IMPIANTO FOTOVOLTAICO EG DAFNE E OPERE CONNESSE

POTENZA IMPIANTO 34 MWp - COMUNE DI COPPARO (FE)

Proponente

EG DAFNE S.R.L.
VIA DEI PELLEGRINI, 22 - 20122 MILANO (MI) P.IVA: 12084690960 PEC: egdafne@pec.it

Alessandro Ceschiat
19.04.2022 15:33:20 GMT+00:00

Progettazione

META STUDIO S.R.L.
VIA SETTEMBRINI, 1 - 65123 PESCARA (PE) P.IVA: 02164240687 PEC: metastudiosrl@pec.it TEL: +39/0854315000

Coordinamento e Responsabile della Progettazione

ING. DOMENICO MEMME
VIA L. SETTEMBRINI, 1 - 65123 PESCARA (PE) PEC: metastudiosrl@pec.it TEL: +39/0854315000 MAIL: d.memme@studiomemme.it DIRECT: +39/3356390349

Firmato digitalmente da
DOMENICO MEMME
CN = DOMENICO MEMME
O = ORDINE DEGLI INGEGNERI DI CHIETI
T = INGEGNERE
C = IT

Collaboratori

ING. LUIGI NARDELLA — *Progettazione Generale e Strutturale*

ING. MAURIZIO ELISIO — *Progettazione Ambientale e Paesaggistica*

DOTT. FIORAVENTE VERì — *Progettazione Elettrica*

Titolo Elaborato

STIMA DELLA PRODUCIBILITA'

LIVELLO PROGETTAZIONE	CODICE ELABORATO	FILENAME	FORMATO	DATA	SCALA
Progetto Definitivo	DOC_REL_3	Nome file	A4	28.02.2022	-

Revisioni

REVISIONE	DATA	DESCRIZIONE	ESEGUITO	VERIFICATO	APPROVATO

Regione Emilia-Romagna

Regione EMILIA ROMAGNA
Provincia di FERRARA
Comune di COPPARO

enfinity®

STIMA DELLA PRODUCIBILITA'

Sommario

1 PREMESSA

La stima della producibilità è stata calcolata con il programma **PVsyst V7.2.8** ed è stata condotta per i due casi di impianto su inseguitori solari mono assiali Trackers e per moduli su postazione fissa:

Caso A: moduli su trackers P= 31,35 MWp;

Caso B: moduli su postazioni fisse, P= 2,746 MW;

La producibilità complessiva è risultata, come dai rapporti seguenti pari a:

E= 55.575 MWh/anno

di cui:

su trackers E= 51.680,00 MWh/anno

si fisse= E= 3.895,00 MWh/anno

2. CASO A: MODULI SU TRACKERS

PVsyst - Simulation report

Grid-Connected System

Project: Copparo

Variant: Copparo_Expected_TS600W (8.77M 4HF, 5m 1VT) 34MWp - 1648 (sin backtracking)_TRACKER

Tracking system

System power: 31.35 MWp

Copparo – Italy

Project summary

Geographical Site
Copparo
Italy

Situation
Latitude 44.96 °N
Longitude 11.01 °E
Altitude 15 m
Time zone UTC+1

Project settings
Albedo 0.20

Meteo data
Copparo
SolarGIS Monthly aver. , period not spec. - Synthetic

System summary

Grid-Connected System

Tracking system

PV Field Orientation
Tracking plane, horizontal N-S axis
Axis azimuth 0 °

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

System information

PV Array
Nb. of modules 52256 units
Pnom total 31.35 MWp

Inverters
Nb. of units 130 units
Pnom total 26.00 MWac
Grid power limit 27.00 MVA
Grid lim. Pnom ratio 1.161

Results summary

Produced Energy 51680 MWh/year
Specific production 1648 kWh/kWp/year
Perf. Ratio PR 82.94 %
Apparent energy 51680 MVAh

Table of contents

General parameters

Grid-Connected System

Tracking system

PV Field Orientation

Orientation	
Tracking plane, horizontal N-S axis	
Axis azimuth	0 °

Trackers configuration	
Nb. of trackers	580 units
Sizes	
Tracker Spacing	5.00 m
Collector width	2.17 m
Ground Cov. Ratio (GCR)	43.4 %
Phi min / max.	-/+ 60.0 °
Shading limit angles	
Phi limits	+/- 64.1 °

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	5.00 m
Tracker width	2.17 m
GCR	43.4 %
Axis height above ground	2.10 m

Bifacial model definitions	
Ground albedo average	0.14
Bifaciality factor	70 %
Rear shading factor	10.0 %
Rear mismatch loss	3.0 %
Shed transparent fraction	4.0 %

Monthly ground albedo values

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
0.11	0.13	0.14	0.16	0.16	0.18	0.18	0.17	0.14	0.12	0.11	0.11	0.14

Grid Injection point

Grid power limitation		Power factor	
Apparent power	27.00 MVA	Cos(phi) (leading)	1.000
Pnom ratio	1.161		

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	TSM-600DEG20C.20
(Custom parameters definition)	
Unit Nom. Power	600 Wp
Number of PV modules	52256 units
Nominal (STC)	31.35 MWp
Modules	1633 Strings x 32 In series
At operating cond. (50°C)	
Pmpp	28.70 MWp
U mpp	1000 V
I mpp	28694 A

Inverter

Manufacturer	Huawei Technologies
Model	SUN2000-215KTL-H3
(Custom parameters definition)	
Unit Nom. Power	200 kVA
Number of inverters	130 units
Total power	26000 kVA
Operating voltage	500-1500 V
Max. power (<=33°C)	215 kVA
Pnom ratio (DC:AC)	1.21

Total PV power

Nominal (STC)	31354 kWp
Total	52256 modules
Module area	147891 m²
Cell area	138269 m²

