



**REPUBBLICA ITALIANA**  
**Regione Sicilia**  
**Comune di Petralia Sottana**



Progetto per la realizzazione di un impianto agrivoltaico avanzato, denominato "Impianto Agrivoltaico Avanzato Petralia Sottana", per la produzione di energia elettrica da fonte solare fotovoltaica della potenza complessiva di 40,57 MWp sito nel comune di Petralia Sottana (PA) in località "Ciampanella e Tudia" e delle relative opere connesse.

**- PROGETTO DEFINITIVO -**

**Petralia S.r.l.**

a Company of **TOZZIgreen**

**COMMITTENTE**

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**ANALISI DI PRODUCIBILITA'  
IMPIANTO**

PROGETTAZIONE:



COMMITTENTE



Scala

Pratica

Codice elaborato

**261pr**

**RS06REL0022A0**

B						
A	FEBBRAIO 2024	PRIMA EMISSIONE	FABIO S. CORVO	CINZIA CICCHITTI	FABIO TORREGROSSA	CRISTIANO VITALI
Rev	Data	Motivazione	Redatto	Verificato	Approvato	Autorizzato

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## Sommario

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Progetto per la realizzazione di un impianto agrivoltaico avanzato, denominato "Petràlia Sottana", per la produzione di energia elettrica da fonte solare fotovoltaica della potenza complessiva di 40,57 MW sito nel Comune di Petralia Sottana (PA) in località "Ciampanella e Tudia" e delle relative opere di connessione ed infrastrutture nei comuni di Castellana Sicula (PA) e Villalba (CL) necessarie per la connessione alla RTN.

## 1. Analisi di producibilità impianto

Per poter stimare la producibilità dell'impianto agrivoltaico si è fatto ricorso al software PVSyst 7.4.6, il quale consente di stimare con un'ottima approssimazione la producibilità di un generico impianto fotovoltaico con pannelli monofacciali, introducendo le caratteristiche del sito, quali:

- Orientamento
- Pendenza;
- Layout;
- Moduli utilizzati;

Nel caso in esame sono stati utilizzati dei moduli bifacciali, che non possono essere implementati dal software assieme alle pendenze del sito; sono state quindi effettuate più simulazioni, a modo di poter tener conto sia dell'effetto positivo sulla producibilità dato dall'utilizzo dei moduli bifacciali, sia dell'effetto negativo dovuto alla pendenza del sito.

### 1.1. Stima del fattore di bifaccialità

In questo primo caso, per poter valutare quanto incida l'utilizzo di un modulo bifacciale sulla producibilità dell'impianto, è stato predisposto un layout con la stessa potenza installata e orientato come da progetto con la sola differenza ricercabile nell'andamento del terreno che per questo caso è stato considerato piatto.

Sono state quindi eseguite 2 simulazioni utilizzando i seguenti moduli:

- A. Pannello da 730 Wp, Monofacciale;
- B. Pannello da 730 Wp, Bifacciale.

