

Comuni di Volturino, Lucera, San Severo
Provincia di Foggia, Regione Puglia

GREEN ENERGY 5 S.R.L.

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Impianto Agrivoltaico “VOLTURINO 63.3”
PD01_21 – SIMULAZIONE ENERGETICA (PVSYST)

IL TECNICO		IL PROPONENTE	
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MARZO 2024			

PVsyst - Simulation report

Grid-Connected System

Project: ITS3VO - Volturino

Variant: PD01_21-Simulazione energetica (Pvsyst)

Tracking system with backtracking

System power: 74.36 MWp

Solcast_site_15191_41513 - Italy

**PVsyst V7.4.0**

VC5, Simulation date:
03/04/24 10:40
with v7.4.0

Project summary**Geographical Site****Solcast_site_15191_41513**

Italy

Situation

Latitude 41.51 °N

Longitude 15.19 °E

Altitude 259 m

Time zone UTC+1

Project settings

Albedo 0.20

Meteo data

Solcast_site_15191_41513

Solcast <https://solcast.com> - 2022**System summary****Grid-Connected System**

Simulation for year no 1

Tracking system with backtracking**PV Field Orientation****Orientation**

Tracking plane, tilted axis

Avg axis tilt -0.7 °

Avg axis azim. 0 °

Tracking algorithm

Irradiance optimization

Backtracking activated

Near Shadings

According to strings

Electrical effect 100 %

Diffuse shading Automatic

System information**PV Array**

Nb. of modules

118032 units

Pnom total

74.36 MWp

Inverters

Nb. of units

234 units

Pnom total

77.22 MWac

Grid power limit

63.30 MWac

Grid lim. Pnom ratio

1.175

User's needs

Unlimited load (grid)

Results summary

Produced Energy	119592.18 MWh/year	Specific production	1608 kWh/kWp/year	Perf. Ratio PR	83.34 %
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General parameters**Grid-Connected System****PV Field Orientation****Orientation**

Tracking plane, tilted axis

Avg axis tilt -0.7 °

Avg axis azimuth 0 °

Models used

Transposition	Perez
Diffuse	Imported
Circumsolar	separate

Horizon

Average Height 4.7 °

Bifacial system

Model	2D Calculation
	unlimited trackers

Bifacial model geometry

Tracker Spacing	9.00 m
Tracker width	5.07 m
GCR	56.3 %
Axis height above ground	3.69 m

Grid power limitation

Active power	63.30 MWac
Pnom ratio	1.175

Tracking system with backtracking**Tracking algorithm**

Irradiance optimization

Backtracking activated

Near Shadings

According to strings

Electrical effect 100 %

Diffuse shading Automatic

Backtracking array

Nb. of trackers 1568 units

Identical arrays

Sizes

Tracker Spacing 9.00 m

Collector width 5.07 m

Ground Cov. Ratio (GCR) 56.3 %

Phi min / max. +/- 38.5 °

Backtracking strategy

Phi limits for BT +/- 55.6 °

Backtracking pitch 8.95 m

Backtracking width 5.07 m

User's needs

Unlimited load (grid)

PV Array Characteristics**PV module**

Manufacturer	Jinkosolar
Model	JKM630N-78HL4-BDV

(Custom parameters definition)

Unit Nom. Power	630 Wp
Number of PV modules	118032 units
Nominal (STC)	74.36 MWp
Modules	4918 Strings x 24 In series

At operating cond. (49°C)

Pmpp	69.18 MWp
U mpp	1025 V
I mpp	67466 A

Inverter

Manufacturer	Huawei Technologies
Model	SUN2000-330KTL-H1-Preliminary V0.1

(Custom parameters definition)

Unit Nom. Power	330 kWac
Number of inverters	234 units
Total power	77220 kWac
Operating voltage	500-1500 V
Pnom ratio (DC:AC)	0.96
Power sharing within this inverter	

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PV Array Characteristics**Total PV power**

Nominal (STC)	74360 kWp
Total	118032 modules
Module area	329936 m ²
Cell area	303998 m ²

Total inverter power

Total power	77220 kWac
Number of inverters	234 units
Pnom ratio	0.96

Array losses**Array Soiling Losses**

Loss Fraction	2.5 %
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Thermal Loss factor

Module temperature according to irradiance	
Uc (const)	29.0 W/m ² K
Uv (wind)	0.0 W/m ² K/m/s

DC wiring losses

Global array res.	0.25 mΩ
Loss Fraction	1.5 % at STC

Serie Diode Loss

Voltage drop	0.7 V
Loss Fraction	0.1 % at STC

LID - Light Induced Degradation

Loss Fraction	0.5 %
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Module Quality Loss