Total Inverter power

Total power	26000 kVA
Nb. of inverters	130 units
Pnom ratio	1.21

Array losses

Array Soiling Losses
Loss Fraction 1.5 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 30.0 W/m²K
Uv (wind) 1.2 W/m²K/m/s

DC wiring losses
Global array res. 0.29 mΩ
Loss Fraction 0.7 % at STC

LID - Light Induced Degradation
Loss Fraction 1.5 %

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 1.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): User defined profile

0°	40°	50°	60°	70°	75°	80°	85°	90°
1.000	1.000	0.998	0.992	0.983	0.961	0.933	0.853	0.000

System losses

Auxiliaries loss
Proportionnal to Power 4.0 W/kW
20.0 kW from Power thresh.
Night aux. cons. 5.00 kW

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 1.70 % at STC
Inverter: SUN2000-215KTL-H3
Wire section (130 Inv.) Copper 130 x 3 x 70 mm²
Average wires length 171 m

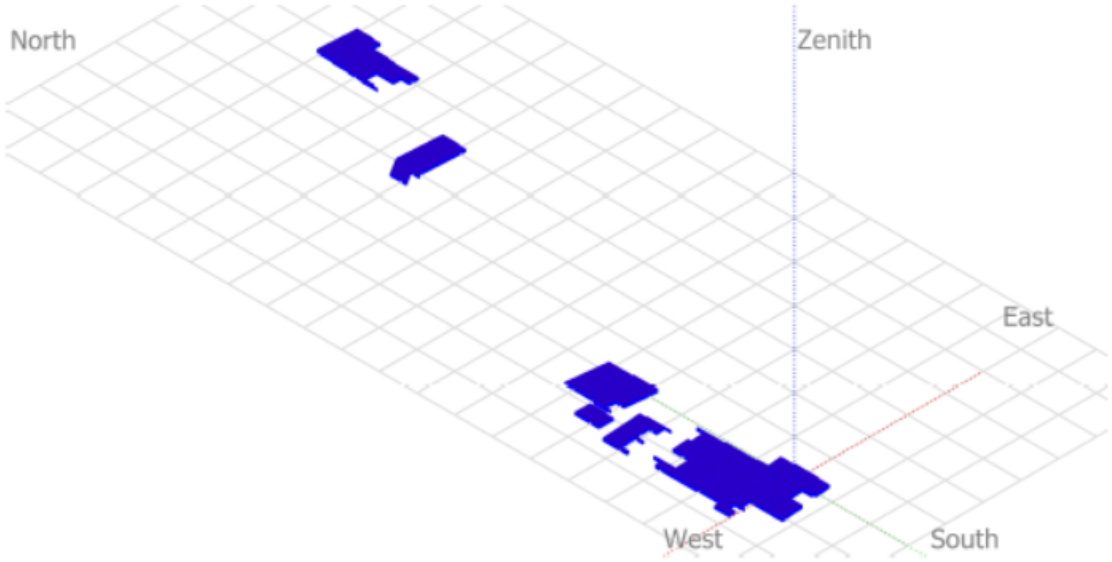
MV line up to Injection
MV Voltage 30 kV
Wires Alu 3 x 1200 mm²
Length 24550 m
Loss Fraction 2.20 % at STC

AC losses in transformers

MV transfo
Grid voltage 30 kV
Operating losses at STC
Nominal power at STC 30776 kVA
Iron loss (24/24 Connexion) 46.16 kW
Loss Fraction 0.15 % at STC
Coils equivalent resistance 3 x 0.34 mΩ
Loss Fraction 1.65 % at STC

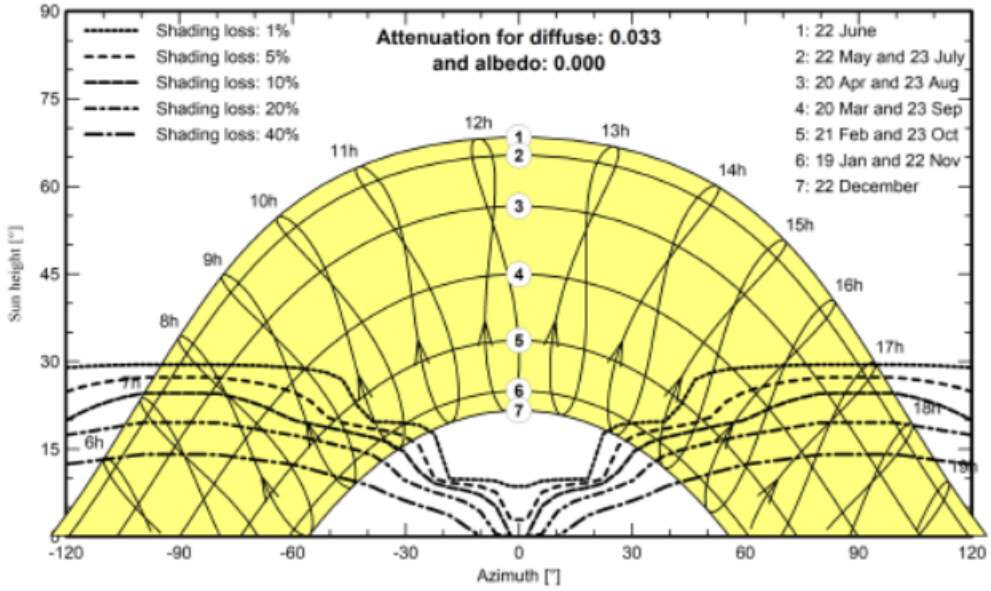
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Copparo - Legal Time

