp	Total power	1100 kWac
Modules	56 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	991 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	0.98
I mpp	974 A		

Array #13 - Sub-array #13

Number of PV modules	1680 units	Number of inverters	1 unit
Nominal (STC)	1159 kWp	Total power	1100 kWac
Modules	60 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	1062 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	1.05
I mpp	1044 A		

Array #14 - Sub-array #14

Number of PV modules	5208 units	Number of inverters	3 units
Nominal (STC)	3594 kWp	Total power	3300 kWac
Modules	186 string x 28 In series		
At operating cond. (50°C)		Operating voltage	895-1500 V
Pmpp	3292 kWp	Max. power (=>25°C)	1265 kWac
U mpp	1017 V	Pnom ratio (DC:AC)	1.09
I mpp	3236 A		

Total PV power

Nominal (STC)	29676 kWp
Total	43008 modules
Module area	133598 m²

Total inverter power

Total power	29450 kWac
Max. power	33080 kWac
Number of inverters	43 units
Pnom ratio	1.01

Array losses

Thermal Loss factor

Module temperature according to irradiance

Uc (const)	20.0 W/m²K
Uv (wind)	0.0 W/m²K/m/s

Serie Diode Loss

Voltage drop	0.7 V
Loss Fraction	0.1 % at STC

Module Quality Loss

Loss Fraction -1.3 %

Module mismatch losses

Array #1 - Transformer TX1
Loss Fraction 2.0 % at MPP

Array #2 - Transformer TX2
Loss Fraction 2.0 % at MPP

Array #3 - Transformer TX3
Loss Fraction 2.0 % at MPP

Array #4 - Transformer TX4
Loss Fraction 2.0 % at MPP

Array #5 - Transformer TX5
Loss Fraction 2.0 % at MPP

Array #6 - Transformer T6
Loss Fraction 2.0 % at MPP

Array #7 - Sub-array #7
Loss Fraction 2.0 % at MPP

Array #8 - Sub-array #8
Loss Fraction 2.0 % at MPP

Array losses

Module mismatch losses

Array #9 - Sub-array #9
Loss Fraction 2.0 % at MPP

Array #10 - Sub-array #10
Loss Fraction 2.0 % at MPP

Array #11 - Sub-array #11
Loss Fraction 2.0 % at MPP

Array #12 - Sub-array #12
Loss Fraction 2.0 % at MPP

Array #13 - Sub-array #13
Loss Fraction 2.0 % at MPP

Array #14 - Sub-array #14
Loss Fraction 2.0 % at MPP

Array #15 - Sub-array #15
Loss Fraction 2.0 % at MPP

IAM loss factor

Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

DC wiring losses

Global wiring resistance 0.63 mΩ
Loss Fraction 1.5 % at STC

Array #1 - Transformer TX1
Global array res. 20 mΩ
Loss Fraction 1.5 % at STC

Array #2 - Transformer TX2
Global array res. 9.4 mΩ
Loss Fraction 1.5 % at STC

Array #3 - Transformer TX3
Global array res. 18 mΩ
Loss Fraction 1.5 % at STC

Array #4 - Transformer TX4
Global array res. 96 mΩ
Loss Fraction 1.5 % at STC

Array #5 - Transformer TX5
Global array res. 7.8 mΩ
Loss Fraction 1.5 % at STC

Array #6 - Transformer T6
Global array res. 8.6 mΩ
Loss Fraction 1.5 % at STC

Array #7 - Sub-array #7
Global array res. 8.6 mΩ
Loss Fraction 1.5 % at STC

Array #8 - Sub-array #8
Global array res. 8.6 mΩ
Loss Fraction 1.5 % at STC

Array #9 - Sub-array #9
Global array res. 8.4 mΩ
Loss Fraction 1.5 % at STC

Array #10 - Sub-array #10
Global array res. 5.7 mΩ
Loss Fraction 1.5 % at STC

Array #11 - Sub-array #11
Global array res. 4.5 mΩ
Loss Fraction 1.5 % at STC

Array #12 - Sub-array #12
Global array res. 17 mΩ
Loss Fraction 1.5 % at STC

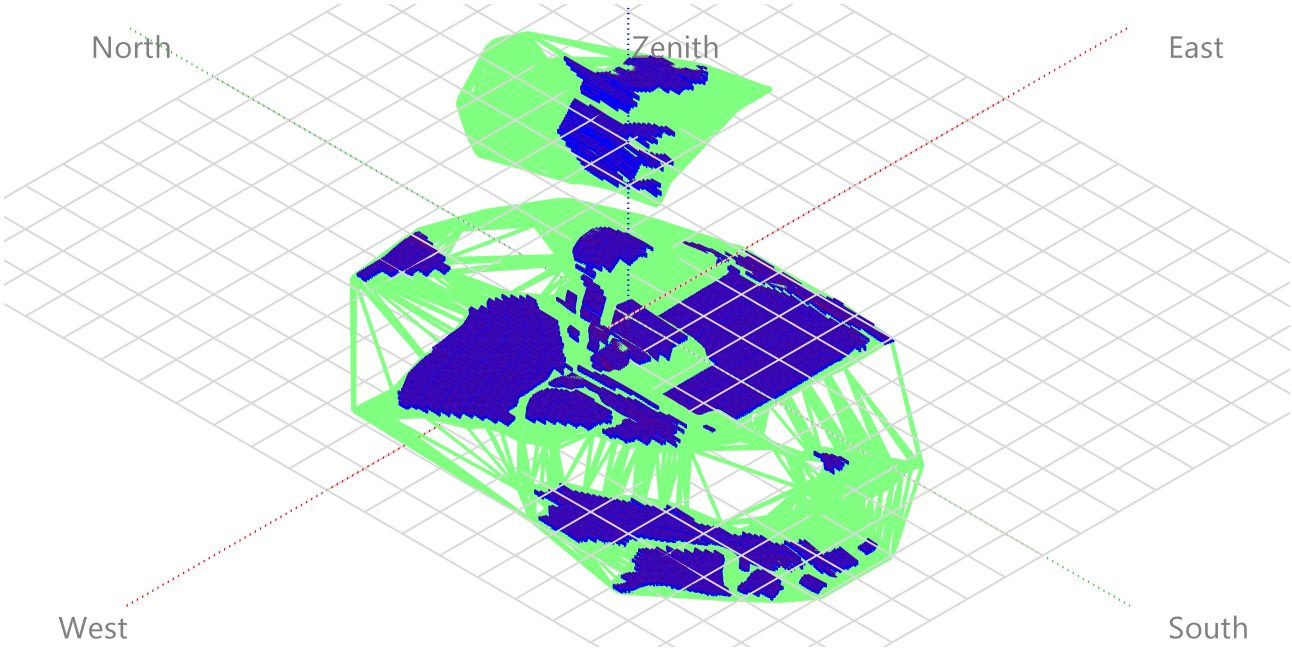
Array #13 - Sub-array #13
Global array res. 16 mΩ
Loss Fraction 1.5 % at STC

Array #14 - Sub-array #14
Global array res. 5.2 mΩ
Loss Fraction 1.5 % at STC

Array #15 - Sub-array #15
Global array res. 15 mΩ
Loss Fraction 1.5 % at STC

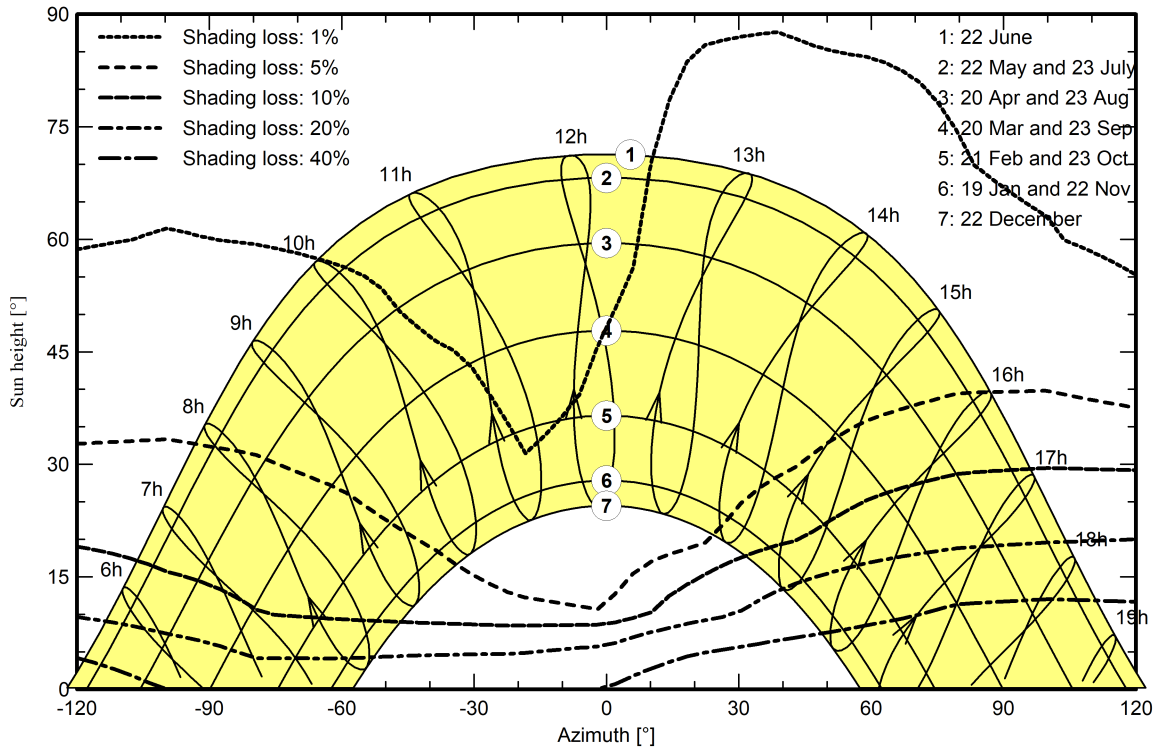
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1



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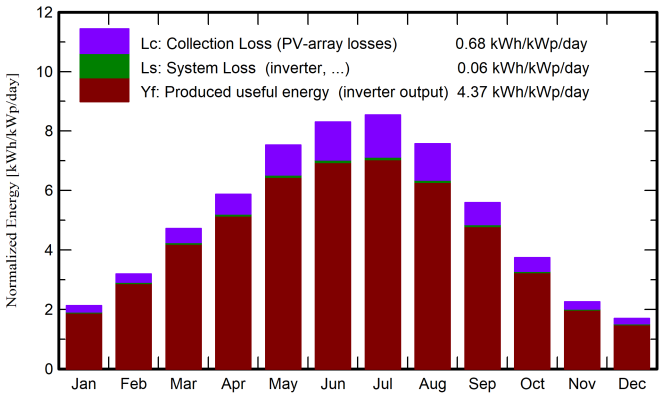
with V7.4.6

Main results

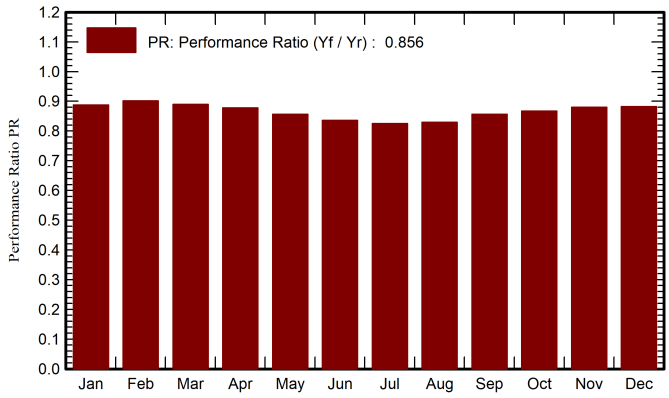
System Production

Produced Energy (P50)	47349502 kWh/year	Specific production (P50)	1596 kWh/kWp/year	Perf. Ratio PR	85.59 %
Produced Energy (P90)	44877806 kWh/year	Specific production (P90)	1512 kWh/kWp/year		
Produced Energy (P95)	44182366 kWh/year	Specific production (P95)	1489 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.90	7.77	65.9	59.1	1766917	1735936	0.888
February	72.5	34.60	8.94	89.3	82.0	2424324	2388741	0.901
March	121.3	56.00	12.20	146.4	136.0	3916869	3864891	0.890
April	147.3	68.60	15.45	176.1	164.5	4647429	4586878	0.878
May	191.8	75.50	19.98	233.6	219.1	6008140	5933603	0.856
June	207.5	80.80	24.45	249.3	234.3	6262356	6183959	0.836
July	215.4	69.90	27.52	264.7	248.8	6562853	6482915	0.825
August	190.1	68.10	27.40	234.7	220.4	5849715	5777277	0.830
September	135.4	51.60	22.17	167.9	156.5	4322815	4268150	0.857
October	93.9	42.60	18.41	116.0	106.5	3029915	2986602	0.867
November	55.6	29.10	13.08	67.7	61.4	1799395	1767604	0.880
December	43.8	26.50	9.08	52.4	46.8	1400947	1372946	0.882
Year	1527.1	629.19	17.25	1864.1	1735.5	47991673	47349502	0.856

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

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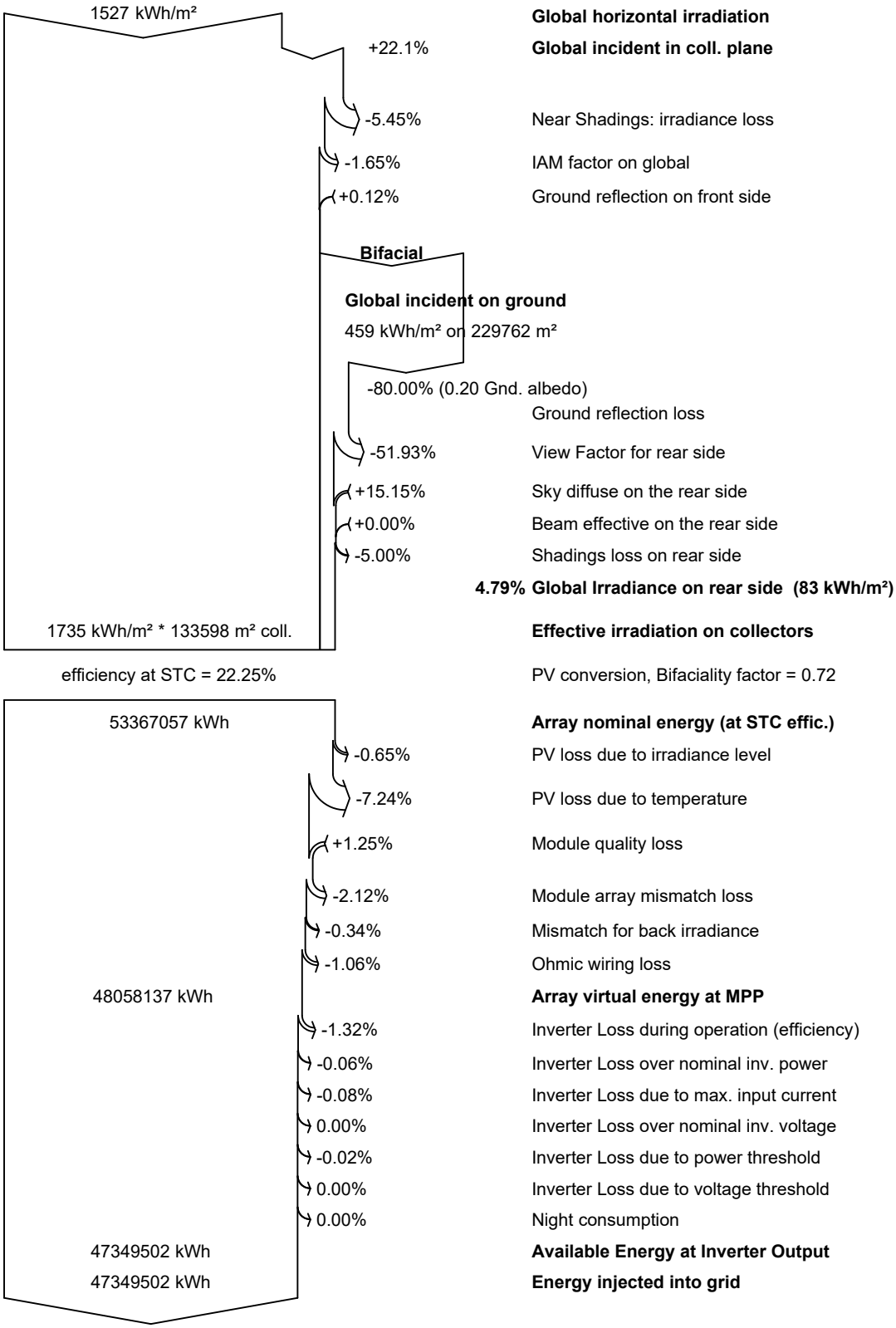
Loss diagram



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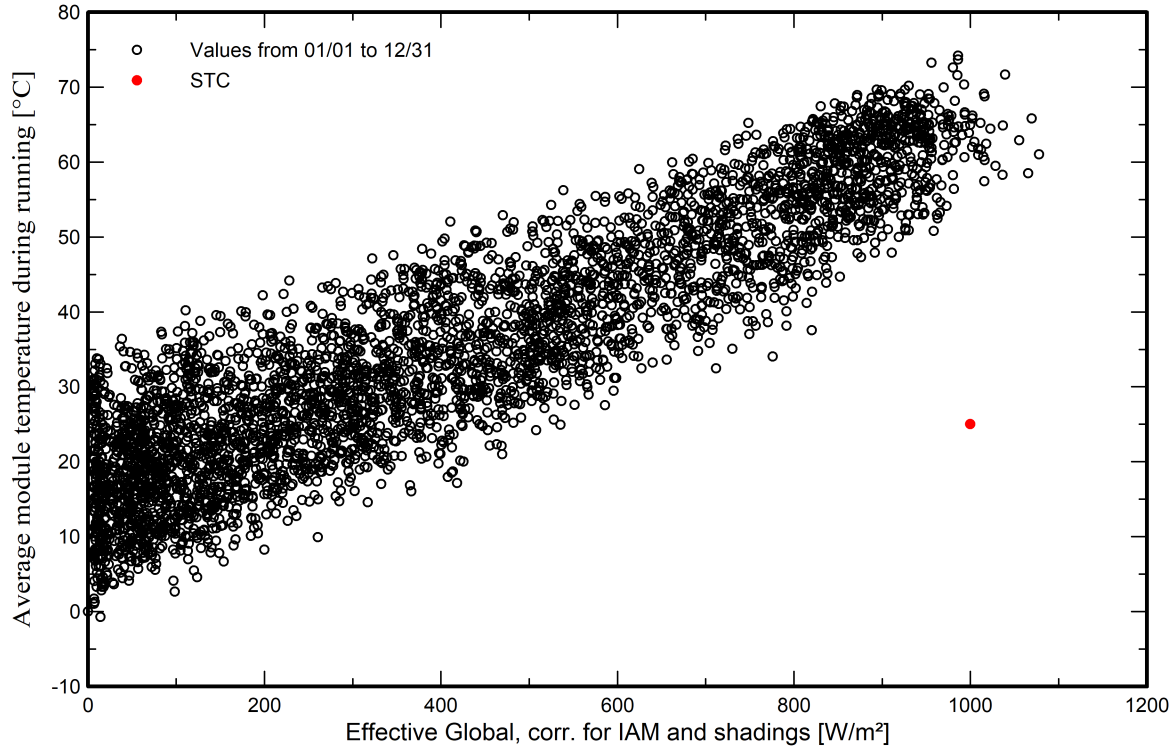
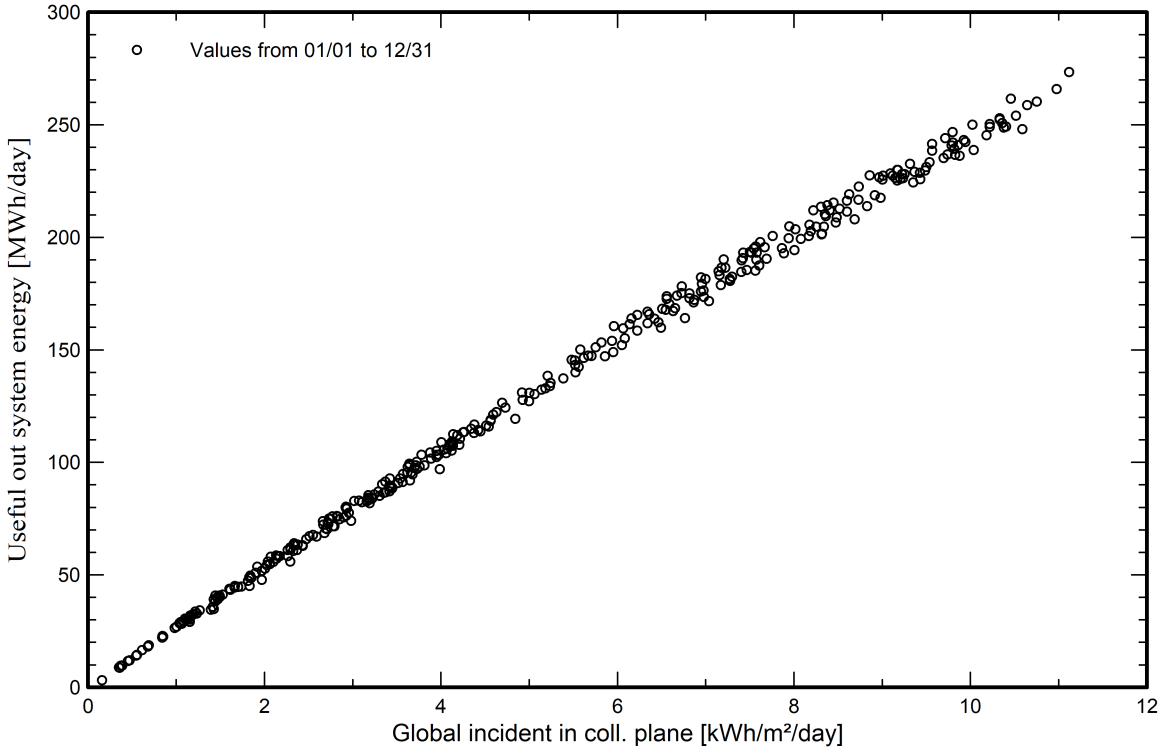
Predef. graphs

Array Temperature vs. Effective Irradiance



Daily Input/Output diagram



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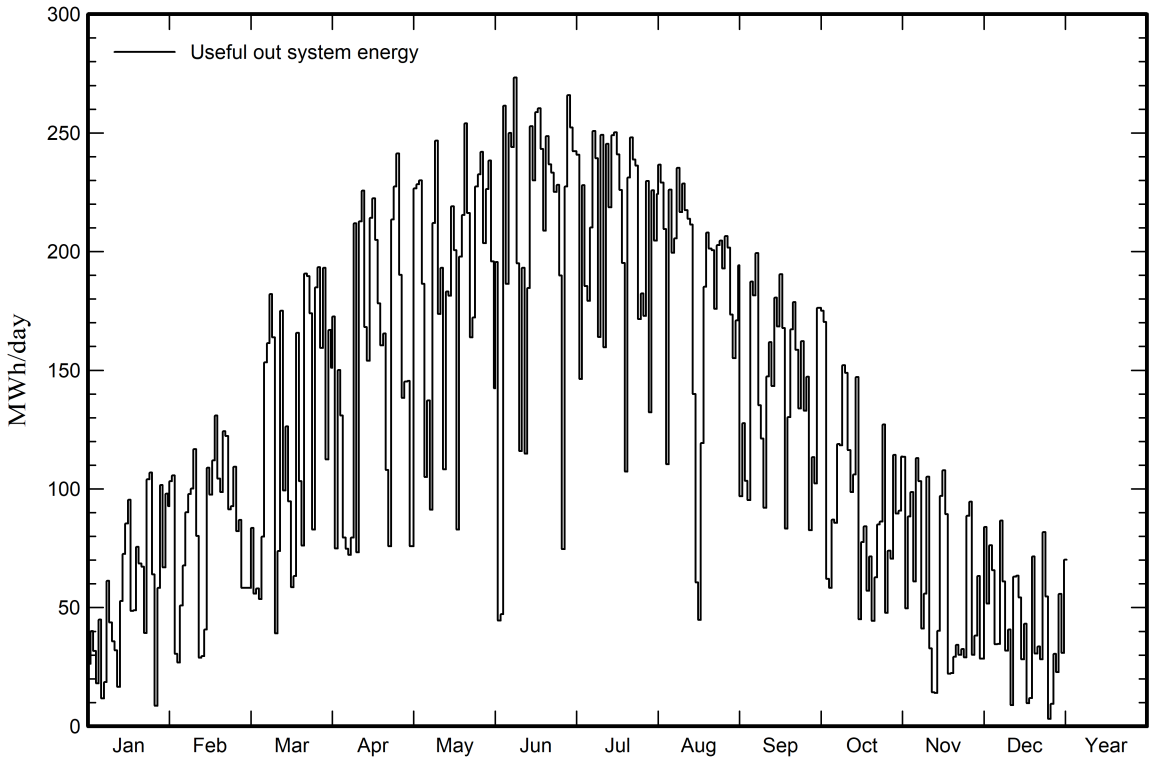
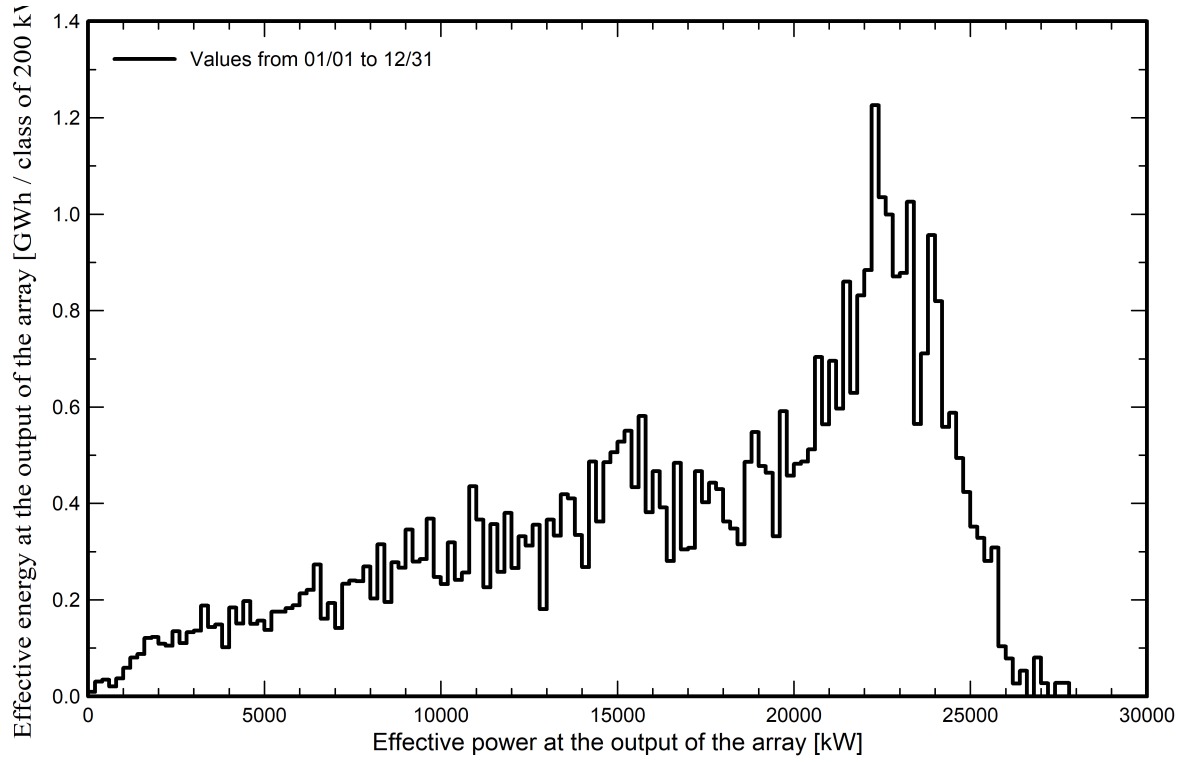
Predef. graphs

