



NOME PROGETTO:

Costruzione ed esercizio di un impianto agrivoltaico avanzato avente potenza installata pari a 21,86MWp e potenza in immissione pari a 17,60MW sito nel Comune di Copparo con opere di connessione insistenti nel Comune di Copparo (Fe), Jolanda di Savoia (Fe), Codigoro (Fe) e Fiscaglia (Fe) - Impianto "COPPARO"

RICHIEDENTE:

VESPERA DEVELOPMENT 05 SRL

società di



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TITOLO ELABORATO:

2.15-PDRT Report di producibilità impianto

SCALA:

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PROGETTAZIONE E COORDINAMENTO

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- Settore civile e ambientale
- Settore industriale
- Settore dell'informazione



ORDINE DEGLI INGEGNERI
DELLA PROVINCIA DI REGGIO CALABRIA

N. REV.	DATA	REVISIONE	ELABORATO	VERIFICATO	VALIDATO
0	09-2024	Prima emissione	Baldacconi	Ing. Bolignano	Ing. Bolignano

PVsyst - Simulation report

Grid-Connected System

Project: VES030

Variant: New simulation variant

Tracking system with backtracking

System power: 21.86 MWp

Macchiavella - Italy

Author

ARATO SRL (Italy)



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23/07/24 15:56
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Project summary

Geographical Site

Macchiavella

Italy

Situation

Latitude 44.95 °N

Longitude 11.90 °E

Altitude 11 m

Time zone UTC+1

Project settings

Albedo 0.20

Weather data

Macchiavella

PVGIS api TMY

System summary

Grid-Connected System

Simulation for year no 1

Tracking system with backtracking

PV Field Orientation

Orientation

Tracking plane, horizontal N-S axis

Avg axis azim. -0.4 °

Tracking algorithm

Irradiance optimization

Backtracking activated

Near Shadings

According to strings : Fast (table)

Electrical effect 100 %

Diffuse shading Automatic

System information

PV Array

Nb. of modules

30368 units

Pnom total

21.86 MWp

Inverters

Nb. of units

55 units

Pnom total

17.60 MWac

Pnom ratio

1.242

User's needs

Unlimited load (grid)

Results summary

Produced Energy	37.20 GWh/year	Specific production	1701 kWh/kWp/year	Perf. Ratio PR	87.36 %
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General parameters

Grid-Connected System

PV Field Orientation

Orientation

Tracking plane, horizontal N-S axis

Avg axis azim. -0.4 °

Models used

Transposition Perez

Diffuse Imported

Circumsolar separate

Horizon

Free Horizon

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing 5.50 m

Tracker width 2.38 m

GCR 43.3 %

Axis height above ground 4.00 m

Tracking system with backtracking

Tracking algorithm

Irradiance optimization

Backtracking activated

Near Shadings

According to strings : Fast (table)

Electrical effect 100 %

Diffuse shading Automatic

Backtracking array

Nb. of trackers 1245 units

Sizes

Tracker Spacing 5.50 m

Collector width 2.38 m

Ground Cov. Ratio (GCR) 43.3 %

Phi min / max. -/+ 55.0 °

Backtracking strategy

Phi limits for BT -/+ 79.9 °

Backtracking pitch 5.50 m

Backtracking width 2.38 m

Parameters choice Selected tracker

User's needs

Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer Luxor

Model LX-720-M-210-132-GG-Bif.

(Custom parameters definition)

Unit Nom. Power 720 Wp

Number of PV modules 30368 units

Nominal (STC) 21.86 MWp

Array #1 - Campi 1-2

Number of PV modules 15886 units

Nominal (STC) 11.44 MWp

Modules 611 string x 26 In series

At operating cond. (50°C)

Pmpp 10.76 MWp

U mpp 1048 V

I mpp 10270 A

Inverter

Manufacturer Sungrow

Model SG350HX-20A-Preliminary

(Custom parameters definition)

Unit Nom. Power 320 kWac

Number of inverters 55 units

Total power 17600 kWac

Number of inverters 28 units

Total power 8960 kWac

Operating voltage 500-1500 V

Max. power (=>30°C) 352 kWac

Pnom ratio (DC:AC) 1.28

Power sharing within this inverter



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PV Array Characteristics

Array #2 - Campi 3-4-5

Number of PV modules	12870 units	Number of inverters	24 units
Nominal (STC)	9266 kWp	Total power	7680 kWac
Modules	495 string x 26 In series		
At operating cond. (50°C)		Operating voltage	500-1500 V
Pmpp	8716 kWp	Max. power (=>30°C)	352 kWac
U mpp	1048 V	Pnom ratio (DC:AC)	1.21
I mpp	8320 A	Power sharing within this inverter	

Array #3 - Campo 6

Number of PV modules	1612 units	Number of inverters	3 units
Nominal (STC)	1161 kWp	Total power	960 kWac
Modules	62 string x 26 In series		
At operating cond. (50°C)		Operating voltage	500-1500 V
Pmpp	1092 kWp	Max. power (=>30°C)	352 kWac
U mpp	1048 V	Pnom ratio (DC:AC)	1.21
I mpp	1042 A	Power sharing within this inverter	

Total PV power

Nominal (STC)	21865 kWp	Total inverter power	
Total	30368 modules	Total power	17600 kWac
Module area	94334 m ²	Max. power	19360 kWac
		Number of inverters	55 units
		Pnom ratio	1.24

Array losses

Array Soiling Losses

Loss Fraction 3.0 %

Thermal Loss factor

Module temperature according to irradiance
Uc (const) 25.0 W/m²K
Uv (wind) 1.2 W/m²K/m/s

