Progetto per la realizzazione di un impianto agrivoltaico avanzato denominato “Pontedera” di potenza pari a 43,2 MWp nel comune di Pontedera (PI) e opere di connessione alla RTN ricadenti nel Comune di Ponsacco (PI)

Relazione di calcolo di producibilità impianto

Firmato digitalmente da:
STANGALINO DAVIDE
Data: 07/10/2024 09:48:57

02/10/2024	**00**	**Emissione per autorizzazione**	**D.Stangalino**	**G. D’Amico/ L. Marabeti/ O.Retini**	**F. Boni Castagnetti**
Data	Rev.	Descrizione Emissione	Preparato	Verificato	Approvato

Logo Committente e Denominazione Commerciale iren green generation Iren Green Generation Tech s.r.l.	ID Documento Committente **H060_FV_BER_00014**
Logo Appaltatore e Denominazione Commerciale TAUW	ID Documento Appaltatore -

Sommario

1 Premessa

La presente relazione riporta il calcolo di producibilità dell'impianto agrivoltaico avanzato denominato "Pontedera" di potenza 43,2 MWp, che la Società Iren Green Generation Tech s.r.l. (da qui anche indicata come IGGT s.r.l.) prevede di realizzare nel territorio del comune di Pontedera (PI) finalizzato alla produzione di energia elettrica rinnovabile, che sarà connesso alla R.T.N. 132 kV attraverso la realizzazione di una Sotto Stazione Elettrica di Utenza e il nuovo Stallo AT nella esistente CP di Ponsacco e-distribuzione.

2 Calcolo della producibilità

Far riferimento al report allegato.

Version 7.4.8

PVsyst - Simulation report

Grid-Connected System

Project: PONTEDERA_PVGis

Variant: VC3

Tracking system with backtracking

System power: 43.20 MWp

PONTEDERA - Italy

MASTER TECH INGEGNERIA

Project: PONTEDERA_PVGis

Variant: VC3

PVsyst V7.4.8
VC3, Simulation date:
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with V7.4.8

Project summary

Geographical Site		Situation		Project settings	
PONTEDERA		Latitude	43.62 °N	Albedo	0.20
Italy		Longitude	10.66 °E		
		Altitude	23 m		
		Time zone	UTC+1		

Weather data
PONTEDERA
PVGIS api TMY

System summary

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

PV Field Orientation		Tracking algorithm		Near Shadings	
Orientation		Astronomic calculation		According to strings : Slow (simul.)	
Tracking plane, horizontal N-S axis		Backtracking activated		Electrical effect	100 %
Axis azimuth	20 °	Wind stow		Diffuse shading	Automatic
		Wind Speed threshold	10 m/s		
		Wind stow position	0 °		

System information

PV Array		Inverters	
Nb. of modules	65640 units	Nb. of units	145 units
Pnom total	43.20 MWp	Pnom total	43.50 MWac
		Pnom ratio	0.993

User's needs
Unlimited load (grid)

Results summary

Produced Energy	75.47 GWh/year	Specific production	1747 kWh/kWp/year	Perf. Ratio PR	86.89 %

Table of contents

Project: PONTEDERA_PVGis

Variant: VC3

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Variant notes

DATABASE METEO

> E' stato utilizzato il database meteo PVGIS 5.2

ORIENTAMENTO

> È stato considerato un azimut +20° (verso Ovest) dell'asse del tracker secondo quanto evinto dal layout.
> Sono stati altresì considerati:
>> limite di rotazione dei tracker +-50°.
>> tecnologia backtracking attiva.
>> 10m/s come limite della velocità del vento che provoca la messa in protezione dei tracker (tilt 0°).

SISTEMA

> È stata considerata la seguete composizione del generatore
>> n. 2735 stringhe da 24 moduli
>> n. 145 inverter
> È stata considerata la tecnlogia bifacciale dei moduli secondo trackers 2D illimitati e parametri geometri derivanti dalle caratteristiche del generatore.
> L'albedo è stato posto pari a 0,2 quale valor medio per suolo con erba.