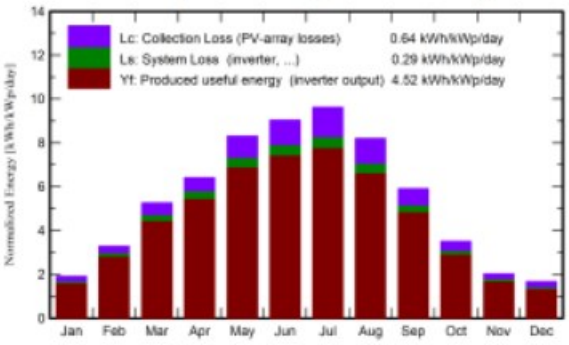


Main results

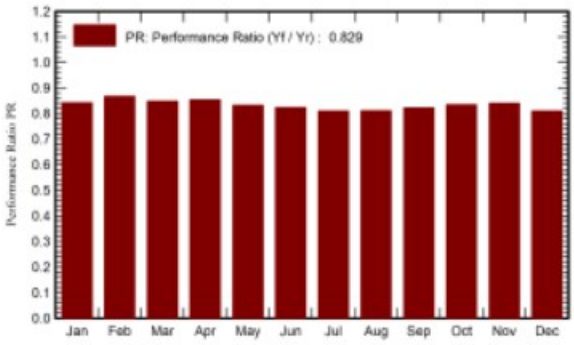
System Production

Produced Energy	51680 MWh/year	Specific production	1648 kWh/kWp/year
Apparent energy	51680 MVAh	Performance Ratio PR	82.94 %

Normalized productions (per installed kWp)