Serie Diode Loss

Voltage drop 0.7 V
Loss Fraction 0.1 % at STC

LID - Light Induced Degradation

Loss Fraction 2.0 %

Module Quality Loss

Loss Fraction 0.0 %

Module mismatch losses

Loss Fraction 1.0 % at MPP

Strings Mismatch loss

Loss Fraction 0.1 %

Module average degradation

Year no 1
Loss factor 0.72 %/year

Mismatch due to degradation

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

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 1.1 mΩ
Loss Fraction 2.0 % at STC



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DC wiring losses

Array #1 - Campi 1-2

Global array res. 2.2 mΩ
Loss Fraction 2.0 % at STC

Array #3 - Campo 6

Global array res. 22 mΩ
Loss Fraction 2.0 % at STC

Array #2 - Campi 3-4-5

Global array res. 2.7 mΩ
Loss Fraction 2.0 % at STC

System losses

Auxiliaries loss

Proportional to Power 8.0 W/kW
0.0 kW from Power thresh.

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage 800 Vac tri
Loss Fraction 2.00 % at STC

Inverter: SG350HX-20A-Preliminary

Wire section (55 Inv.) Copper 55 x 3 x 150 mm²
Average wires length 261 m

MV line up to Injection

MV Voltage 36 kV
Average each inverter
Wires Copper 3 x 50 mm²
Length 25590 m
Loss Fraction 2.00 % at STC

AC losses in transformers

MV transfo

Medium voltage 36 kV

One transfo parameters

Nominal power at STC 2.69 MVA
Iron Loss (night disconnect) 2.57 kVA
Iron loss fraction 0.10 % at STC
Copper loss 40.39 kVA
Copper loss fraction 1.50 % at STC
Coils equivalent resistance 3 x 3.57 mΩ

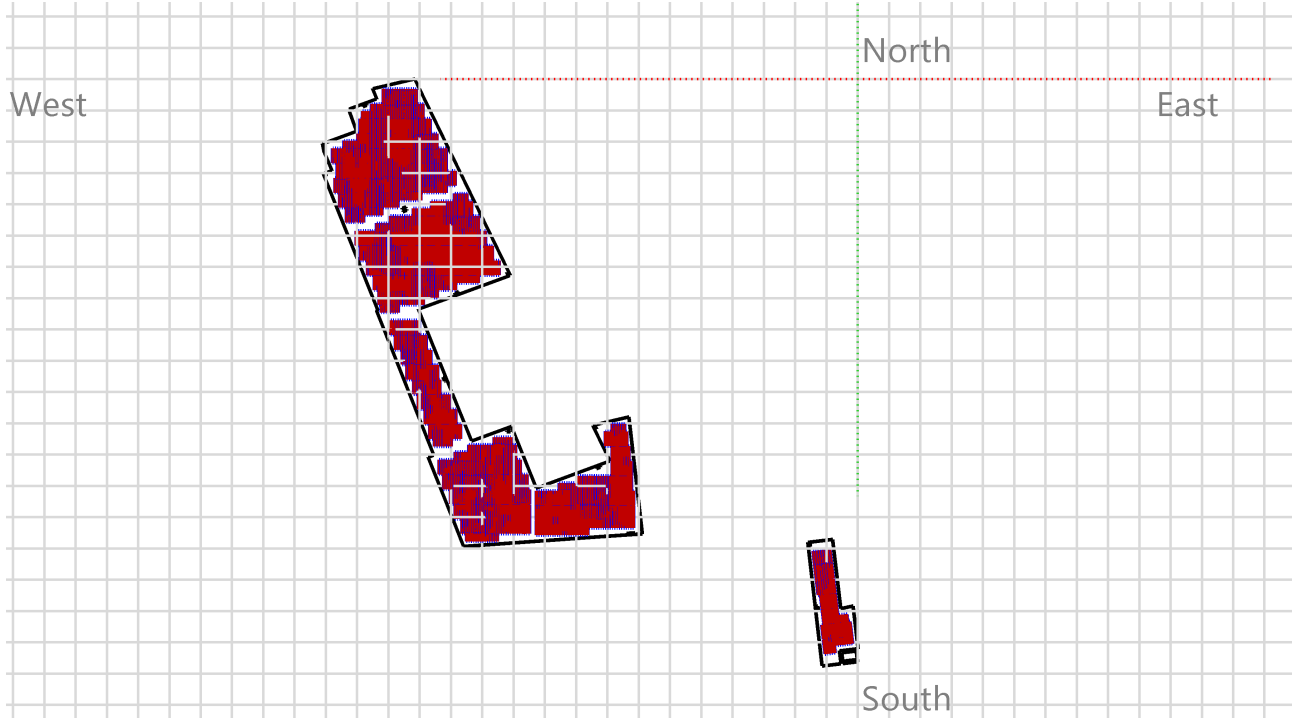
Operating losses at STC (full system)

Nb. identical MV transfos 8
Nominal power at STC 21.54 MVA
Iron loss (night disconnect) 20.60 kVA
Copper loss 323.12 kVA