PERDITE

> Parametri Termici
>> Sono stati considerati moduli montati "liberi" con circolazione d'aria.
> Perdite Ohmiche
>> Tenuto conto della conformazione geometrica del campo si è ipotizzata una cdt media sui circuiti DC pari al 1% (come da richiesta del cliente).
>> Si è altresì considerato l'impiego di n.27 trasformatori con perdite a vuoto 0,1% e perdite a carico 1%; ai collegamenti fra inverter e trasformatori è stata attribuita una perdita pari a 1%.
>> Considerata la geometria dell'impianto si è ipotizzato un collegamto MT fra trasformatori e punto di consegna pari a 1500m con una perdita pari allo 0,1%.
> Qualità dei moduli
>> Sono stati considerati i parametri di default anche per il LID dato che nel .pan non è stato compilato il campo specifico.
> Sporco
>> È stato considerato un fattore di perdita annuale pari al 3%.
> Perdite IAM
>> Sono state considerate le perdite dichiarate dal costruttore.
> Ausiliari
>> Sono stata considerate consumi ausiliari pari a 145kW (10kW per cabina di trasformazione e 5kW per la cabina di consegna) comprendenti il consumo dei sistemi di raffreddamento.
>> Sono state considerate perdite notturne addizionali pari a 45kW (3kW per cabina di trasformazione) comprendenti le perdite della cabina di consegna.
> Decadimento
>> La simulazione è stata condotta con riferimento a primo anno e quindi non si è tenuto conto delle perdite per decadimento.
> Indisponibilità
>> È stata impostata una indisponibilità al 2% suddivisa in 5 periodi random.
> Correzione spettrale
>> Sono stati considerati i valori default di correzione spettrale per la tecnologia di moduli considerata.

ORIZZONTE

> Il profilo dell'orizzonte è stato importato da PVGIS 5.2.

CREAZIONE DELLO SCENARIO OMBRE

> Considerando l'assenza di fonti d'ombra significative è stato creato un modello "generico" del generatore (non rispondente alla reale disposizione dei moduli) il quale però rispetta le caratteristiche geometriche rilevanti:
>> superficie radiante pari a quella reale
>> pitch 5,5m
>> azimuth +20° (per tutto il generatore)
>> altenzza dell'asse tracker da terra 3m (dato ipotizzato)
>> ombreggiamento secondo le stringhe dei moduli

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Variant: VC3

Variant notes

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Project: PONTEDERA_PVGis
Variant: VC3

General parameters

Grid-Connected System

Tracking system with backtracking

PV Field Orientation

Orientation	
Tracking plane, horizontal N-S axis	
Axis azimuth	20 °

Tracking algorithm	
Astronomic calculation	
Backtracking activated	
Wind stow	
Wind Speed threshold	10 m/s
Wind stow position	0 °

Backtracking array	
Nb. of trackers	461 units
Sizes	
Tracker Spacing	5.50 m
Collector width	2.38 m
Ground Cov. Ratio (GCR)	43.3 %
Phi min / max.	-/+ 50.0 °
Backtracking strategy	
Phi limits for BT	-/+ 64.2 °
Backtracking pitch	5.50 m
Backtracking width	2.38 m

Models used

Transposition	Perez
Diffuse	Imported
Circumsolar	separate

Horizon	
Average Height	1.6 °

Near Shadings	
According to strings : Slow (simul.)	
Electrical effect	100 %
Diffuse shading	Automatic

User's needs
Unlimited load (grid)

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	2.10 m

Bifacial model definitions	
Ground albedo	0.20
Bifaciality factor	70 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	LONGi solar
Model	LR7-72HYD-650M
(Custom parameters definition)	
Unit Nom. Power	650 Wp
Number of PV modules	12288 units
Nominal (STC)	7987 kWp

Array #1 - Campo_1

Number of PV modules	6960 units
Nominal (STC)	4524 kWp
Modules	290 string x 24 In series
At operating cond. (50°C)	
Pmpp	4232 kWp
U mpp	1001 V
I mpp	4227 A

Inverter

Manufacturer	Huawei Technologies
Model	SUN2000-330KTL-H1
(Original PVsyst database)	
Unit Nom. Power	300 kWac
Number of inverters	28 units
Total power	8400 kWac