## Analisi di producibilità impianto

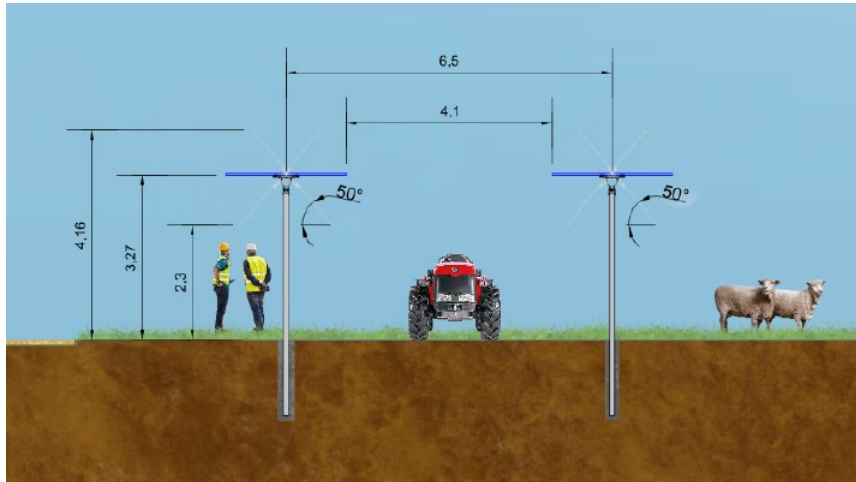


Figura 1: Disposizione tracker monoassiale

Una volta predisposto il layout sono state eseguite le simulazioni A e B, i valori della producibilità ottenuti sono i seguenti:

	Simulazione A: Pannello Monofacciale 730 Wp	Simulazione B: Pannello Bifacciale 730 Wp (albedo 0.23)
Producibilità Stimata	1.960 kWh/kWp	2.102 kWh/kWp

Siccome le due grandezze sono correlate dalla seguente relazione:

$$P(B) = P(A) * f$$

Dove:

- $P(A)$ : Producibilità relativa alla simulazione A;
- $P(B)$ : Producibilità relativa alla simulazione B;
- $f$ : Fattore di bifaccialità;

Il fattore di producibilità è stato stimato come segue:

$$f = \frac{P(A)}{P(B)} = 7.2\%$$

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Progetto per la realizzazione di un impianto agrivoltaico avanzato, denominato "Petràlia Sottana", per la produzione di energia elettrica da fonte solare fotovoltaica della potenza complessiva di 40,57 MW sito nel Comune di Petràlia Sottana (PA) in località "Ciampanella e Tudia" e delle relative opere di connessione ed infrastrutture nei comuni di Castellana Sicula (PA) e Villalba (CL) necessarie per la connessione alla RTN.

## 1.2. Stima producibilità sito

Una volta stimato il valore del fattore di bifaccialità, come detto in precedenza, si è quindi resa necessaria un'altra simulazione (C) che tenesse conto dell'orografia del sito dell'impianto. Per tale simulazione sono stati considerati pannelli da 730 Wp Monofacciali la producibilità risulta:

$$P(C)=1.850 \text{ kWh/kWp}$$

A seguire sono allegati i report prodotti con il software PVSyst per i casi citati in precedenza.

# PVsyst - Simulation report

## Grid-Connected System

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Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS, pitch 7.4m Flat Terrain

Tracking system with backtracking

System power: 40.57 MWp

PetraliaSottana - Italia

**Autore**

Tozzi Green Spa (Italy)



# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

## PVsyst V7.4.6

VDC, Simulation date:  
26/03/24 15:03  
with V7.4.6

Tozzi Green Spa (Italy)

### Project summary

<b>Geographical Site</b>		<b>Situation</b>		<b>Project settings</b>	
PetraliaSottana		Latitude	37.64 °N	Albedo	0.20
Italia		Longitude	13.99 °E		
		Altitude	705 m		
		Time zone	UTC		
<b>Weather data</b>					
PetraliaSottana					
SolarGIS Monthly aver. , period not spec. - Sintetico					

### System summary

<b>Grid-Connected System</b>		<b>Tracking system with backtracking</b>			
<b>PV Field Orientation</b>		<b>Tracking algorithm</b>		<b>Near Shadings</b>	
<b>Orientation</b>		Irradiance optimization		Linear shadings : Slow (simul.)	
Tracking plane, horizontal N-S axis		Backtracking activated		Diffuse shading Automatic	
Axis azimuth 180 °					
<b>System information</b>					
<b>PV Array</b>					
Nb. of modules	55580 units	<b>Inverters</b>		Nb. of units 123 units	
Pnom total	40.57 MWp			Pnom total 36.90 MWac	
				Pnom ratio 1.100	
<b>User's needs</b>					
Unlimited load (grid)					