Daily System Output Energy



Array Power Distribution



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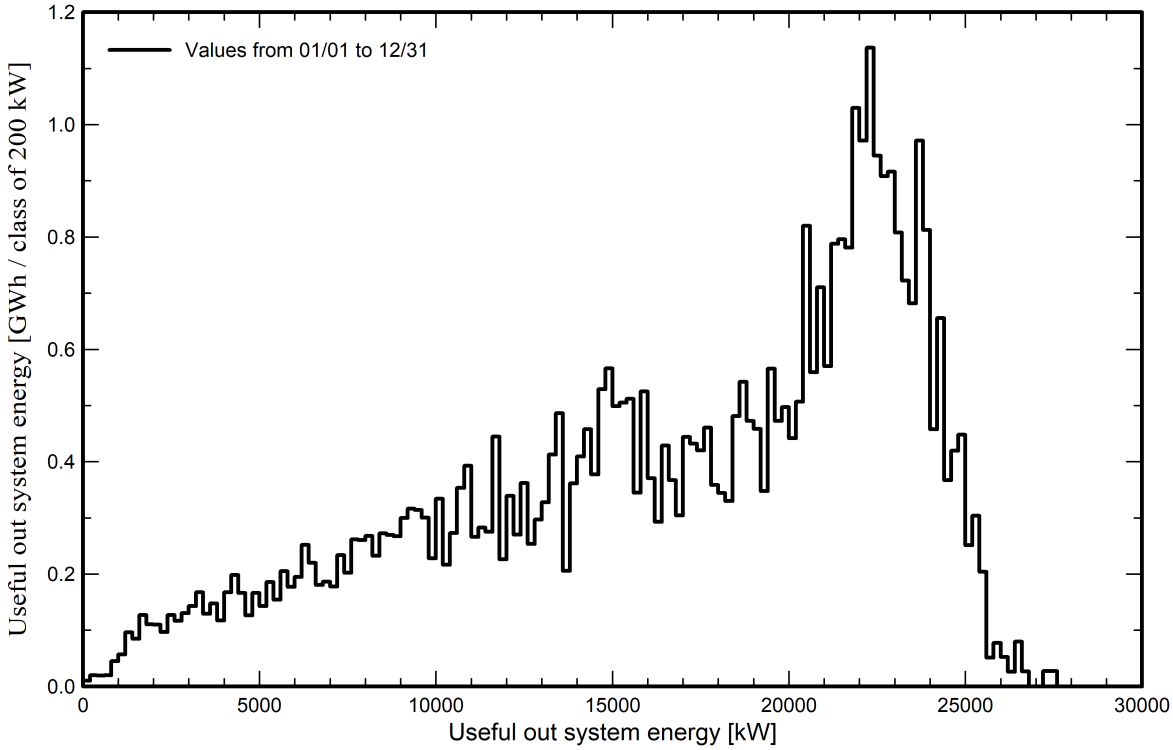
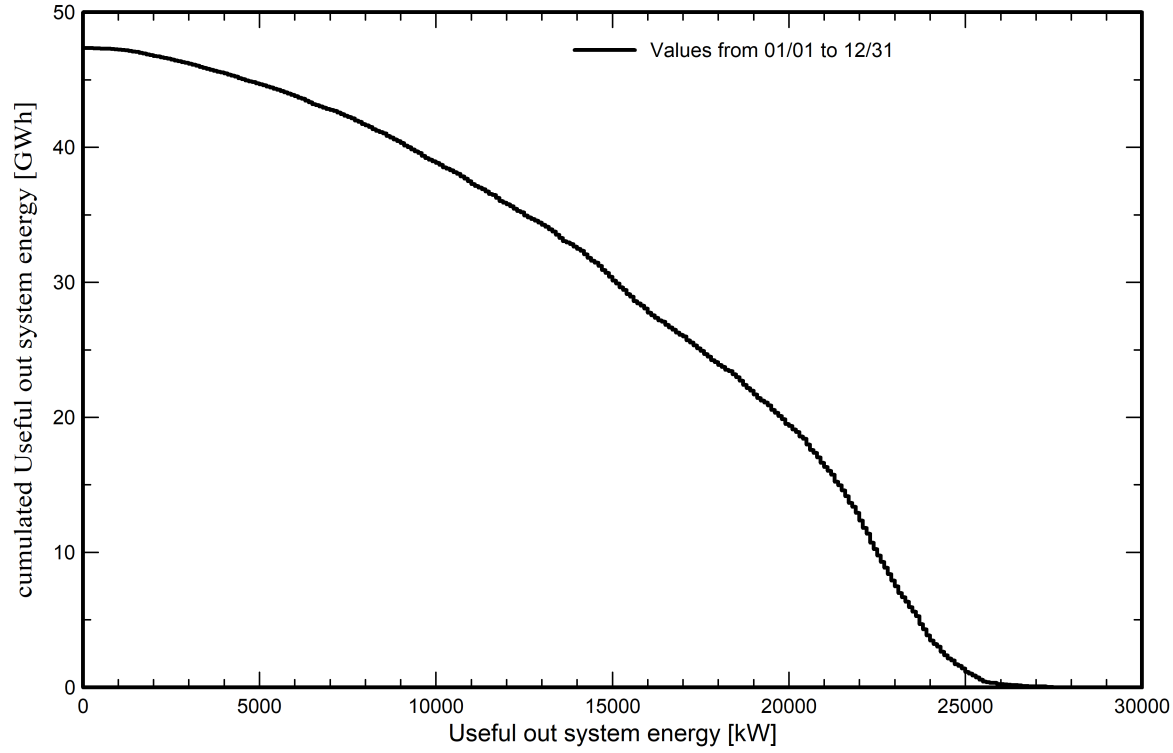
Predef. graphs

System Output Power Distribution



System Output Power cumulative distribution



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P50 - P90 evaluation

Weather data

Source	Meteonorm 8.1 (1996-2015); Sat=57%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	3.7 %

Specified Deviation

Climate change	0.0 %

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 %

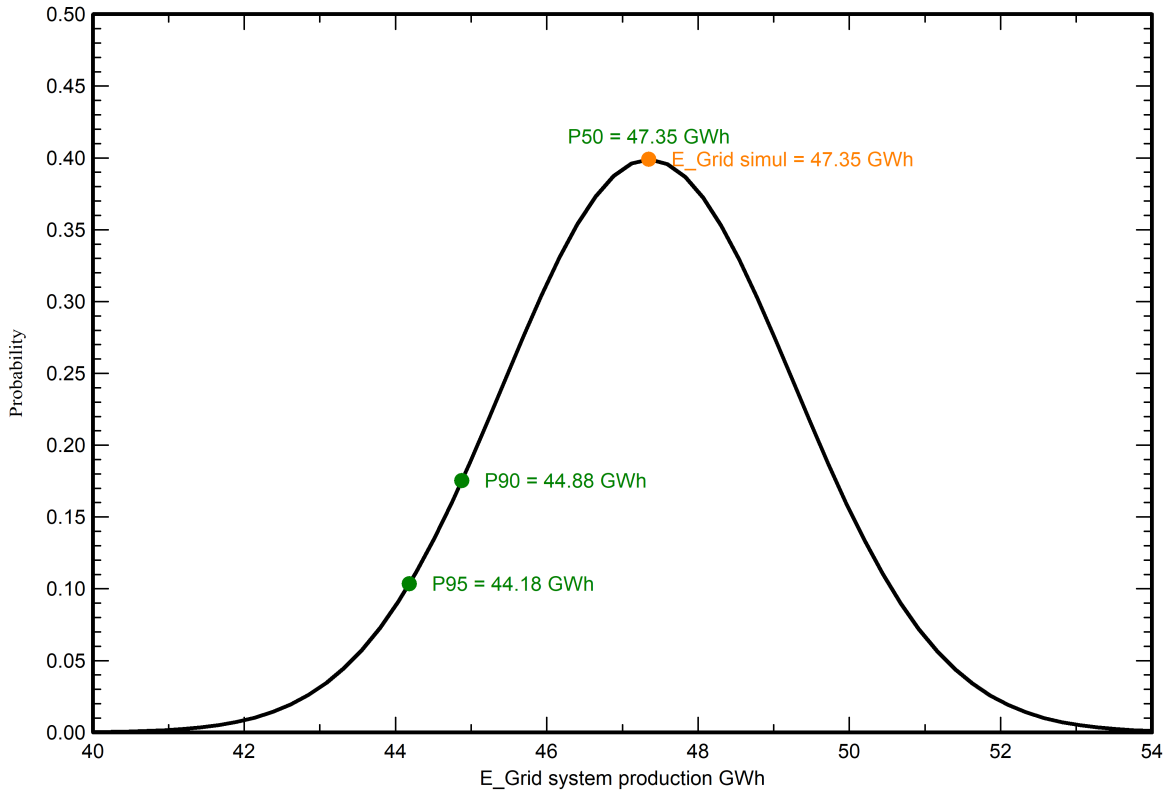
Global variability (weather data + system)

Variability (Quadratic sum)	4.1 %

Annual production probability

Variability	1.93 GWh
P50	47.35 GWh
P90	44.88 GWh
P95	44.18 GWh

Probability distribution



Single-line diagram

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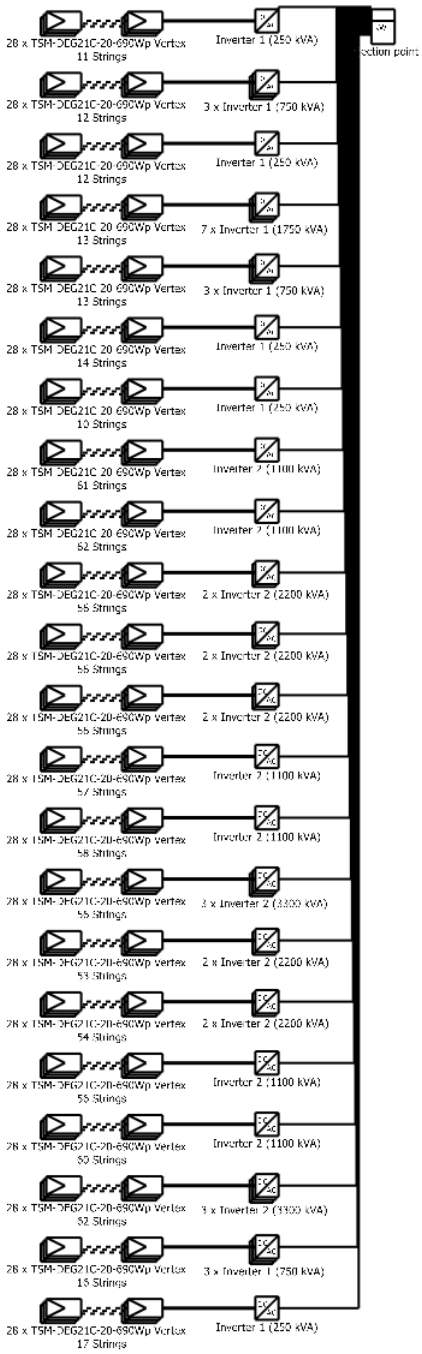

PV module	TSM-DEG21C-20-690Wp Vertex
Inverter 1	SG250-HX
Inverter 2	SG1100UD-MV
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry Final	Studio Santi srl (Italy)
	VC0 : Tracker_EW	03/27/24

Version 7.3.1

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry_Final Update

Variant: Lotto_2

Tracking system with backtracking

System power: 580 kWp

Riano - Italy

Author

Signature

PVsyst V7.3.1
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Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	126 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015); Sat=57% - Synthetic

System summary

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation	
Tracking plane, tilted axis	
Avg axis tilt	0.5 °
Avg axis azim.	-60.8 °

Tracking algorithm
Astronomic calculation
Backtracking activated

Near Shadings
Linear shadings

System information

PV Array

Nb. of modules	840 units
Pnom total	580 kWp

Inverters

Nb. of units	2 units
Pnom total	500 kWac
Pnom ratio	1.159

User's needs
Unlimited load (grid)

Results summary

Produced Energy	724438 kWh/year	Specific production	1250 kWh/kWp/year	Perf. Ratio PR	68.28 %

Table of contents

PVsyst V7.3.1
VC1, Simulation date:
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with v7.3.1

General parameters

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation

Tracking plane, tilted axis	
Avg axis tilt	0.5 °
Avg axis azim.	-60.8 °

Tracking algorithm

Astronomic calculation	
Backtracking activated	

Backtracking array

Nb. of trackers	34 units
Identical arrays	

Sizes

Tracker Spacing	4.10 m
Collector width	2.38 m
Ground Cov. Ratio (GCR)	58.2 %
Phi min / max.	-/+ 55.0 °

Backtracking strategy

Phi limits for BT	-/+ 54.2 °
Backtracking pitch	4.10 m
Backtracking width	2.38 m

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	4.10 m
Tracker width	2.38 m
GCR	58.2 %
Axis height above ground	1.50 m

Bifacial model definitions

Ground albedo	0.20
Bifaciality factor	72 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	840 units
Nominal (STC)	580 kWp
Modules	30 Strings x 28 In series
At operating cond. (50°C)	
Pmpp	531 kWp
U mpp	1017 V
I mpp	522 A

Inverter

Manufacturer	Sungrow
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	2 units
Total power	500 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.16
Power sharing within this inverter	

Total PV power

Nominal (STC)	580 kWp
Total	840 modules
Module area	2609 m²

Total inverter power

Total power	500 kWac
Number of inverters	2 units
Pnom ratio	1.16

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Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 29.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 4.2 mΩ
Loss Fraction 0.2 % at STC

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 0.70 % at STC
Inverter: SG250-HX
Wire section (2 Inv.) Copper 2 x 3 x 120 mm²
Average wires length 100 m

MV line up to Injection
MV Voltage 36 kV
Wires Copper 3 x 25 mm²
Length 1000 m
Loss Fraction 0.03 % at STC

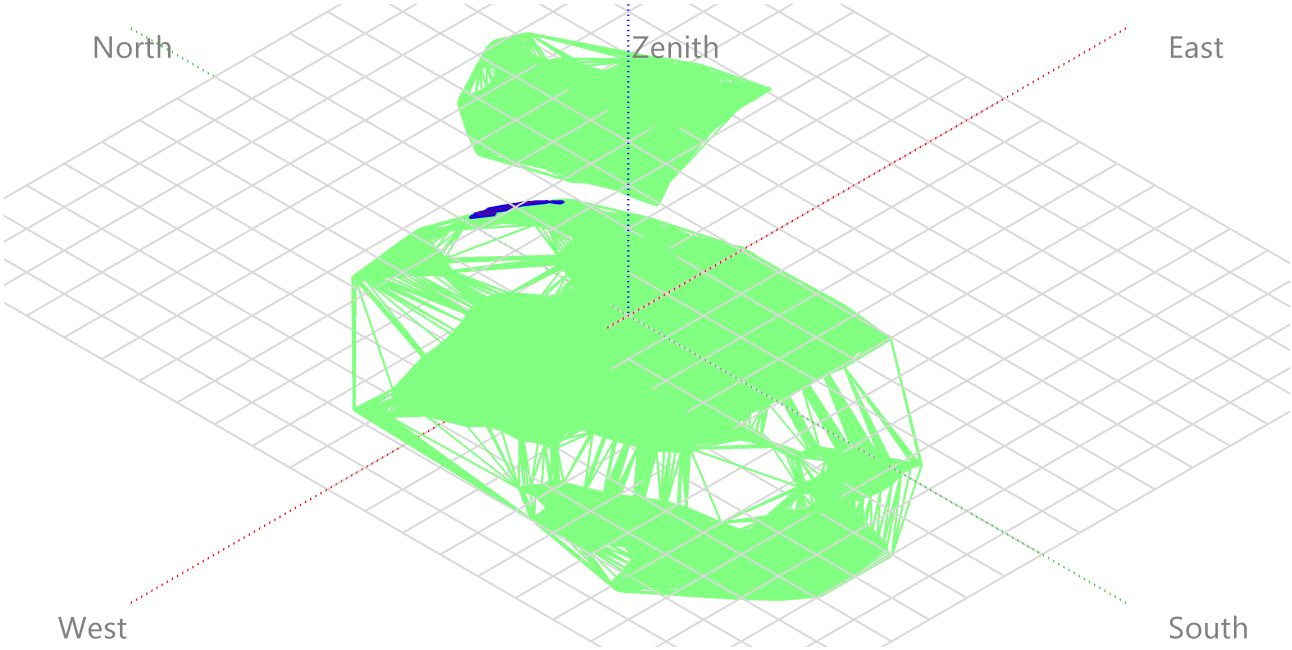
AC losses in transformers

MV transfo
Medium voltage 36 kV
Transformer parameters
Nominal power at STC 574 kVA
Iron Loss (24/24 Connexion) 0.61 kVA
Iron loss fraction 0.11 % at STC
Copper loss 5.38 kVA
Copper loss fraction 0.94 % at STC
Coils equivalent resistance 3 x 10.46 mΩ

PVsyst V7.3.1
VC1, Simulation date:
03/27/24 14:11
with v7.3.1

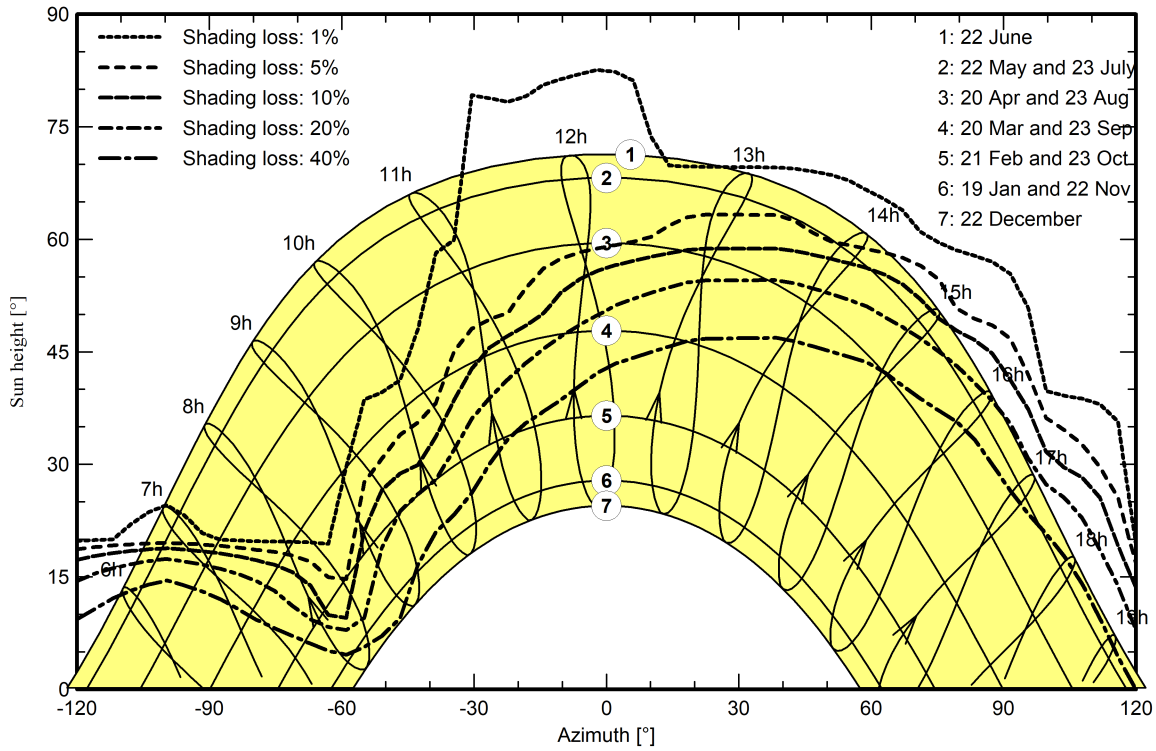
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

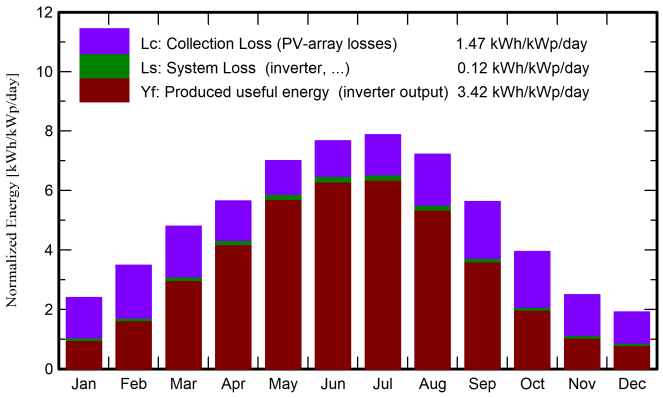


Main results

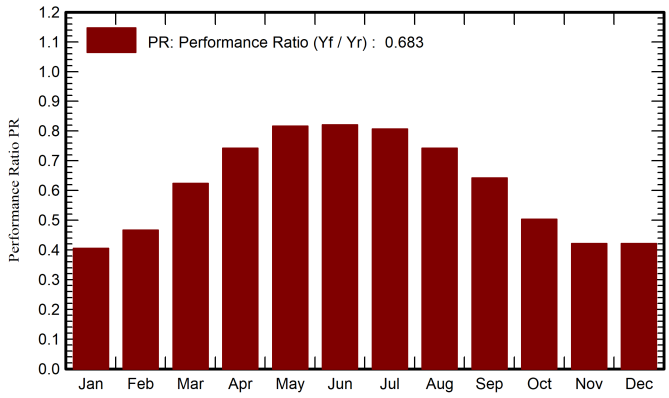
System Production

Produced Energy (P50)	724438 kWh/year	Specific production (P50)	1250 kWh/kWp/year	Performance Ratio PR	68.28 %
Produced Energy (P90)	686547 kWh/year	Produced Energy (P90)	1185 kWh/kWp/year		
Produced Energy (P95)	675886 kWh/year	Produced Energy (P95)	1166 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



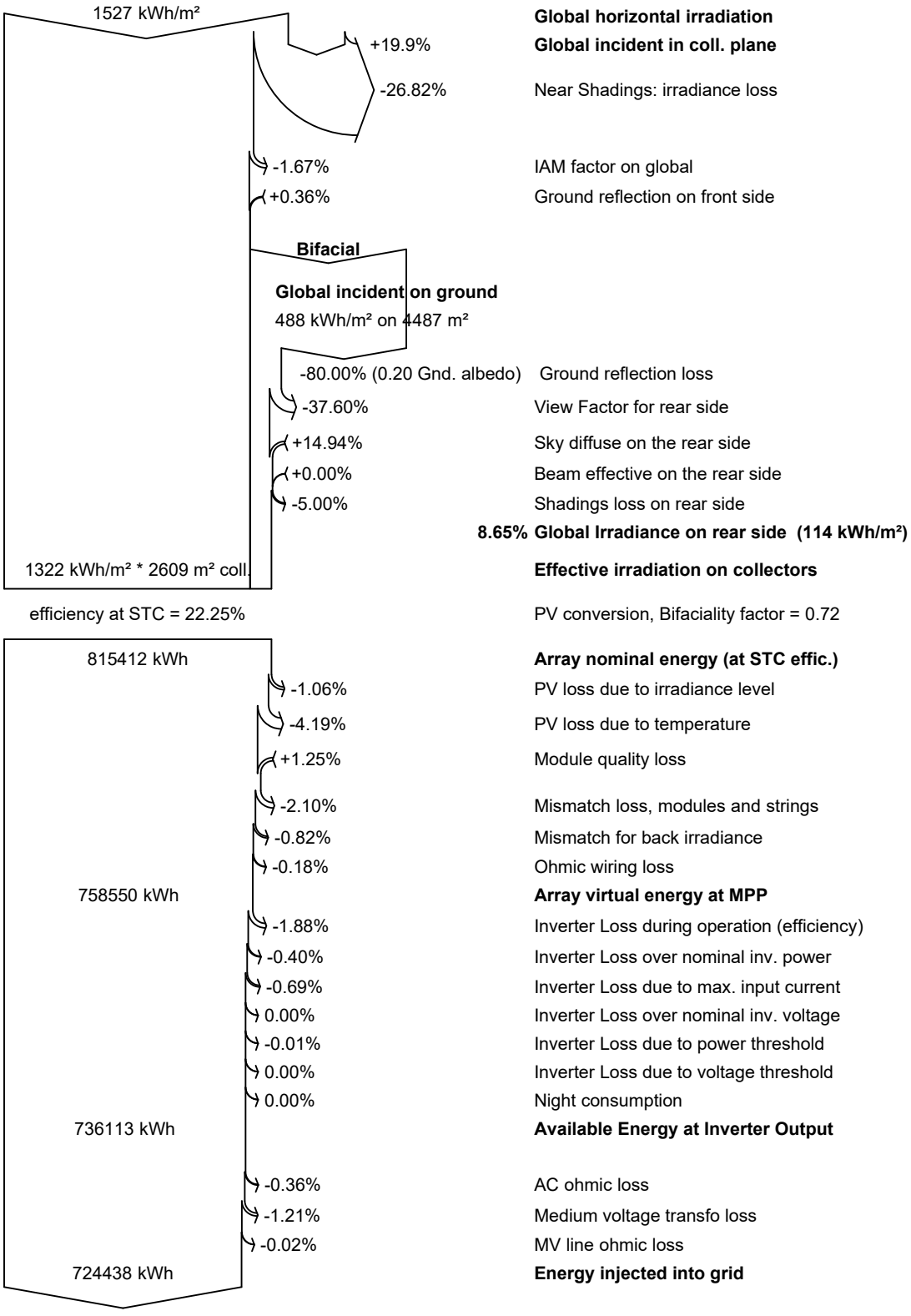
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.90	7.77	74.1	31.2	18785	17396	0.405
February	72.5	34.60	8.94	97.6	46.2	27833	26414	0.467
March	121.3	56.00	12.20	148.7	93.4	55741	53736	0.623
April	147.3	68.60	15.45	169.4	128.8	75299	72918	0.743
May	191.8	75.50	19.98	217.1	186.6	105724	102703	0.816
June	207.5	80.80	24.45	230.2	205.2	112713	109528	0.821
July	215.4	69.90	27.52	244.2	214.6	117458	114223	0.807
August	190.1	68.10	27.40	223.8	179.4	99116	96267	0.742
September	135.4	51.60	22.17	168.7	113.2	64897	62779	0.642
October	93.9	42.60	18.41	122.5	64.0	37400	35697	0.503
November	55.6	29.10	13.08	74.9	33.0	19679	18291	0.421
December	43.8	26.50	9.08	59.2	26.4	15812	14487	0.422
Year	1527.1	629.19	17.25	1830.5	1322.0	750457	724438	0.683

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

Loss diagram



PVsyst V7.3.1
VC1, Simulation date:
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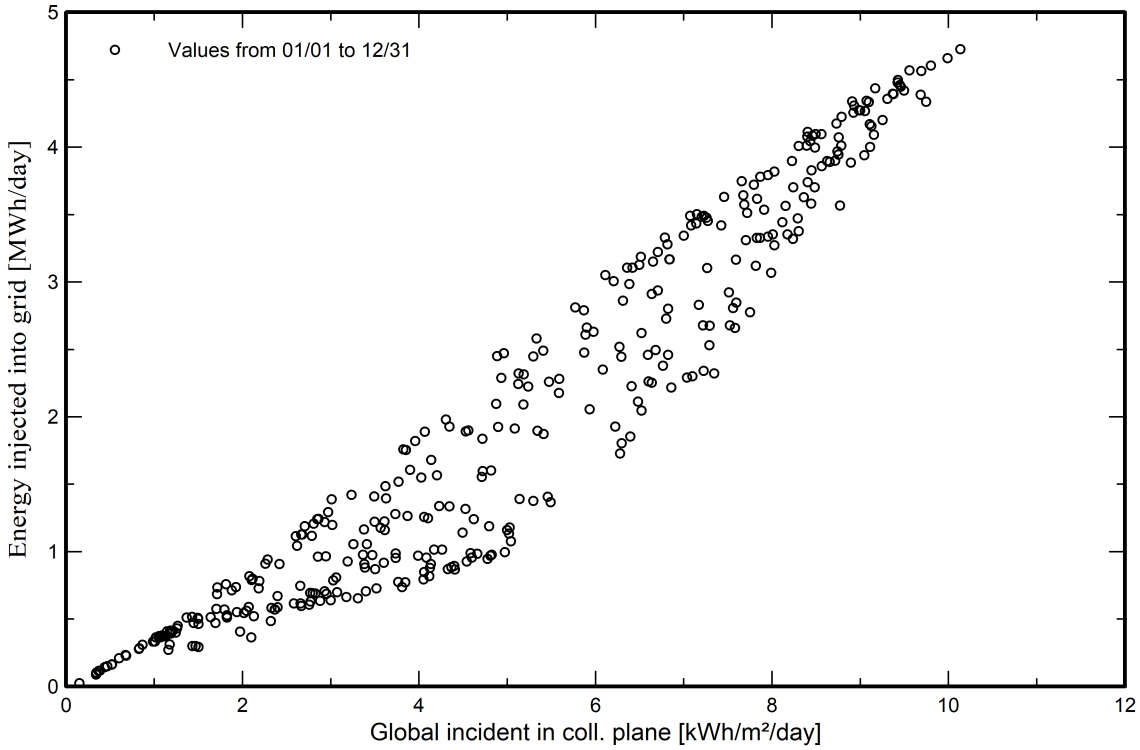
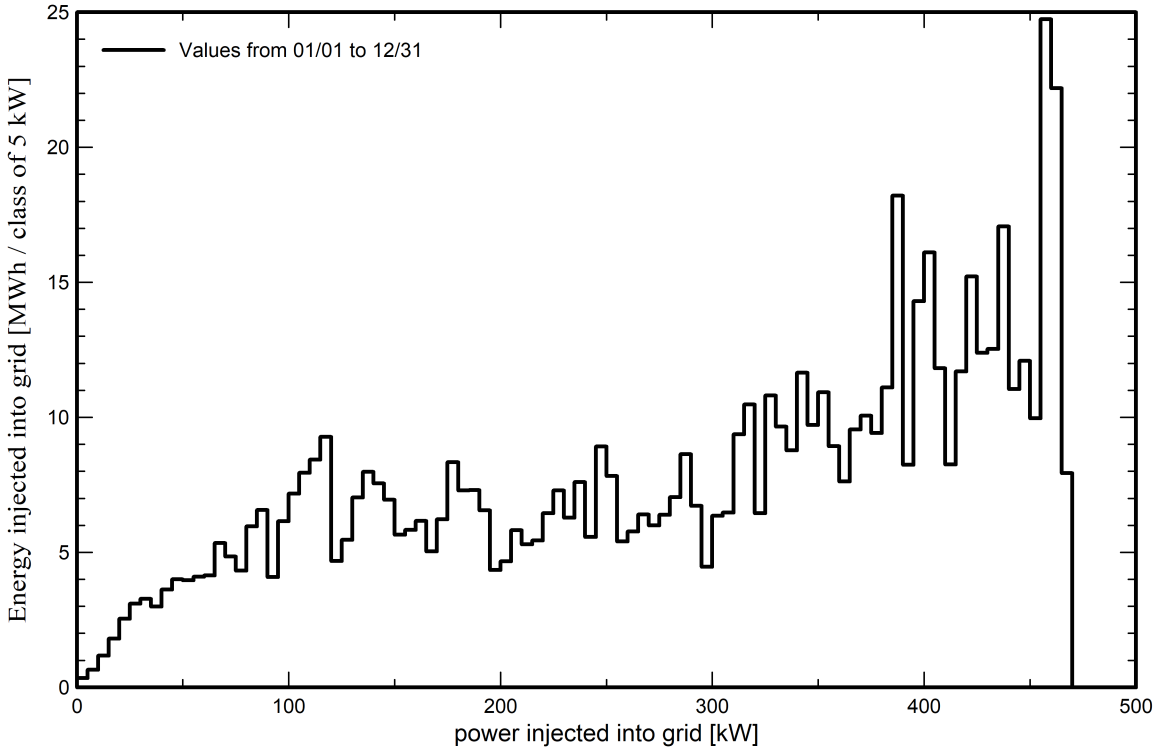
with v7.3.1

Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015); Sat=57%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	3.7 %

Specified Deviation

Climate change	0.0 %

Global variability (meteo + system)

Variability (Quadratic sum)	4.1 %

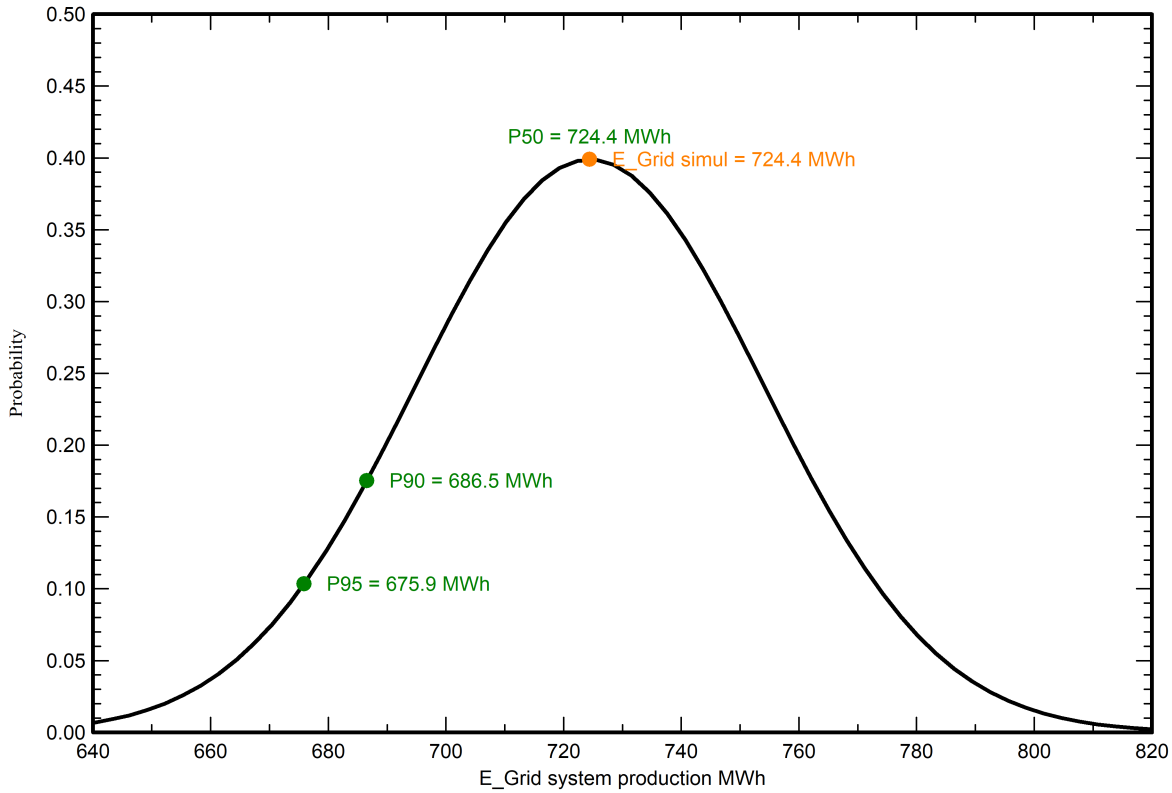
Simulation and parameters uncertainties

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

Annual production probability

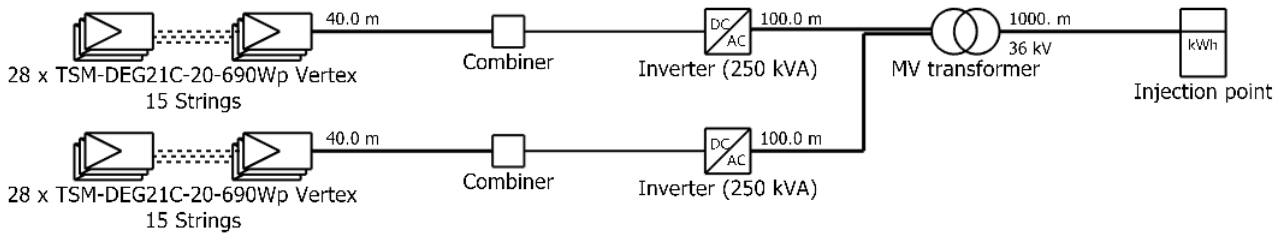
Variability	29.5 MWh
P50	724.4 MWh
P90	686.5 MWh
P95	675.9 MWh

Probability distribution



Single-line diagram

PVsyst V7.3.1
VC1, Simulation date:
03/27/24 14:11
with v7.3.1



PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG250-HX
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry_Final Update	
	VC1 : Lotto_2	03/27/24

Version 7.3.1

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry_Final Update

Variant: Lotto 5

Tracking system with backtracking

System power: 1758 kWp

Riano - Italy

Author

Signature

PVsyst V7.3.1
VC2, Simulation date:
03/28/24 10:39
with v7.3.1

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	126 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015); Sat=57% - Synthetic

System summary

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation	
Tracking plane, tilted axis	
Avg axis tilt	1.1 °
Avg axis azim.	-27.8 °

Tracking algorithm
Astronomic calculation
Backtracking activated

Near Shadings
Linear shadings

System information

PV Array

Nb. of modules	2548 units
Pnom total	1758 kWp

Inverters

Nb. of units	6 units
Pnom total	1500 kWac
Pnom ratio	1.172

User's needs
Unlimited load (grid)

Results summary

Produced Energy	2421779 kWh/year	Specific production	1377 kWh/kWp/year	Perf. Ratio PR	73.33 %

Table of contents

General parameters

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation

Tracking plane, tilted axis	
Avg axis tilt	1.1 °
Avg axis azim.	-27.8 °

Tracking algorithm

Astronomic calculation	
Backtracking activated	

Backtracking array

Nb. of trackers	95 units
Identical arrays	

Sizes

Tracker Spacing	4.10 m
Collector width	2.38 m
Ground Cov. Ratio (GCR)	58.2 %
Phi min / max.	-/+ 55.0 °

Backtracking strategy

Phi limits for BT	-/+ 54.2 °
Backtracking pitch	4.10 m
Backtracking width	2.38 m

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

Bifacial system

Model: 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	4.10 m
Tracker width	2.38 m
GCR	58.2 %
Axis height above ground	1.50 m

Bifacial model definitions

Ground albedo	0.20
Bifaciality factor	72 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	2548 units
Nominal (STC)	1758 kWp
Modules	91 Strings x 28 In series
At operating cond. (50°C)	
Pmpp	1611 kWp
U mpp	1017 V
I mpp	1583 A

Inverter

Manufacturer	Sungrow
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	6 units
Total power	1500 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.17
Power sharing within this inverter	

Total PV power

Nominal (STC)	1758 kWp
Total	2548 modules
Module area	7915 m²

Total inverter power

Total power	1500 kWac
Number of inverters	6 units
Pnom ratio	1.17

PVsyst V7.3.1
VC2, Simulation date:
03/28/24 10:39
with v7.3.1

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 29.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 3.3 mΩ
Loss Fraction 0.5 % at STC

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 0.90 % at STC
Inverter: SG250-HX
Wire section (6 Inv.) Copper 6 x 3 x 95 mm²
Average wires length 100 m

MV line up to Injection
MV Voltage 36 kV
Wires Copper 3 x 35 mm²
Length 1000 m
Loss Fraction 0.07 % at STC

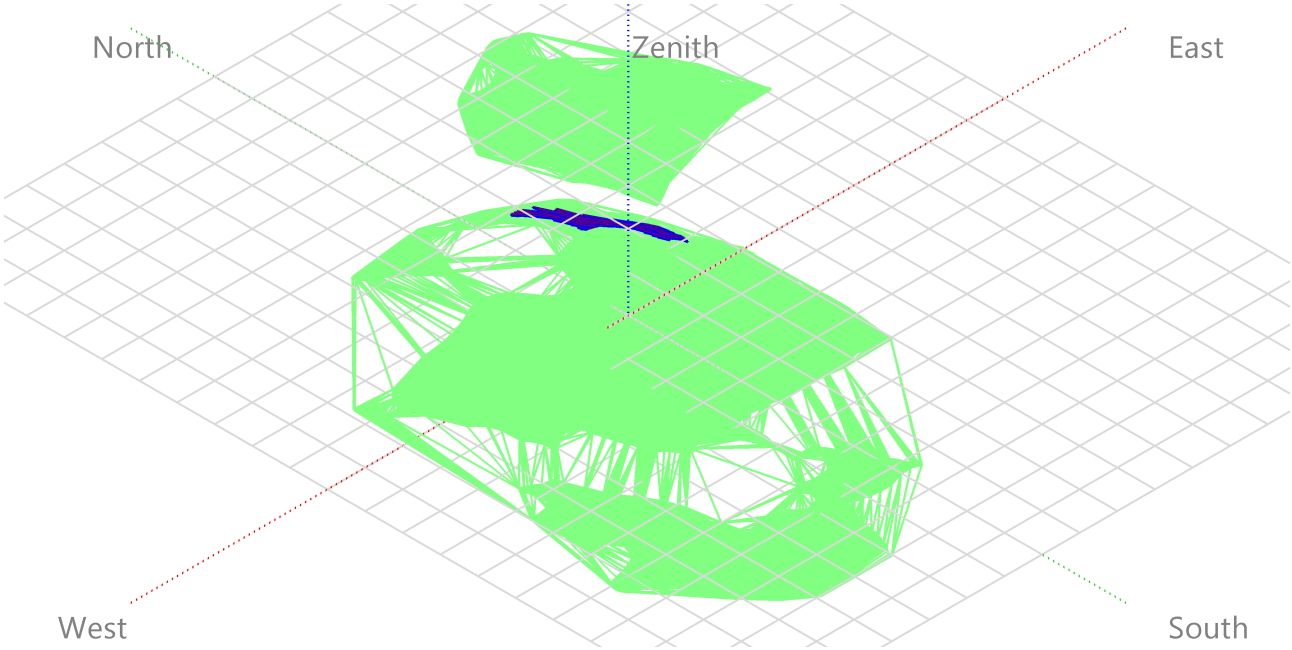
AC losses in transformers

MV transfo
Medium voltage 36 kV
Transformer parameters
Nominal power at STC 1.74 MVA
Iron Loss (24/24 Connexion) 1.88 kVA
Iron loss fraction 0.11 % at STC
Copper loss 16.17 kVA
Copper loss fraction 0.93 % at STC
Coils equivalent resistance 3 x 3.42 mΩ

PVsyst V7.3.1
VC2, Simulation date:
03/28/24 10:39
with v7.3.1

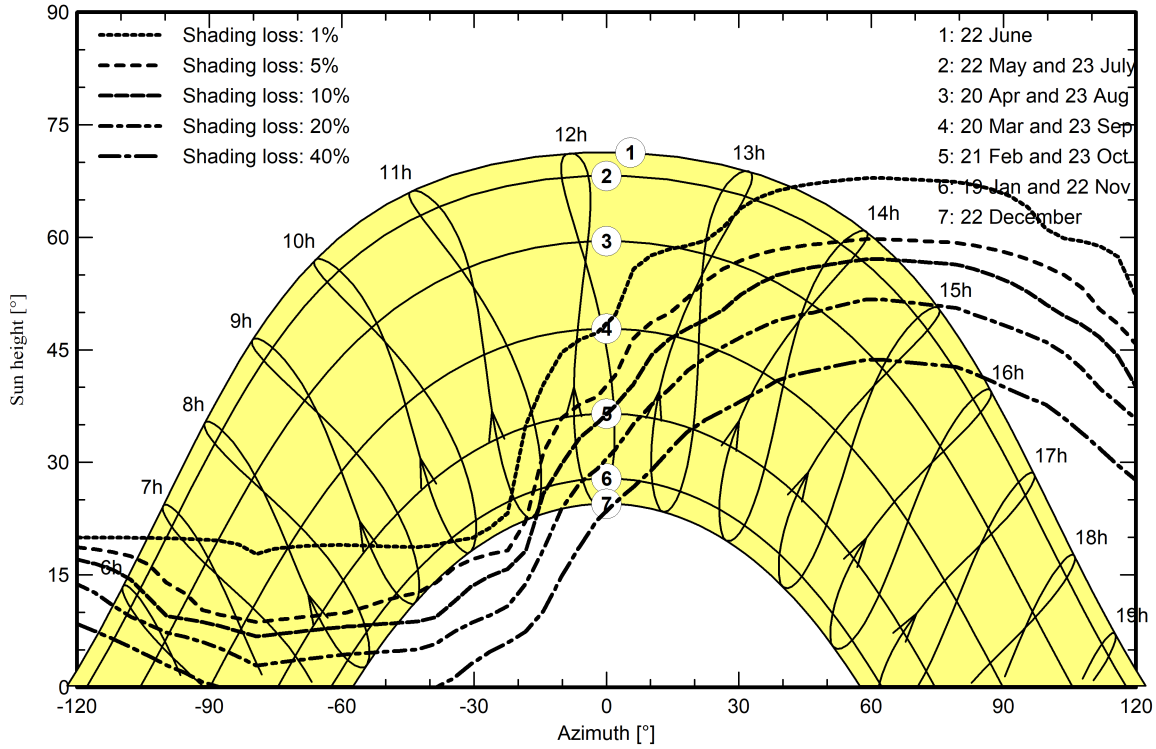
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

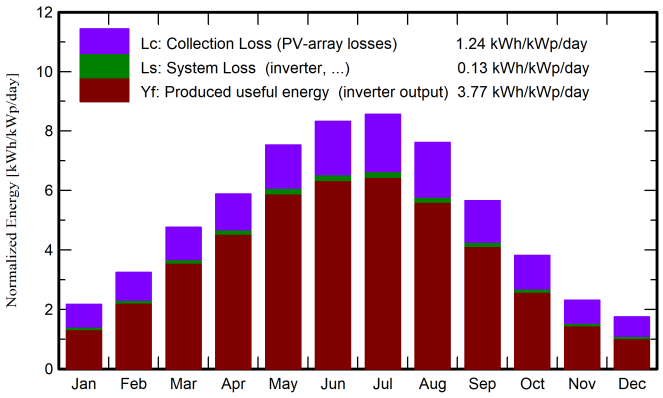


Main results

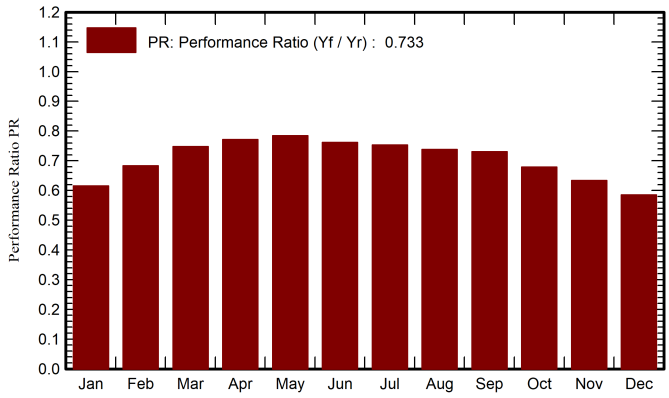
System Production

Produced Energy (P50)	2421779 kWh/year	Specific production (P50)	1377 kWh/kWp/year	Performance Ratio PR	73.33 %
Produced Energy (P90)	2295109 kWh/year	Produced Energy (P90)	1305 kWh/kWp/year		
Produced Energy (P95)	2259469 kWh/year	Produced Energy (P95)	1285 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

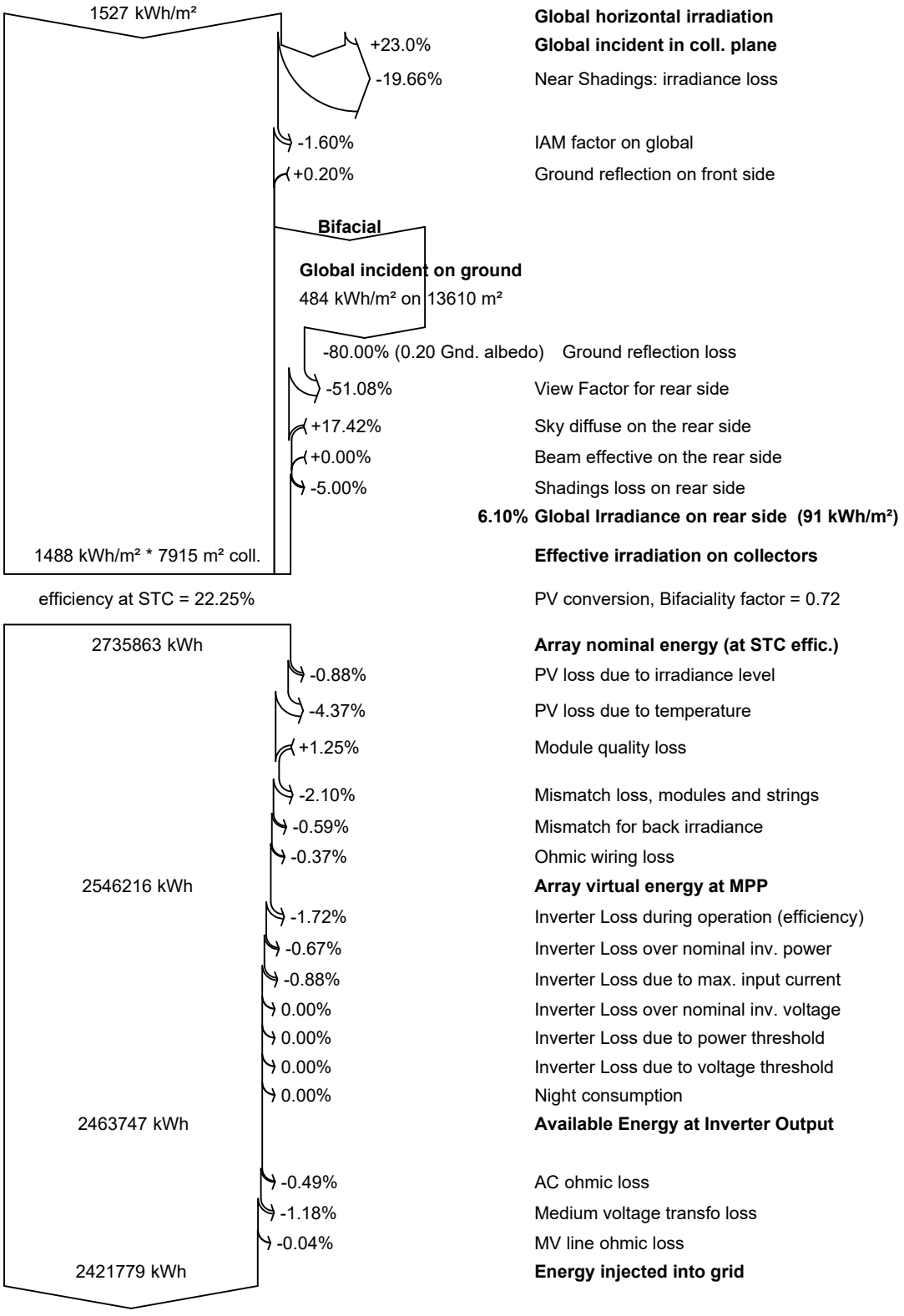
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.90	7.77	67.2	42.4	77055	72655	0.615
February	72.5	34.60	8.94	91.0	63.1	113961	109259	0.683
March	121.3	56.00	12.20	147.7	113.4	201140	194275	0.748
April	147.3	68.60	15.45	176.4	143.1	247291	239357	0.772
May	191.8	75.50	19.98	233.3	198.6	331526	321505	0.784
June	207.5	80.80	24.45	249.9	213.9	345221	334845	0.762
July	215.4	69.90	27.52	265.5	225.4	362360	351705	0.753
August	190.1	68.10	27.40	236.0	193.4	315655	306153	0.738
September	135.4	51.60	22.17	169.8	132.1	225139	217944	0.730
October	93.9	42.60	18.41	118.3	84.1	146911	141218	0.679
November	55.6	29.10	13.08	69.1	45.5	81465	77029	0.634
December	43.8	26.50	9.08	54.3	33.1	59951	55834	0.585
Year	1527.1	629.19	17.25	1878.5	1488.1	2507675	2421779	0.733

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

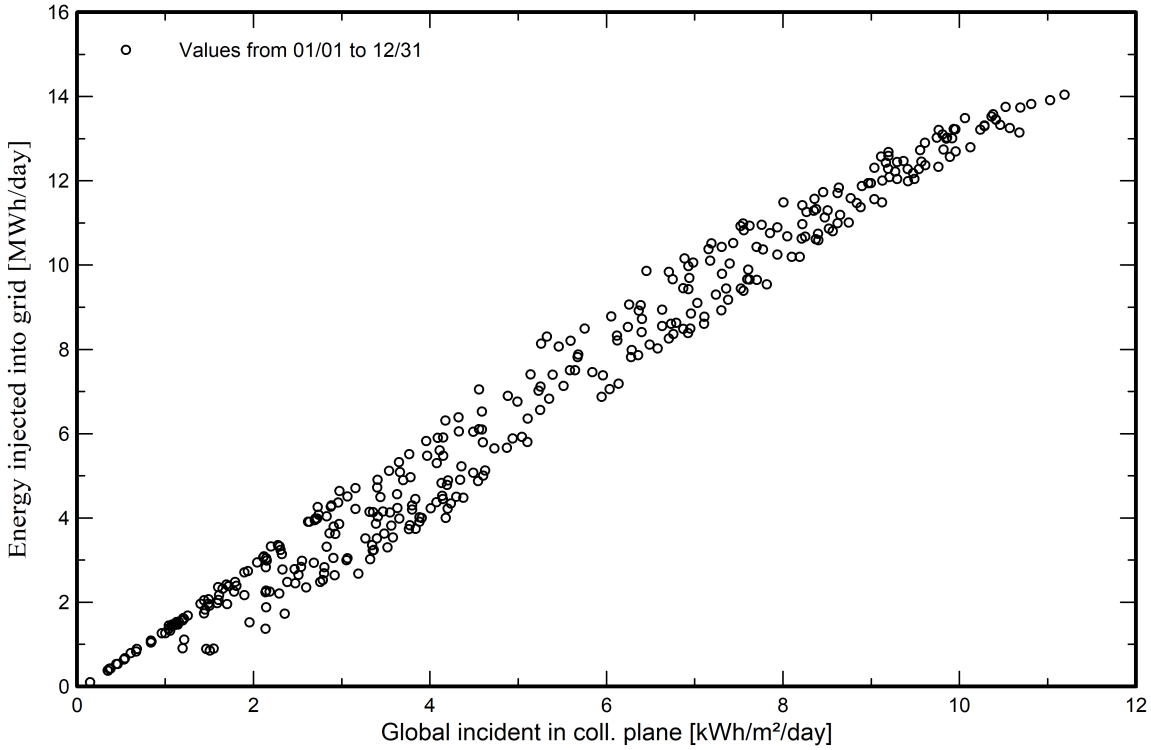
PVsyst V7.3.1
VC2, Simulation date:
03/28/24 10:39
with v7.3.1

Loss diagram

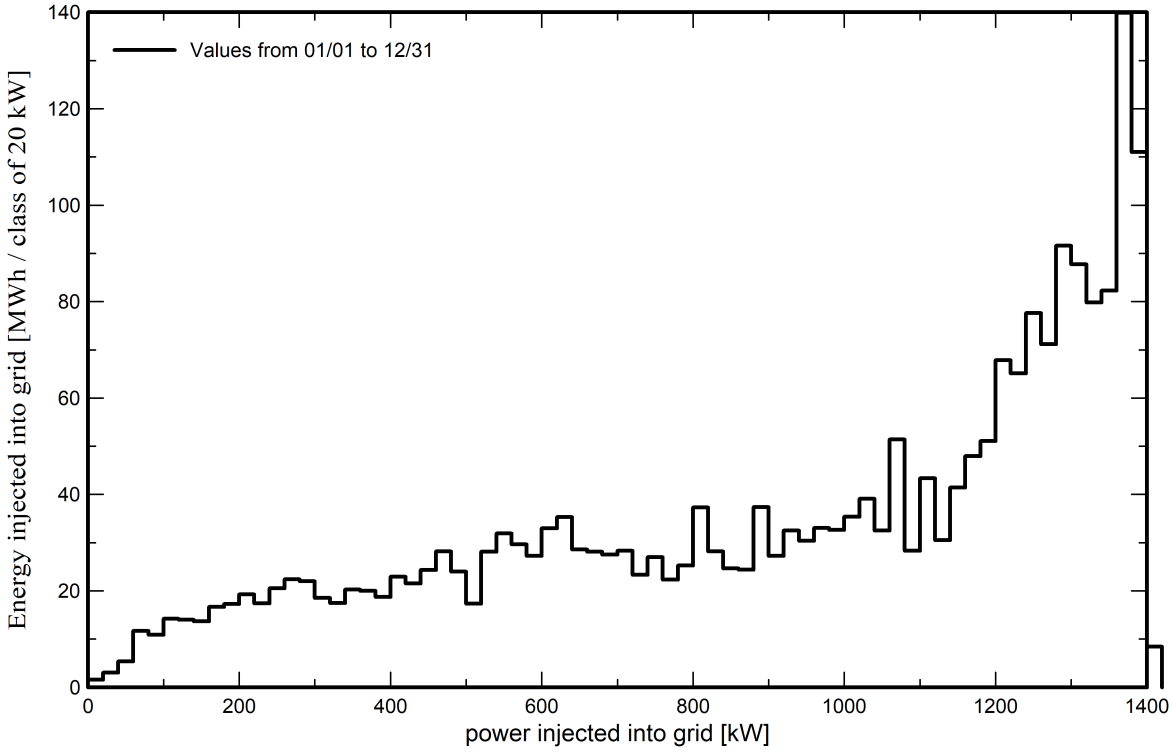


Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015); Sat=57%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	3.7 %

Specified Deviation

Climate change	0.0 %

Global variability (meteo + system)