Number of inverters	96 * MPPT 17%	16 units
Total power		4800 kWac
Operating voltage		550-1500 V
Max. power (=>30°C)		330 kWac
Pnom ratio (DC:AC)		0.94
No power sharing between MPPTs		

Project: PONTEDERA_PVGis

Variant: VC3

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PV Array Characteristics

Array #2 - Campo_2

Number of PV modules	2616 units	Number of inverters	36 * MPPT 17% 6 units
Nominal (STC)	1700 kWp	Total power	1800 kWac
Modules	109 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	1591 kWp	Max. power (=>30°C)	330 kWac
U mpp	1001 V	Pnom ratio (DC:AC)	0.94
I mpp	1589 A	No power sharing between MPPTs	

Array #7 - Campo_7

Number of PV modules	1392 units	Number of inverters	18 * MPPT 17% 3 units
Nominal (STC)	905 kWp	Total power	900 kWac
Modules	58 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	846 kWp	Max. power (=>30°C)	330 kWac
U mpp	1001 V	Pnom ratio (DC:AC)	1.01
I mpp	845 A	No power sharing between MPPTs	

Array #9 - Campo_9

Number of PV modules	1320 units	Number of inverters	18 * MPPT 17% 3 units
Nominal (STC)	858 kWp	Total power	900 kWac
Modules	55 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	803 kWp	Max. power (=>30°C)	330 kWac
U mpp	1001 V	Pnom ratio (DC:AC)	0.95
I mpp	802 A	No power sharing between MPPTs	

PV module		**Inverter**	
Manufacturer	LONGi solar	Manufacturer	Huawei Technologies
Model	LR7-72HYD-660M	Model	SUN2000-330KTL-H1
(Custom parameters definition)		(Original PVsyst database)	
Unit Nom. Power	660 Wp	Unit Nom. Power	300 kWac
Number of PV modules	53352 units	Number of inverters	117 units
Nominal (STC)	35.21 MWp	Total power	35100 kWac

Array #3 - Campo_3

Number of PV modules	8232 units	Number of inverters	108 * MPPT 17% 18 units
Nominal (STC)	5433 kWp	Total power	5400 kWac
Modules	343 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	5083 kWp	Max. power (=>30°C)	330 kWac
U mpp	1006 V	Pnom ratio (DC:AC)	1.01
I mpp	5054 A	No power sharing between MPPTs	

Array #4 - Campo_4

Number of PV modules	17952 units	Number of inverters	234 * MPPT 17% 39 units
Nominal (STC)	11.85 MWp	Total power	11700 kWac
Modules	748 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	11.09 MWp	Max. power (=>30°C)	330 kWac
U mpp	1006 V	Pnom ratio (DC:AC)	1.01
I mpp	11022 A	No power sharing between MPPTs	

Project: PONTEDERA_PVGis

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PV Array Characteristics

Array #5 - Campo_5

Number of PV modules	11976 units	Number of inverters	156 * MPPT 17% 26 units
Nominal (STC)	7904 kWp	Total power	7800 kWac
Modules	499 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	7395 kWp	Max. power (=>30°C)	330 kWac
U mpp	1006 V	Pnom ratio (DC:AC)	1.01
I mpp	7353 A	No power sharing between MPPTs	

Array #6 - Campo_6

Number of PV modules	4416 units	Number of inverters	60 * MPPT 17% 10 units
Nominal (STC)	2915 kWp	Total power	3000 kWac
Modules	184 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	2727 kWp	Max. power (=>30°C)	330 kWac
U mpp	1006 V	Pnom ratio (DC:AC)	0.97
I mpp	2711 A	No power sharing between MPPTs	

Array #8 - Campo_8

Number of PV modules	10776 units	Number of inverters	144 * MPPT 17% 24 units
Nominal (STC)	7112 kWp	Total power	7200 kWac
Modules	449 string x 24 In series		
At operating cond. (50°C)		Operating voltage	550-1500 V
Pmpp	6654 kWp	Max. power (=>30°C)	330 kWac
U mpp	1006 V	Pnom ratio (DC:AC)	0.99
I mpp	6616 A	No power sharing between MPPTs	