Performance Ratio PR

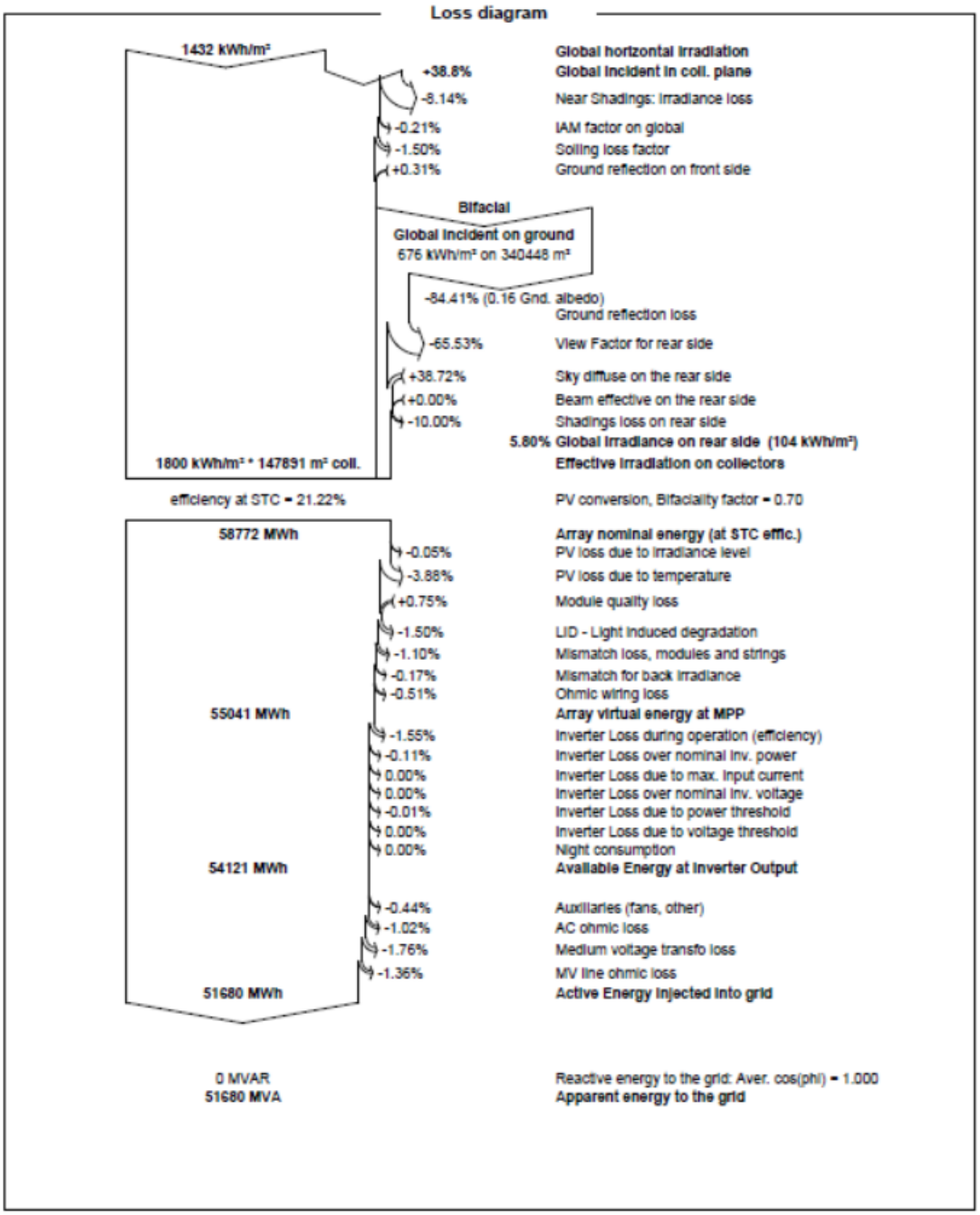


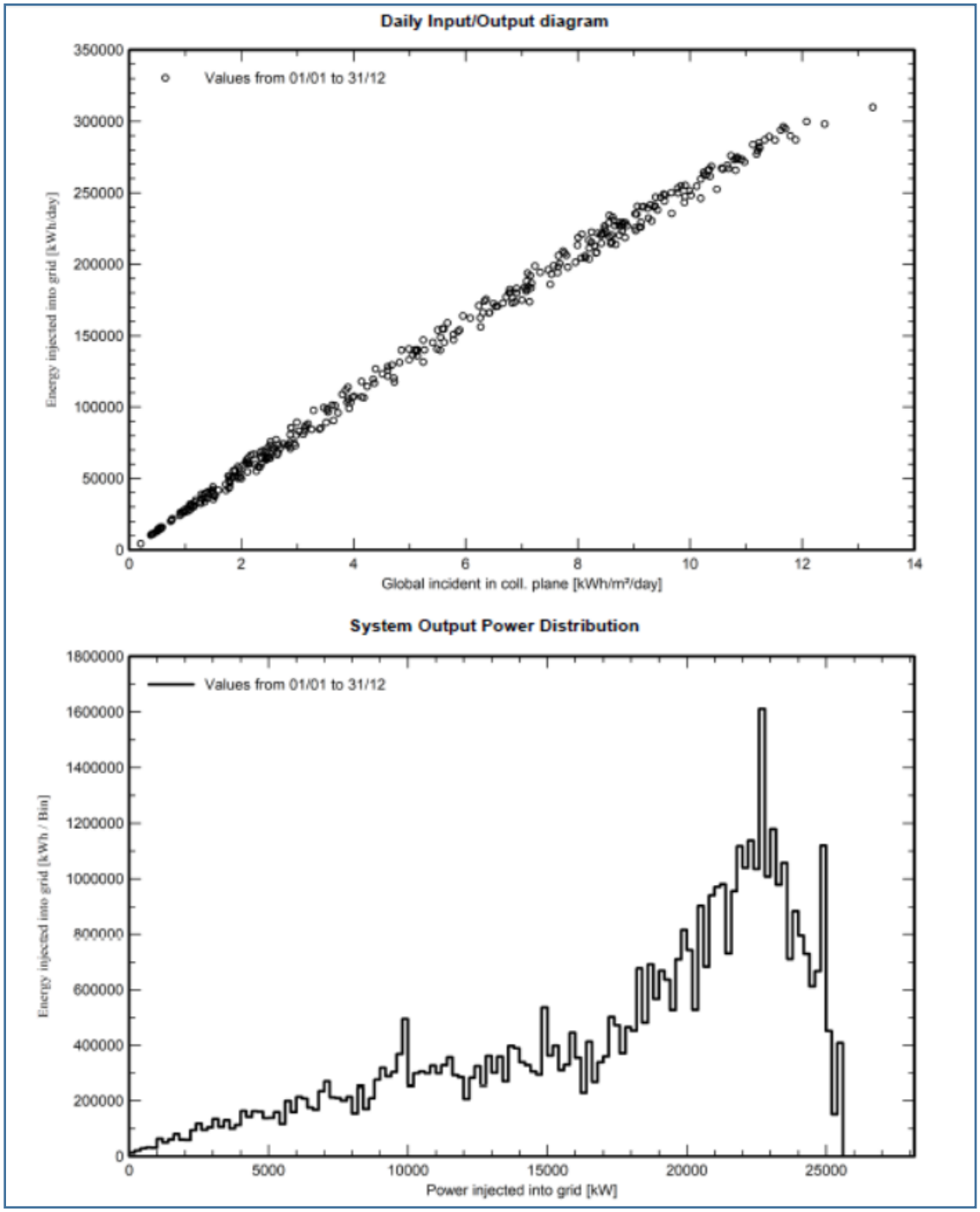
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	41.8	22.50	3.90	59.3	50.7	1663	1567	0.842
February	64.1	29.50	5.50	91.9	81.4	2638	2497	0.867
March	115.9	48.70	10.10	163.3	146.1	4613	4346	0.849
April	142.4	62.10	14.20	192.2	176.1	5477	5149	0.854
May	185.9	79.20	19.20	257.6	235.2	7152	6723	0.832
June	200.3	82.70	23.50	271.2	250.4	7471	7009	0.824
July	215.3	77.30	25.90	298.3	274.5	8081	7572	0.810
August	181.2	69.20	25.30	254.3	232.3	6890	6467	0.811
September	128.5	54.30	20.30	177.4	160.5	4869	4576	0.823
October	79.1	40.40	15.10	108.8	96.5	3016	2846	0.835
November	43.0	23.70	9.50	61.0	53.2	1707	1609	0.841
December	34.4	18.70	4.30	51.9	43.1	1403	1320	0.811
Year	1431.9	608.30	14.79	1987.3	1799.9	54980	51680	0.829

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		


Loss diagram
1432 kWh/m²
Global horizontal irradiation
+38.8%
Global incident in coll. plane
-8.14%
Near Shadings: irradiance loss
-0.21%
IAM factor on global
-1.50%
Soiling loss factor
+0.31%
Ground reflection on front side
Bifacial
Global incident on ground
676 kWh/m² on 340448 m²
-84.41% (0.16 Gnd. albedo)
Ground reflection loss
-65.53%
View Factor for rear side
+38.72%
Sky diffuse on the rear side
+0.00%
Beam effective on the rear side
-10.00%
Shadings loss on rear side
5.80%
Global irradiance on rear side (104 kWh/m²)
1800 kWh/m² * 147891 m² coll.
Effective irradiation on collectors
efficiency at STC = 21.22%
PV conversion, Bifaciality factor = 0.70
58772 MWh
Array nominal energy (at STC effic.)
-0.05%
PV loss due to irradiance level
-3.88%
PV loss due to temperature
+0.75%
Module quality loss
-1.50%
LID - Light induced degradation
-1.10%
Mismatch loss, modules and strings
-0.17%
Mismatch for back irradiance
-0.51%
Ohmic wiring loss
55041 MWh
Array virtual energy at MPP
-1.55%
Inverter Loss during operation (efficiency)
-0.11%
Inverter Loss over nominal Inv. power
0.00%
Inverter Loss due to max. input current
0.00%
Inverter Loss over nominal Inv. voltage
-0.01%
Inverter Loss due to power threshold
0.00%
Inverter Loss due to voltage threshold
0.00%
Night consumption
54121 MWh
Available Energy at Inverter Output
-0.44%
Auxiliaries (fans, other)
-1.02%
AC ohmic loss
-1.76%
Medium voltage transfo loss
-1.36%
MV line ohmic loss
51680 MWh
Active Energy injected into grid
0 MVAR
Reactive energy to the grid: Aver. cos(phi) = 1.000
51680 MVA
Apparent energy to the grid