Variability (Quadratic sum)	4.1 %

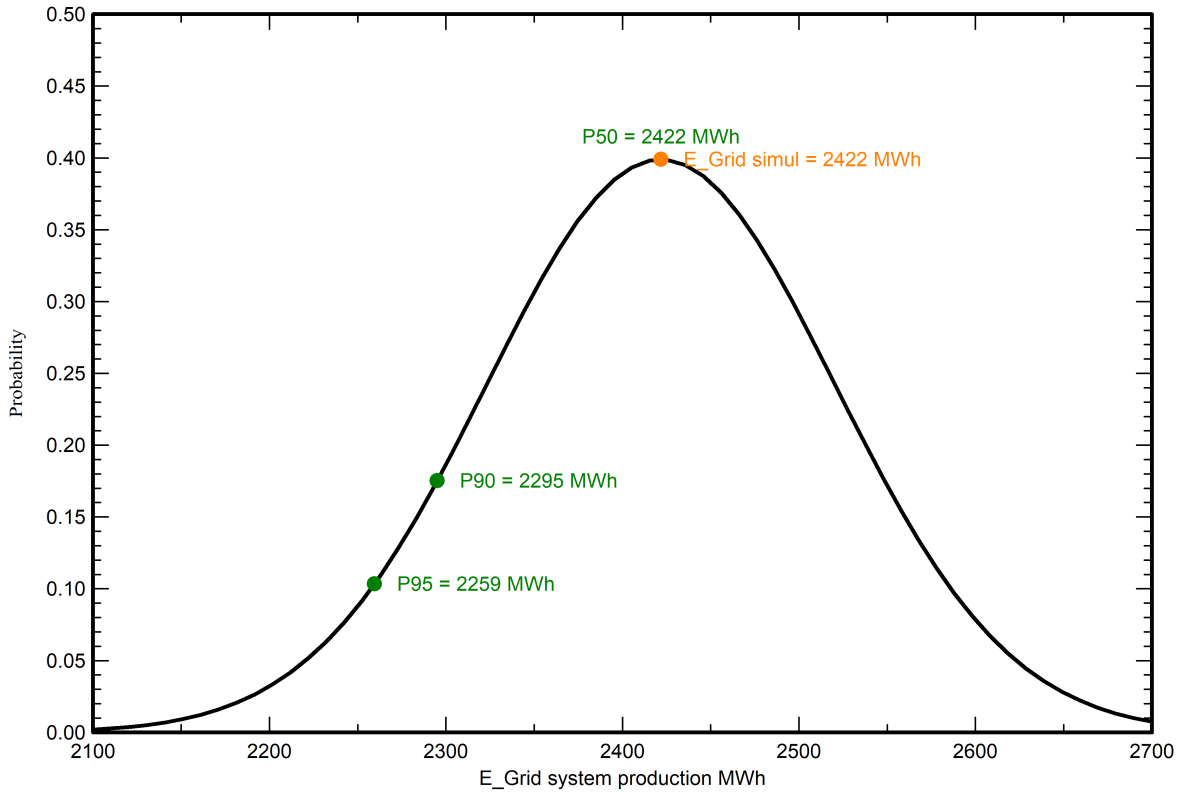
Simulation and parameters uncertainties

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

Annual production probability

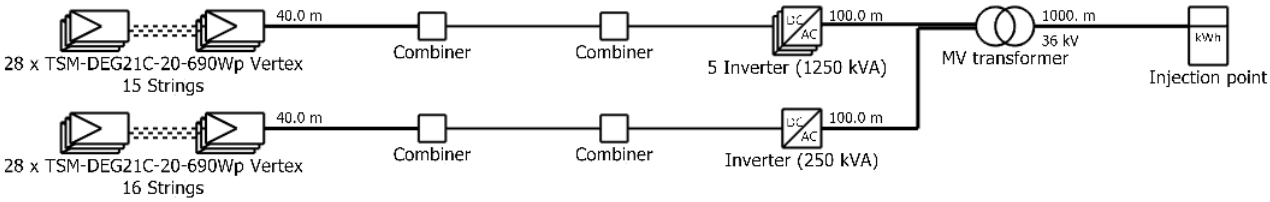
Variability	99 MWh
P50	2422 MWh
P90	2295 MWh
P95	2259 MWh

Probability distribution



Single-line diagram

PVsyst V7.3.1
VC2, Simulation date:
03/28/24 10:39
with v7.3.1



PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG250-HX
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry_Final Update	
	VC2 : Lotto 5	03/28/24

Version 7.4.6

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry Final

Variant: lotto 6

Tracking system with backtracking

System power: 792 kWp

Riano - Italy

Author

Studio Santi srl (Italy)

PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	186 m
Time zone	UTC+1

Project settings
Albedo 0.20

Weather data
Riano
Meteonorm 8.1 (1996-2015); Sat=57% - Synthetic

System summary

Grid-Connected System

Tracking system with backtracking

PV Field Orientation
Orientation
Tracking plane, tilted axis

Avg axis tilt	1.2 °
Avg axis azim.	-20.3 °

Tracking algorithm
Astronomic calculation
Backtracking activated

Near Shadings
Linear shadings : Fast (table)
Diffuse shading Automatic

System information

PV Array

Nb. of modules	1148 units
Pnom total	792 kWp

Inverters

Nb. of units	3 units
Pnom total	750 kWac
Pnom ratio	1.056

User's needs
Unlimited load (grid)

Results summary

Produced Energy	1125784 kWh/year	Specific production	1421 kWh/kWp/year	Perf. Ratio PR	75.39 %

Table of contents

General parameters

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation

Tracking plane, tilted axis	
Avg axis tilt	1.2 °
Avg axis azim.	-20.3 °

Tracking algorithm

Astronomic calculation	
Backtracking activated	

Backtracking array

Nb. of trackers	48 units
Identical arrays	

Sizes

Tracker Spacing	4.10 m
Collector width	2.38 m
Ground Cov. Ratio (GCR)	58.2 %
Phi min / max.	-/+ 55.0 °

Backtracking strategy

Phi limits for BT	-/+ 54.2 °
Backtracking pitch	4.10 m
Backtracking width	2.38 m

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings : Fast (table)
Diffuse shading Automatic

User's needs
Unlimited load (grid)

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	4.10 m
Tracker width	2.38 m
GCR	58.2 %
Axis height above ground	1.50 m

Bifacial model definitions

Ground albedo	0.20
Bifaciality factor	72 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	1148 units
Nominal (STC)	792 kWp
Modules	41 string x 28 In series
At operating cond. (50°C)	
Pmpp	726 kWp
U mpp	1017 V
I mpp	713 A

Inverter

Manufacturer	Sungrow
Model	SG250-HX
(Original PVsyst database)	
Unit Nom. Power	250 kWac
Number of inverters	3 units
Total power	750 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.06
Power sharing within this inverter	

Total PV power

Nominal (STC)	792 kWp
Total	1148 modules
Module area	3566 m²

Total inverter power

Total power	750 kWac
Number of inverters	3 units
Pnom ratio	1.06

PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 23 mΩ
Loss Fraction 1.5 % at STC

Serie Diode Loss
Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

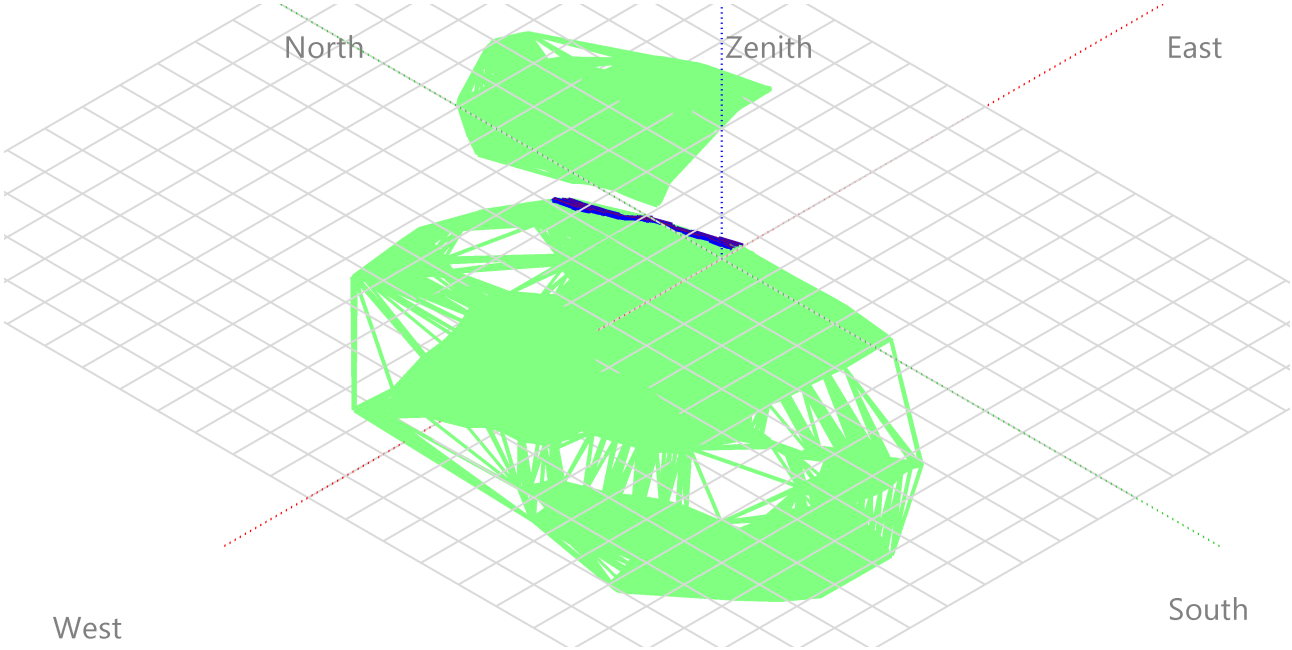
IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

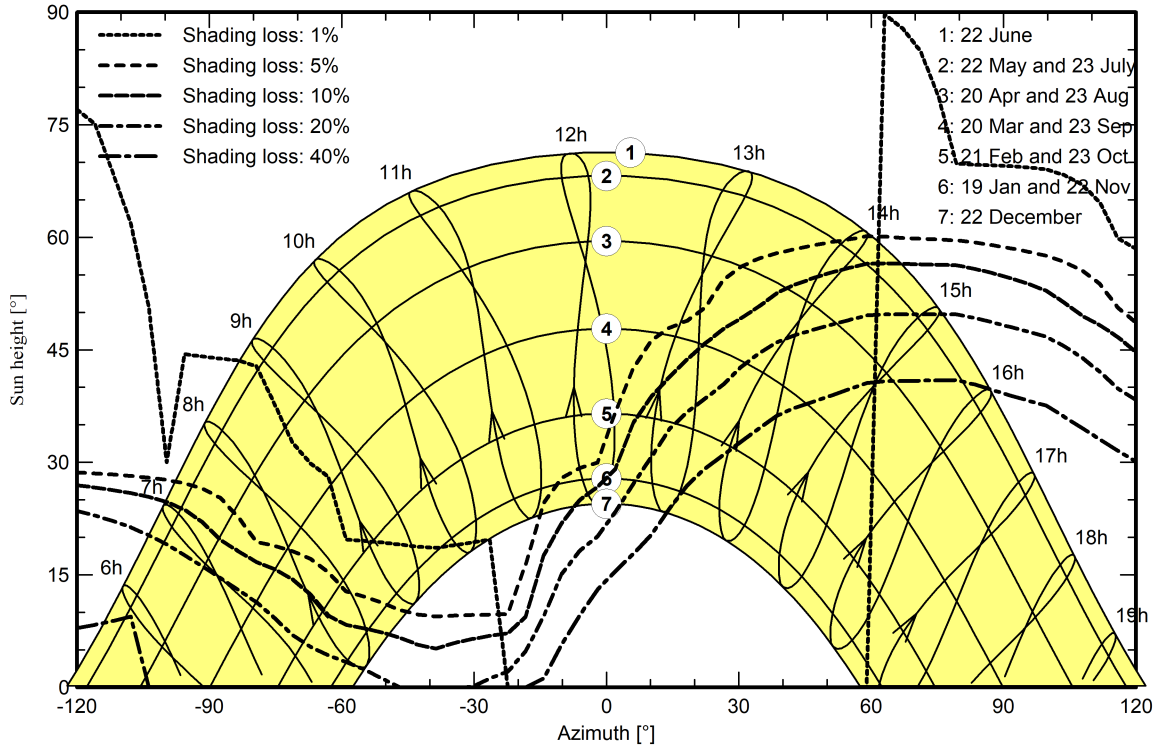
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1



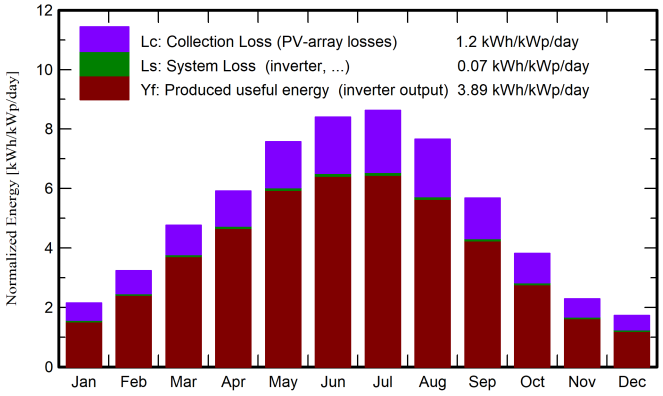
PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Main results

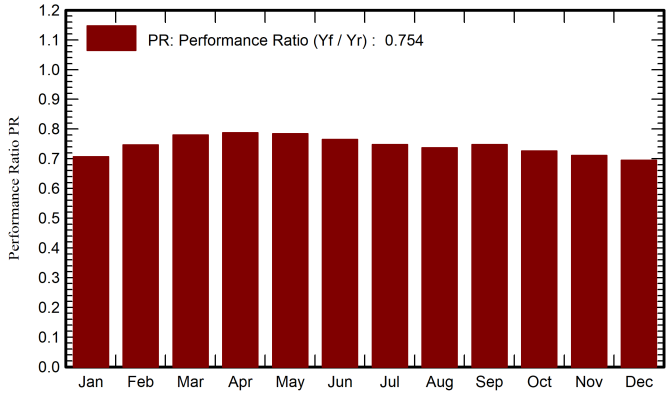
System Production

Produced Energy (P50)	1125784 kWh/year	Specific production (P50)	1421 kWh/kWp/year	Perf. Ratio PR	75.39 %
Produced Energy (P90)	1099760 kWh/year	Specific production (P90)	1388 kWh/kWp/year		
Produced Energy (P95)	1092437 kWh/year	Specific production (P95)	1379 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

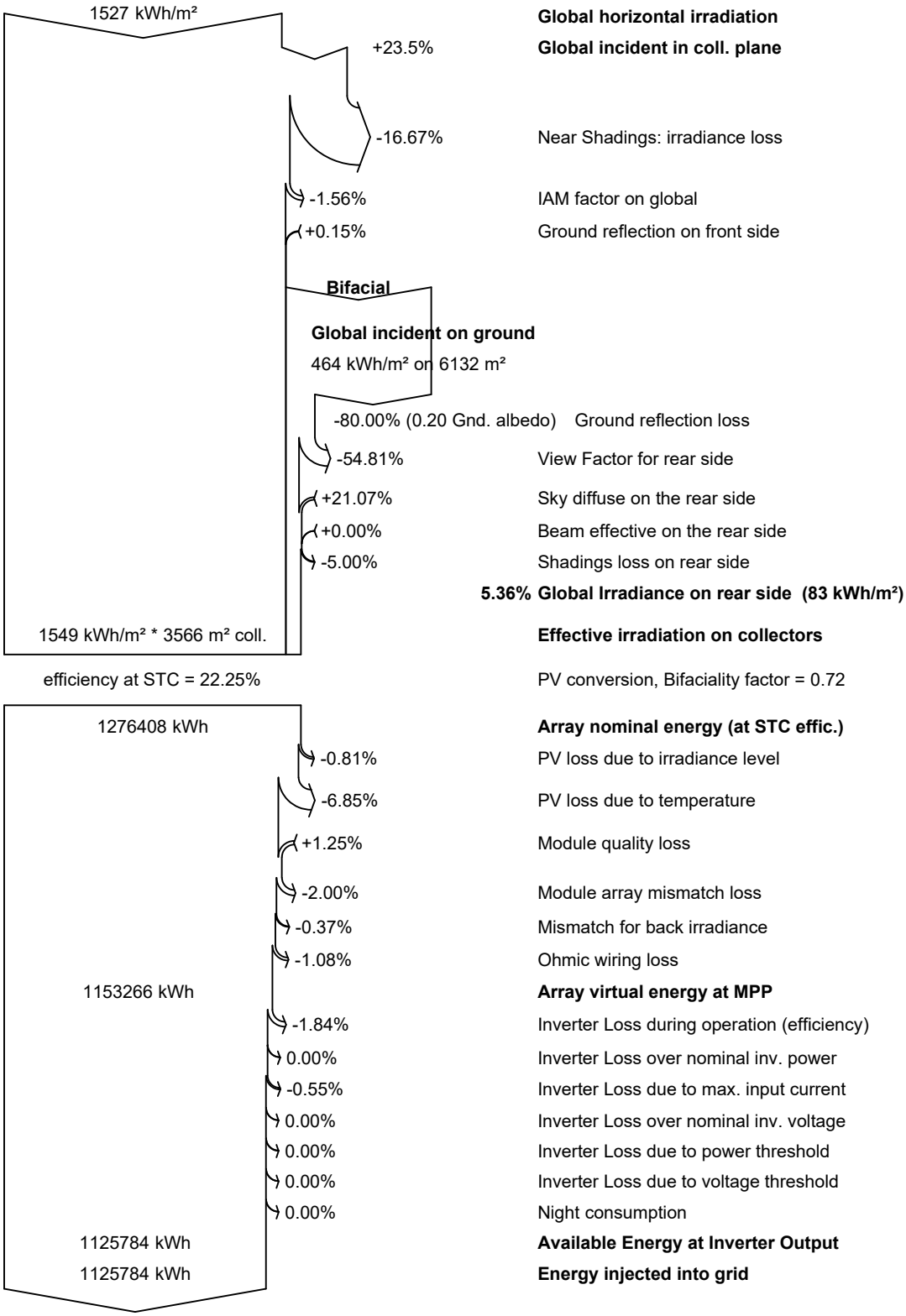
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.90	7.77	66.7	47.9	38649	37336	0.707
February	72.5	34.60	8.94	90.6	68.8	54906	53577	0.747
March	121.3	56.00	12.20	147.7	119.8	93037	91310	0.780
April	147.3	68.60	15.45	177.5	148.6	112744	110805	0.788
May	191.8	75.50	19.98	234.9	202.3	148175	145922	0.784
June	207.5	80.80	24.45	251.9	217.4	154888	152582	0.765
July	215.4	69.90	27.52	267.5	228.4	160856	158533	0.748
August	190.1	68.10	27.40	237.5	198.0	140812	138682	0.737
September	135.4	51.60	22.17	170.4	138.0	102615	100852	0.747
October	93.9	42.60	18.41	118.2	90.8	69578	68005	0.727
November	55.6	29.10	13.08	68.7	50.5	39971	38652	0.711
December	43.8	26.50	9.08	53.6	38.2	30773	29528	0.695
Year	1527.1	629.19	17.25	1885.2	1548.8	1147005	1125784	0.754

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

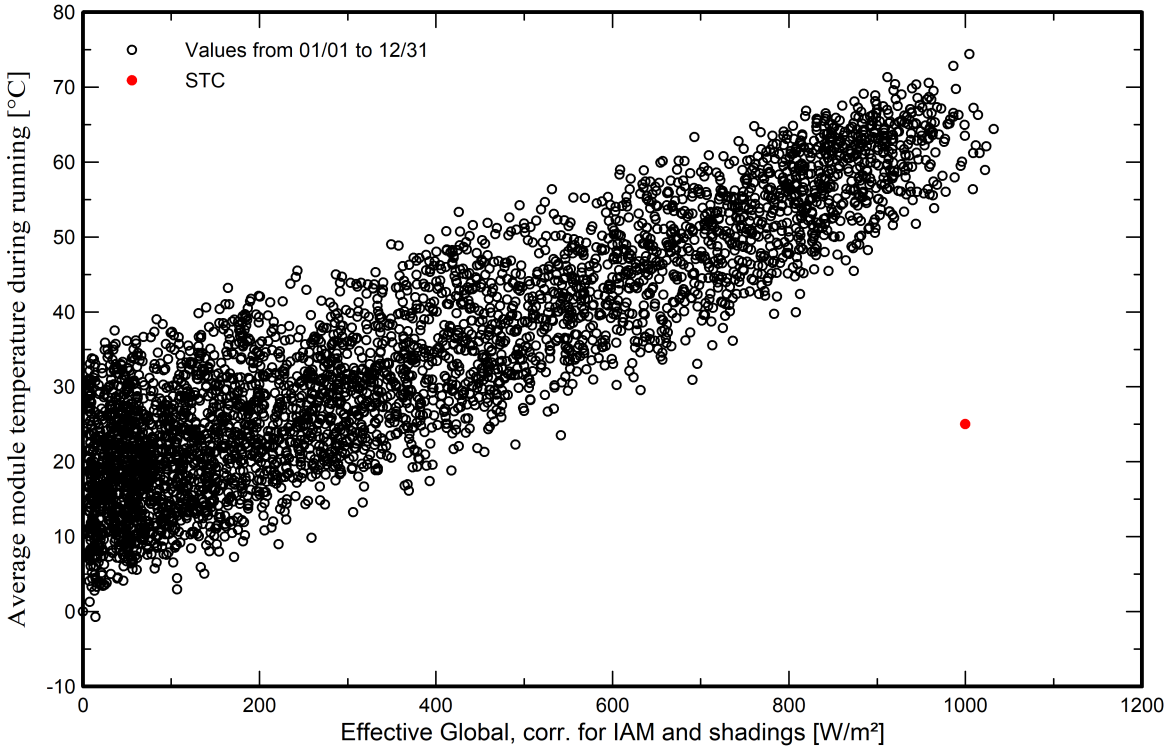
Loss diagram



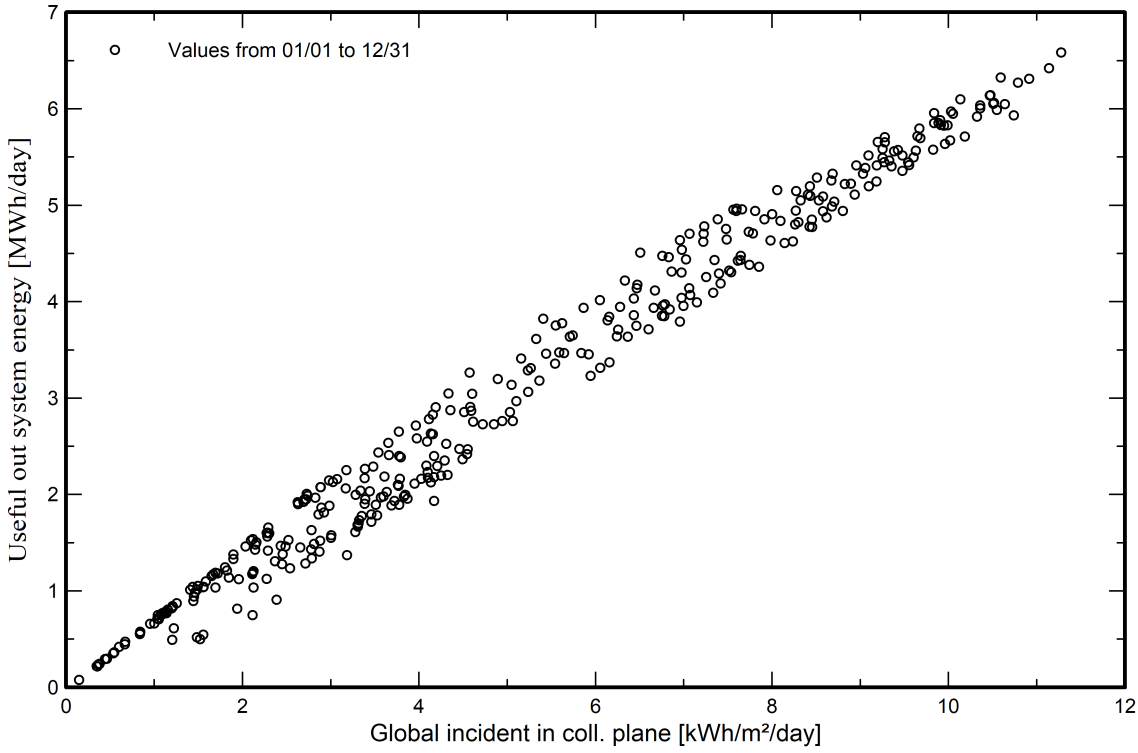
PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Predef. graphs

Array Temperature vs. Effective Irradiance



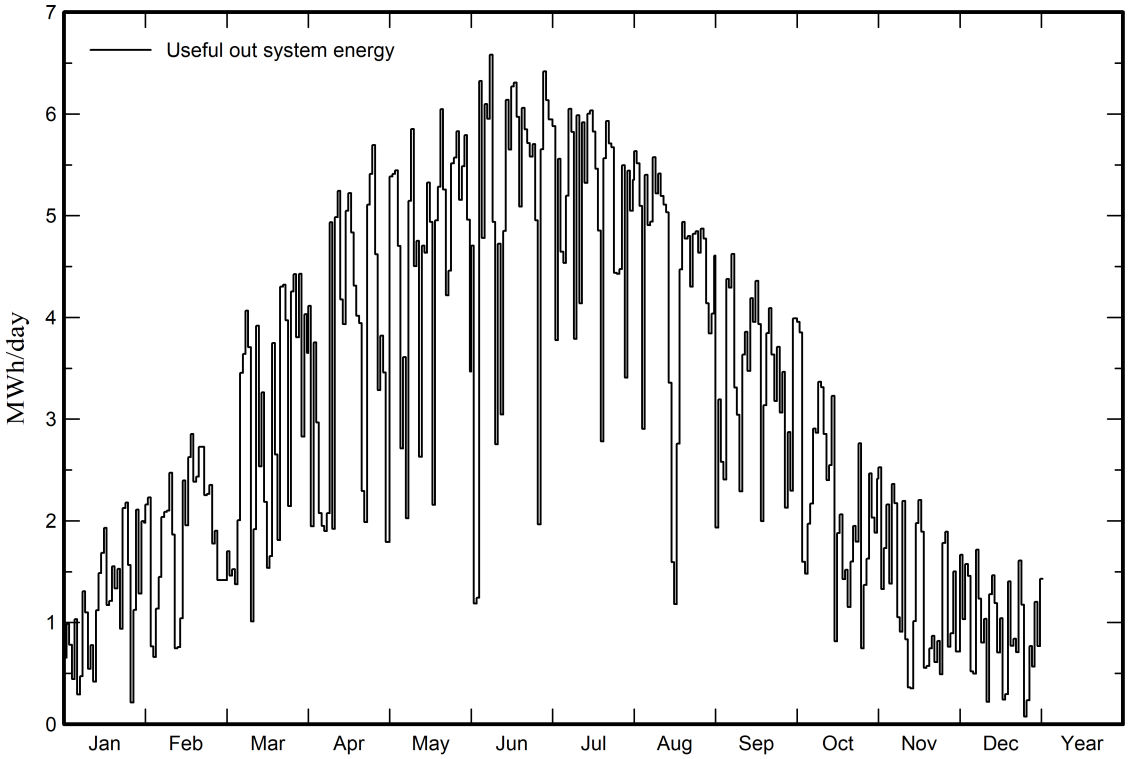
Daily Input/Output diagram



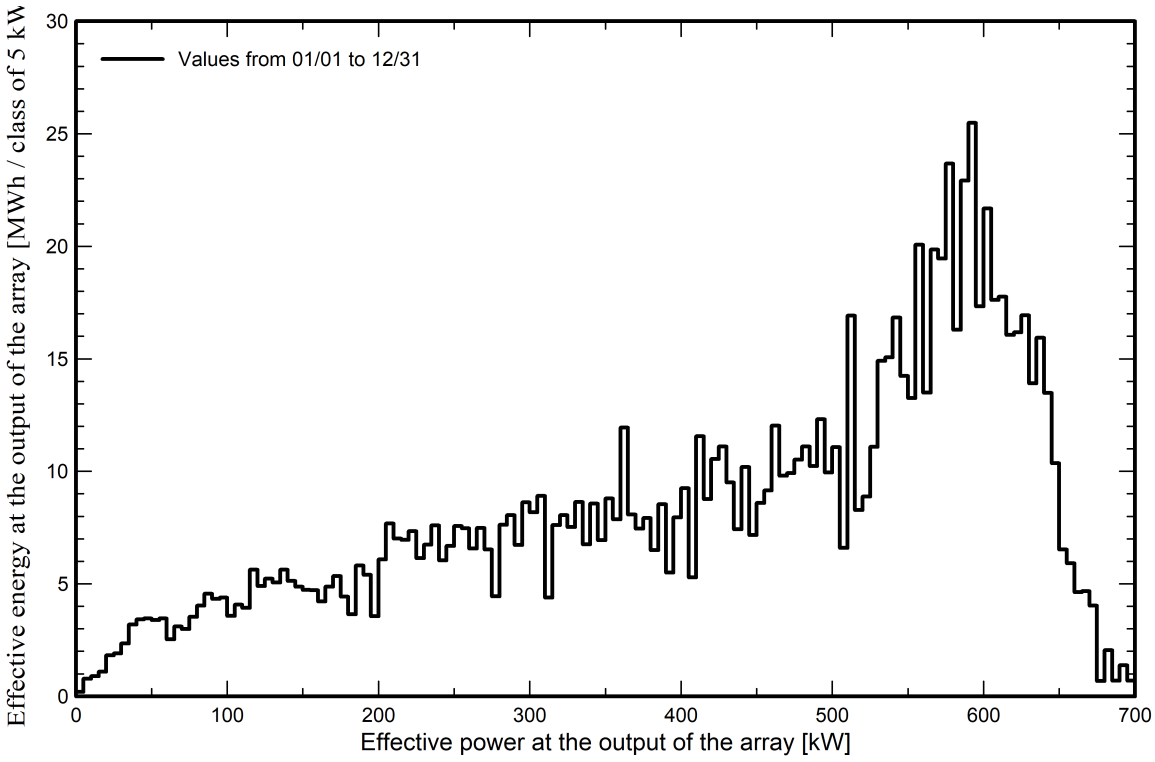
PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Predef. graphs