Total PV power		**Total inverter power**	
Nominal (STC)	43200 kWp	Total power	43500 kWac
Total	65640 modules	Number of inverters	145 units
Module area	177306 m²	Pnom ratio	0.99
Cell area	164940 m²	No power sharing	

Array losses

Array Soiling Losses
Loss Fraction 3.0 %

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

LID - Light Induced Degradation
Loss Fraction 2.0 %

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

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	0.990	0.970	0.910	0.820	0.000

Project: PONTEDERA_PVGis

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Array losses

Spectral correction
FirstSolar model
Precipitable water estimated from relative humidity

Coefficient Set	C0	C1	C2	C3	C4	C5
Monocrystalline Si	0,85914	-0,02088	-0,0058853	0,12029	0,026814	-0,001781

DC wiring losses

Global wiring resistance 0.27 mΩ
Loss Fraction 1.0 % at STC

Array #1 - Campo_1
Global array res. 2.6 mΩ
Loss Fraction 1.0 % at STC

Array #2 - Campo_2
Global array res. 6.8 mΩ
Loss Fraction 1.0 % at STC

Array #3 - Campo_3
Global array res. 2.2 mΩ
Loss Fraction 1.0 % at STC

Array #4 - Campo_4
Global array res. 0.99 mΩ
Loss Fraction 1.0 % at STC

Array #5 - Campo_5
Global array res. 1.5 mΩ
Loss Fraction 1.0 % at STC

Array #6 - Campo_6
Global array res. 4.0 mΩ
Loss Fraction 1.0 % at STC

Array #7 - Campo_7
Global array res. 13 mΩ
Loss Fraction 1.0 % at STC

Array #8 - Campo_8
Global array res. 1.6 mΩ
Loss Fraction 1.0 % at STC

Array #9 - Campo_9
Global array res. 14 mΩ
Loss Fraction 1.0 % at STC

System losses

Unavailability of the system
Time fraction 2.0 %
7.3 days,
5 periods

Auxiliaries loss
constant (fans) 145.0 kW
10.0 kW from Power thresh.
Night aux. cons. 45.0 kW

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 800 Vac tri
Loss Fraction 0.94 % at STC
Inverter: SUN2000-330KTL-H1
Wire section (145 Inv.) Alu 145 x 3 x 185 mm²
Average wires length 120 m

MV line up to Injection
MV Voltage 30 kV
Average each inverter
Wires Alu 3 x 240 mm²
Length 1500 m
Loss Fraction 0.10 % at STC

AC losses in transformers

MV transfo	
Grid voltage	30 kV
One transfo in each sub-array	
Array #1 - Campo_1	
Transformer parameters	
Nominal power at STC	4.48 MVA
Iron Loss (24/24 Connexion)	4.80 kVA
Iron loss fraction	0.11 % at STC
Copper loss	41.78 kVA
Copper loss fraction	0.93 % at STC
Coils equivalent resistance	3 x 1.33 mΩ
Array #2 - Campo_2	
Transformer parameters	
Nominal power at STC	1.68 MVA
Iron Loss (24/24 Connexion)	1.80 kVA
Iron loss fraction	0.11 % at STC
Copper loss	15.74 kVA
Copper loss fraction	0.94 % at STC
Coils equivalent resistance	3 x 3.56 mΩ
Array #3 - Campo_3	
Transformer parameters	
Nominal power at STC	5.38 MVA
Iron Loss (24/24 Connexion)	5.40 kVA
Iron loss fraction	0.10 % at STC
Copper loss	53.56 kVA
Copper loss fraction	1.00 % at STC
Coils equivalent resistance	3 x 1.19 mΩ
Array #4 - Campo_4	
Transformer parameters	
Nominal power at STC	11.73 MVA
Iron Loss (24/24 Connexion)	11.70 kVA
Iron loss fraction	0.10 % at STC
Copper loss	117.56 kVA
Copper loss fraction	1.00 % at STC
Coils equivalent resistance	3 x 0.55 mΩ
Array #5 - Campo_5	
Transformer parameters	
Nominal power at STC	7.82 MVA
Iron Loss (24/24 Connexion)	7.79 kVA
Iron loss fraction	0.10 % at STC
Copper loss	78.48 kVA
Copper loss fraction	1.00 % at STC
Coils equivalent resistance	3 x 0.82 mΩ
Array #6 - Campo_6	
Transformer parameters	
Nominal power at STC	2.88 MVA
Iron Loss (24/24 Connexion)	3.00 kVA
Iron loss fraction	0.10 % at STC
Copper loss	27.75 kVA
Copper loss fraction	0.96 % at STC
Coils equivalent resistance	3 x 2.13 mΩ