Loss Fraction	-0.8 %
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Module mismatch losses

Loss Fraction	1.0 % at MPP
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Strings Mismatch loss

Loss Fraction	0.1 %
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Module average degradation

Year no	1
Loss factor	0.4 %/year

Mismatch due to degradation

Imp RMS dispersion	0.4 %/year
Vmp RMS dispersion	0.4 %/year

IAM loss factor

Incidence effect (IAM): User defined profile

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	1.000	1.000	1.000	0.987	0.969	0.929	0.741	0.000

System losses**Auxiliaries loss**

constant (fans)	20.0 kW
0.0 kW from Power thresh.	
Night aux. cons.	7.0 kW

AC wiring losses**Inv. output line up to MV transfo**

Inverter voltage	800 Vac tri
Loss Fraction	1.28 % at STC

Inverter: SUN2000-330KTL-H1-Preliminary V0.1

Wire section (234 Inv.)	Alu 234 x 3 x 300 mm ²
Average wires length	250 m

MV line up to HV Transfo

MV Voltage	30 kV
Wires	Alu 3 x 3000 mm ²
Length	27000 m
Loss Fraction	2.30 % at STC

HV line up to Injection

HV line voltage	150 kV
Wires	Alu 3 x 240 mm ²
Length	500 m
Loss Fraction	0.02 % at STC



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AC losses in transformers

MV transfo

Medium voltage 30 kV

Transformer parameters

Nominal power at STC	73.07 MVA
Iron Loss (24/24 Connexion)	77.45 kVA
Iron loss fraction	0.11 % at STC
Copper loss	691.93 kVA
Copper loss fraction	0.95 % at STC
Coils equivalent resistance	3 x 0.08 mΩ

HV transfo

Grid voltage 150 kV

Transformer from Datasheets

Nominal power	80000 kVA
Iron Loss (24/24 Connexion)	176.00 kVA
Iron loss fraction	0.22 % of PNom
Copper loss	400.00 kVA
Copper loss fraction	0.50 % at PNom
Coils equivalent resistance	3 x 56.25 mΩ



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Horizon definition

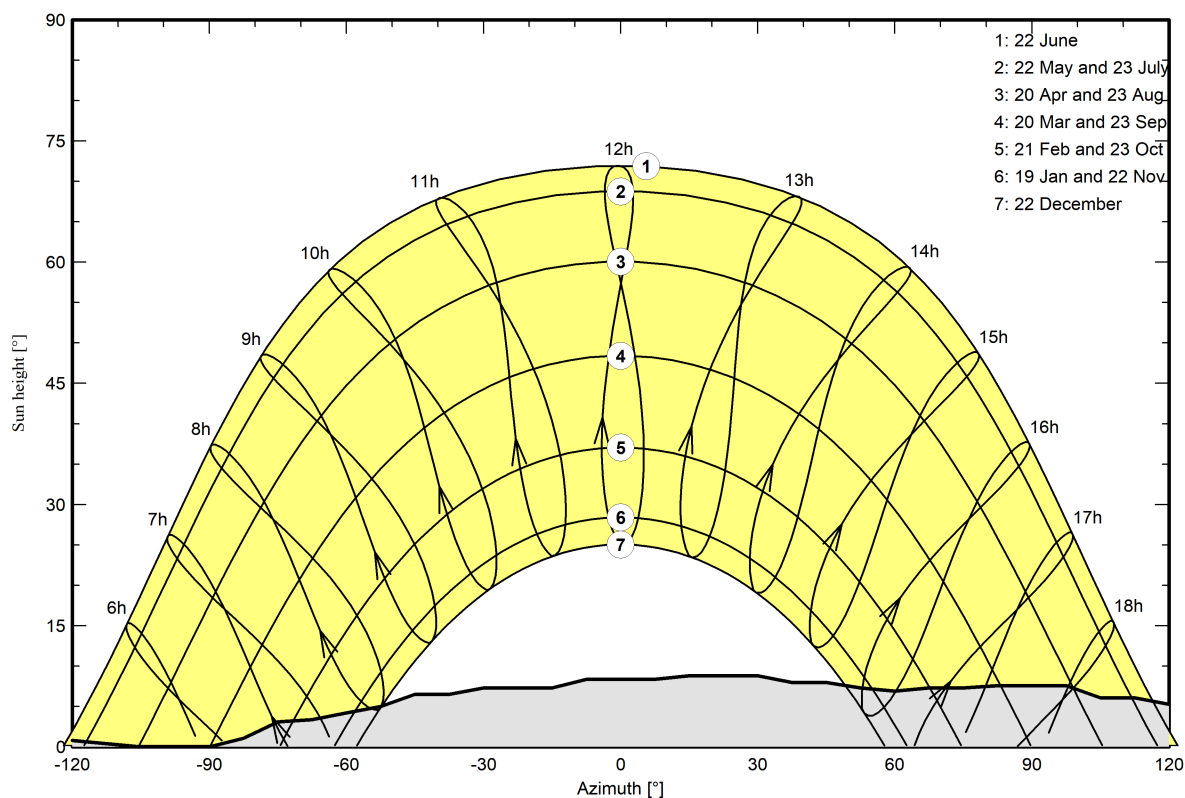
Horizon from PVGIS website API, Lat=41°30'46", Long=15°11'27", Alt=277m