Daily System Output Energy



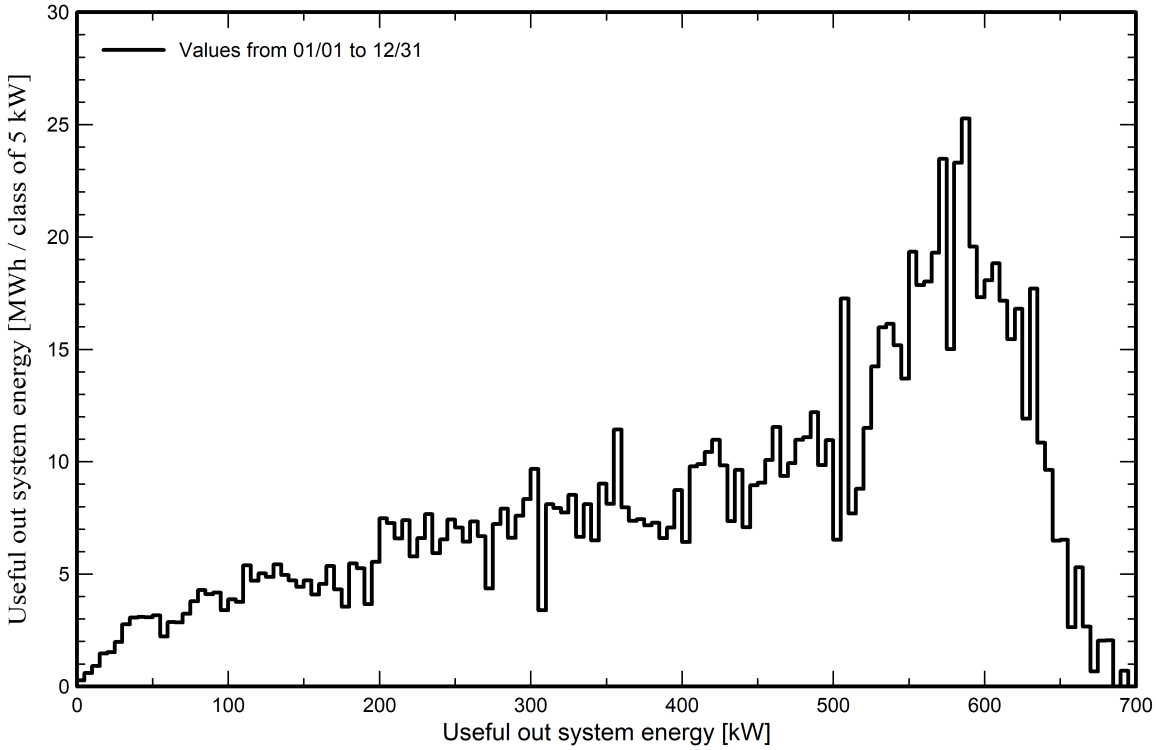
Array Power Distribution



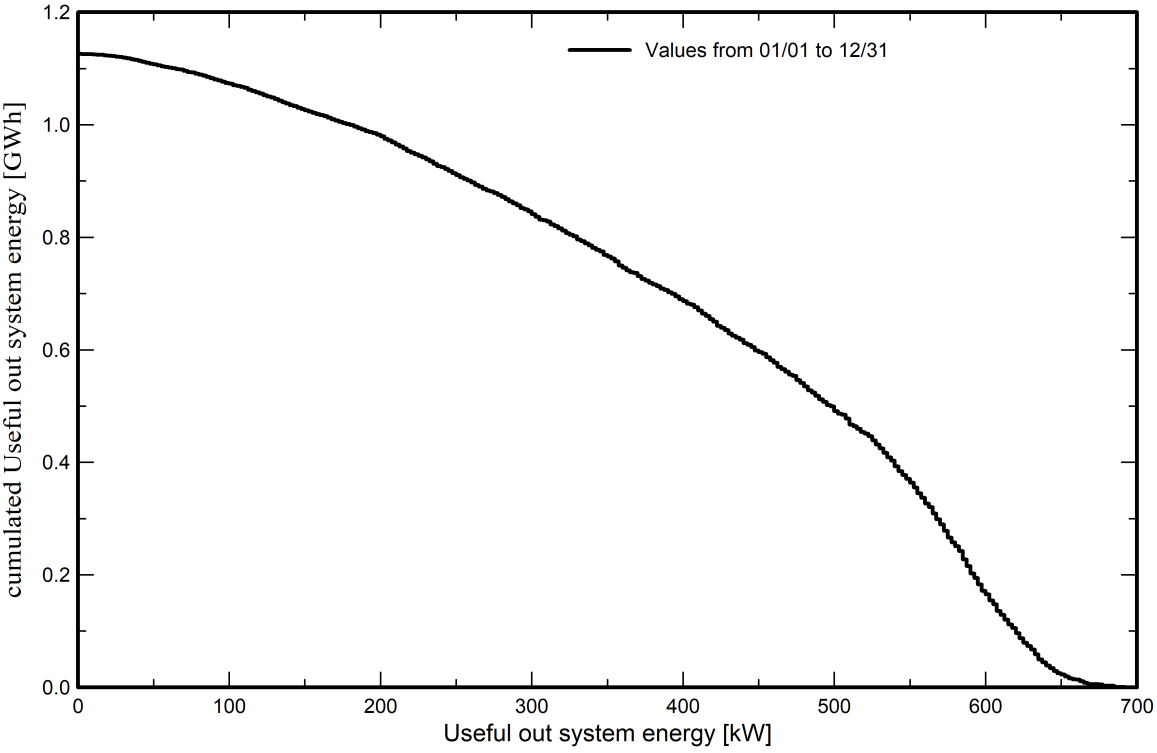
PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

Predef. graphs

System Output Power Distribution



System Output Power cumulative distribution



PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6

P50 - P90 evaluation

Weather data

Source	Meteonorm 8.1 (1996-2015); Sat=57%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	0.0 %
Specified Deviation	
Climate change	0.0 %

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 %

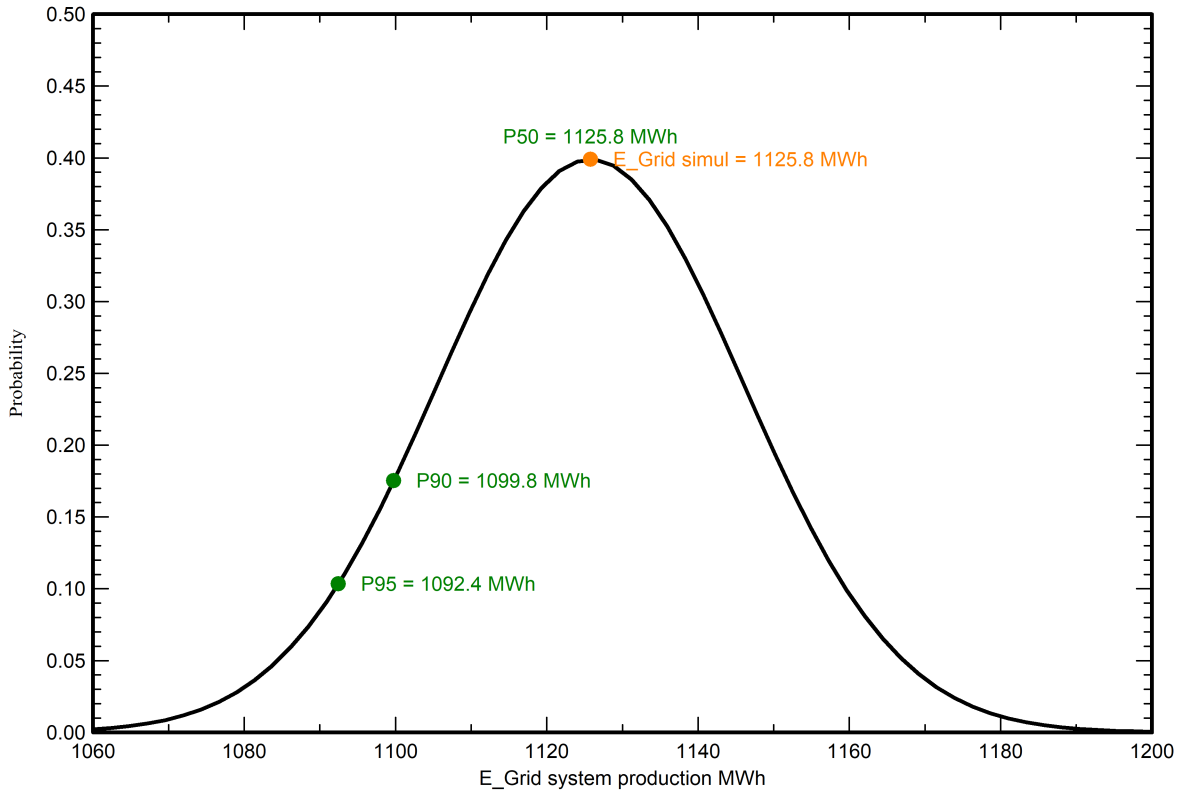
Global variability (weather data + system)

Variability (Quadratic sum)	1.8 %

Annual production probability

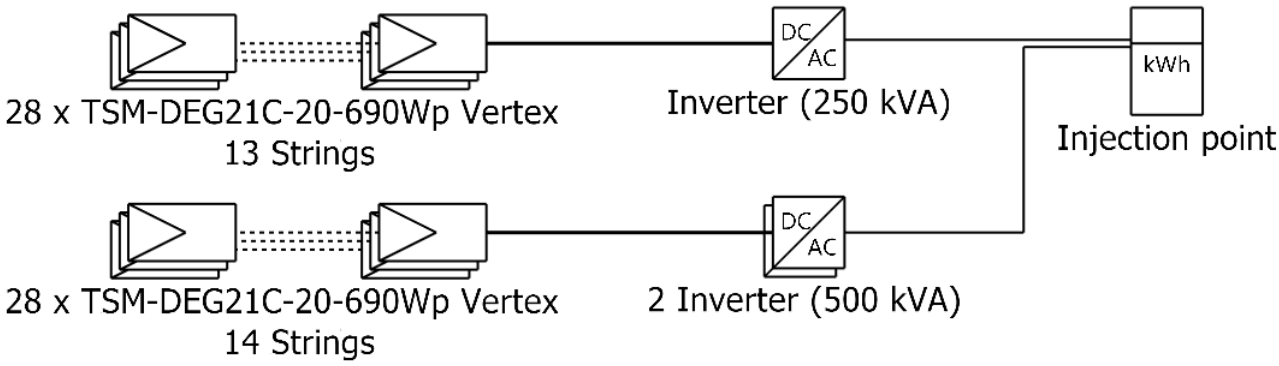
Variability	20.3 MWh
P50	1125.8 MWh
P90	1099.8 MWh
P95	1092.4 MWh

Probability distribution



Single-line diagram

PVsyst V7.4.6
VC1, Simulation date:
03/27/24 17:09
with V7.4.6



PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG250-HX
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry Final	Studio Santi srl (Italy)
	VC1 : lotto 6	03/27/24

Version 7.4.5

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry ver 2

Variant: Parete 1_1

Sheds on ground

System power: 464 kWp

Riano - Italy

Author

Studio Santi srl (Italy)

Project: Riano Quarry ver 2

Variant: New simulation variant

Studio Santi srl (Italy)

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	186 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015), Sat=44% - Synthetic

System summary

Grid-Connected System

Sheds on ground

PV Field Orientation
Fixed plane
Tilt/Azimuth 89 / 0 °

Near Shadings
Linear shadings : Fast (table)

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	672 units
Pnom total	464 kWp

Inverters

Nb. of units	4 units
Pnom total	444 kWac
Pnom ratio	1.044

Results summary

Produced Energy	446454 kWh/year	Specific production	963 kWh/kWp/year	Perf. Ratio PR	81.14 %

Table of contents

General parameters

Grid-Connected System

Sheds on ground

PV Field Orientation

Orientation		Sheds configuration	Models used	
Fixed plane			Transposition	Perez
Tilt/Azimuth	89 / 0 °		Diffuse	Perez, Meteonorm
			Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings : Fast (table)

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	672 units
Nominal (STC)	464 kWp
Modules	24 string x 28 In series
At operating cond. (50°C)	
Pmpp	425 kWp
U mpp	1017 V
I mpp	418 A

Inverter

Manufacturer	Sungrow
Model	SG111-HV
(Original PVsyst database)	
Unit Nom. Power	111 kWac
Number of inverters	4 units
Total power	444 kWac
Operating voltage	780-1450 V
Pnom ratio (DC:AC)	1.04

Total PV power

Nominal (STC)	464 kWp
Total	672 modules
Module area	2087 m²

Total inverter power

Total power	444 kWac
Number of inverters	4 units
Pnom ratio	1.04

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 40 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

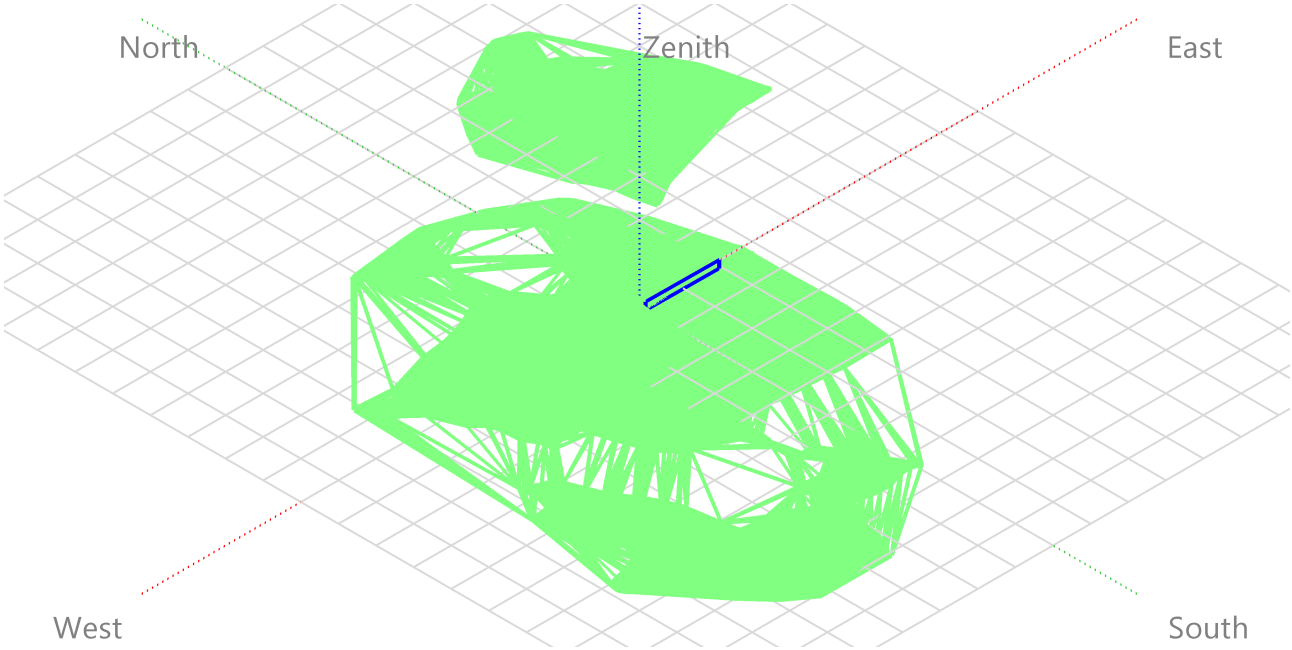
Strings Mismatch loss
Loss Fraction 0.2 %

IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

Near shadings parameter

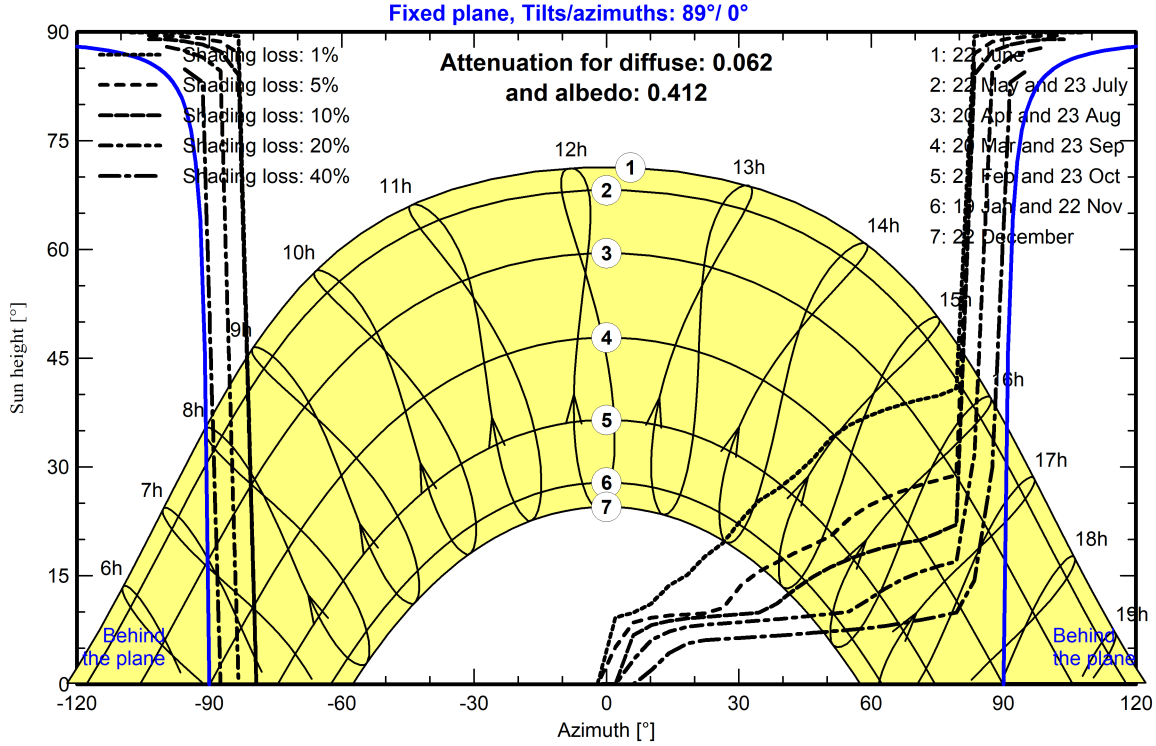
Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

Fixed plane, Tilts/azimuths: 89°/ 0°

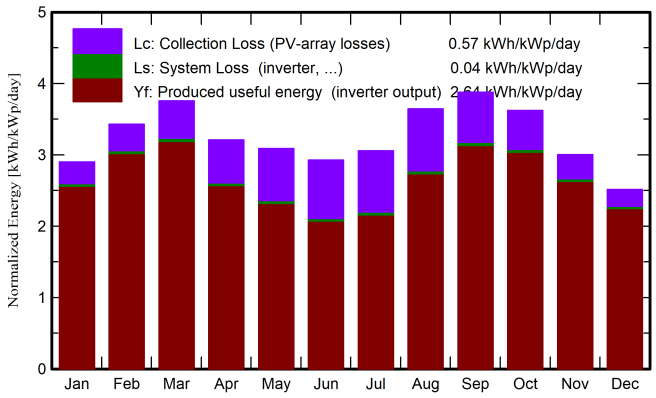


Main results

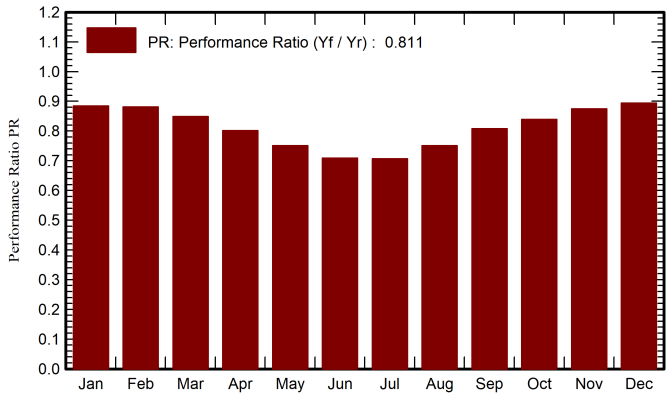
System Production

Produced Energy (P50)	446454 kWh/year	Specific production (P50)	963 kWh/kWp/year	Perf. Ratio PR	81.14 %
Produced Energy (P90)	436133 kWh/year	Specific production (P90)	941 kWh/kWp/year		
Produced Energy (P95)	433229 kWh/year	Specific production (P95)	934 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

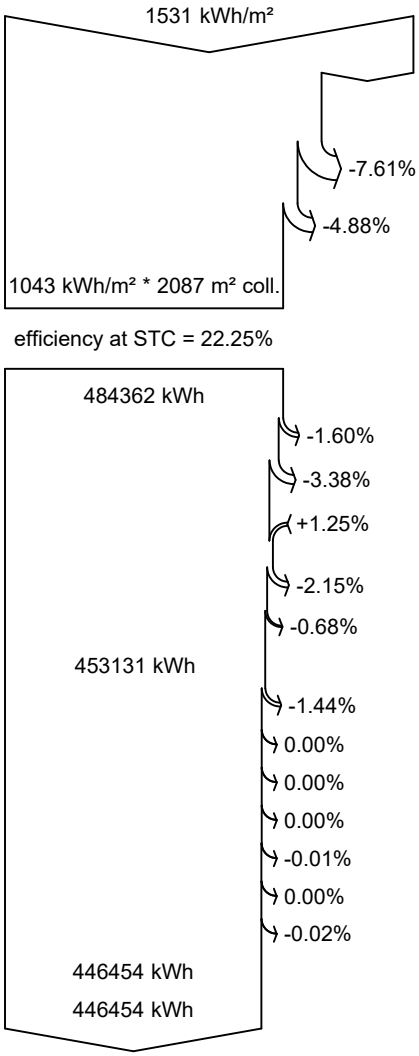
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.6	25.25	7.41	89.8	84.2	37361	36847	0.885
February	73.2	34.62	8.25	96.0	89.5	39774	39250	0.881
March	121.0	57.31	11.30	116.5	104.8	46495	45863	0.849
April	147.6	72.06	14.57	96.2	82.5	36311	35754	0.801
May	192.3	79.67	18.87	95.8	78.1	33927	33341	0.751
June	207.5	84.34	23.34	87.8	68.7	29365	28858	0.709
July	215.8	74.44	26.38	94.8	74.9	31598	31053	0.706
August	191.0	67.56	26.26	113.0	95.0	39954	39346	0.751
September	135.9	56.67	21.37	116.4	103.8	44203	43569	0.808
October	93.4	42.45	17.62	112.2	102.7	44268	43674	0.839
November	56.1	27.72	12.60	90.1	85.0	37087	36567	0.875
December	44.5	25.09	8.71	78.0	73.7	32786	32333	0.894
Year	1530.8	647.17	16.44	1186.7	1043.0	453131	446454	0.811

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

PVsyst V7.4.5
VC6, Simulation date:
02/19/24 15:04
with v7.4.5

Loss diagram

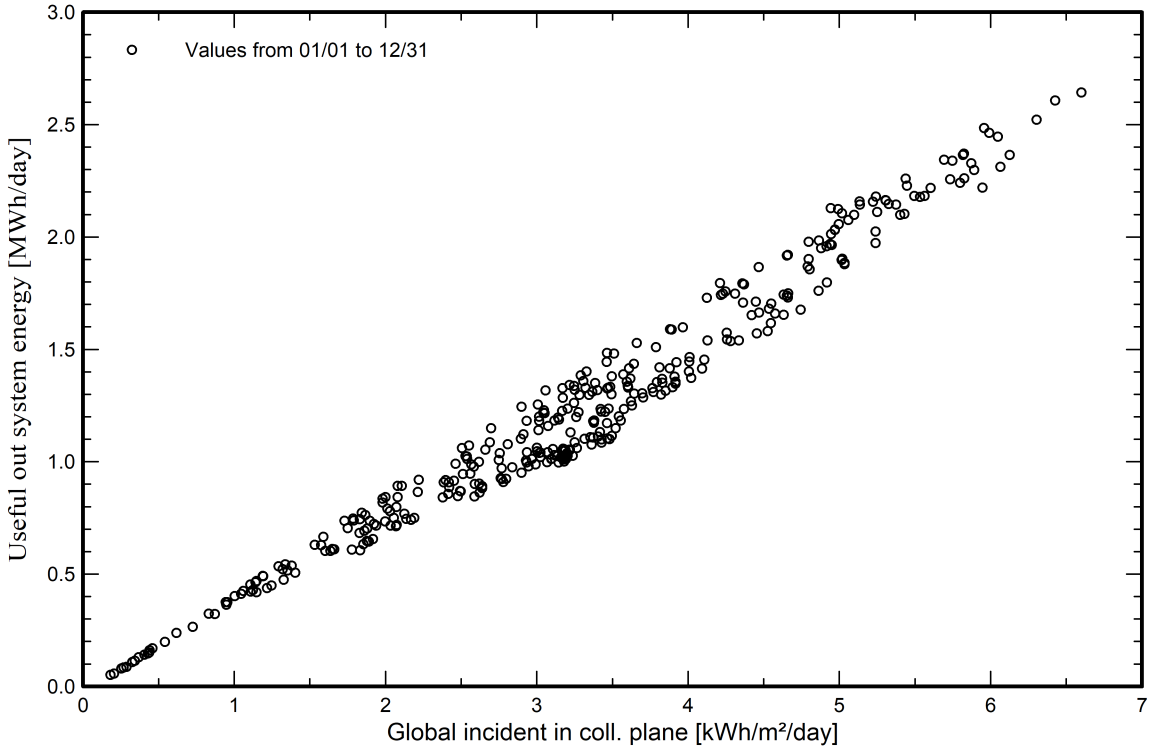


	Global horizontal irradiation
-22.48%	**Global incident in coll. plane**
	Near Shadings: irradiance loss
	IAM factor on global
	Effective irradiation on collectors
	PV conversion
	Array nominal energy (at STC effic.)
	PV loss due to irradiance level
	PV loss due to temperature
	Module quality loss
	Mismatch loss, modules and strings
	Ohmic wiring loss
	Array virtual energy at MPP
	Inverter Loss during operation (efficiency)
	Inverter Loss over nominal inv. power
	Inverter Loss due to max. input current
	Inverter Loss over nominal inv. voltage
	Inverter Loss due to power threshold
	Inverter Loss due to voltage threshold
	Night consumption
	Available Energy at Inverter Output
	Energy injected into grid