### Results summary

Produced Energy	79503495 kWh/year	Specific production	1959 kWh/kWp/year	Perf. Ratio PR	83.95 %
Apparent energy	82141159 kVAh/year				

### Table of contents

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# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

## PVsyst V7.4.6

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Tozzi Green Spa (Italy)

### General parameters

#### Grid-Connected System

#### PV Field Orientation

##### Orientation

Tracking plane, horizontal N-S axis  
Axis azimuth 180 °

#### Models used

Transposition Perez  
Diffuse Perez, Meteonorm  
Circumsolar separate

#### Horizon

Free Horizon

#### Grid injection point

##### Power factor

Cos(phi) (lagging) 0.970

#### Tracking system with backtracking

##### Tracking algorithm

Irradiance optimization  
Backtracking activated

#### Near Shadings

Linear shadings : Slow (simul.)  
Diffuse shading Automatic

##### Backtracking array

Nb. of trackers 992 units

##### Sizes

Tracker Spacing 7.40 m  
Collector width 2.38 m  
Ground Cov. Ratio (GCR) 32.2 %  
Phi min / max. -/+ 50.0 °

##### Backtracking strategy

Phi limits for BT -/+ 71.1 °  
Backtracking pitch 7.40 m  
Backtracking width 2.38 m

#### User's needs

Unlimited load (grid)

### PV Array Characteristics

#### PV module

Manufacturer Tongwei Solar  
Model TWMHF-66HD695-730-GG-Bifacial (TG)  
(Custom parameters definition)

Unit Nom. Power 730 Wp  
Number of PV modules 55580 units  
Nominal (STC) 40.57 MWp  
Modules 1985 string x 28 In series

#### At operating cond. (50°C)

Pmpp 38.18 MWp  
U mpp 1114 V  
I mpp 34287 A

#### Total PV power

Nominal (STC) 40573 kWp  
Total 55580 modules  
Module area 172651 m<sup>2</sup>

#### Inverter

Manufacturer Huawei Technologies  
Model SUN2000-330KTL-H1- (TG)  
(Custom parameters definition)

Unit Nom. Power 300 kWac  
Number of inverters 123 units  
Total power 36900 kWac  
Operating voltage 500-1500 V  
Max. power (=>30°C) 330 kWac  
Pnom ratio (DC:AC) 1.10  
Power sharing within this inverter

#### Total inverter power

Total power 36900 kWac  
Max. power 40590 kWac  
Number of inverters 123 units  
Pnom ratio 1.10  
PNom limit forced to active power





# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

## PVsyst V7.4.6

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### Array losses

#### Array Soiling Losses

Loss Fraction 2.5 %

#### Thermal Loss factor

Module temperature according to irradiance

Uc (const) 29.0 W/m<sup>2</sup>K

Uv (wind) 0.0 W/m<sup>2</sup>K/m/s

#### DC wiring losses

Global array res. 0.38 mΩ

Loss Fraction 1.1 % at STC

#### 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 -0.2 %

#### 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

### System losses

#### Unavailability of the system

Time fraction 0.8 %

2.9 days,

3 periods

#### Auxiliaries loss

constant (fans) 5.00 kW

0.0 kW from Power thresh.