AC losses in transformers

MV transfo	
Grid voltage	30 kV
One transfo in each sub-array	
Array #7 - Campo_7	
Transformer parameters	
Nominal power at STC	895 kVA
Iron Loss (24/24 Connexion)	0.90 kVA
Iron loss fraction	0.10 % at STC
Copper loss	8.91 kVA
Copper loss fraction	1.00 % at STC
Coils equivalent resistance	3 x 7.11 mΩ
Array #8 - Campo_8	
Transformer parameters	
Nominal power at STC	7.04 MVA
Iron Loss (24/24 Connexion)	7.19 kVA
Iron loss fraction	0.10 % at STC
Copper loss	68.83 kVA
Copper loss fraction	0.98 % at STC
Coils equivalent resistance	3 x 0.89 mΩ
Array #9 - Campo_9	
Transformer parameters	
Nominal power at STC	849 kVA
Iron Loss (24/24 Connexion)	0.90 kVA
Iron loss fraction	0.11 % at STC
Copper loss	8.01 kVA
Copper loss fraction	0.94 % at STC
Coils equivalent resistance	3 x 7.11 mΩ

Project: PONTEDERA_PVGis

Variant: VC3

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Horizon definition

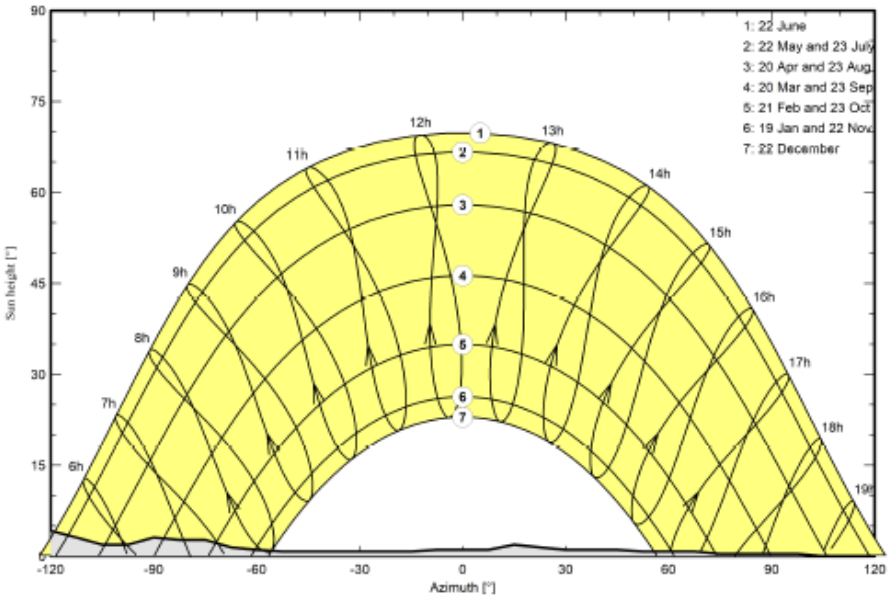
Horizon from PVGIS website API, Lat=43°37'8", Long=10°39'49", Alt=23m

Average Height	1.6 °	Albedo Factor	0.96
Diffuse Factor	0.99	Albedo Fraction	100 %