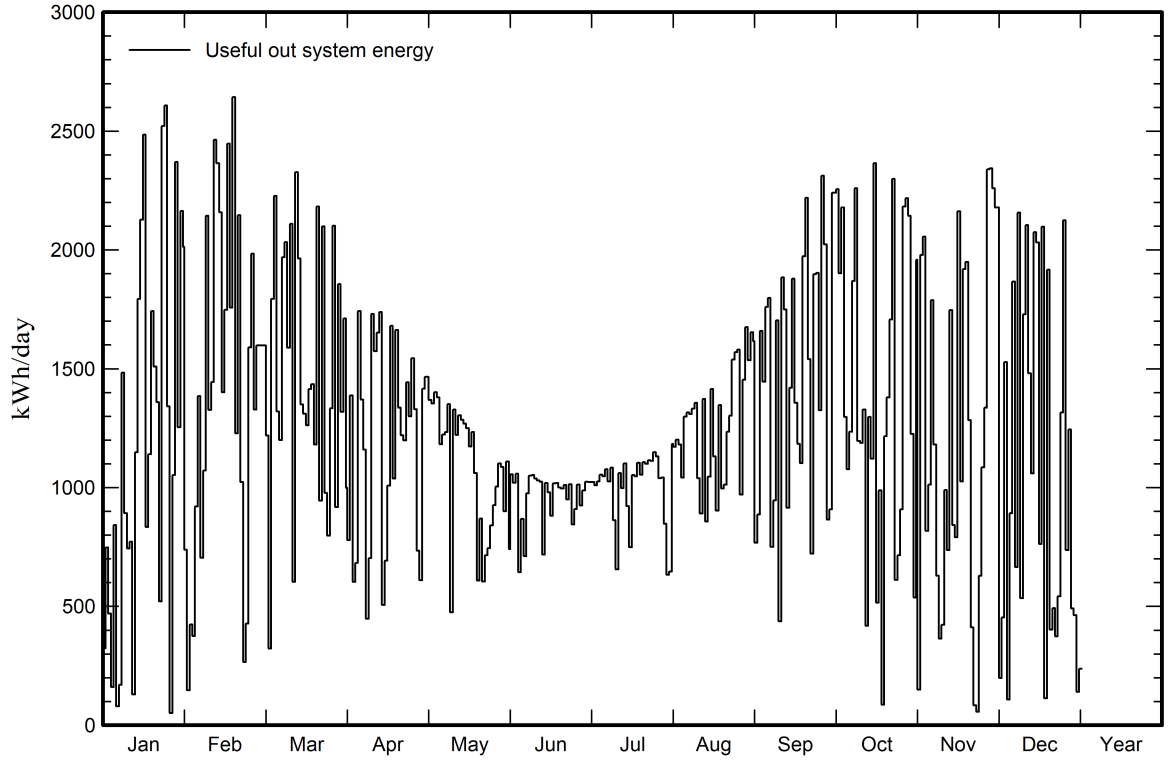
PVsyst V7.4.5
VC6, Simulation date:
02/19/24 15:04
with v7.4.5

Predef. graphs

Daily Input/Output diagram



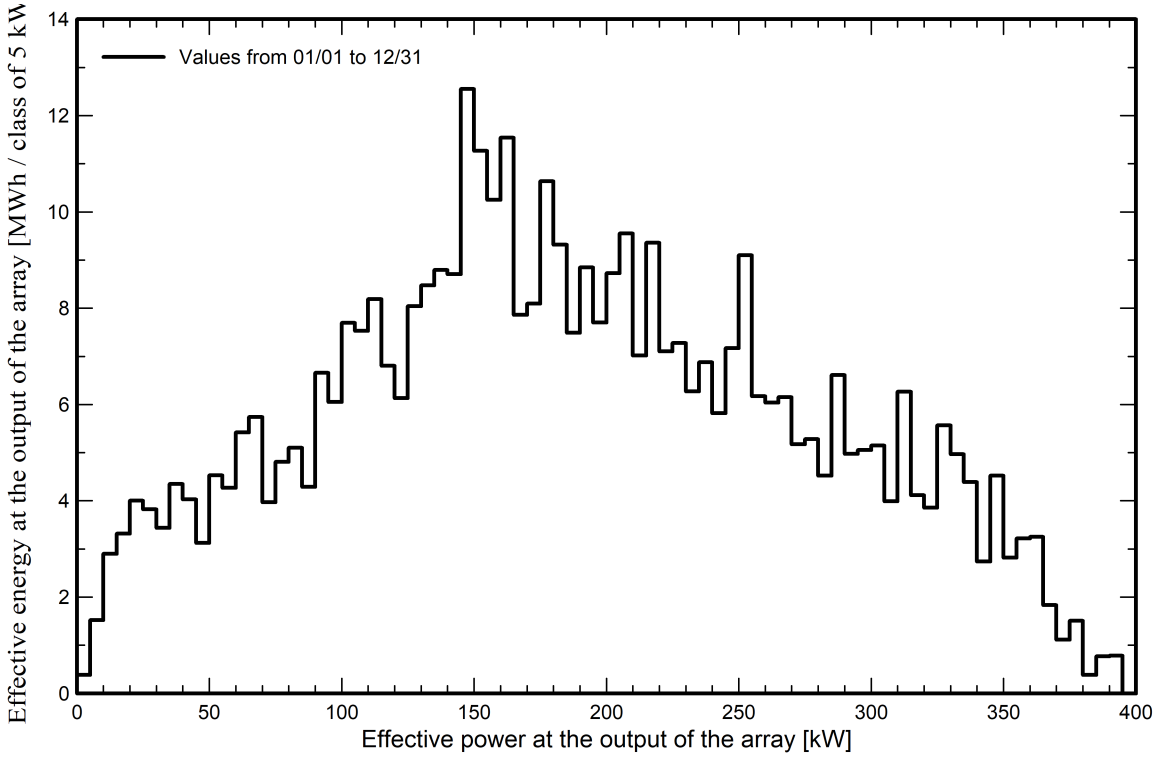
Daily System Output Energy



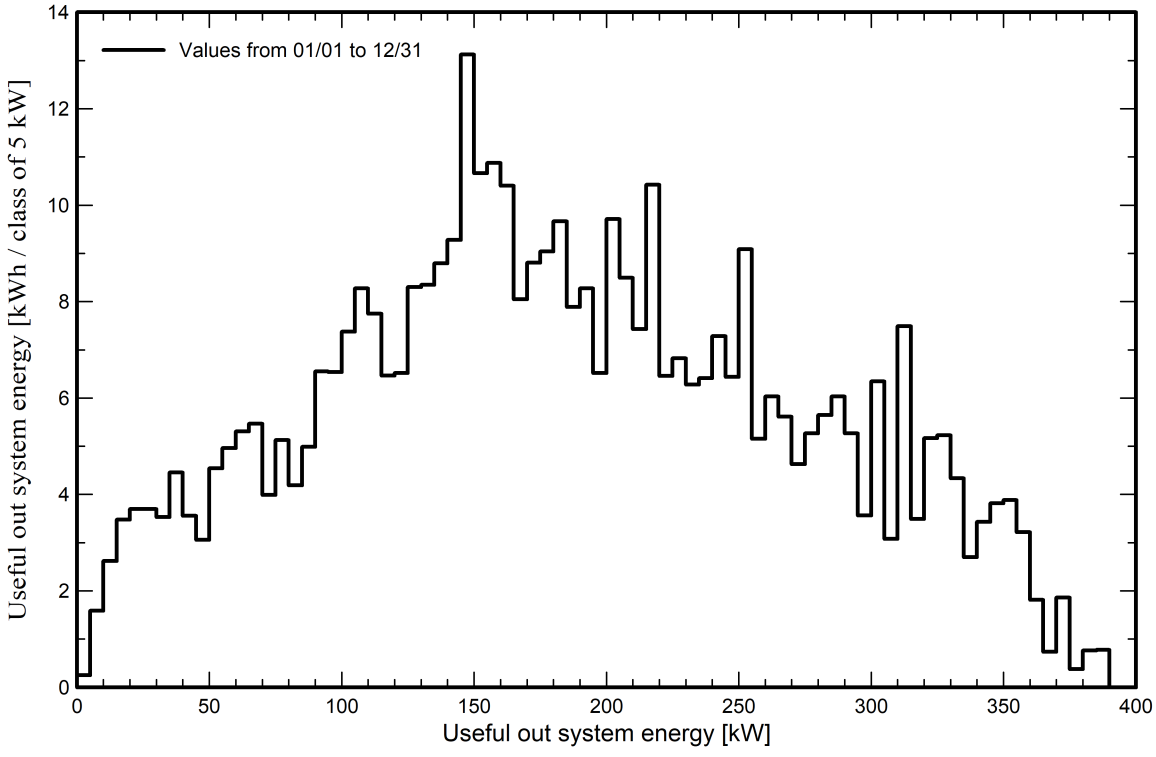
PVsyst V7.4.5
VC6, Simulation date:
02/19/24 15:04
with v7.4.5

Predef. graphs

Array Power Distribution



System Output Power Distribution



PVsyst V7.4.5
VC6, Simulation date:
02/19/24 15:04
with v7.4.5

P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015), Sat=44%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	0.0 %
Specified Deviation	
Climate change	0.0 %

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 %

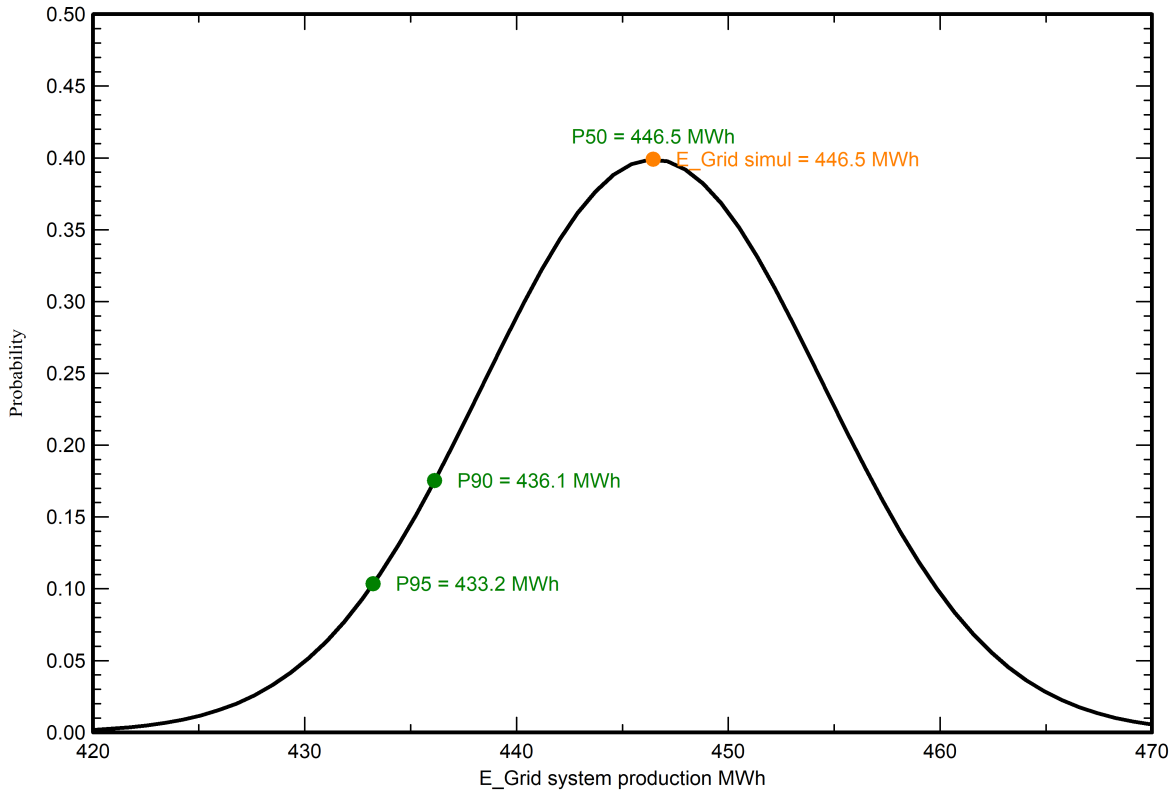
Global variability (meteo + system)

Variability (Quadratic sum)	1.8 %

Annual production probability

Variability	8.0 MWh
P50	446.5 MWh
P90	436.1 MWh
P95	433.2 MWh

Probability distribution



Single-line diagram

PVsyst V7.4.5
VC6, Simulation date:
02/19/24 15:04
with v7.4.5

PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG111-HV
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry ver 2	Studio Santi srl (Italy)
	VC6 : New simulation variant	02/19/24

Version 7.4.5

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry ver 2

Variant: Layout Parete_1_2

Tables on a building

System power: 773 kWp

Riano - Italy

Author

Studio Santi srl (Italy)

PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	186 m
Time zone	UTC+1

Project settings
Albedo 0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015), Sat=44% - Synthetic

System summary

Grid-Connected System

Tables on a building

PV Field Orientation
Fixed plane
Tilt/Azimuth 62.2 / -3.3 °

Near Shadings
Linear shadings : Fast (table)

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	1120 units
Pnom total	773 kWp

Inverters

Nb. of units	2 units
Pnom total	700 kWac
Pnom ratio	1.104

Results summary

Produced Energy	1075647 kWh/year	Specific production	1392 kWh/kWp/year	Perf. Ratio PR	87.08 %

Table of contents

General parameters

Grid-Connected System | **Tables on a building**

PV Field Orientation

Orientation		**Sheds configuration**	**Models used**	
Fixed plane			Transposition	Perez
Tilt/Azimuth	62.2 / -3.3 °		Diffuse	Perez, Meteonorm
			Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings : Fast (table)

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-DEG21C-20-690Wp Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	1120 units
Nominal (STC)	773 kWp
Modules	40 string x 28 In series
At operating cond. (50°C)	
Pmpp	708 kWp
U mpp	1017 V
I mpp	696 A

Inverter

Manufacturer	Sungrow
Model	SG350-HX
(Custom parameters definition)	
Unit Nom. Power	350 kWac
Number of inverters	2 units
Total power	700 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.10
Power sharing within this inverter	

Total PV power

Nominal (STC)	773 kWp
Total	1120 modules
Module area	3479 m²

Total inverter power

Total power	700 kWac
Number of inverters	2 units
Pnom ratio	1.10

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 24 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.2 %

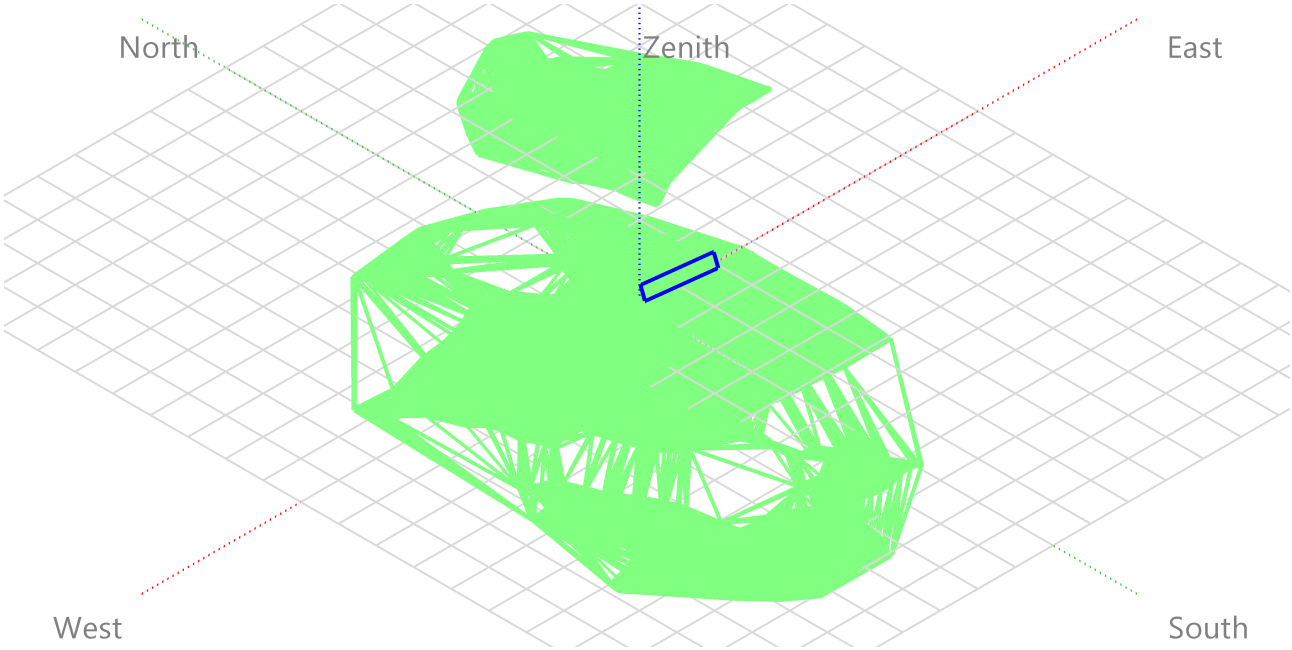
IAM loss factor
Incidence effect (IAM): Fresnel, AR coating, n(glass)=1.526, n(AR)=1.290

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000

PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

Near shadings parameter

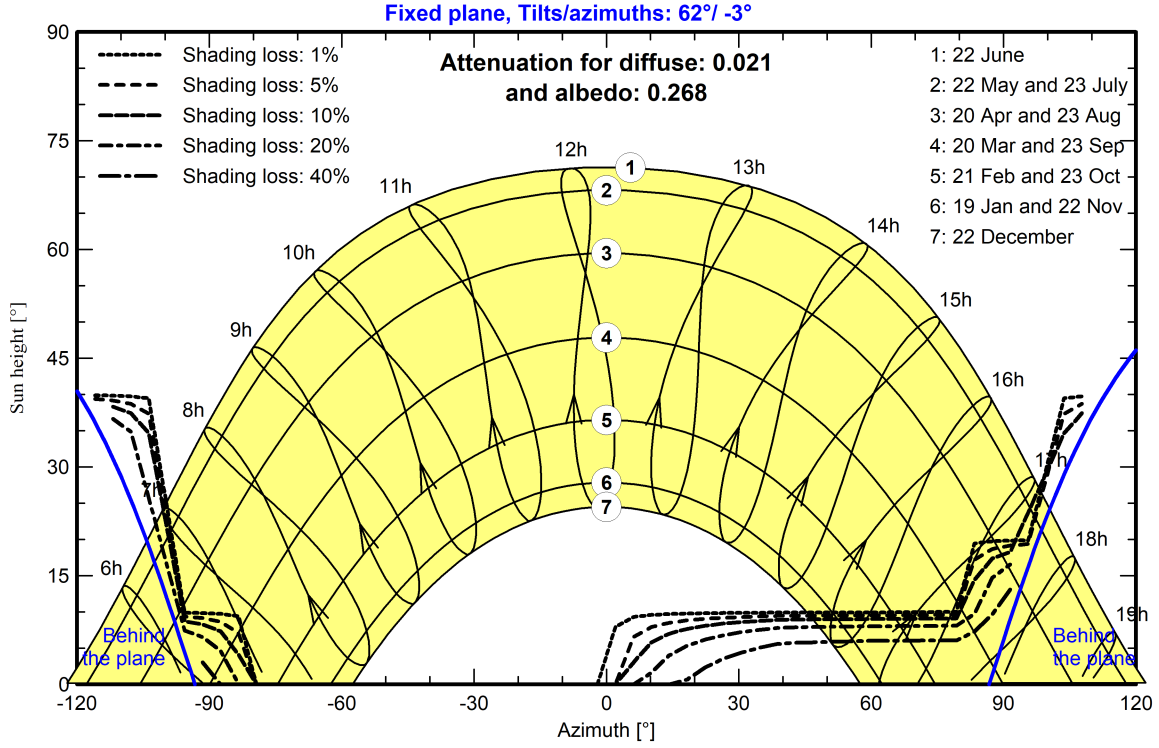
Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

Fixed plane, Tilts/azimuths: 62°/ -3°

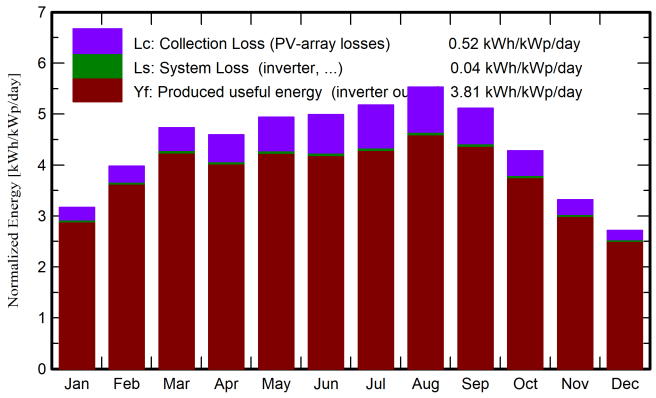


Main results

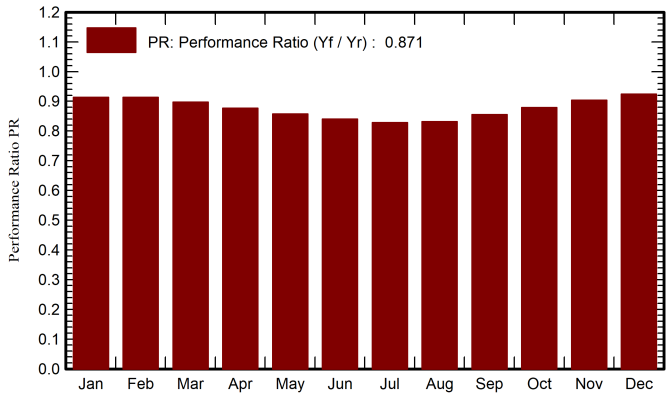
System Production

Produced Energy (P50)	1075647 kWh/year	Specific production (P50)	1392 kWh/kWp/year	Perf. Ratio PR	87.08 %
Produced Energy (P90)	1019497 kWh/year	Specific production (P90)	1319 kWh/kWp/year		
Produced Energy (P95)	1003699 kWh/year	Specific production (P95)	1299 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

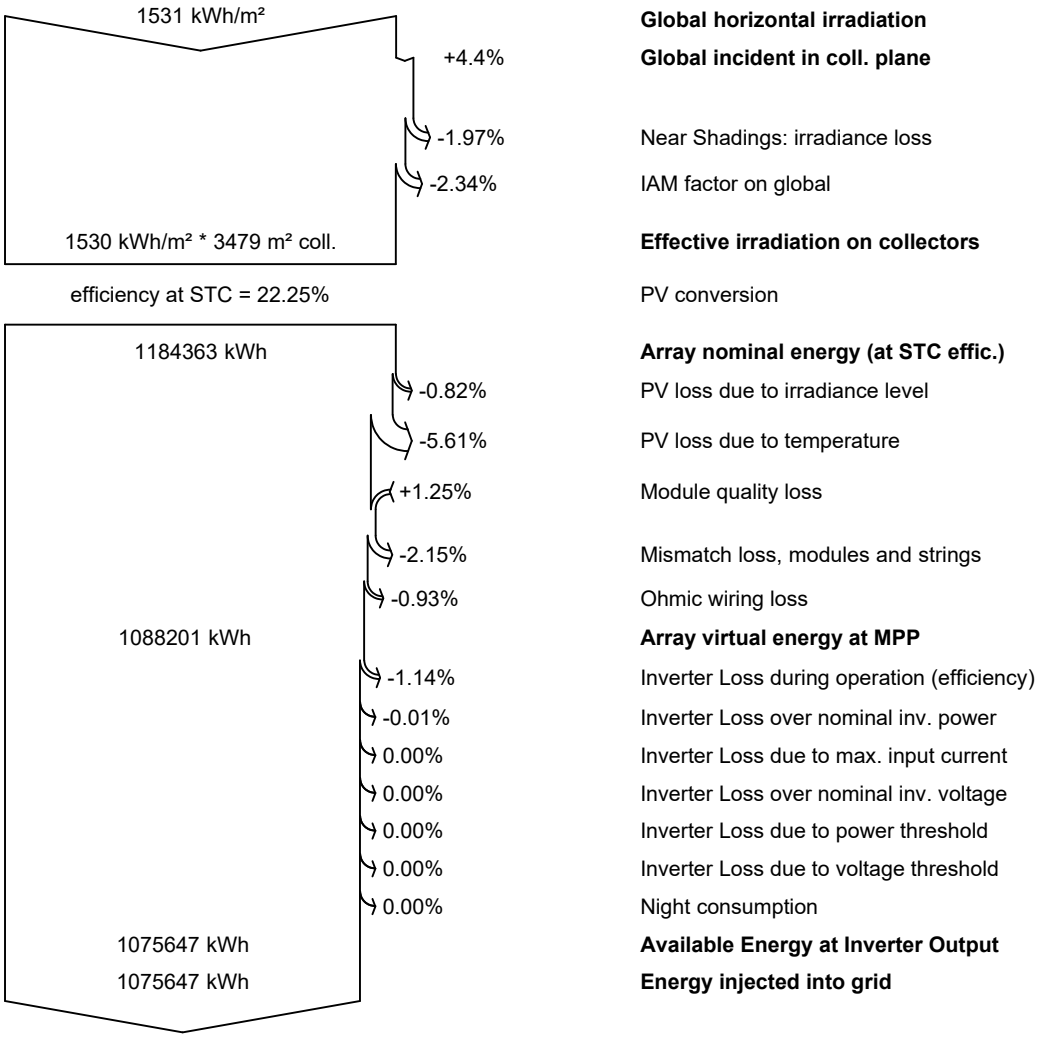
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.6	25.25	7.41	98.1	95.5	70134	69289	0.914
February	73.2	34.62	8.25	111.3	108.6	79461	78584	0.913
March	121.0	57.31	11.30	146.7	141.1	102793	101694	0.897
April	147.6	72.06	14.57	137.8	130.9	94444	93339	0.877
May	192.3	79.67	18.87	153.0	144.4	102663	101437	0.858
June	207.5	84.34	23.34	149.7	140.3	98351	97214	0.840
July	215.8	74.44	26.38	160.4	150.9	103974	102762	0.829
August	191.0	67.56	26.26	171.4	162.6	111398	110144	0.832
September	135.9	56.67	21.37	153.4	147.4	102567	101426	0.855
October	93.4	42.45	17.62	132.6	128.4	91052	90046	0.879
November	56.1	27.72	12.60	99.6	97.5	70424	69567	0.904
December	44.5	25.09	8.71	84.2	82.4	60845	60144	0.924
Year	1530.8	647.17	16.44	1598.3	1530.2	1088105	1075647	0.871

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

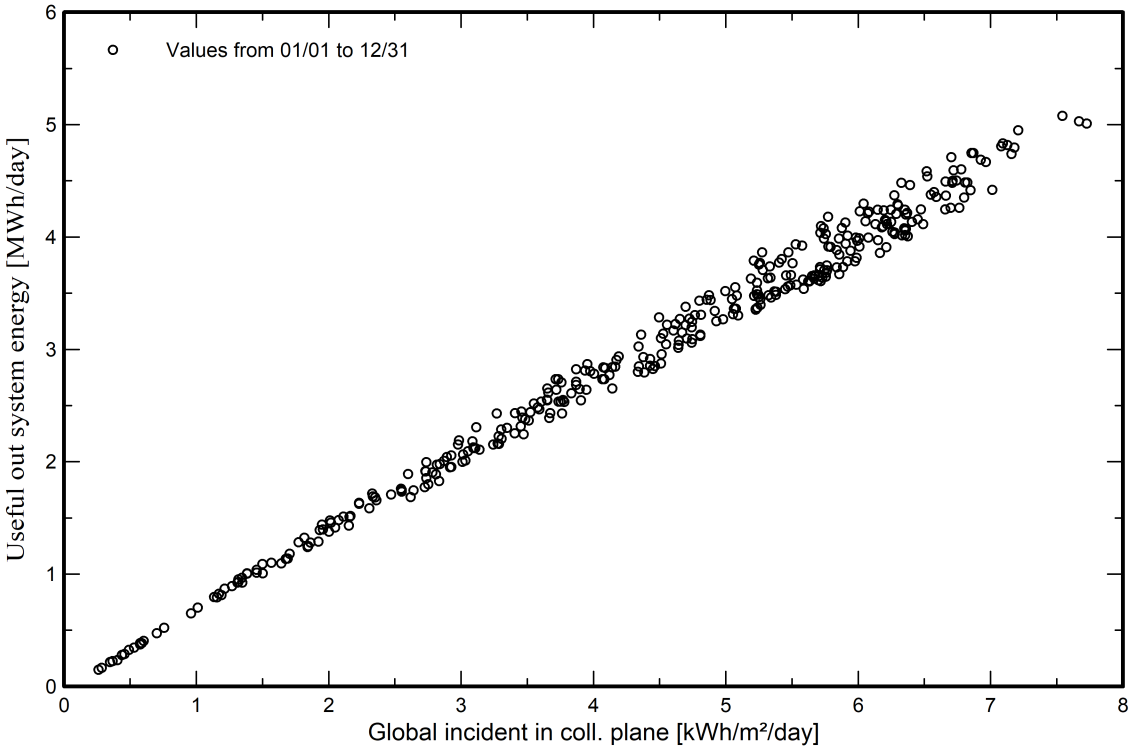
Loss diagram



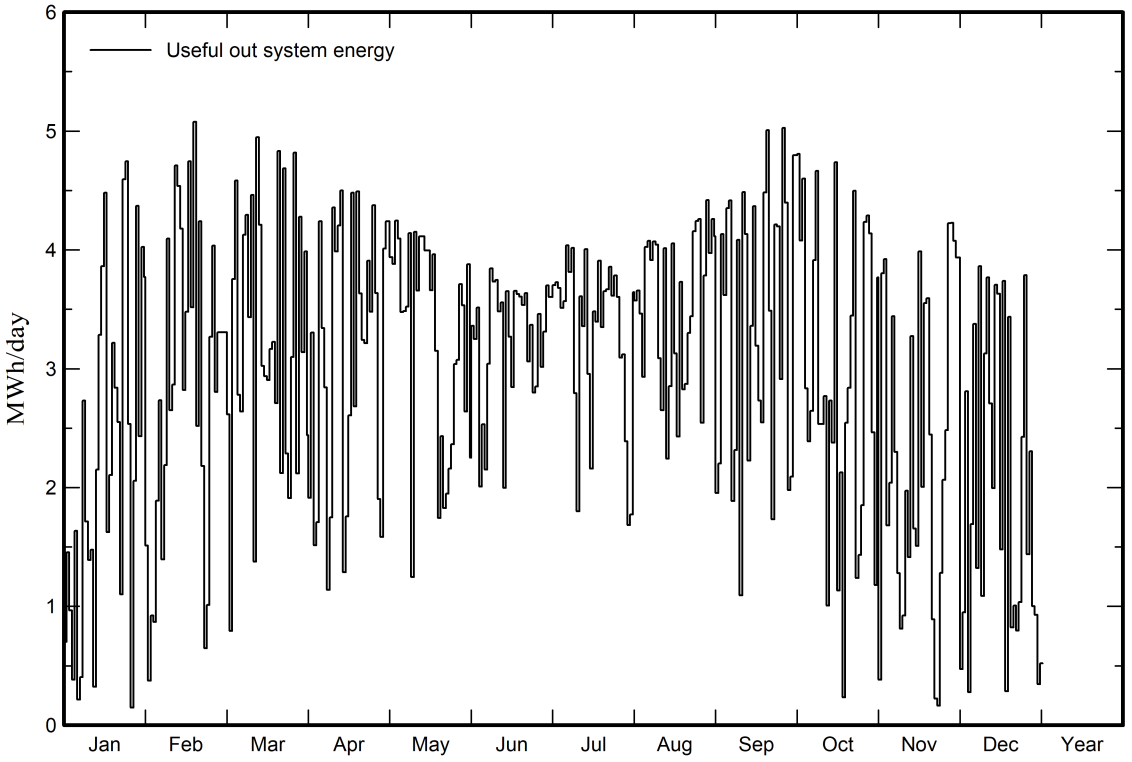
PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