Night aux. cons. 10.00 kW

### AC wiring losses

#### Inv. output line up to MV transfo

Inverter voltage 800 Vac tri

Loss Fraction 1.59 % at STC

#### Inverter: SUN2000-330KTL-H1- (TG)

Wire section (123 Inv.) Alu 123 x 3 x 240 mm<sup>2</sup>

Average wires length 225 m

#### MV line up to Injection

MV Voltage 36 kV

Average each inverter

Wires Alu 3 x 700 mm<sup>2</sup>

Length 16450 m

Loss Fraction 0.40 % at STC

### AC losses in transformers

#### MV transfo

Medium voltage 36 kV

#### One transfo parameters

Nominal power at STC 6.64 MVA

Iron Loss (24/24 Connexion) 6.18 kVA

Iron loss fraction 0.09 % at STC

Copper loss 71.77 kVA

Copper loss fraction 1.08 % at STC

Coils equivalent resistance 3 x 1.04 mΩ

#### Operating losses at STC (full system)

Nb. identical MV transfos 6

Nominal power at STC 39.86 MVA

Iron loss (24/24 Connexion) 37.06 kVA

Copper loss 430.64 kVA



# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
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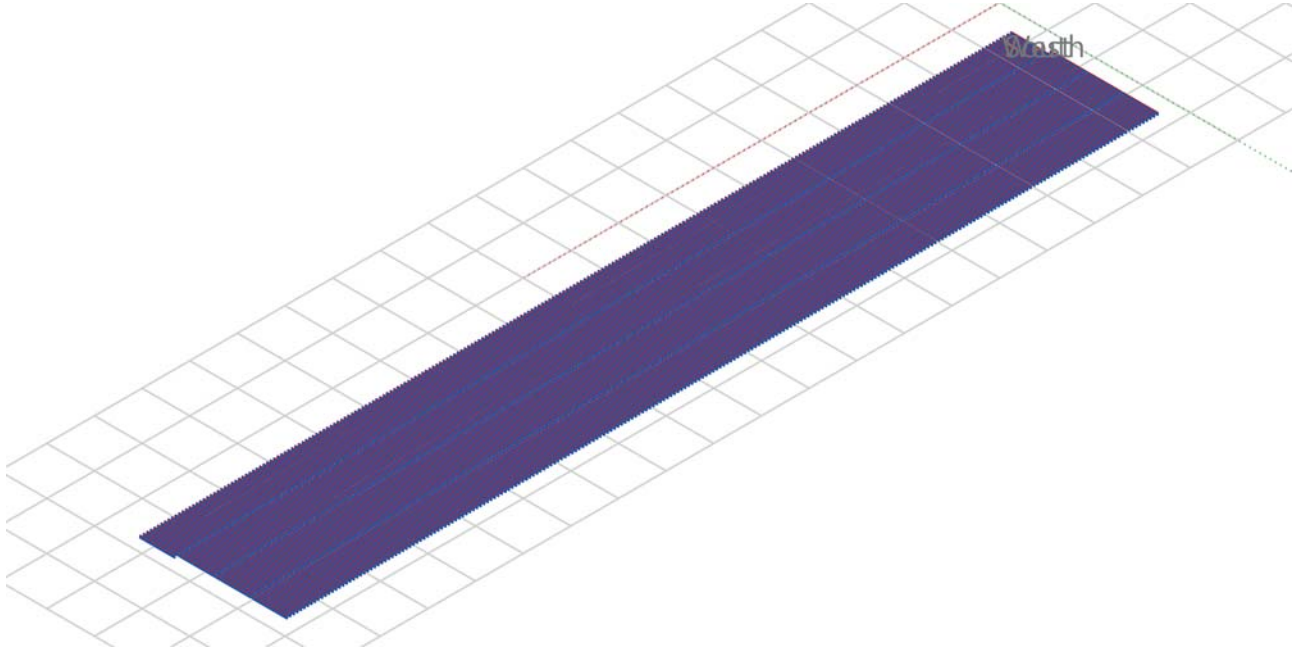
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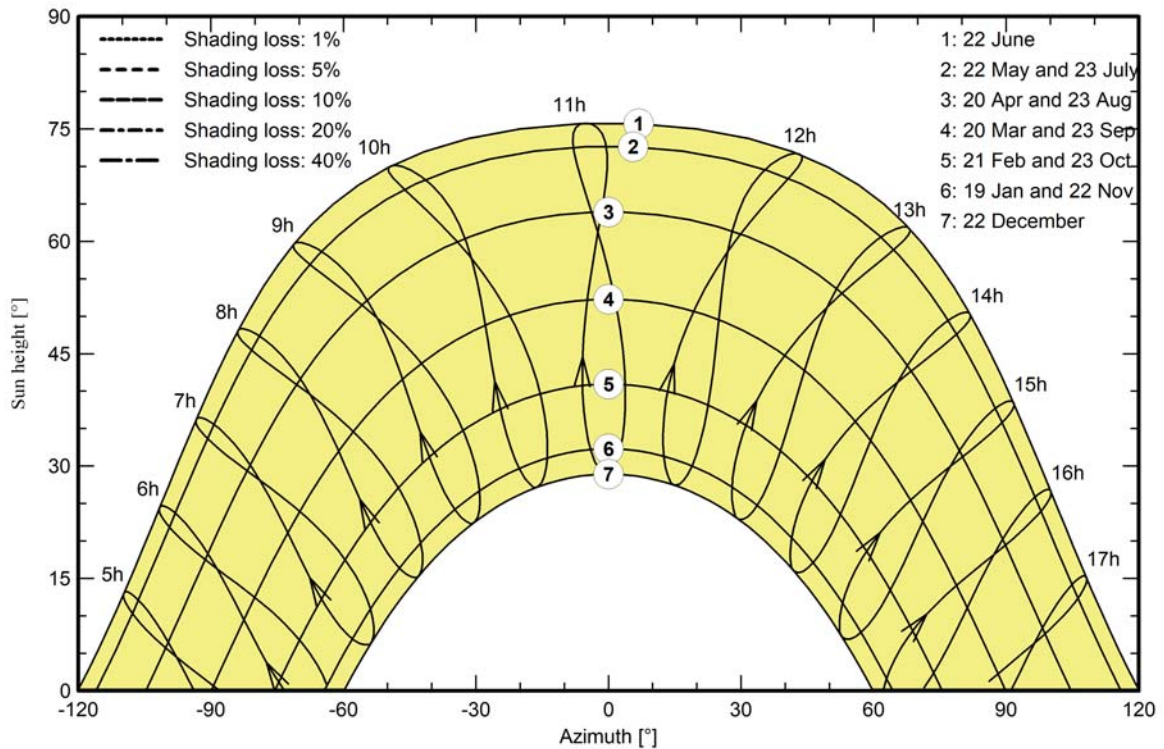
## Near shadings parameter