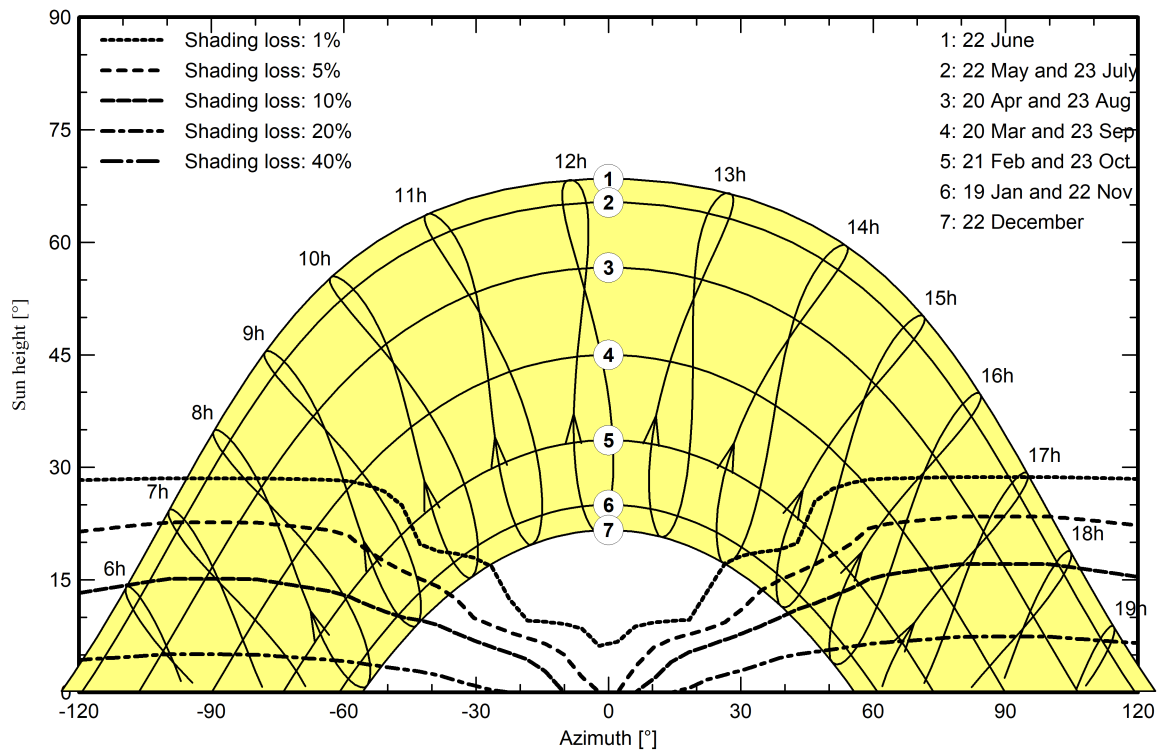
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1





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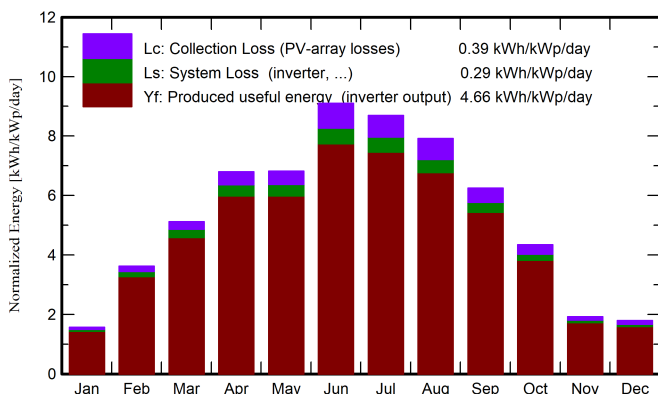
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Main results

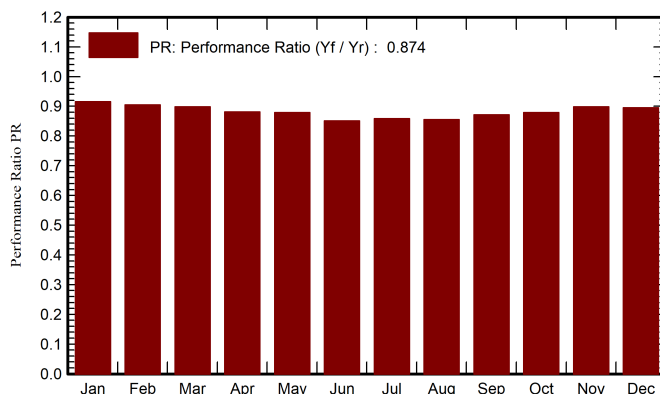
System Production

Produced Energy (P50)	37.20 GWh/year	Specific production (P50)	1701 kWh/kWp/year	Perf. Ratio PR	87.36 %
Produced Energy (P75)	36.20 GWh/year	Specific production (P75)	1656 kWh/kWp/year		
Produced Energy (P90)	35.30 GWh/year	Specific production (P90)	1614 kWh/kWp/year		

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m ²	kWh/m ²	°C	kWh/m ²	kWh/m ²	GWh	GWh	ratio
January	39.0	24.46	3.42	48.6	44.7	1.019	0.973	0.916
February	74.3	30.09	2.52	101.3	94.8	2.110	2.005	0.905
March	120.6	46.98	8.62	158.7	150.5	3.302	3.115	0.898
April	155.3	61.77	14.51	203.9	194.0	4.178	3.927	0.881
May	169.2	77.09	17.17	211.4	201.4	4.325	4.062	0.879
June	212.0	75.41	25.19	273.0	261.0	5.427	5.082	0.851
July	209.9	78.07	24.14	269.6	257.6	5.403	5.062	0.859
August	187.5	64.40	26.39	245.4	234.5	4.894	4.591	0.856
September	142.1	54.49	21.41	187.3	178.1	3.786	3.569	0.871
October	99.5	36.21	15.02	134.8	127.1	2.736	2.591	0.879
November	45.3	26.32	11.62	57.7	53.3	1.186	1.133	0.899
December	42.1	21.48	5.05	55.5	50.5	1.136	1.086	0.895
Year	1496.6	596.79	14.65	1947.3	1847.4	39.501	37.196	0.874