Horizon profile

Azimuth [°]	-180	-173	-165	-158	-150	-143	-135	-120	-113	-105	-98	-90	-83
Height [°]	1.5	2.3	2.3	3.4	3.8	3.4	4.2	4.2	3.1	1.9	1.9	3.1	2.7
Azimuth [°]	-75	-68	-60	-53	-15	-8	8	15	23	30	45	53	68
Height [°]	2.7	1.5	1.1	0.8	0.8	1.1	1.1	1.9	1.5	1.1	1.1	0.8	0.8
Azimuth [°]	75	98	105	120	128	143	150	158	165	173	180		
Height [°]	0.4	0.4	0.0	0.0	0.4	2.7	2.7	1.9	1.1	1.5	1.5		

Sun Paths (Height / Azimuth diagram)



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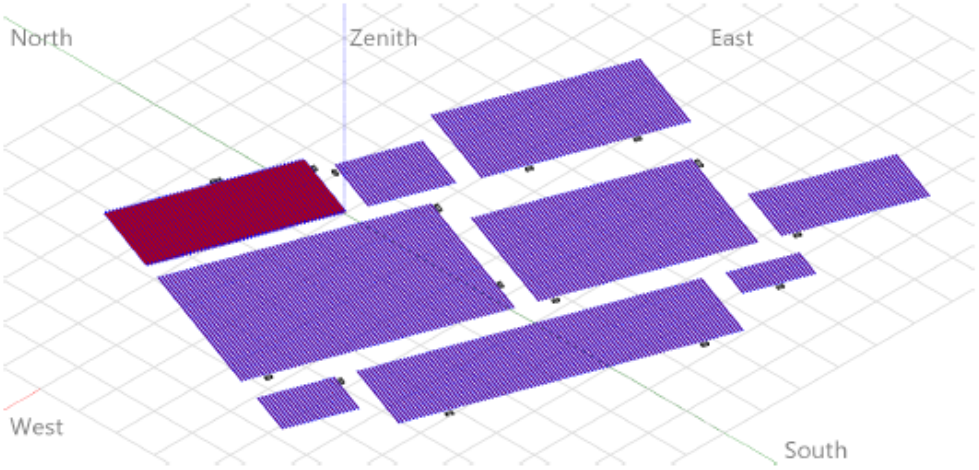
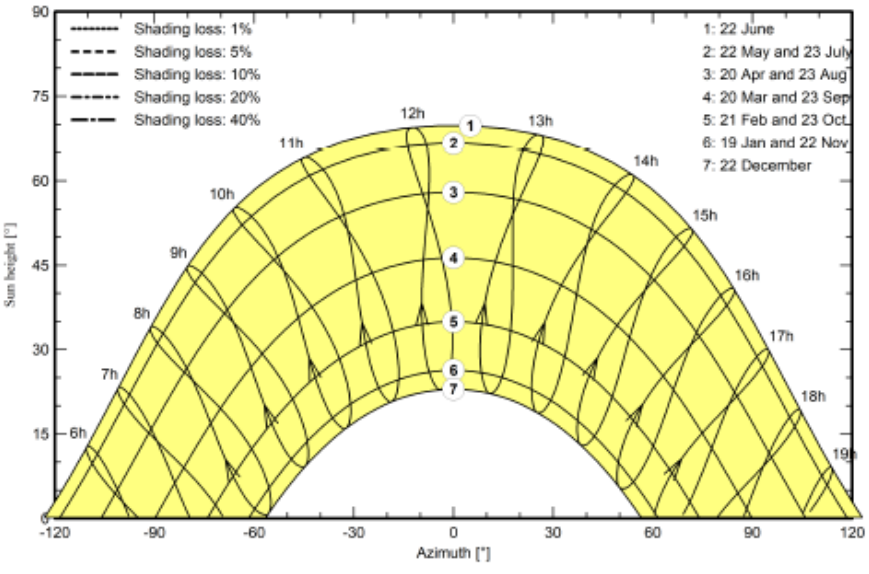
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1