Perspective of the PV-field and surrounding shading scene



## Iso-shadings diagram

Orientation #1





# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

**PVsyst V7.4.6**

VDC, Simulation date:  
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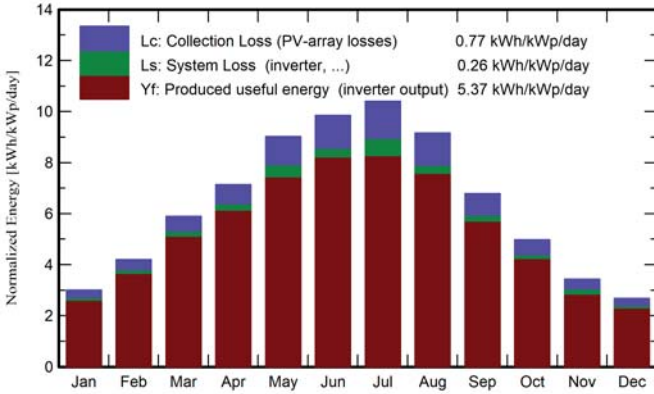
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## Main results

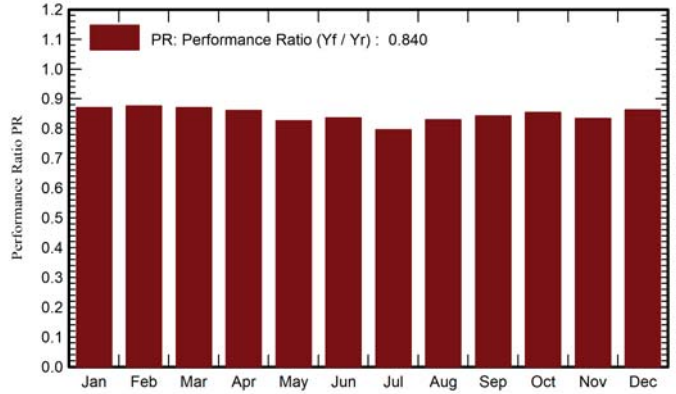
### System Production

Produced Energy	79503495 kWh/year	Specific production	1959 kWh/kWp/year
Apparent energy	82141159 kWh/year	Perf. Ratio PR	83.95 %

**Normalized productions (per installed kWp)**



**Performance Ratio PR**



## Balances and main results

	GlobHor kWh/m <sup>2</sup>	DiffHor kWh/m <sup>2</sup>	T_Amb °C	GlobInc kWh/m <sup>2</sup>	GlobEff kWh/m <sup>2</sup>	EArray kWh	E_Grid kWh	PR ratio
January	68.1	29.40	6.30	93.2	87.5	3412512	3292407	0.871
February	86.6	35.80	6.20	117.7	111.2	4327055	4179293	0.875
March	135.9	52.40	8.20	182.8	173.8	6699451	6459068	0.871
April	163.4	63.90	10.80	214.4	204.5	7786041	7489051	0.861
May	210.0	72.90	16.30	279.7	267.0	9978026	9381334	0.827
June	221.8	71.10	21.60	295.7	282.7	10437506	10028259	0.836
July	240.2	66.00	24.60	322.5	308.6	11263907	10419369	0.796
August	210.1	61.70	24.60	284.0	271.6	9944617	9550511	0.829
September	150.9	55.50	20.10	203.8	194.1	7233447	6962750	0.842
October	114.4	45.90	16.30	154.2	146.1	5538699	5346666	0.854
November	74.8	33.60	11.30	102.9	96.6	3721740	3481651	0.834
December	61.0	28.20	7.69	83.2	77.9	3021805	2913136	0.863
<b>Year</b>	<b>1737.2</b>	<b>616.40</b>	<b>14.55</b>	<b>2334.1</b>	<b>2221.6</b>	<b>83364807</b>	<b>79503495</b>	<b>0.840</b>

### 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: Petralia Sottana

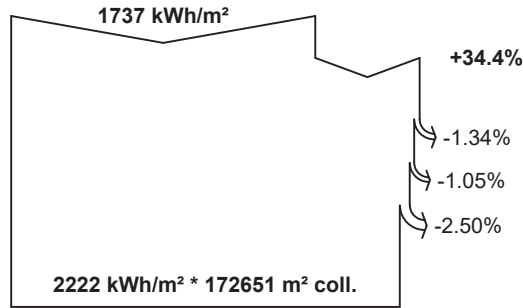
Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

PVsyst V7.4.6

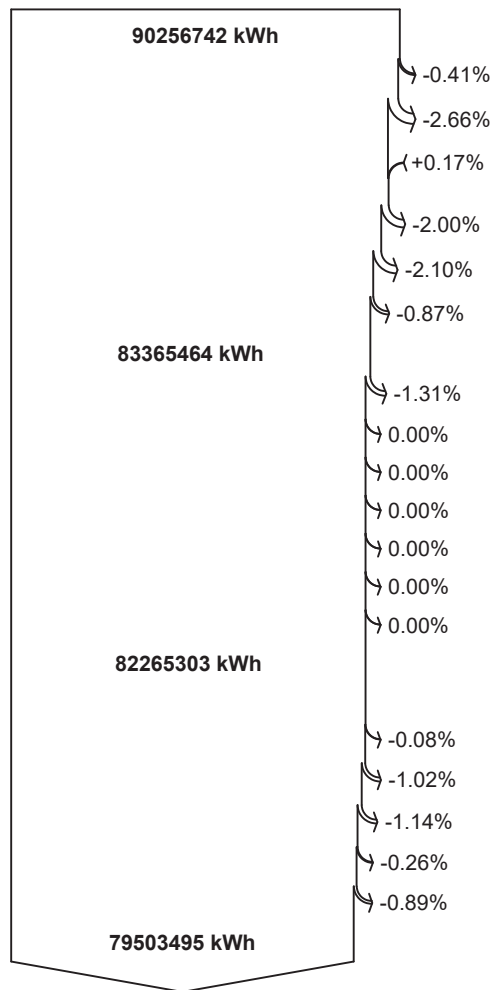
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## Loss diagram