Legends

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

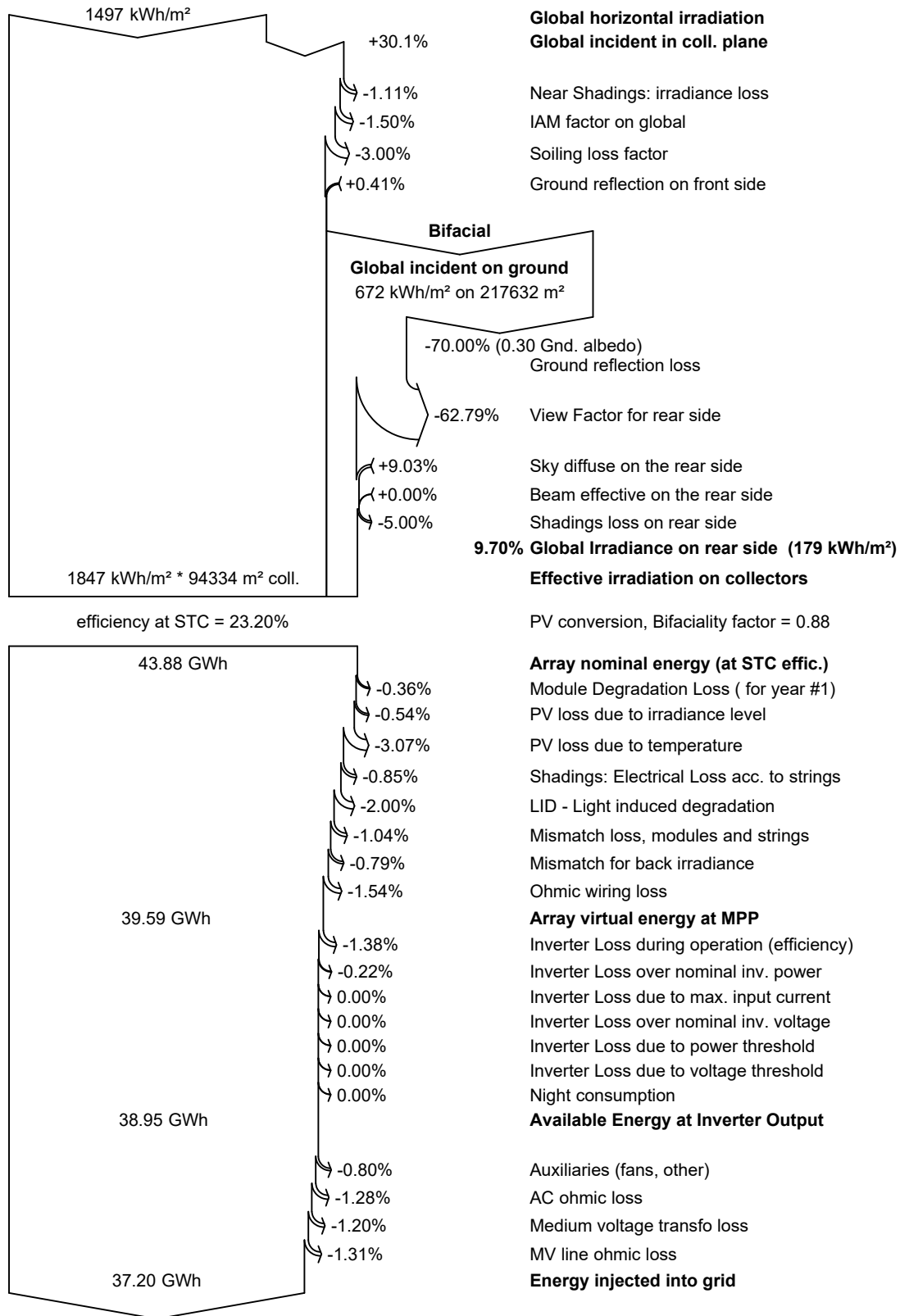


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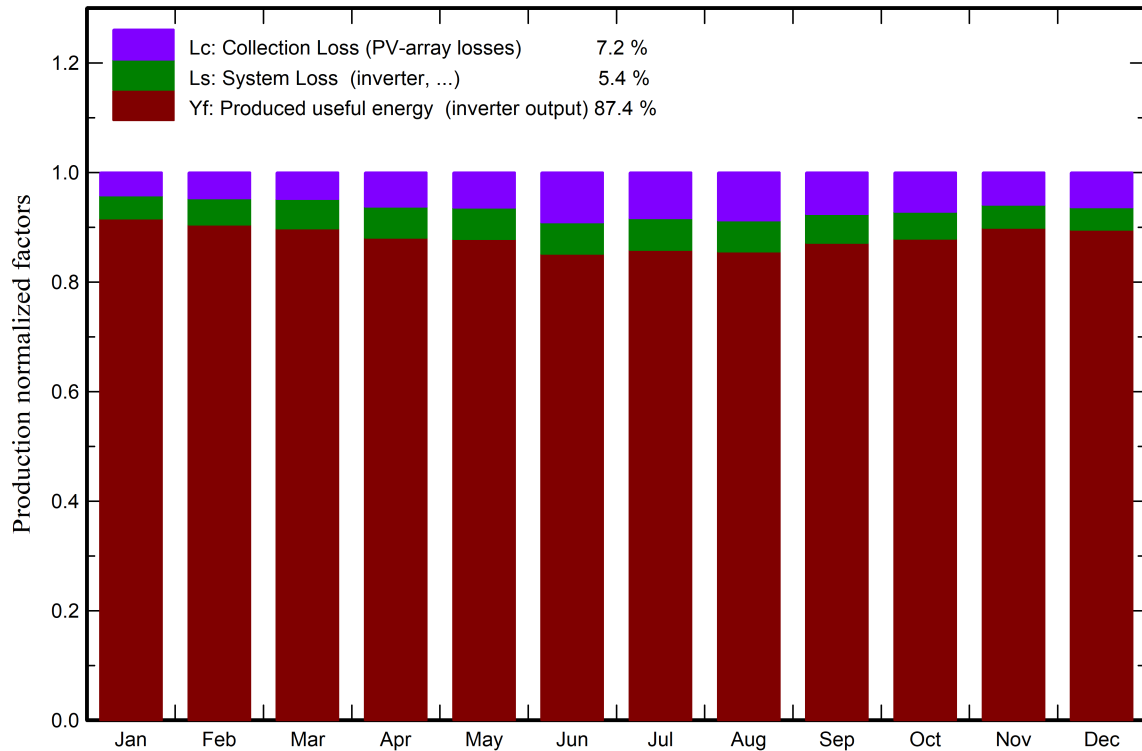
Loss diagram