Daily Input/Output diagram
Values from 01/01 to 31/12
Energy injected into grid [kWh/day]
Global incident in coll. plane [kWh/m²/day]
System Output Power Distribution
Values from 01/01 to 31/12
Energy injected into grid [kWh / Bin]
Power injected into grid [kW]

2. CASO B: MODULI SU POSTAZIONI FISSE

PVsyst - Simulation report

Grid-Connected System

Project: Copparo

Variant: Copparo_Expected_TS600W (8.77M 4HF, 5m 1VT) 34MWp - 1419_FIXED

Sheds system

System power: 2746 kWp

Copparo - Italy

Project summary

Geographical Site		Situation		Project settings	
Copparo		Latitude	44.96 °N	Albedo	0.20
Italy		Longitude	11.01 °E		
		Altitude	15 m		
		Time zone	UTC+1		

Meteo data
Copparo
SolarGIS Monthly aver. , period not spec. - Synthetic

System summary

Grid-Connected System		Sheds system		
PV Field Orientation		**Near Shadings**		**User's needs**
Fixed plane		According to strings		Unlimited load (grid)
Tilt/Azimuth	25 / 0 °	Electrical effect	80 %	

System information

PV Array		Inverters	
Nb. of modules	4576 units	Nb. of units	11 units
Pnom total	2746 kWp	Pnom total	2200 kWac
		Pnom ratio	1.248

Results summary

Produced Energy	3895 MWh/year	Specific production	1419 kWh/kWp/year	Perf. Ratio PR	85.80 %
Apparent energy	3895 MVAh				

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General parameters

Grid-Connected System

Sheds system

PV Field Orientation

Orientation		Sheds configuration		Models used	
Fixed plane		Nb. of sheds	47 units	Transposition	Perez
Tilt/Azimuth	25 / 0 °	Sizes		Diffuse	Perez, Meteonorm
		Sheds spacing	8.77 m	Circumsolar	separate
		Collector width	5.27 m		
		Ground Cov. Ratio (GCR)	60.0 %		
		Shading limit angle			
		Limit profile angle	29.1 °		

Horizon	Near Shadings	User's needs
Free Horizon	According to strings	Unlimited load (grid)
	Electrical effect 80 %	

Bifacial system

Model: 2D Calculation, unlimited sheds

Bifacial model geometry		Bifacial model definitions	
Sheds spacing	8.77 m	Ground albedo average	0.14
Sheds width	5.27 m	Bifaciality factor	70 %
Limit profile angle	29.1 °	Rear shading factor	10.0 %
GCR	60.0 %	Rear mismatch loss	3.0 %
Height above ground	1.50 m	Shed transparent fraction	4.0 %

Monthly ground albedo values

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
0.11	0.13	0.14	0.16	0.16	0.18	0.18	0.17	0.14	0.12	0.11	0.11	0.14

Grid injection point

Power factor

Cos(phi) (leading) 1.000

PV Array Characteristics

PV module		Inverter	
Manufacturer	Trina Solar	Manufacturer	Huawei Technologies
Model	TSM-600DEG20C.20	Model	SUN2000-215KTL-H3
(Custom parameters definition)		(Custom parameters definition)	
Unit Nom. Power	600 Wp	Unit Nom. Power	200 kVA
Number of PV modules	4576 units	Number of inverters	11 units
Nominal (STC)	2746 kWp	Total power	2200 kVA
Modules	143 Strings x 32 In series	Operating voltage	500-1500 V
At operating cond. (50°C)		Max. power (=>33°C)	215 kVA
Pmpp	2513 kWp	Pnom ratio (DC:AC)	1.25
U mpp	1000 V		
I mpp	2513 A		

Total PV power		Total inverter power	
Nominal (STC)	2746 kWp	Total power	2200 kVA
Total	4576 modules	Nb. of inverters	11 units
Module area	12951 m²	Pnom ratio	1.25
Cell area	12108 m²		

Array losses

Array Soiling Losses
Loss Fraction 1.5 %

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 30.0 W/m²K
Uv (wind) 1.2 W/m²K/m/s

DC wiring losses
Global array res. 3.5 mΩ
Loss Fraction 0.8 % at STC

LID - Light Induced Degradation
Loss Fraction 1.5 %

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 1.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): User defined profile

0°	40°	50°	60°	70°	75°	80°	85°	90°
1.000	1.000	0.998	0.992	0.983	0.961	0.933	0.853	0.000

System losses

Auxiliaries loss
Proportionnal to Power 4.0 W/kW
20.0 kW from Power thresh.
Night aux. cons. 5.00 kW