efficiency at STC = 23.53%



20648591 kVARh  
82141159 kVAh

**Global horizontal irradiation**

**Global incident in coll. plane**

Near Shadings: irradiance loss

IAM factor on global

Soiling loss factor

**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

LID - Light induced degradation

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**

Auxiliaries (fans, other)

AC ohmic loss

Medium voltage transfo loss

MV line ohmic loss

System unavailability

**Active Energy injected into grid**

Reactive energy to the grid: Aver. cos(phi) = 0.970

**Apparent energy to the grid**



# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Monofacial panel 1V Tracker NS,  
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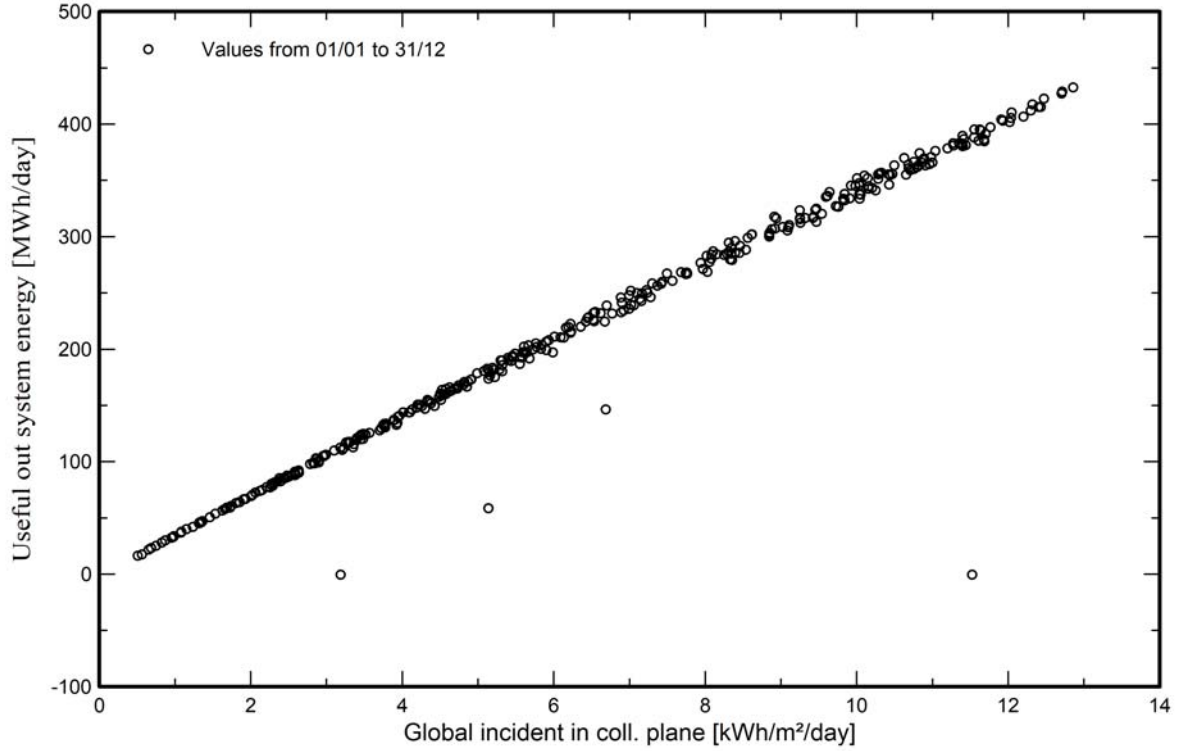
PVsyst V7.4.6