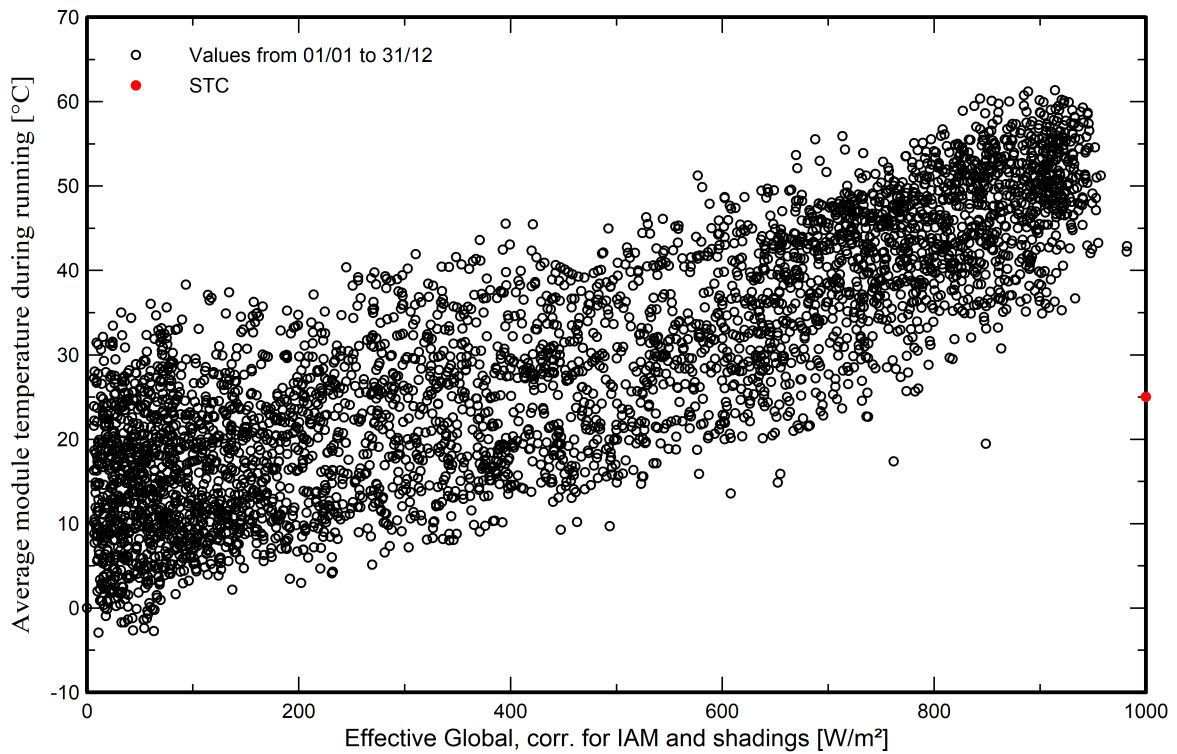


Predef. graphs

Normalized Production and Loss Factors



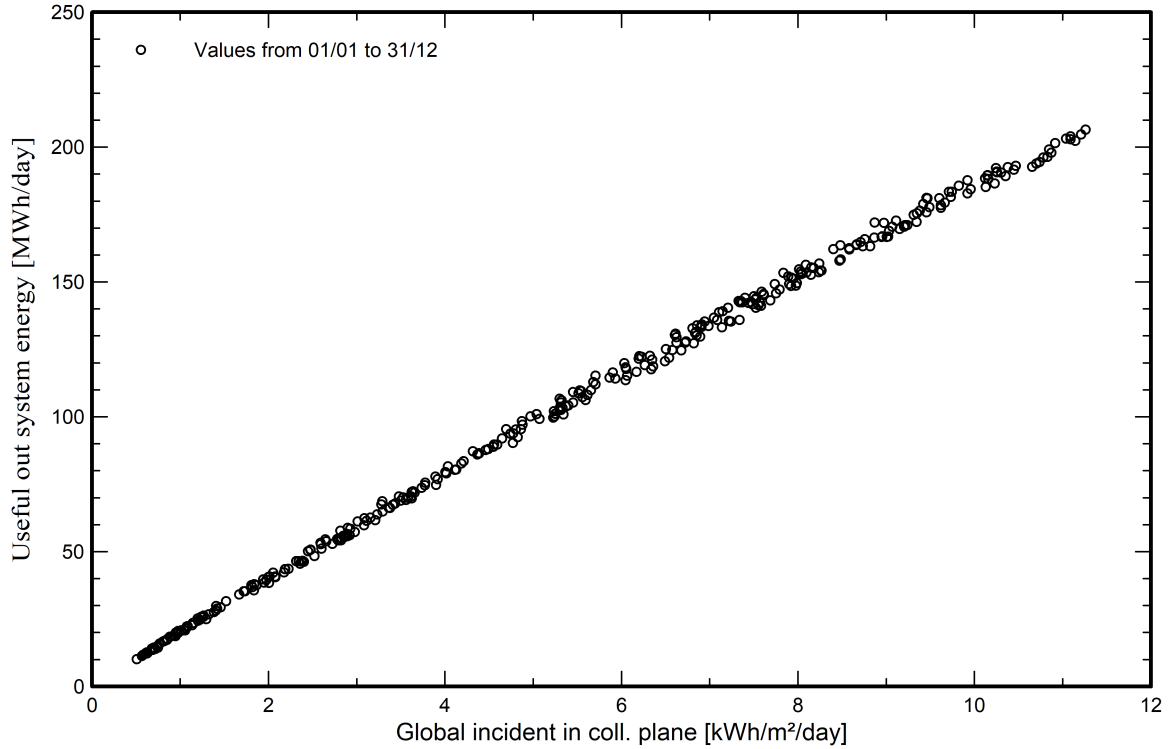
Array Temperature vs. Effective Irradiance