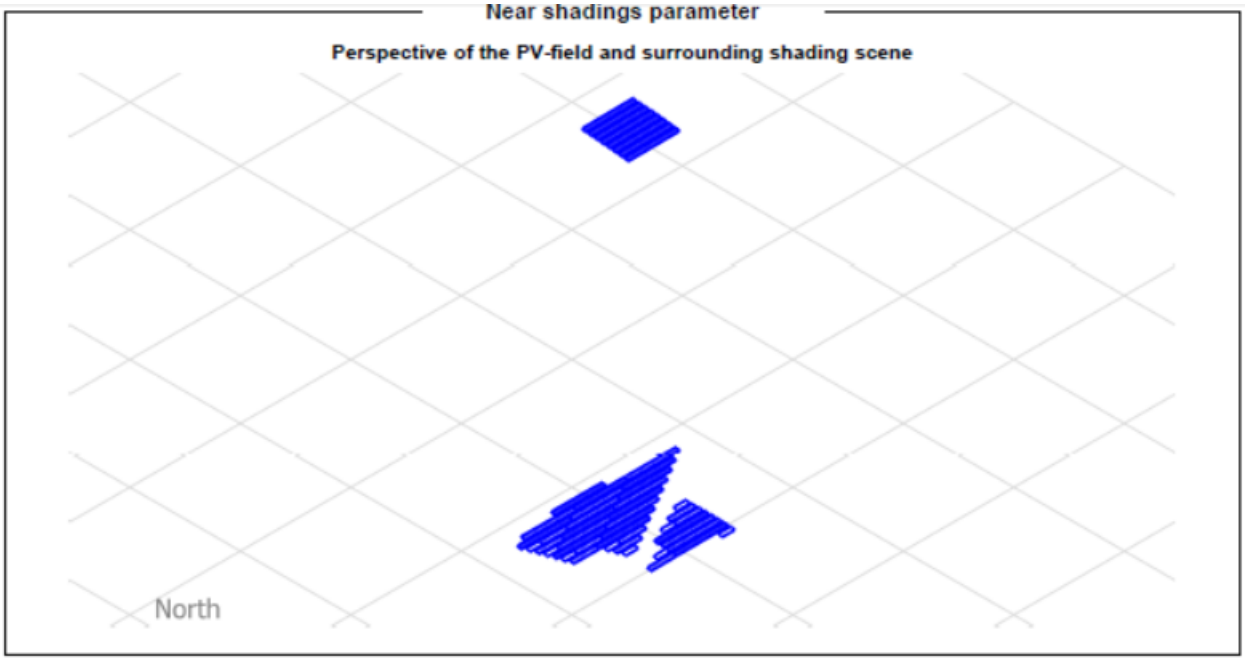
AC wiring losses

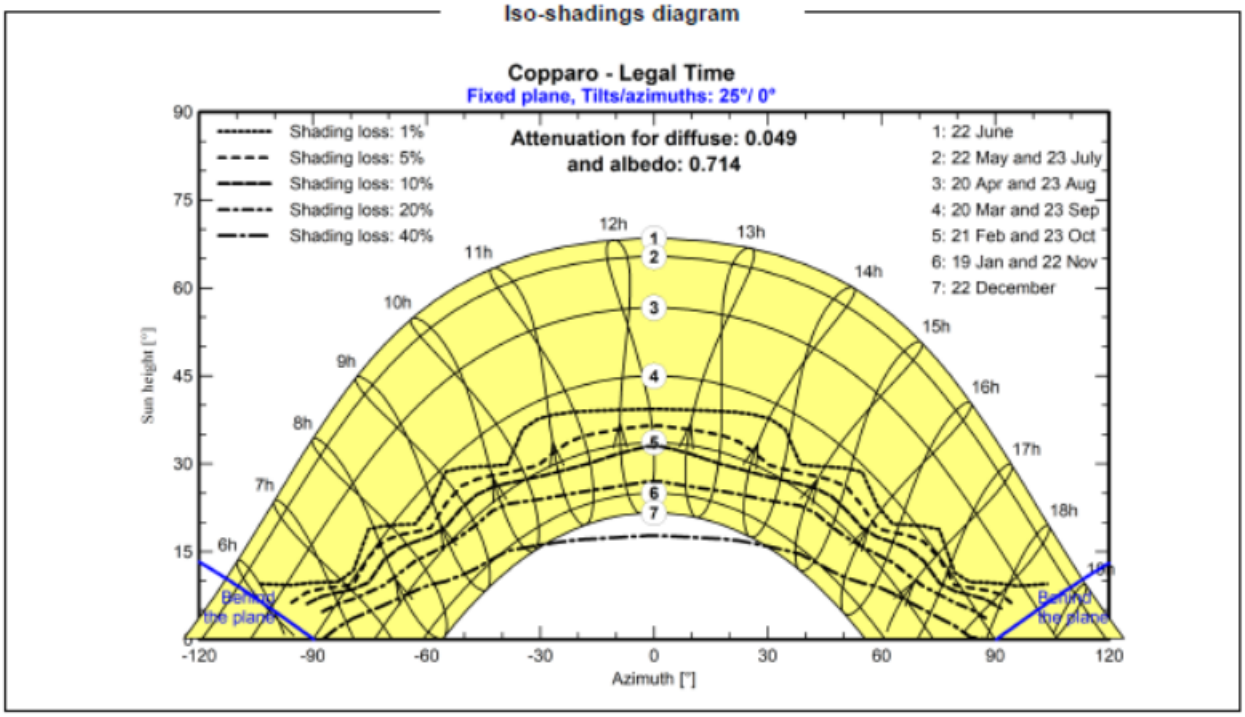
Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 1.77 % at STC
Inverter: SUN2000-215KTL-H3
Wire section (11 Inv.) Copper 11 x 3 x 70 mm²
Average wires length 172 m

MV line up to Injection
MV Voltage 30 kV
Wires Alu 3 x 1200 mm²
Length 20600 m
Loss Fraction 0.16 % at STC

AC losses in transformers

MV transfo
Grid voltage 30 kV
Operating losses at STC
Nominal power at STC 2695 kVA
Iron loss (24/24 Connexion) 4.04 kW
Loss Fraction 0.15 % at STC
Coils equivalent resistance 3 x 3.92 mΩ
Loss Fraction 1.65 % at STC


Near shadings parameter
Perspective of the PV-field and surrounding shading scene
North