Average Height	4.7 °	Albedo Factor	0.67
Diffuse Factor	0.95	Albedo Fraction	100 %

Horizon profile

Azimuth [°]	-180	-173	-165	-158	-150	-143	-135	-128	-120	-113	-105	-90	-83	-75
Height [°]	1.9	1.9	1.5	1.1	1.1	0.8	0.8	0.4	0.8	0.4	0.0	0.0	1.1	3.1
Azimuth [°]	-68	-60	-53	-45	-38	-30	-15	-8	8	15	30	38	45	53
Height [°]	3.4	4.2	5.0	6.5	6.5	7.3	7.3	8.4	8.4	8.8	8.8	8.0	8.0	7.3
Azimuth [°]	60	68	75	83	98	105	113	120	128	143	150	158	165	180
Height [°]	6.9	7.3	7.3	7.6	7.6	6.1	6.1	5.3	5.0	5.0	3.1	3.1	1.9	1.9

Sun Paths (Height / Azimuth diagram)



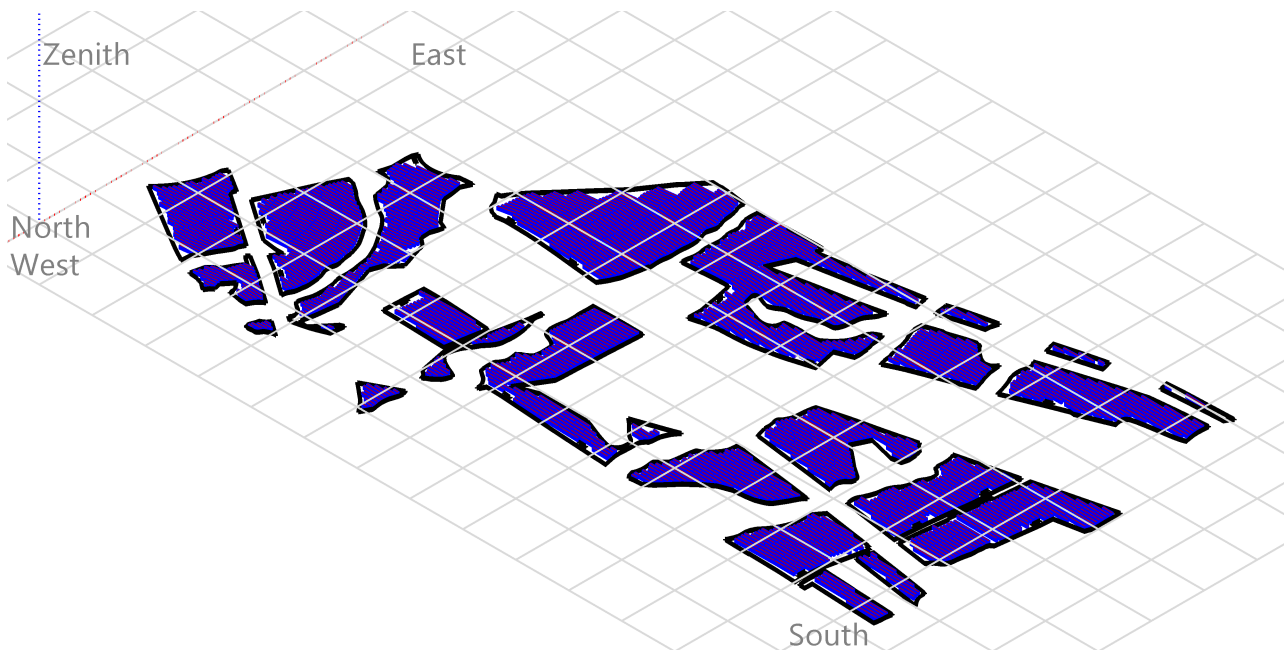


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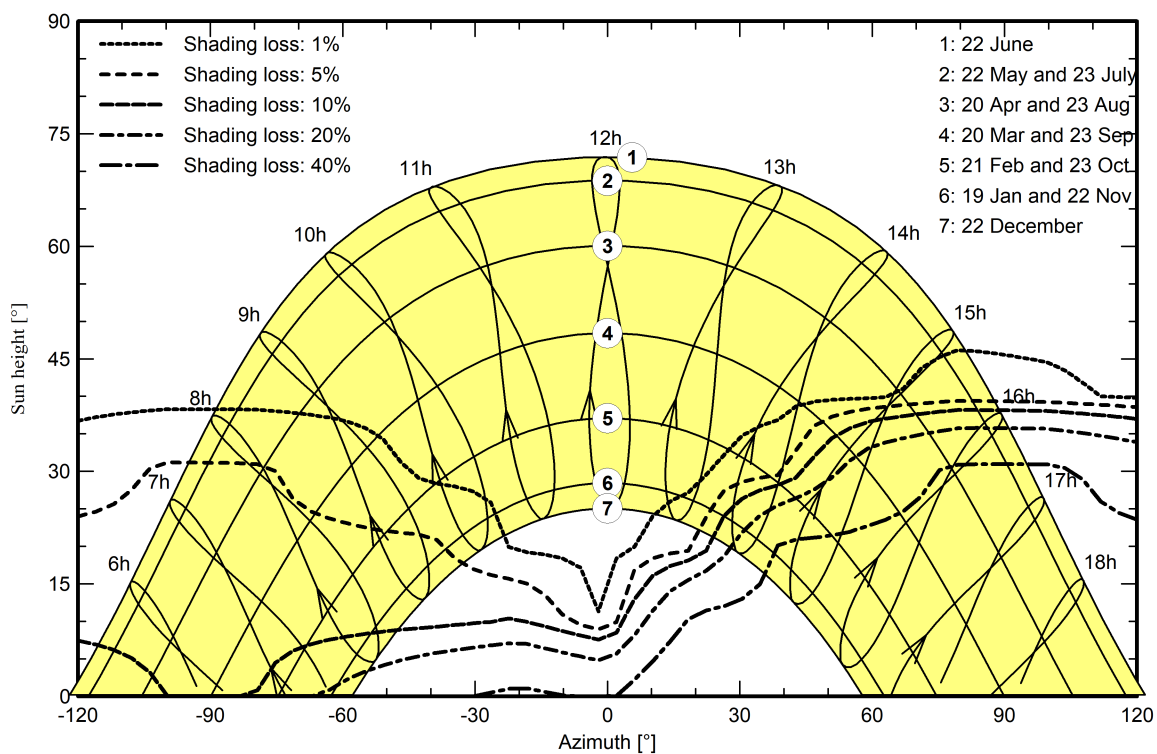
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1