Project: PONTEDERA_PVGis

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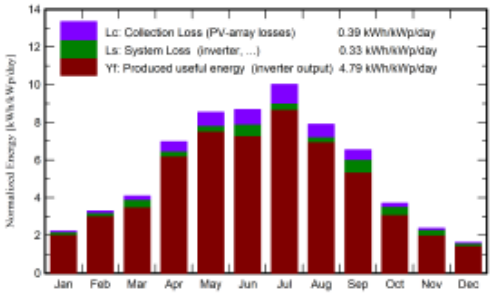
Main results

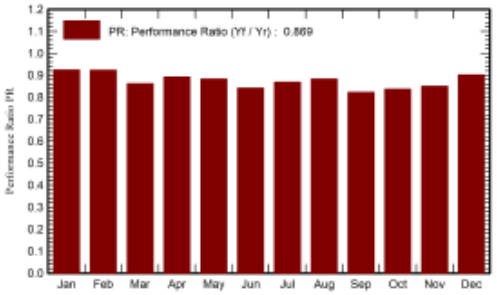
System Production

Produced Energy	75.47 GWh/year	Specific production	1747 kWh/kWp/year
		Perf. Ratio PR	86.89 %

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 GWh	E_Grid GWh	PR ratio
January	51.2	22.15	4.11	69.0	65.0	2.94	2.75	0.924
February	68.9	29.68	5.90	92.4	87.4	3.89	3.69	0.923
March	100.4	47.69	9.04	126.8	120.0	5.24	4.72	0.862
April	161.4	57.75	14.85	209.3	199.1	8.40	8.06	0.892
May	208.7	71.37	17.57	264.5	252.0	10.50	10.09	0.883
June	207.5	76.06	21.02	260.4	248.0	10.27	9.46	0.841
July	237.7	63.38	23.47	310.5	296.4	12.09	11.65	0.868
August	189.2	69.82	21.98	244.6	232.9	9.70	9.34	0.883
September	148.4	48.15	21.68	196.1	186.8	7.81	6.96	0.822
October	87.0	40.39	13.46	115.2	109.0	4.76	4.17	0.838
November	54.4	28.98	11.14	71.5	67.2	3.00	2.62	0.849
December	38.3	22.16	5.55	50.3	47.0	2.14	1.96	0.902
Year	1553.2	577.58	14.18	2010.6	1910.7	80.75	75.47	0.869