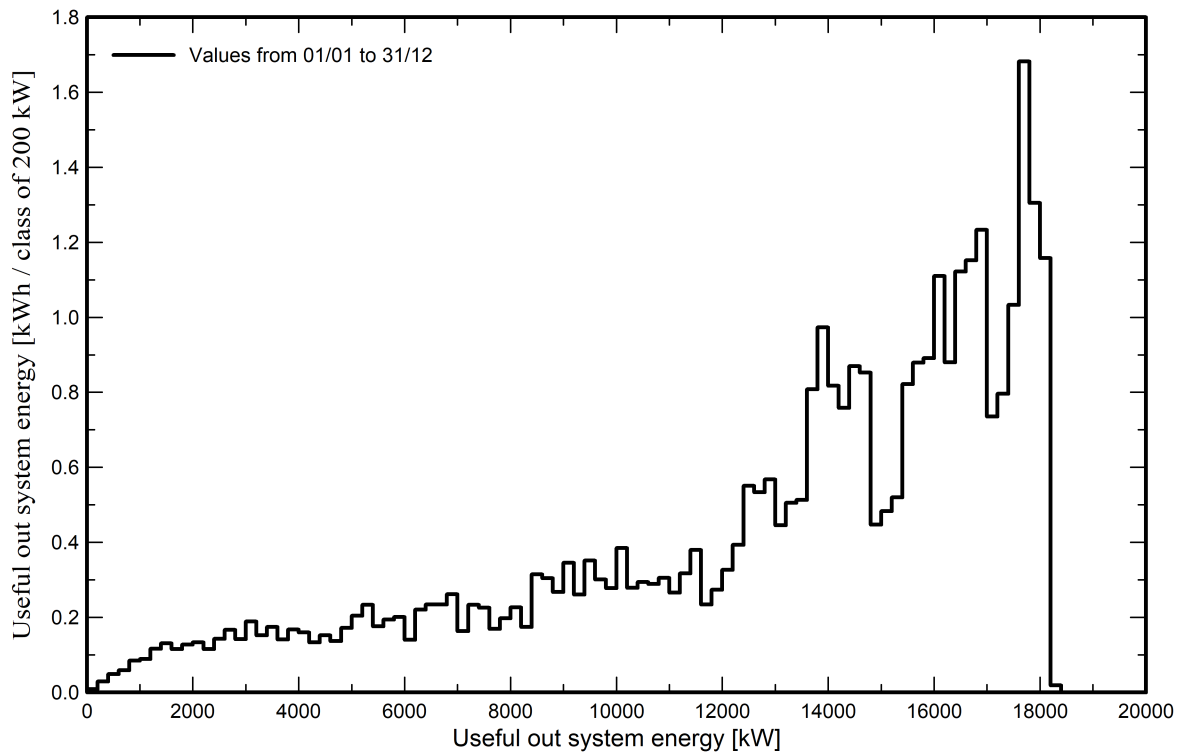


Predef. graphs

Daily Input/Output diagram



System Output Power Distribution





Aging Tool

Aging Parameters

Time span of simulation 30 years

Module average degradation

Loss factor 0.72 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

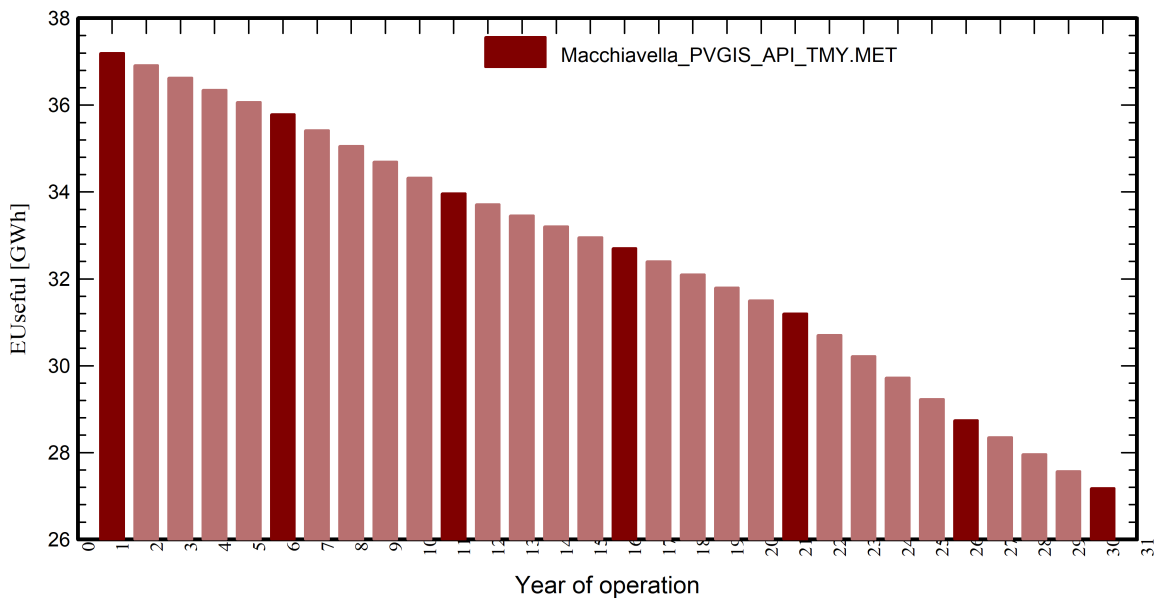
Vmp RMS dispersion 0.4 %/year

Weather data used in the simulation

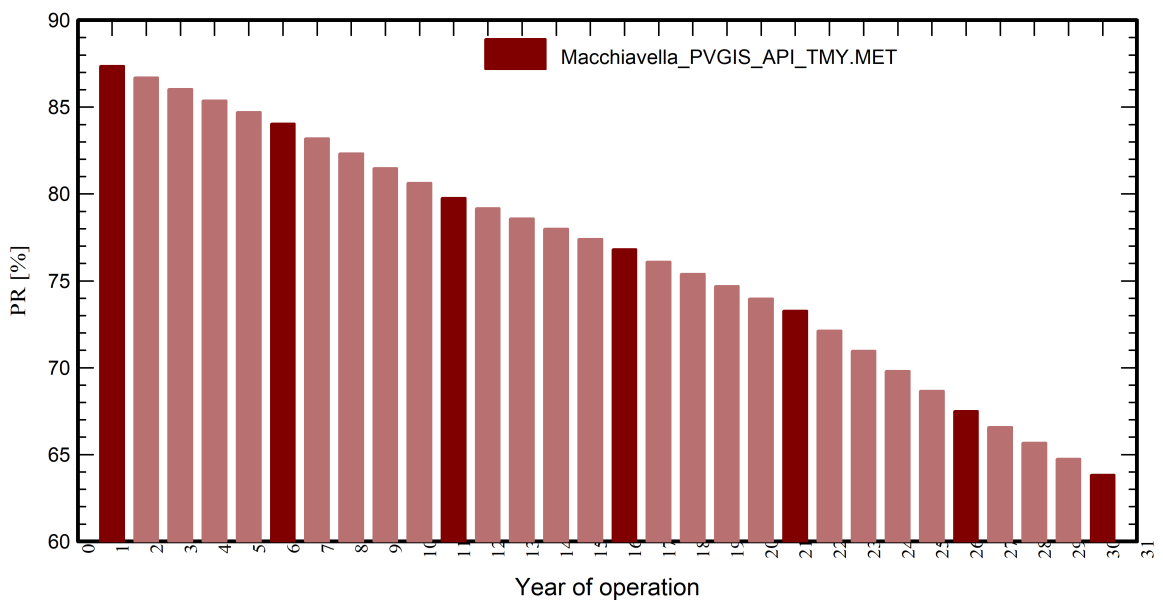
Macchiavella PVGIS API TMY

Years reference year

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 0.72 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

Vmp RMS dispersion 0.4 %/year

Weather data used in the simulation

Macchiavella PVGIS API TMY

Years reference year

	EUseful	PR	PR loss
Year	GWh	%	%
1	37.20	87.37	-0.38
2	36.92	86.70	-1.13
3	36.63	86.04	-1.89
4	36.35	85.38	-2.65
5	36.07	84.71	-3.40
6	35.79	84.05	-4.16
7	35.42	83.20	-5.13
8	35.06	82.34	-6.11
9	34.69	81.48	-7.09
10	34.33	80.63	-8.06
11	33.96	79.77	-9.04
12	33.71	79.18	-9.71
13	33.46	78.59	-10.39
14	33.21	77.99	-11.07
15	32.95	77.40	-11.74
16	32.70	76.81	-12.42
17	32.40	76.10	-13.22
18	32.10	75.40	-14.03
19	31.80	74.69	-14.83
20	31.50	73.98	-15.64
21	31.20	73.28	-16.44
22	30.71	72.12	-17.76
23	30.22	70.97	-19.08
24	29.72	69.81	-20.39
25	29.23	68.66	-21.71
26	28.74	67.50	-23.03
27	28.35	66.59	-24.07
28	27.96	65.67	-25.11
29	27.57	64.76	-26.16
30	27.18	63.84	-27.20



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P50 - P90 evaluation

Weather data

Source PVGIS api TMY
Kind TMY, multi-year
Year-to-year variability(Variance) 3.7 %