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Main results

System Production

Produced Energy

119592.18 MWh/year

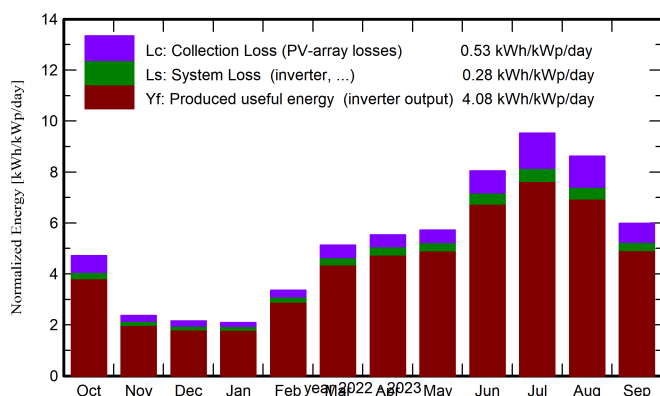
Specific production

1608 kWh/kWp/year

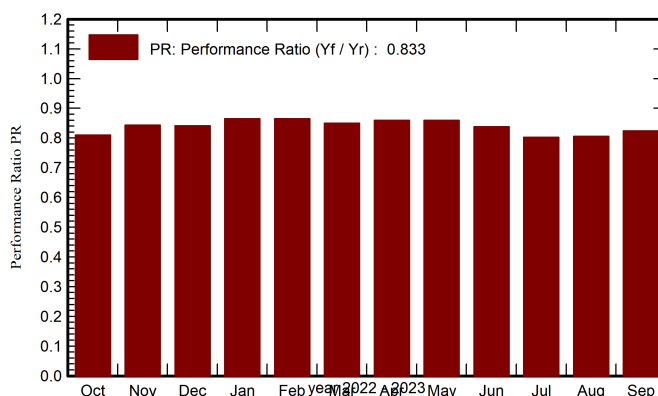
Perf. Ratio PR

83.34 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	ratio
Oct. 22	3.6	0.70	17.43	4.7	4.4	303	284	0.810
Nov. 22	58.8	27.69	12.38	71.0	66.4	4805	4451	0.843
Dec. 22	54.7	22.78	10.36	66.9	62.0	4530	4185	0.841
Jan. 23	54.0	27.89	7.53	64.7	60.5	4496	4157	0.865
Feb. 23	76.2	31.22	7.27	94.2	88.8	6478	6057	0.865
Mar. 23	127.3	44.09	10.95	159.0	150.7	10723	10051	0.850
Apr. 23	138.0	59.35	11.85	165.9	158.1	11321	10603	0.860
May 23	150.4	75.33	16.62	177.2	169.5	12094	11335	0.860
June 23	198.4	81.78	22.18	241.4	231.1	16045	15055	0.839
July 23	235.6	60.96	28.46	295.4	282.5	18817	17628	0.803
Aug. 23	210.4	45.97	25.64	267.4	255.2	17102	16025	0.806
Sep. 23	144.0	48.61	23.08	179.7	170.8	11733	11006	0.824
Oct. 23	112.1	30.46	20.05	142.3	134.6	9339	8756	0.827
Period	1563.6	556.84	16.42	1929.7	1834.7	127786	119592	0.833