Predef. graphs

Daily Input/Output diagram



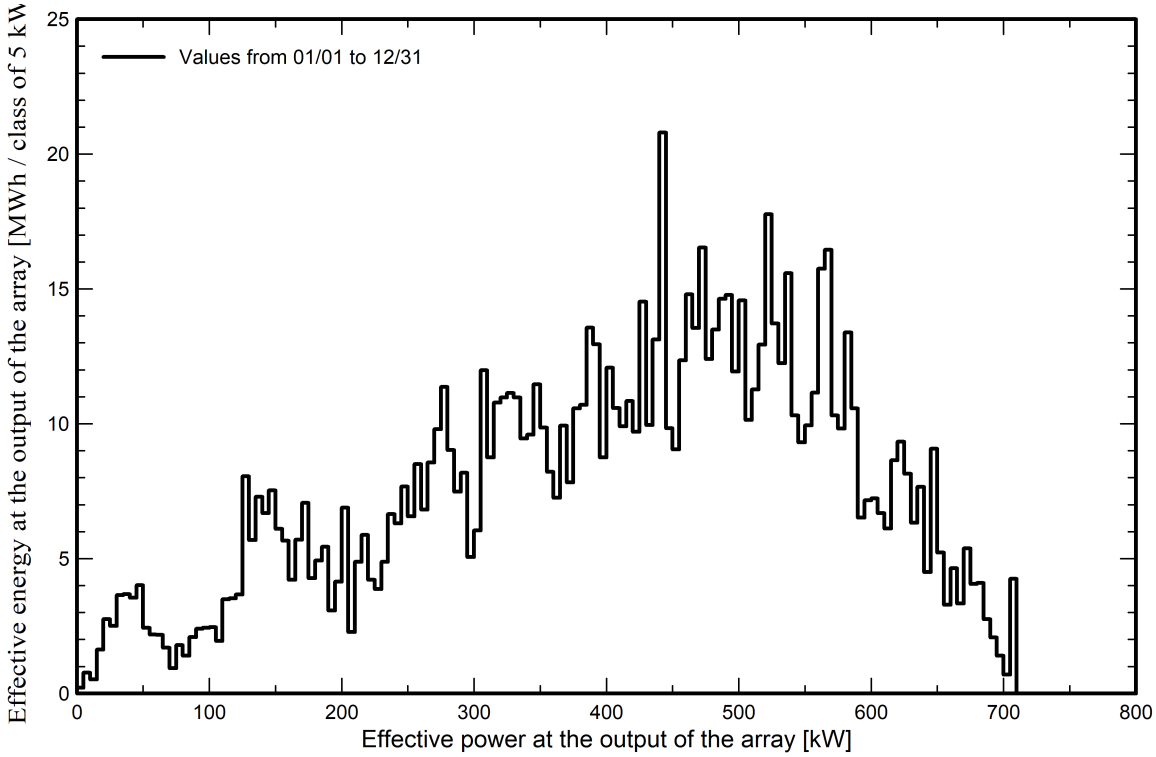
Daily System Output Energy



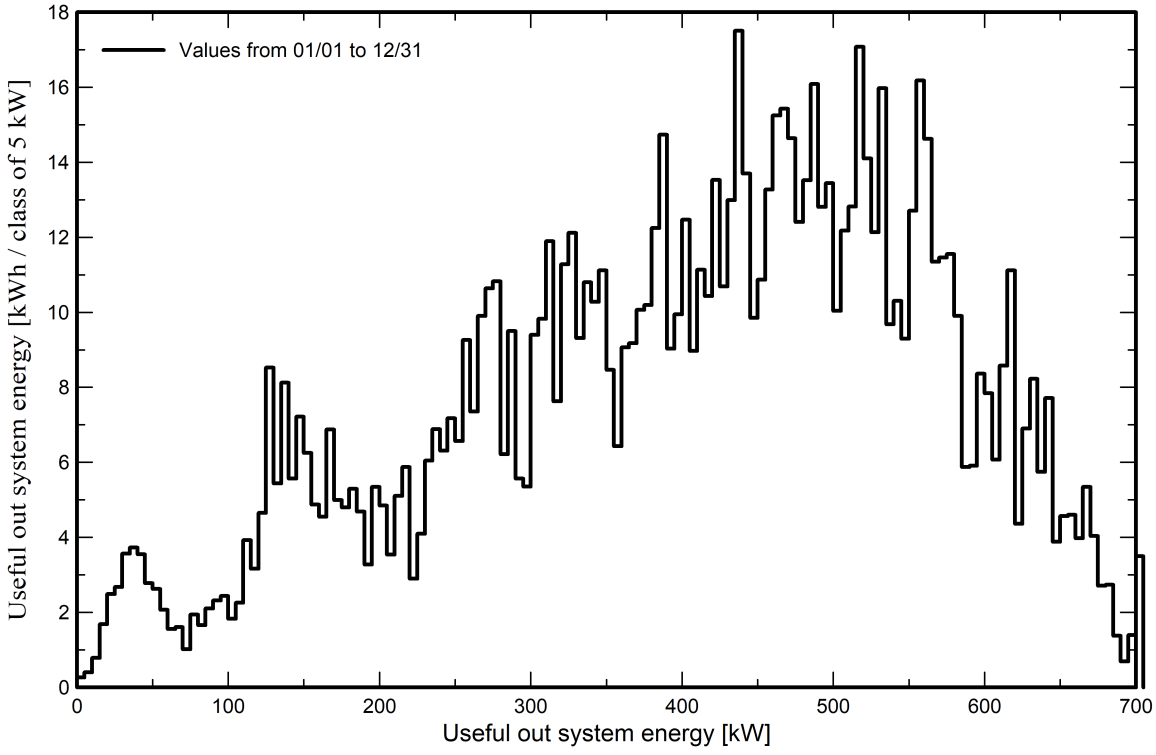
PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

Predef. graphs

Array Power Distribution



System Output Power Distribution



PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5

P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015), Sat=44%
Kind	Monthly averages
Synthetic - Multi-year average	
Year-to-year variability(Variance)	3.7 %
Specified Deviation	
Climate change	0.0 %

Global variability (meteo + system)

Variability (Quadratic sum)	4.1 %

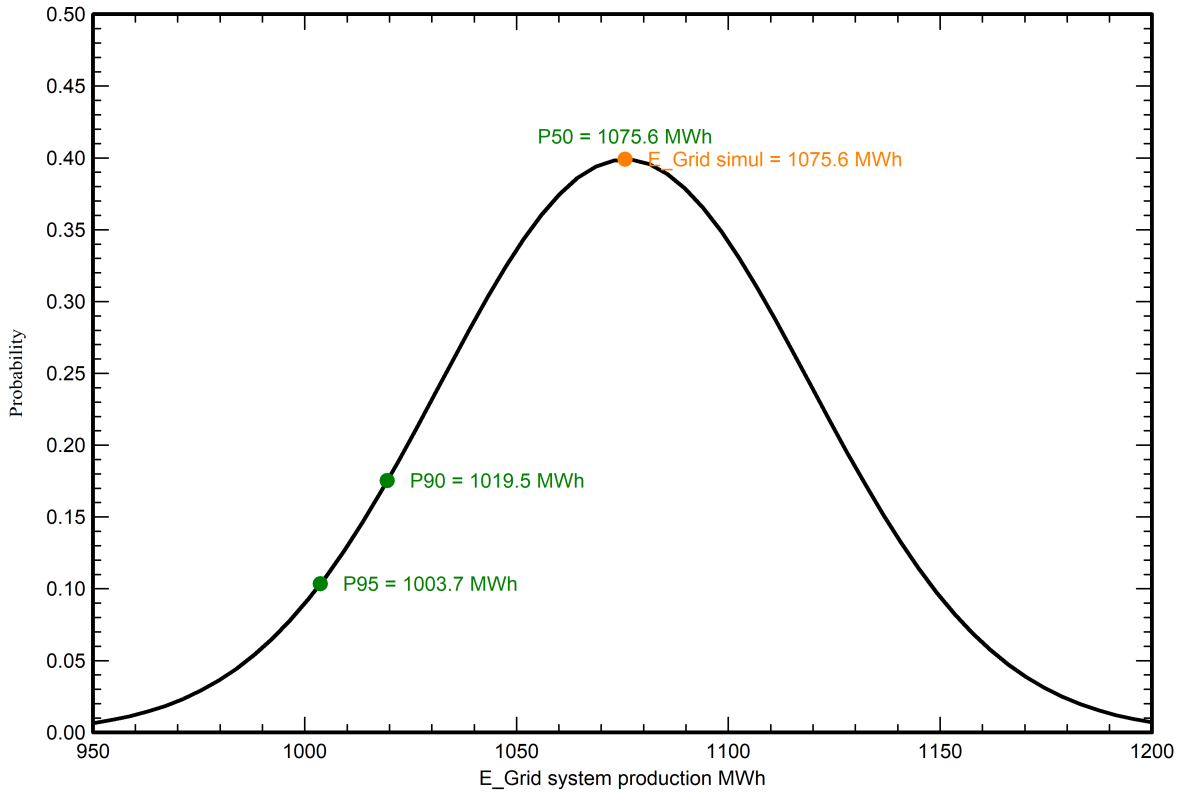
Simulation and parameters uncertainties

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

Annual production probability

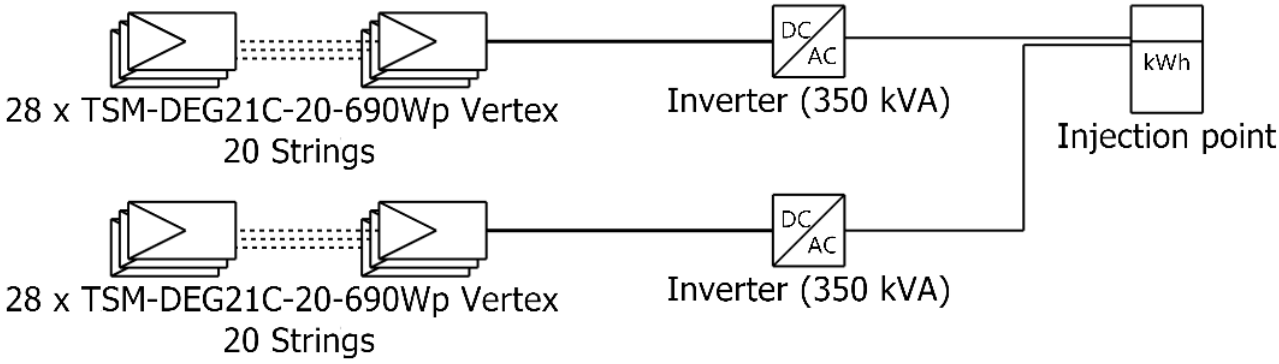
Variability	43.8 MWh
P50	1075.6 MWh
P90	1019.5 MWh
P95	1003.7 MWh

Probability distribution



Single-line diagram

PVsyst V7.4.5
VC8, Simulation date:
02/19/24 17:12
with v7.4.5



PV module	TSM-DEG21C-20-690Wp Vertex
Inverter	SG350-HX
String	28 x TSM-DEG21C-20-690Wp Vertex

	Riano Quarry ver 2	Studio Santi srl (Italy)
	VC8 : Layout Parete_1_2	02/19/24

Version 7.3.1

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry

Variant: Parete 2_2

Sheds on ground

System power: 449 kWp

Riano - Italy

Author

PVsyst V7.3.1
VCC, Simulation date:
19/02/24 18:13
with v7.3.1

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	126 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015), Sat=57% - Synthetic

System summary

Grid-Connected System

Sheds on ground

PV Field Orientation
Fixed plane
Tilt/Azimuth 77 / -0.2 °

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	650 units
Pnom total	449 kWp

Inverters

Nb. of units	1 unit
Pnom total	350 kWac
Pnom ratio	1.281

Results summary

Produced Energy	547453 kWh/year	Specific production	1221 kWh/kWp/year	Perf. Ratio PR	88.33 %

Table of contents

General parameters

Grid-Connected System

Sheds on ground

PV Field Orientation

Orientation		Sheds configuration	Models used	
Fixed plane			Transposition	Perez
Tilt/Azimuth	77 / -0.2 °		Diffuse	Perez, Meteonorm
			Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	TrinaSolar
Model	Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	650 units
Nominal (STC)	449 kWp
Modules	26 Strings x 25 In series
At operating cond. (50°C)	
Pmpp	422 kWp
U mpp	933 V
I mpp	452 A

Inverter

Manufacturer	Sungrow
Model	SG350-HX
(Custom parameters definition)	
Unit Nom. Power	350 kWac
Number of inverters	1 unit
Total power	350 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.28
Power sharing within this inverter	

Total PV power

Nominal (STC)	449 kWp
Total	650 modules
Module area	2019 m²
Cell area	85800 m²

Total inverter power

Total power	350 kWac
Number of inverters	1 unit
Pnom ratio	1.28

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 33 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -1.3 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

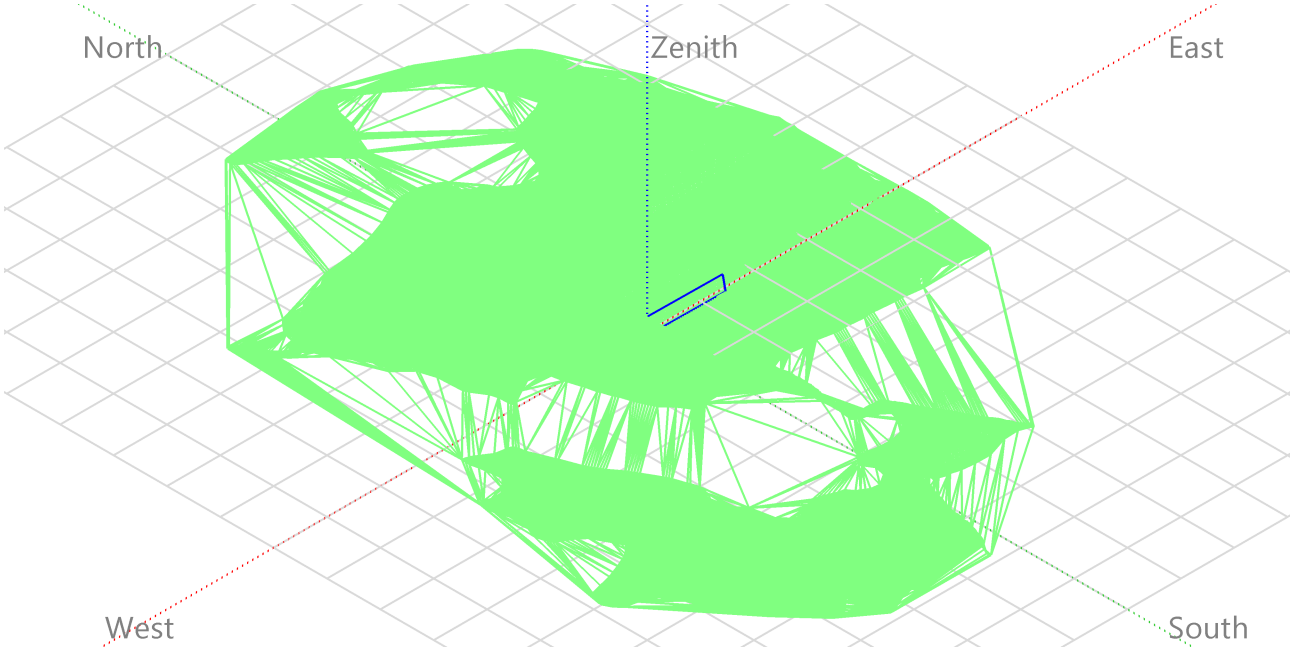
Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

Near shadings parameter

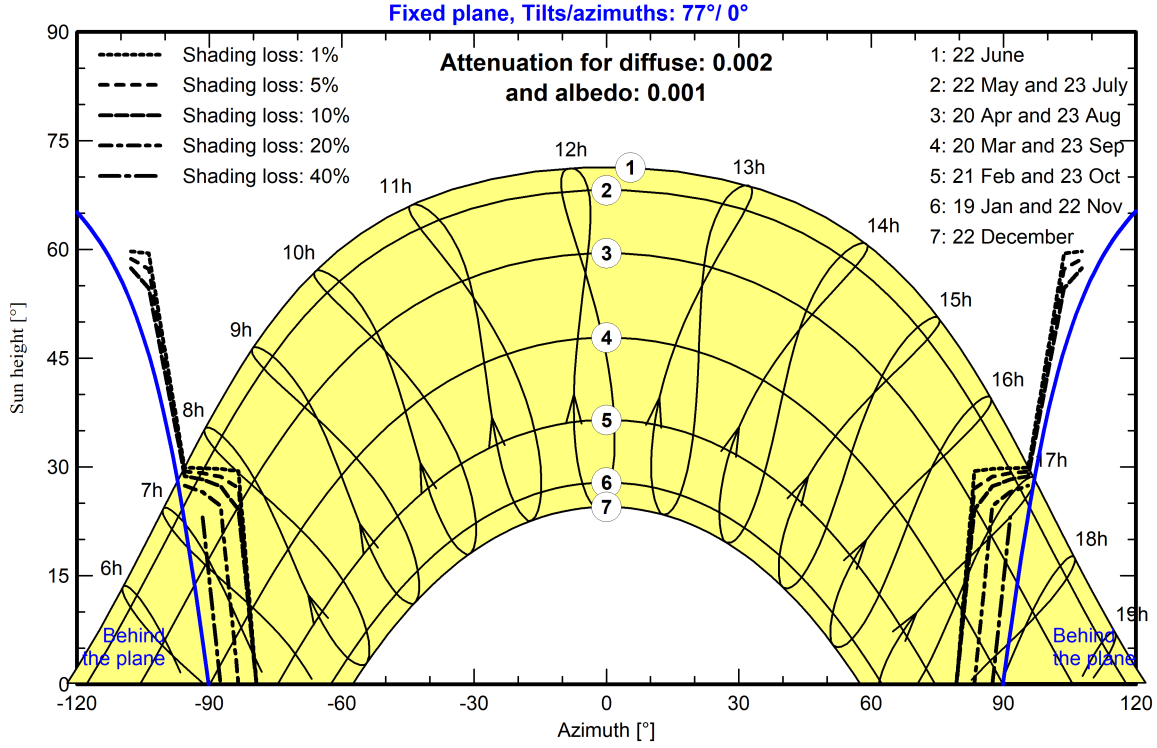
Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

Fixed plane, Tilts/azimuths: 77° / 0°

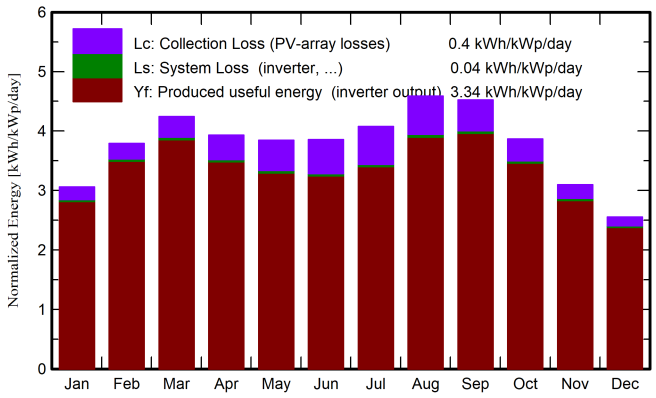


Main results

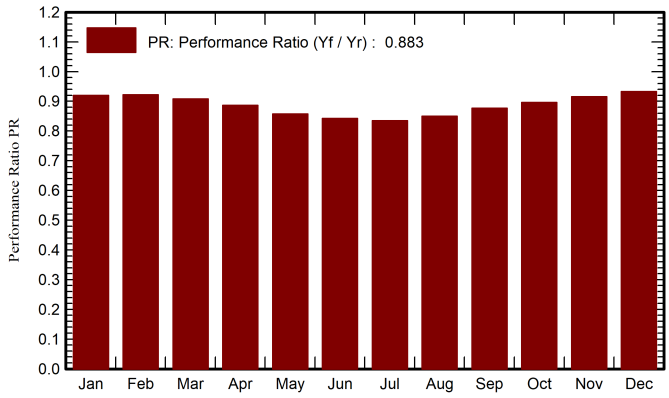
System Production

Produced Energy	547453 kWh/year	Specific production	1221 kWh/kWp/year
		Performance Ratio PR	88.33 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

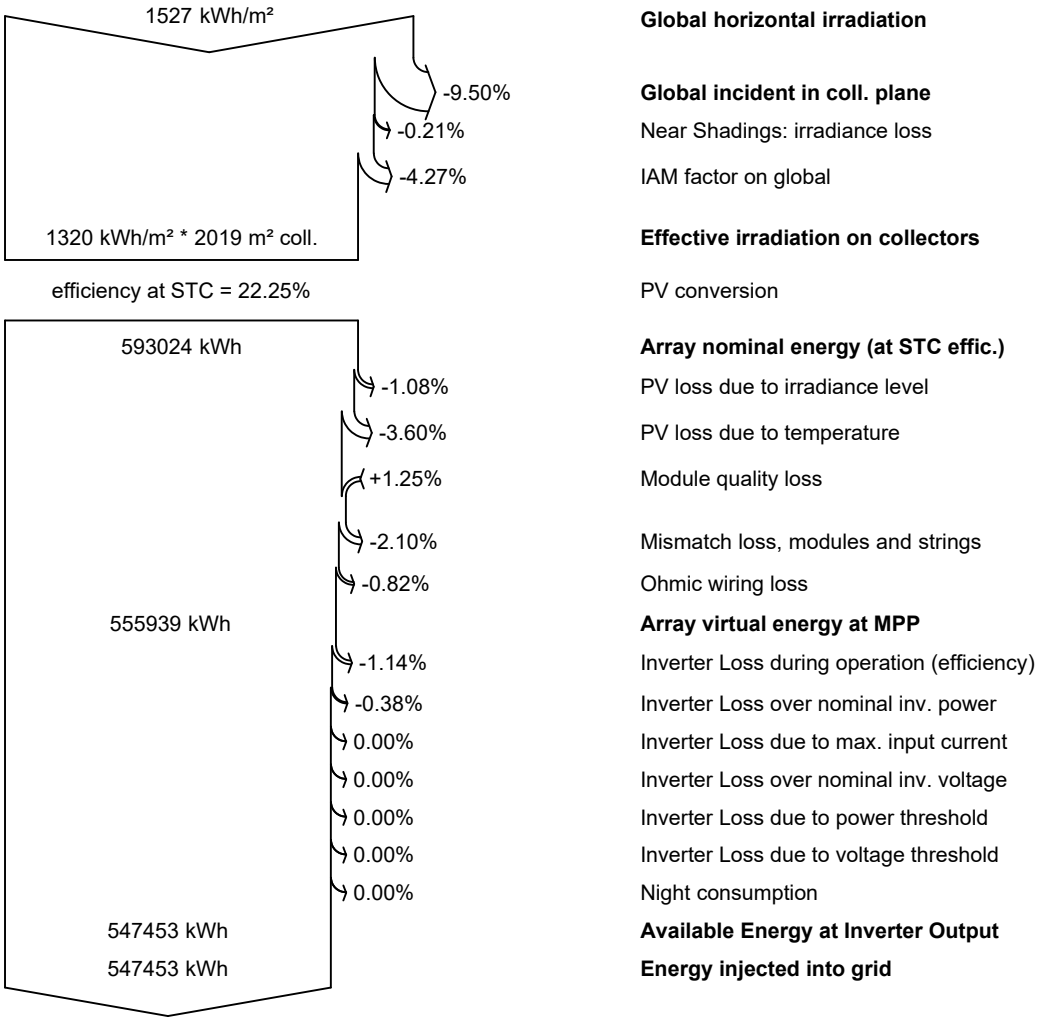
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.85	7.77	94.9	93.7	39619	39163	0.920
February	72.5	34.58	8.94	106.2	104.4	44398	43904	0.922
March	121.3	55.99	12.20	131.6	127.1	54193	53601	0.908
April	147.3	68.59	15.45	117.9	111.7	47430	46871	0.886
May	191.8	75.54	19.98	119.2	110.4	46437	45867	0.858
June	207.5	80.82	24.45	115.7	106.2	44245	43714	0.842
July	215.4	69.88	27.52	126.4	116.3	47877	47298	0.835
August	190.1	68.09	27.40	142.3	133.5	54867	54247	0.850
September	135.4	51.62	22.17	135.7	130.1	53943	53329	0.876
October	93.9	42.58	18.41	119.9	117.1	48718	48179	0.896
November	55.6	29.14	13.08	92.9	91.6	38611	38158	0.916
December	43.8	26.46	9.08	79.1	78.1	33502	33121	0.933
Year	1527.0	629.15	17.25	1381.9	1320.2	553839	547453	0.883

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

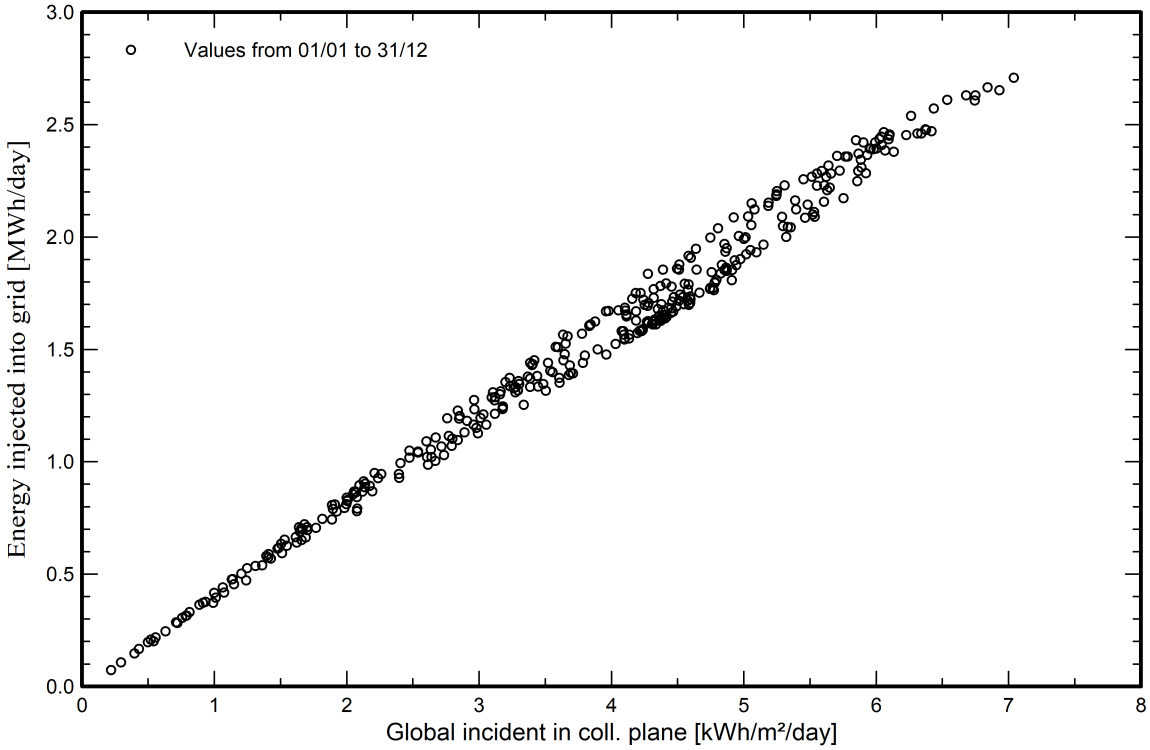
PVsyst V7.3.1
VCC, Simulation date:
19/02/24 18:13
with v7.3.1