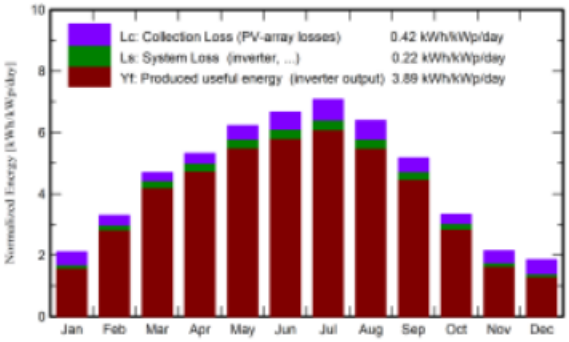

Iso-shadings diagram
Copparo - Legal Time
Fixed plane, Tilts/azimuths: 25°/ 0°
Attenuation for diffuse: 0.049
and albedo: 0.714
Shading loss: 1%
Shading loss: 5%
Shading loss: 10%
Shading loss: 20%
Shading loss: 40%
1: 22 June
2: 22 May and 23 July
3: 20 Apr and 23 Aug
4: 20 Mar and 23 Sep
5: 21 Feb and 23 Oct
6: 19 Jan and 22 Nov
7: 22 December
Sun height [°]
Azimuth [°]
Behind the plane
Behind the plane

Main results

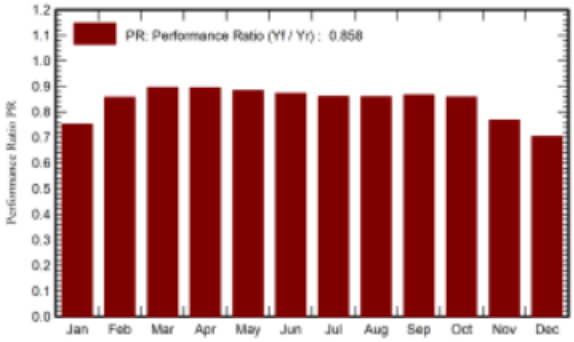
System Production

Produced Energy (P50)	3895 MWh/year	Specific production (P50)	1419 kWh/kWp/year	Performance Ratio PR	85.80 %
Produced Energy (P90)	3.80 GWh/year	Specific production (P90)	1385 kWh/kWp/year		
Produced Energy (P95)	3.78 GWh/year	Specific production (P95)	1375 kWh/kWp/year		
Apparent energy	3895 MVAh				

Normalized productions (per installed kWp)