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

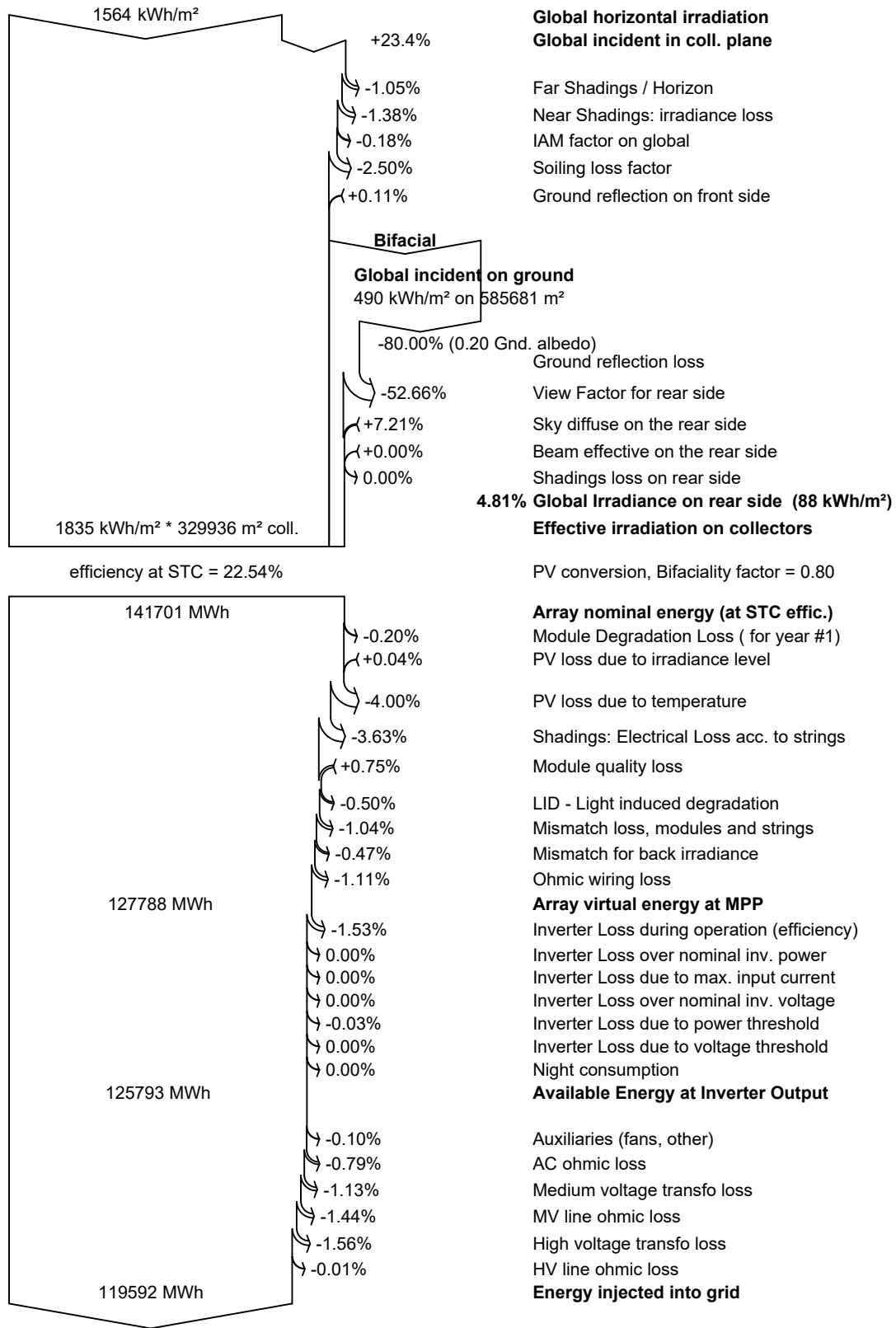
PR Performance Ratio



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Loss diagram