Loss diagram

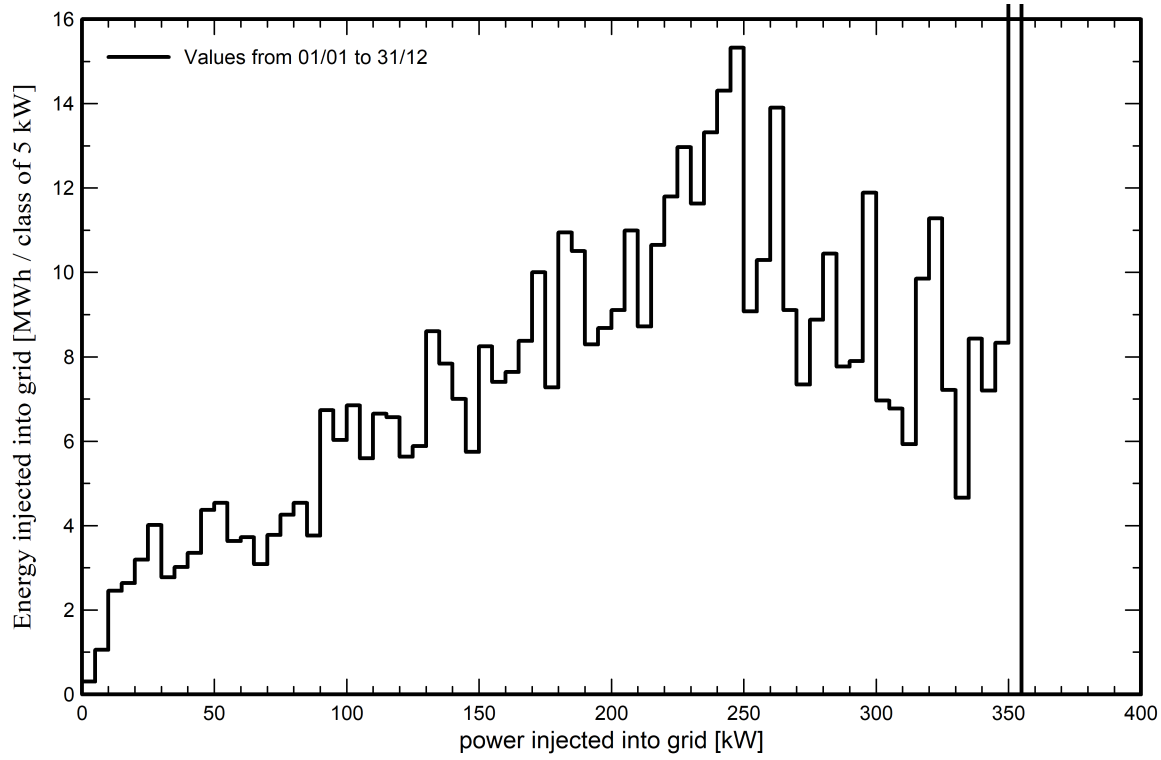


Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



PVsyst V7.3.1
VCC, Simulation date:
19/02/24 18:13
with v7.3.1

P50 - P90 evaluation

Meteo data

Source	Meteonorm 8.1 (1996-2015), Sat=57%
Kind	Not defined
Year-to-year variability(Variance)	0.0 %
Specified Deviation	

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 %

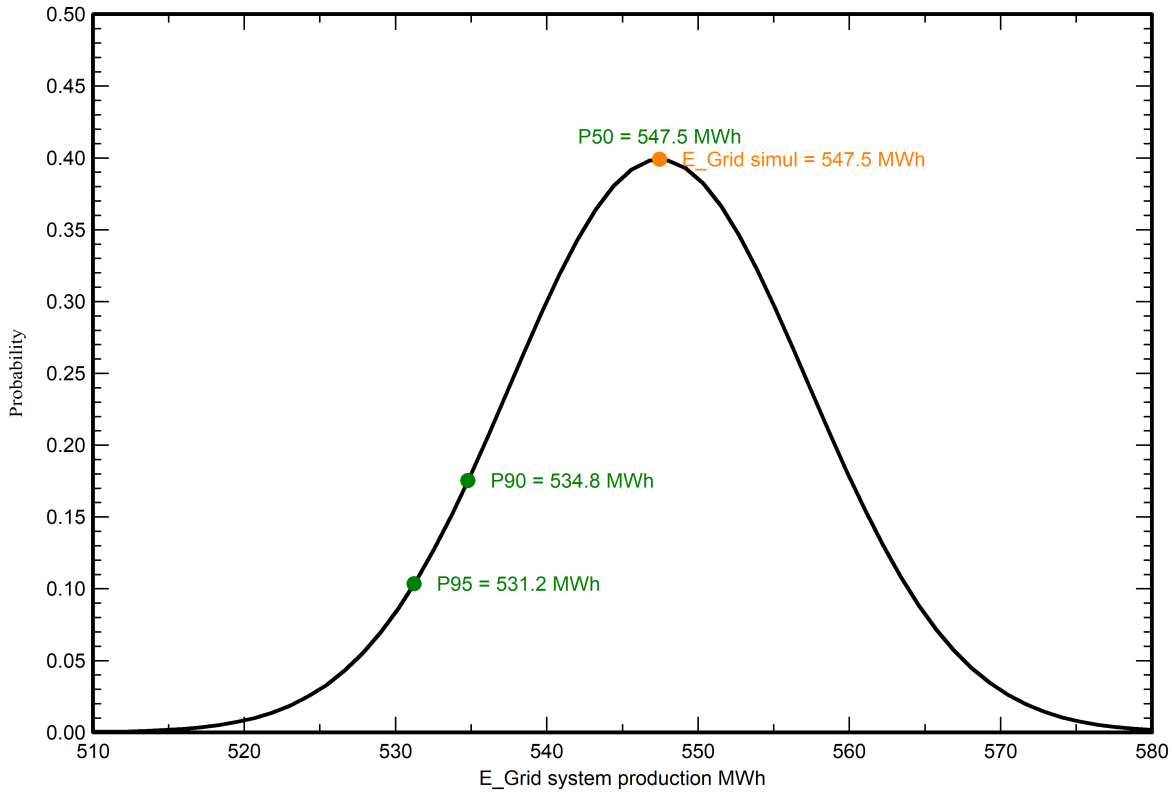
Global variability (meteo + system)

Variability (Quadratic sum)	1.8 %

Annual production probability

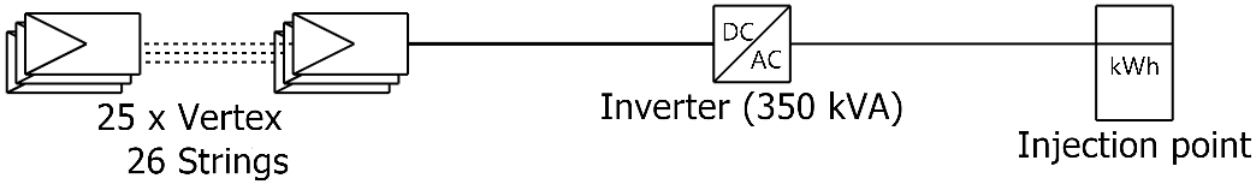
Variability	9.9 MWh
P50	547.5 MWh
P90	534.8 MWh
P95	531.2 MWh

Probability distribution



Single-line diagram

PVsyst V7.3.1
VCC, Simulation date:
19/02/24 18:13
with v7.3.1



PV module	Vertex
Inverter	SG350-HX
String	25 x Vertex

	Riano Quarry	
	VCC : Rack Parete 02	19/02/24

Version 7.3.1

PVsyst - Simulation report

Grid-Connected System

Project: Riano Quarry

Variant: Parete_2_ 2

Tables on a building

System power: 897 kWp

Riano - Italy

Author

PVsyst V7.3.1
VCA, Simulation date:
19/02/24 18:38
with v7.3.1

Project summary

Geographical Site
Riano
Italy

Situation

Latitude	42.09 °N
Longitude	12.51 °E
Altitude	126 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Riano
Meteonorm 8.1 (1996-2015), Sat=57% - Synthetic

System summary

Grid-Connected System

Tables on a building

PV Field Orientation
Fixed plane
Tilt/Azimuth 77 / -0.2 °

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	1300 units
Pnom total	897 kWp

Inverters

Nb. of units	2 units
Pnom total	700 kWac
Pnom ratio	1.281

Results summary

Produced Energy	993309 kWh/year	Specific production	1107 kWh/kWp/year	Perf. Ratio PR	80.13 %

Table of contents

General parameters

Grid-Connected System

Tables on a building

PV Field Orientation

Orientation		Sheds configuration		Models used	
Fixed plane				Transposition	Perez
Tilt/Azimuth	77 / -0.2 °			Diffuse	Perez, Meteonorm
				Circumsolar	separate

Horizon	Near Shadings	User's needs
Free Horizon	Linear shadings	Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	TrinaSolar
Model	Vertex
(Custom parameters definition)	
Unit Nom. Power	690 Wp
Number of PV modules	1300 units
Nominal (STC)	897 kWp
Modules	52 Strings x 25 In series
At operating cond. (50°C)	
Pmpp	844 kWp
U mpp	933 V
I mpp	905 A

Inverter

Manufacturer	Sungrow
Model	SG350-HX
(Custom parameters definition)	
Unit Nom. Power	350 kWac
Number of inverters	2 units
Total power	700 kWac
Operating voltage	500-1450 V
Pnom ratio (DC:AC)	1.28
Power sharing within this inverter	

Total PV power

Nominal (STC)	897 kWp
Total	1300 modules
Module area	4038 m²
Cell area	171600 m²

Total inverter power

Total power	700 kWac
Number of inverters	2 units
Pnom ratio	1.28

Array losses

Thermal Loss factor

Module temperature according to irradiance

Uc (const)	20.0 W/m²K
Uv (wind)	0.0 W/m²K/m/s

DC wiring losses

Global array res.	17 mΩ
Loss Fraction	1.5 % at STC

Module Quality Loss

Loss Fraction	-1.3 %

Module mismatch losses

Loss Fraction	2.0 % at MPP

Strings Mismatch loss

Loss Fraction	0.1 %

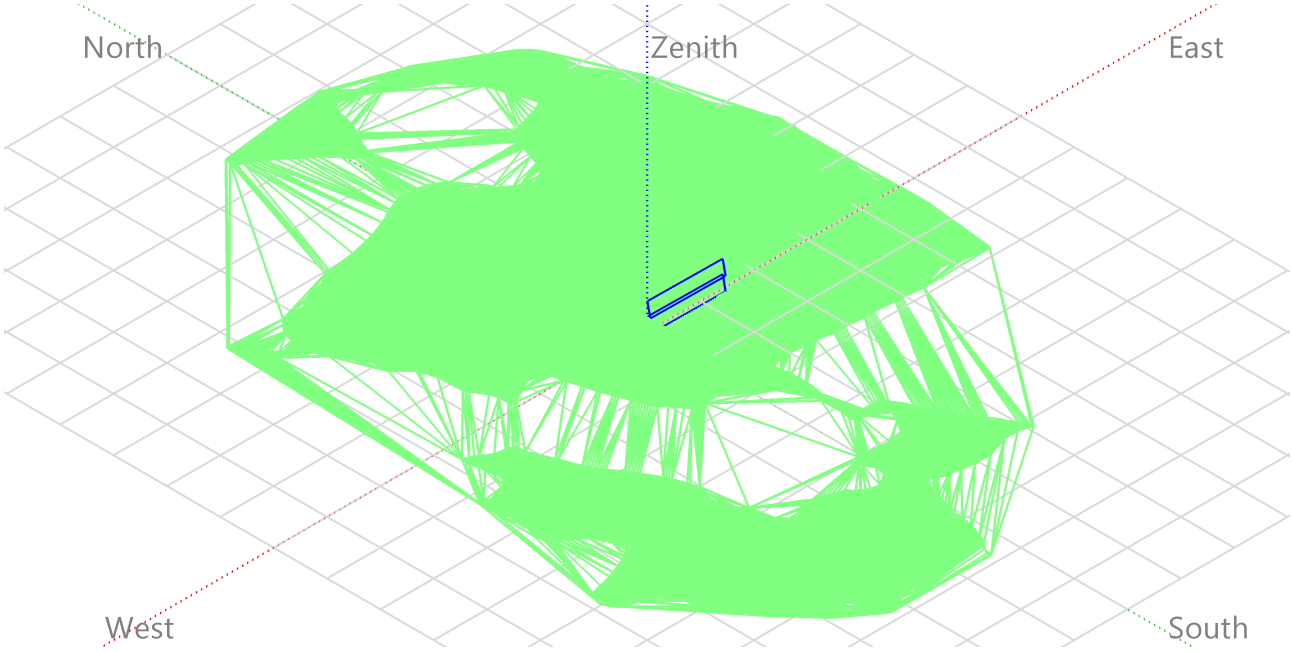
IAM loss factor

Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

Near shadings parameter

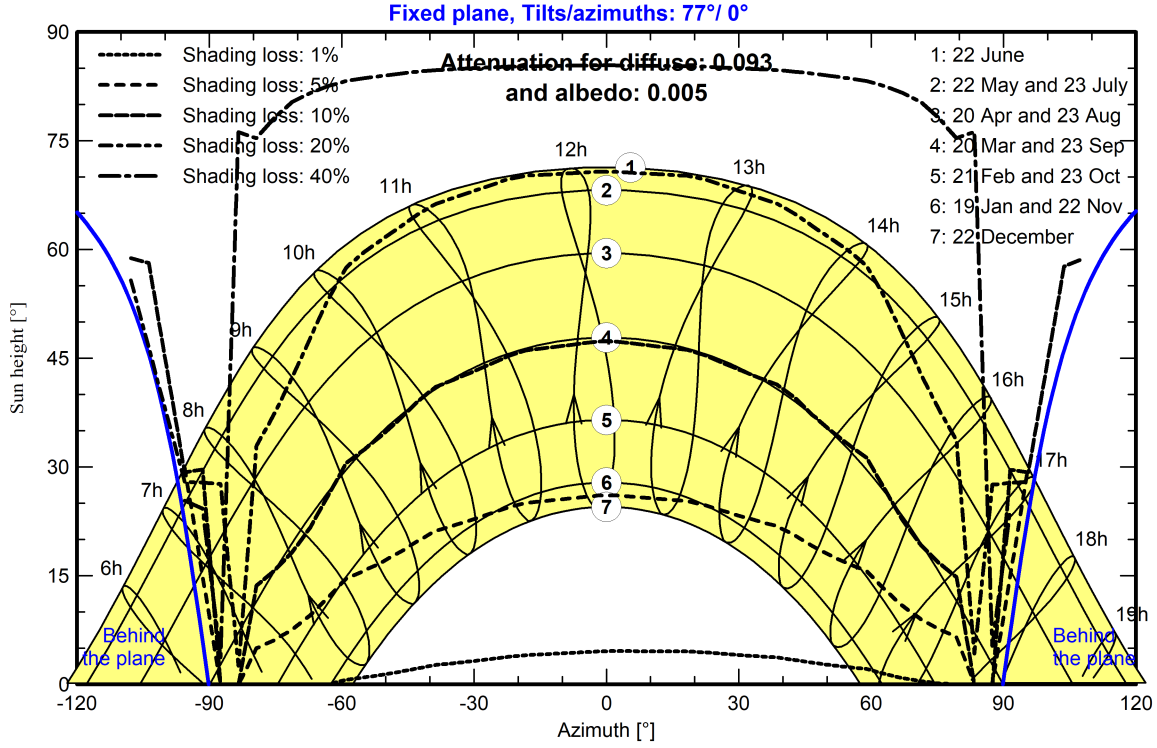
Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

Fixed plane, Tilts/azimuths: 77°/ 0°

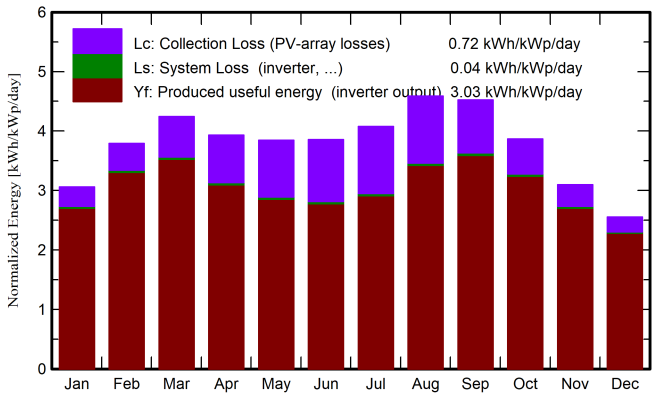


Main results

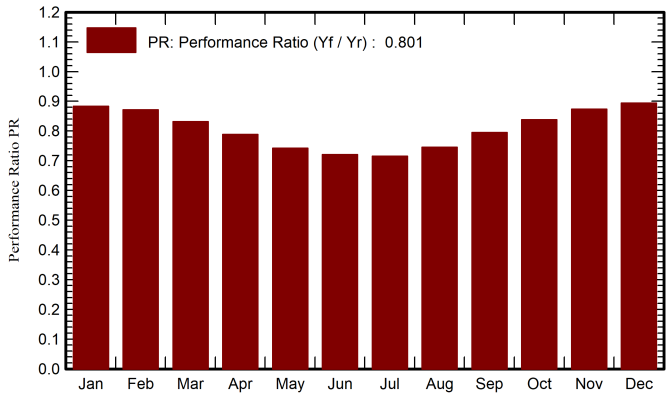
System Production

Produced Energy	993309 kWh/year	Specific production	1107 kWh/kWp/year
		Performance Ratio PR	80.13 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

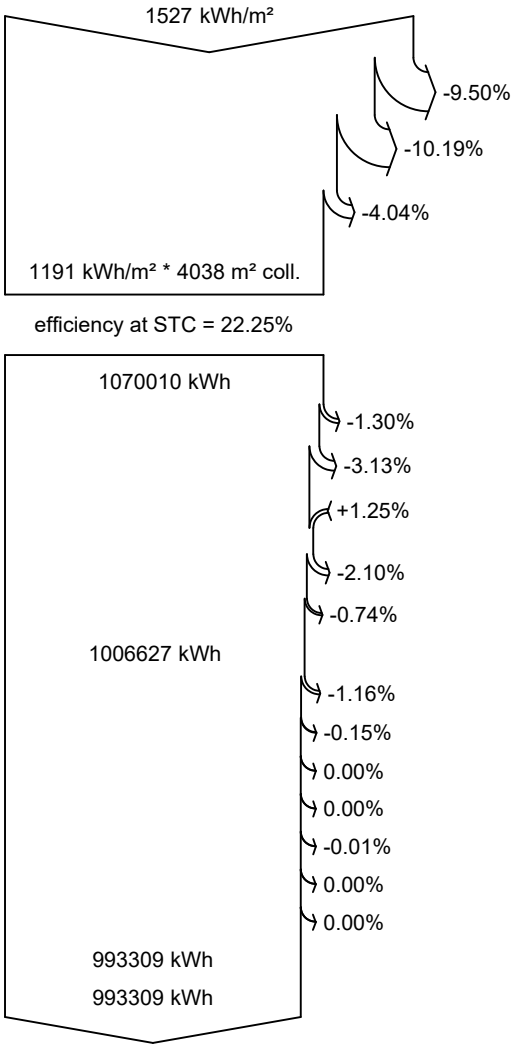
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	52.5	25.85	7.77	94.9	89.0	76075	75192	0.883
February	72.5	34.58	8.94	106.2	97.7	83959	83022	0.871
March	121.3	55.99	12.20	131.6	115.8	99199	98113	0.831
April	147.3	68.59	15.45	117.9	99.1	84397	83376	0.788
May	191.8	75.54	19.98	119.2	95.4	80434	79397	0.742
June	207.5	80.82	24.45	115.7	90.8	75844	74875	0.721
July	215.4	69.88	27.52	126.4	99.4	82081	81038	0.715
August	190.1	68.09	27.40	142.3	116.7	96306	95199	0.746
September	135.4	51.62	22.17	135.7	117.3	97830	96708	0.795
October	93.9	42.58	18.41	119.9	108.4	91159	90142	0.838
November	55.6	29.14	13.08	92.9	86.8	73656	72783	0.873
December	43.8	26.46	9.08	79.1	74.5	64201	63463	0.894
Year	1527.0	629.15	17.25	1381.9	1191.0	1005141	993309	0.801

Legends

GlobHor	Global horizontal irradiation
DiffHor	Horizontal diffuse 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
PR	Performance Ratio

PVsyst V7.3.1
VCA, Simulation date:
19/02/24 18:38
with v7.3.1

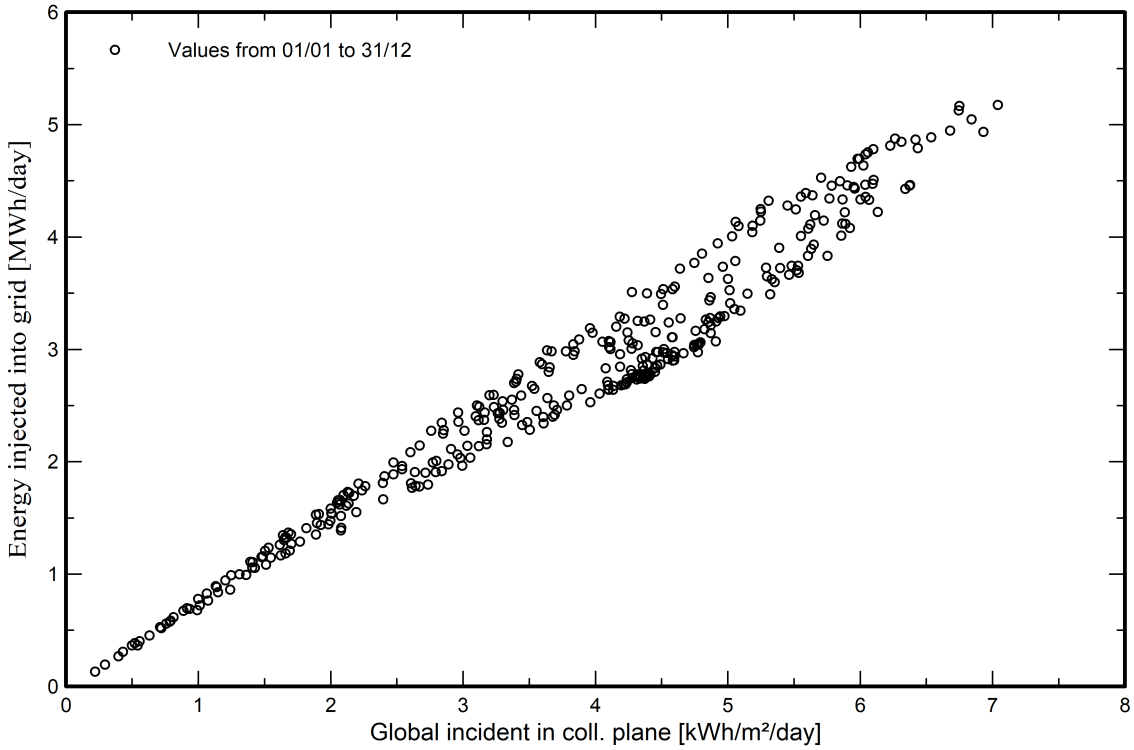
Loss diagram



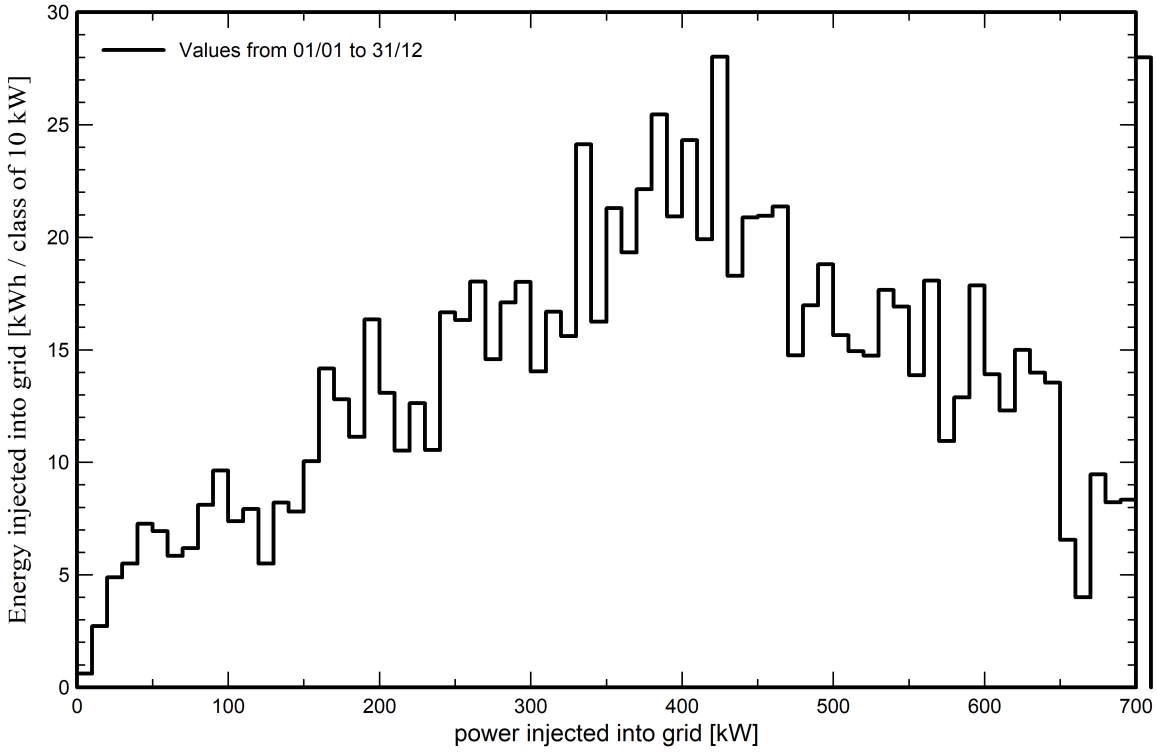
Global horizontal irradiation
Global incident in coll. plane
Near Shadings: irradiance loss
IAM factor on global
Effective irradiation on collectors
PV conversion
Array nominal energy (at STC effic.)
PV loss due to irradiance level
PV loss due to temperature
Module quality loss
Mismatch loss, modules and strings
Ohmic wiring loss
Array virtual energy at MPP
Inverter Loss during operation (efficiency)
Inverter Loss over nominal inv. power
Inverter Loss due to max. input current
Inverter Loss over nominal inv. voltage
Inverter Loss due to power threshold
Inverter Loss due to voltage threshold
Night consumption
Available Energy at Inverter Output
Energy injected into grid

Predef. graphs

Daily Input/Output diagram

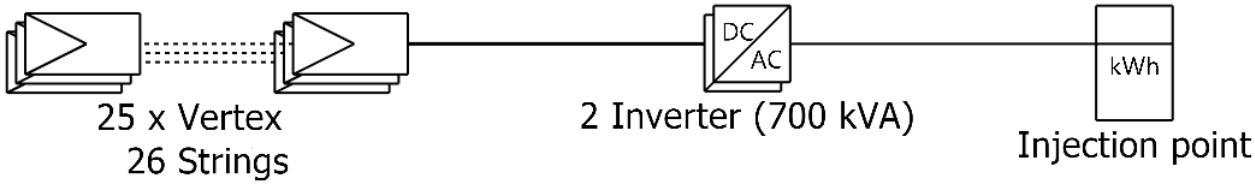


System Output Power Distribution



Single-line diagram

PVsyst V7.3.1
VCA, Simulation date:
19/02/24 18:38
with v7.3.1



PV module	Vertex
Inverter	SG350-HX
String	25 x Vertex

	Riano Quarry	
	VCA : Rack_Parete_2	19/02/24