Legends

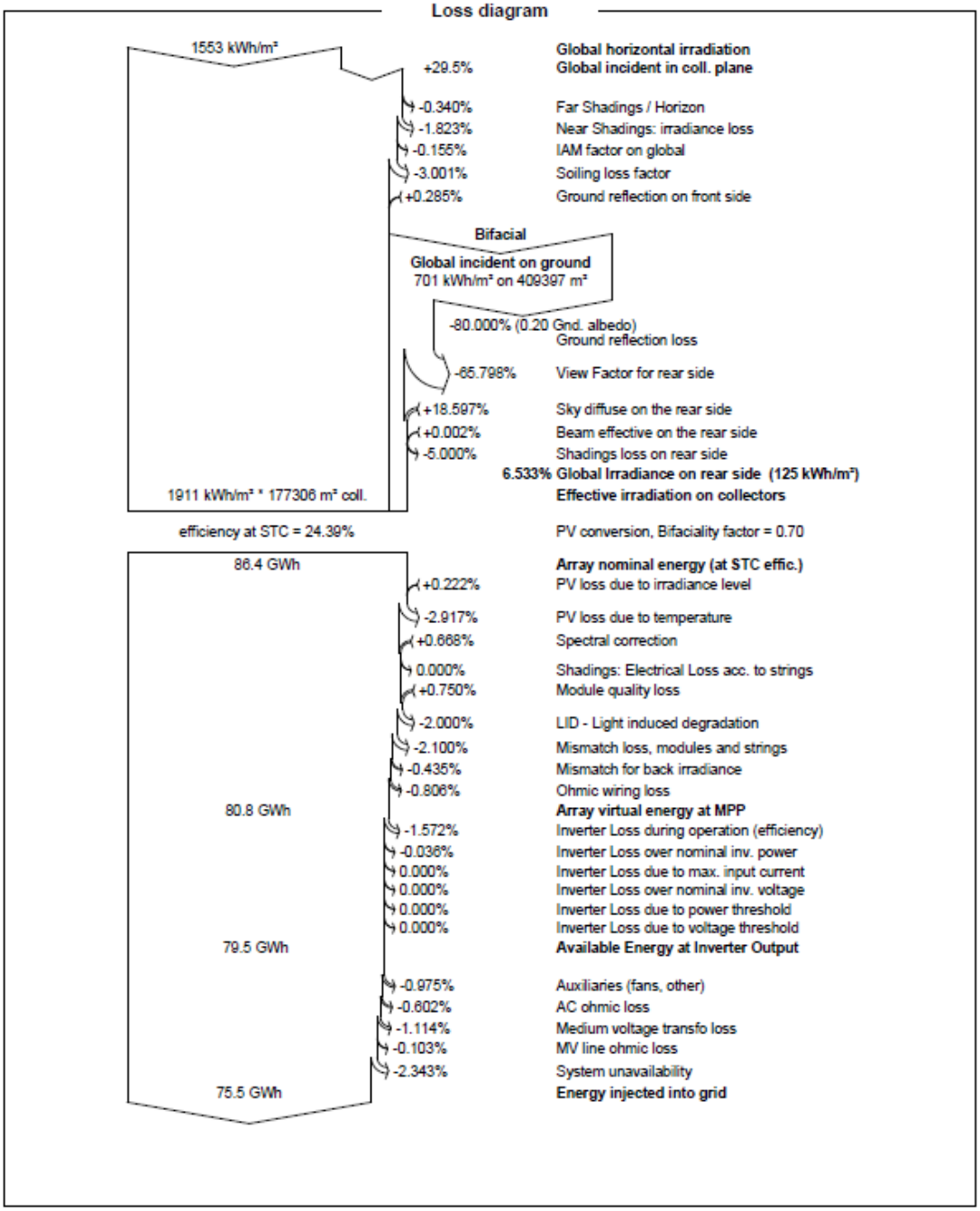
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Project: PONTEDERA_PVGis

Variant: VC3

PVsyst V7.4.8
VC3, Simulation date:
17/09/24 09:53
with V7.4.8

Loss diagram



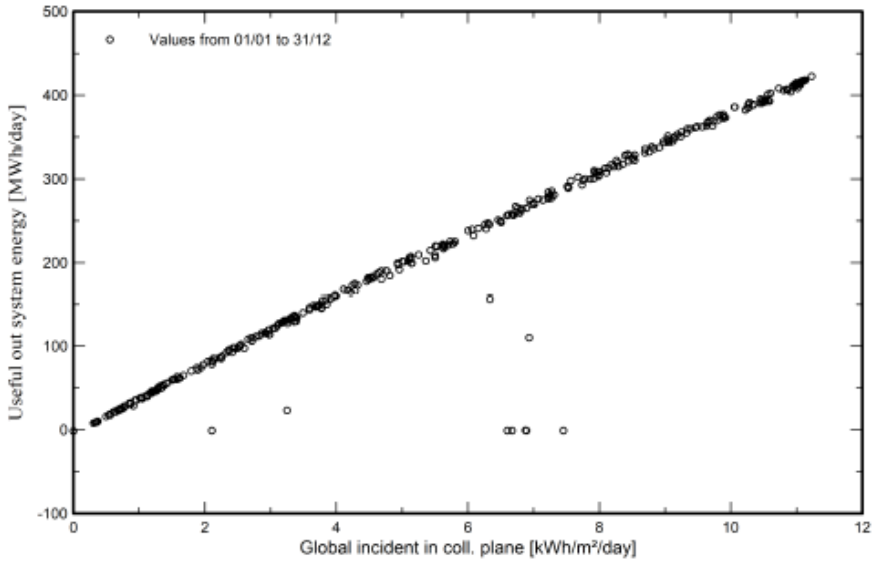
Project: PONTEDERA_PVGis

Variant: VC3

PVsyst V7.4.8
VC3, Simulation date:
17/09/24 09:53
with V7.4.8

Predef. graphs

Diagramma giornaliero entrata/uscita



Distribuzione potenza in uscita sistema