Performance Ratio PR

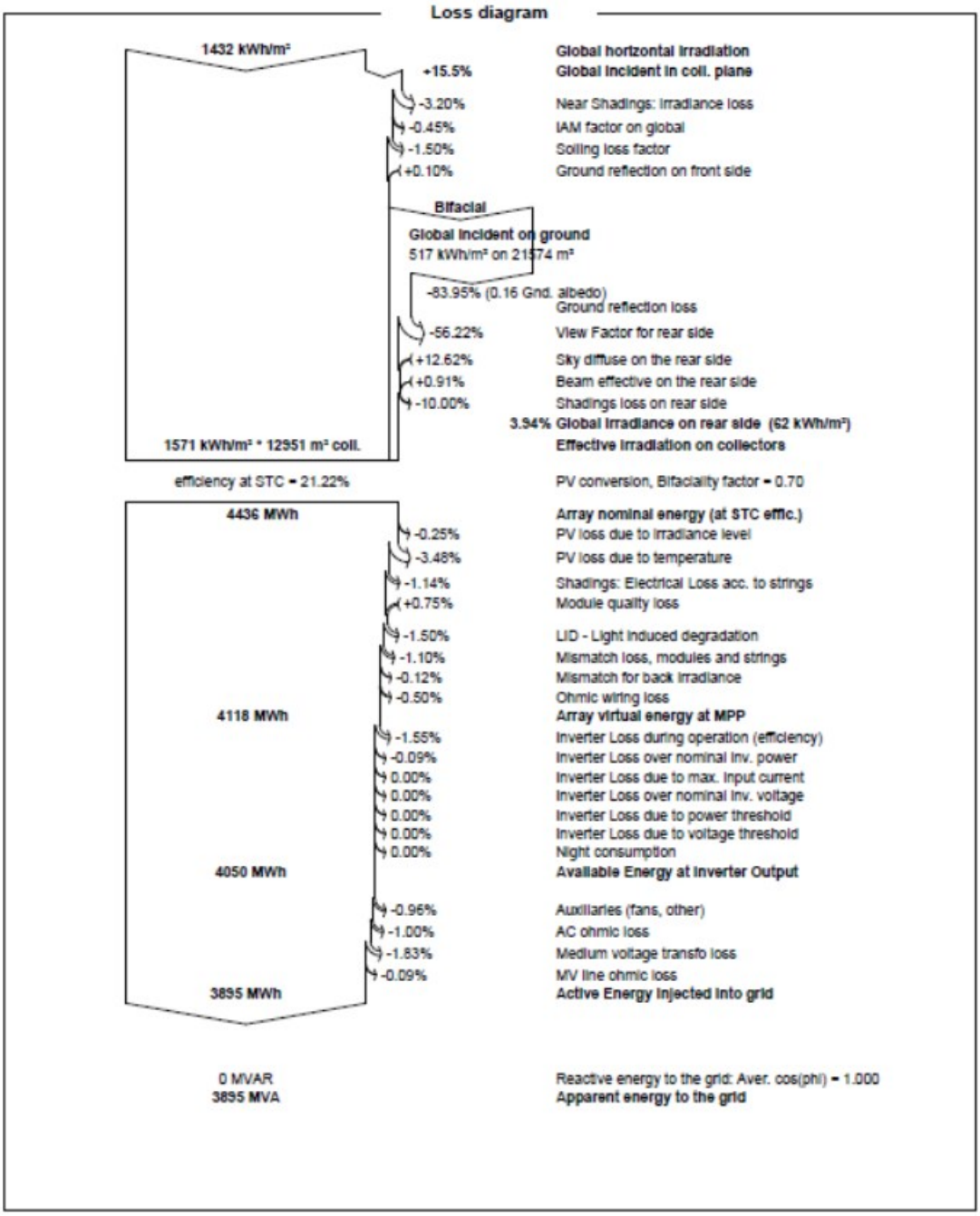


Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
January	41.8	22.50	3.90	65.4	56.5	144.9	135.1	0.752
February	64.1	29.50	5.50	92.4	86.6	230.2	217.6	0.858
March	115.9	48.70	10.10	145.6	140.1	377.5	357.7	0.895
April	142.4	62.10	14.20	159.6	153.8	412.7	391.6	0.894
May	185.9	79.20	19.20	192.8	185.8	492.6	468.2	0.885
June	200.3	82.70	23.50	199.7	192.5	503.8	478.7	0.873
July	215.3	77.30	25.90	219.5	212.1	546.6	518.9	0.861
August	181.2	69.20	25.30	198.2	191.4	493.1	467.9	0.860
September	128.5	54.30	20.30	155.0	149.5	389.6	368.9	0.867
October	79.1	40.40	15.10	103.3	98.1	258.1	243.5	0.858
November	43.0	23.70	9.50	64.4	57.3	145.5	135.9	0.768
December	34.4	18.70	4.30	57.4	47.2	119.8	110.9	0.704
Year	1431.9	608.30	14.79	1653.4	1570.9	4114.3	3894.8	0.858

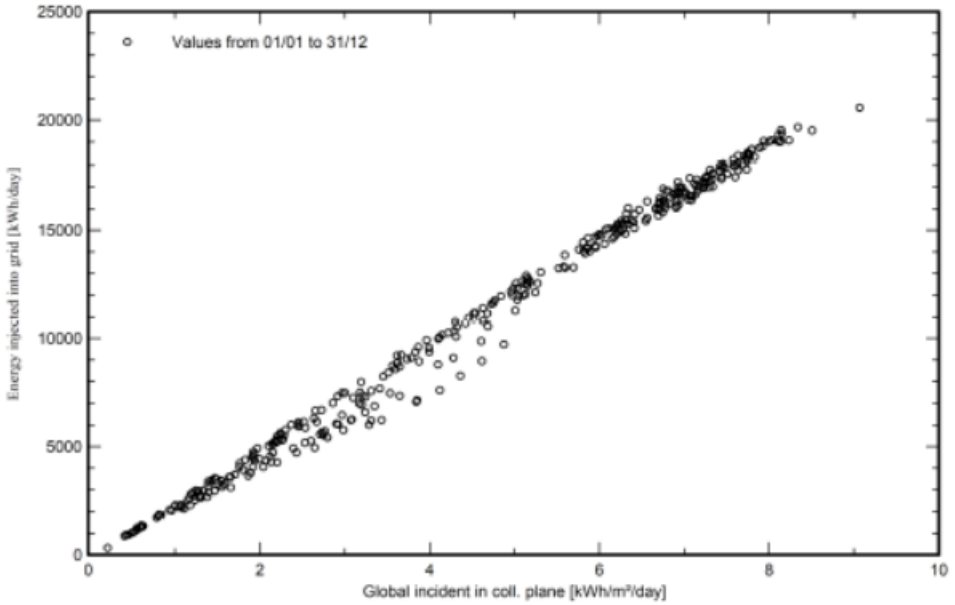
Legends

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		


Loss diagram
1432 kWh/m²
+15.5%
Global horizontal irradiation
Global incident in coll. plane
-3.20%
Near Shadings: irradiance loss
-0.45%
IAM factor on global
-1.50%
Soiling loss factor
+0.10%
Ground reflection on front side
Bifacial
Global incident on ground
517 kWh/m² on 21574 m²
-83.95% (0.16 Gnd. albedo)
Ground reflection loss
-56.22%
View Factor for rear side
+12.62%
Sky diffuse on the rear side
+0.91%
Beam effective on the rear side
-10.00%
Shadings loss on rear side
3.94%
Global irradiance on rear side (62 kWh/m²)
1571 kWh/m² * 12951 m² coll.
Effective irradiation on collectors
efficiency at STC = 21.22%
PV conversion, Bifaciality factor = 0.70
4436 MWh
Array nominal energy (at STC effic.)
-0.25%
PV loss due to irradiance level
-3.48%
PV loss due to temperature
-1.14%
Shadings: Electrical Loss acc. to strings
+0.75%
Module quality loss
-1.50%
LID - Light induced degradation
-1.10%
Mismatch loss, modules and strings
-0.12%
Mismatch for back irradiance
-0.50%
Ohmic wiring loss
4118 MWh
Array virtual energy at MPP
-1.55%
Inverter Loss during operation (efficiency)
-0.09%
Inverter Loss over nominal Inv. power
0.00%
Inverter Loss due to max. input current
0.00%
Inverter Loss over nominal Inv. voltage
0.00%
Inverter Loss due to power threshold
0.00%
Inverter Loss due to voltage threshold
0.00%
Night consumption
4050 MWh
Available Energy at Inverter Output
-0.96%
Auxiliaries (fans, other)
-1.00%
AC ohmic loss
-1.83%
Medium voltage transfo loss
-0.09%
MV line ohmic loss
3895 MWh
Active Energy injected into grid
0 MVAR
Reactive energy to the grid: Aver. cos(phi) = 1.000
3895 MVA
Apparent energy to the grid

Special graphs

Daily Input/Output diagram



System Output Power Distribution