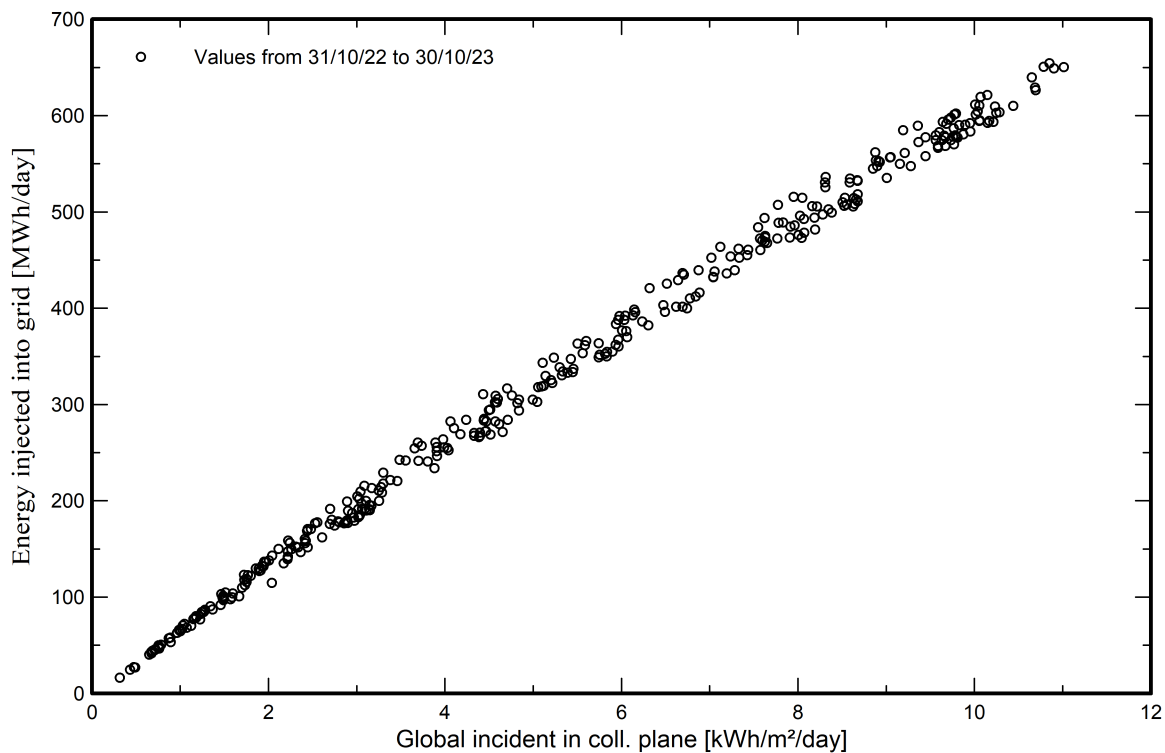


PVsyst V7.4.0

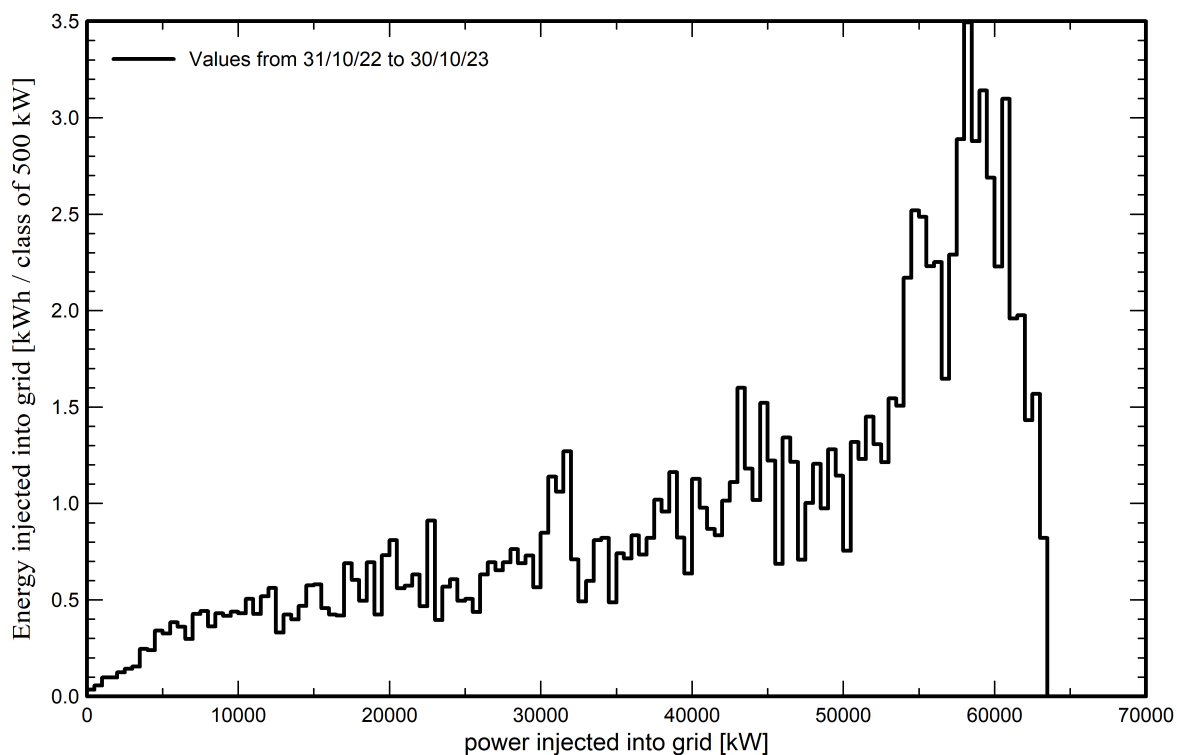
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Predef. graphs