Specified Deviation

Climate change 0.0 %

Global variability (weather data + system)

Variability (Quadratic sum) 4.0 %

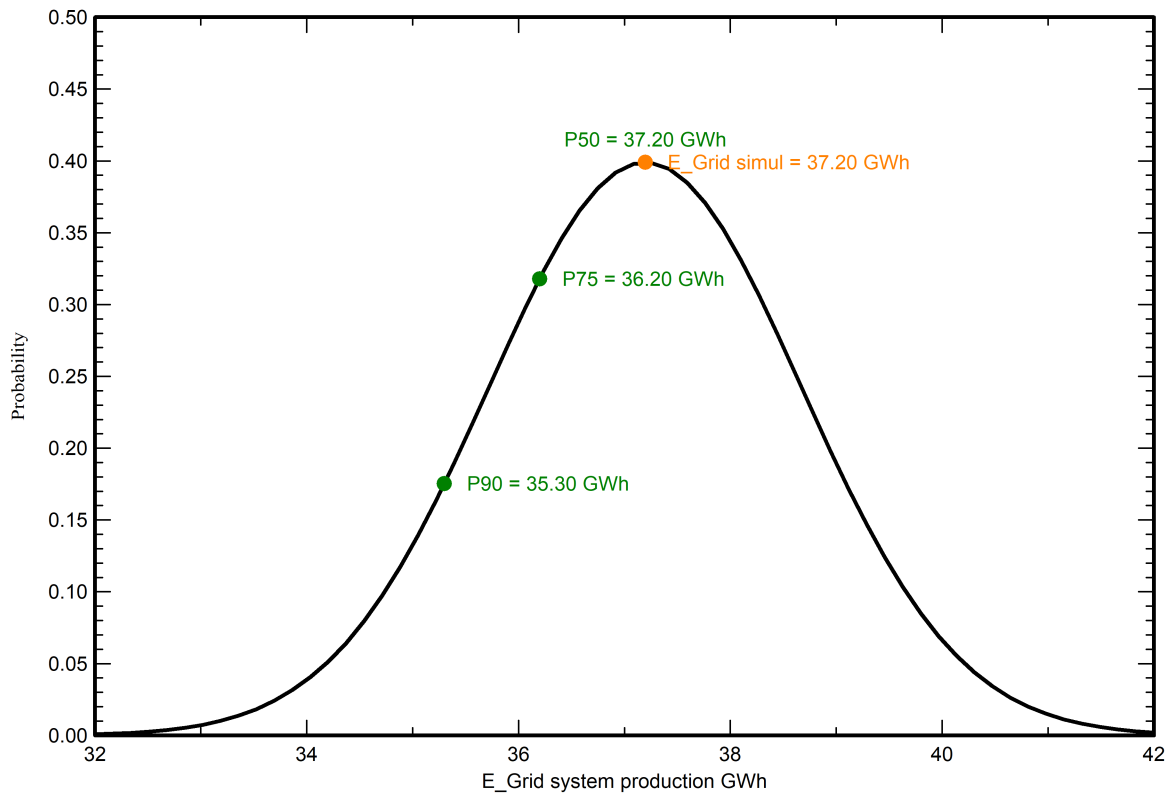
Simulation and parameters uncertainties

PV module modelling/parameters 1.0 %
Inverter efficiency uncertainty 0.5 %
Soiling and mismatch uncertainties 1.0 %
Degradation uncertainty 0.4 %

Annual production probability

Variability 1.48 GWh
P50 37.20 GWh
P75 36.20 GWh
P90 35.30 GWh

Probability distribution





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CO₂ Emission Balance

Total: 422981.7 tCO₂

Generated emissions

Total: 35955.08 tCO₂

Source: Detailed calculation from table below

Replaced Emissions

Total: 528932.9 tCO₂

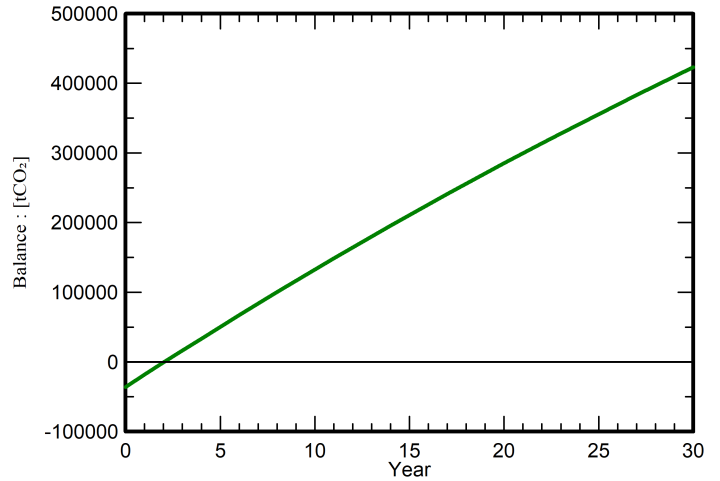
System production: 37196.41 MWh/yr

Grid Lifecycle Emissions: 474 gCO₂/kWh

Source: Custom value supplied by user

Lifetime: 30 years

Annual degradation: 1.0 %

Saved CO₂ Emission vs. Time**System Lifecycle Emissions Details**

Item	LCE	Quantity	Subtotal
[kgCO ₂]			
Modules	1641 kgCO ₂ /kWp	21865 kWp	35887046
Supports	42.3 kgCO ₂ /units	1245 units	52664
Inverters	280 kgCO ₂ /units	55.0 units	15374