Diagramma giornaliero entrata/uscita



Distribución de potencia de salida del sistema





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Aging Tool

Aging Parameters

Time span of simulation 30 years

Module average degradation

Loss factor 0.4 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

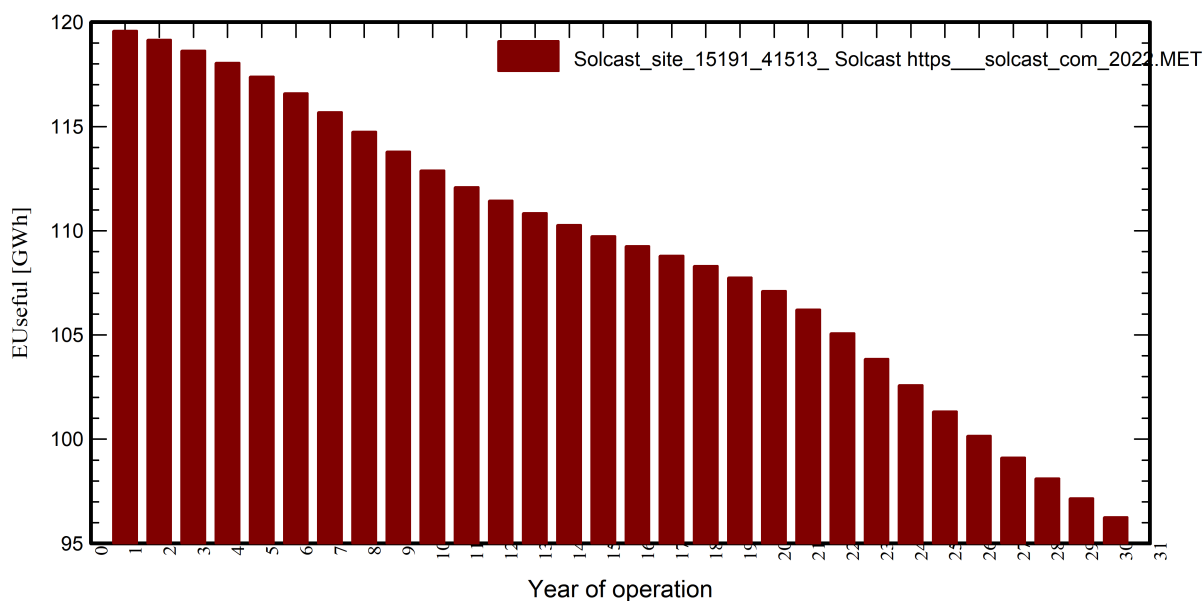
Vmp RMS dispersion 0.4 %/year

Meteo used in the simulation

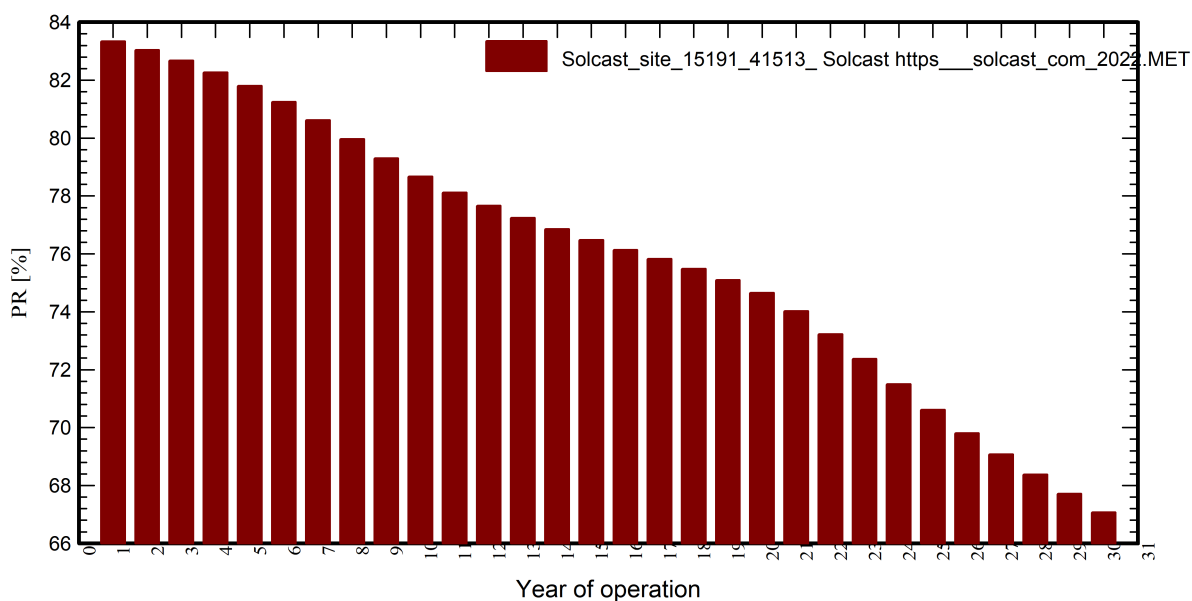
Solcast site 15191 41513 Solcast https solcast com

Years 2022

Useful out system energy



Performance Ratio



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Aging Tool**Aging Parameters**

Time span of simulation 30 years

Module average degradation

Loss factor 0.4 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

Vmp RMS dispersion 0.4 %/year

Meteo used in the simulation

Solcast site 15191 41513 Solcast [https solcast com](https://solcast.com)

Years 2022

	EUseful	PR	PR loss
Year	GWh	%	%
1	119.59	83.34	-0.18
2	119.15	83.04	-0.55
3	118.64	82.68	-0.98
4	118.05	82.27	-1.47
5	117.39	81.81	-2.02
6	116.59	81.25	-2.69
7	115.68	80.62	-3.45
8	114.74	79.96	-4.23
9	113.80	79.30	-5.02
10	112.88	78.67	-5.79
11	112.09	78.12	-6.44
12	111.44	77.67	-6.98
13	110.84	77.25	-7.48
14	110.28	76.85	-7.96
15	109.74	76.48	-8.41
16	109.25	76.14	-8.81
17	108.80	75.82	-9.19
18	108.31	75.48	-9.60
19	107.76	75.10	-10.06
20	107.11	74.65	-10.60
21	106.22	74.02	-11.35
22	105.07	73.23	-12.30
23	103.85	72.38	-13.32
24	102.60	71.50	-14.37
25	101.33	70.62	-15.42
26	100.17	69.81	-16.40
27	99.12	69.08	-17.27
28	98.12	68.38	-18.10
29	97.16	67.71	-18.90
30	96.25	67.08	-19.67



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P50 - P90 evaluation

Meteo data

Source Solcast <https://solcast.com>
Kind Monthly averages
2022 - Multi-year average
Year-to-year variability(Variance) 3.0 %

Specified Deviation

Climate change 3.0 %

Global variability (meteo + system)

Variability (Quadratic sum) 3.5 %

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 4.31 GWh
P50 123.18 GWh
P90 117.65 GWh
P95 116.10 GWh

Probability distribution