VDC, Simulation date:  
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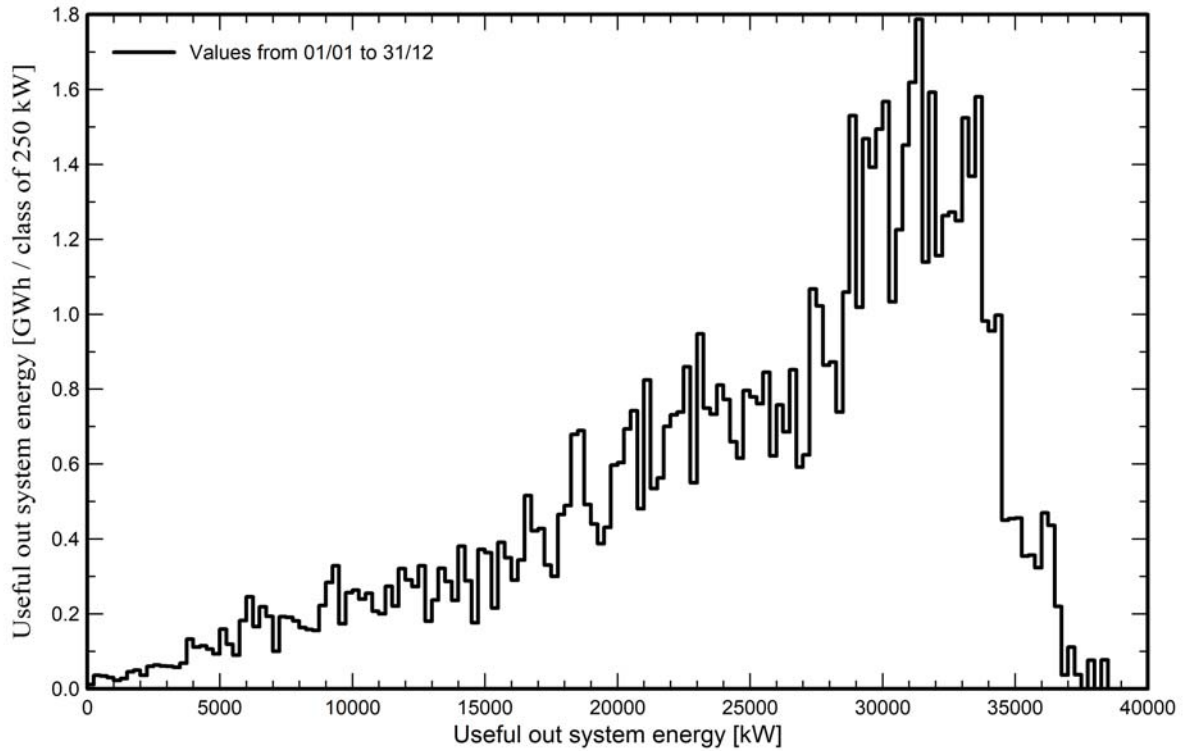
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## Predef. graphs

### Diagramma giornaliero entrata/uscita



### Distribuzione potenza in uscita sistema





# Project: Petralia Sottana

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## PVsyst V7.4.6

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### P50 - P90 evaluation

#### Weather data

Source SolarGIS Monthly aver. , period not spec.  
Kind TMY, multi-year  
Year-to-year variability(Variance) 2.5 %

#### Specified Deviation

Climate change 0.0 %

#### Global variability (weather data + system)

Variability (Quadratic sum) 3.1 %

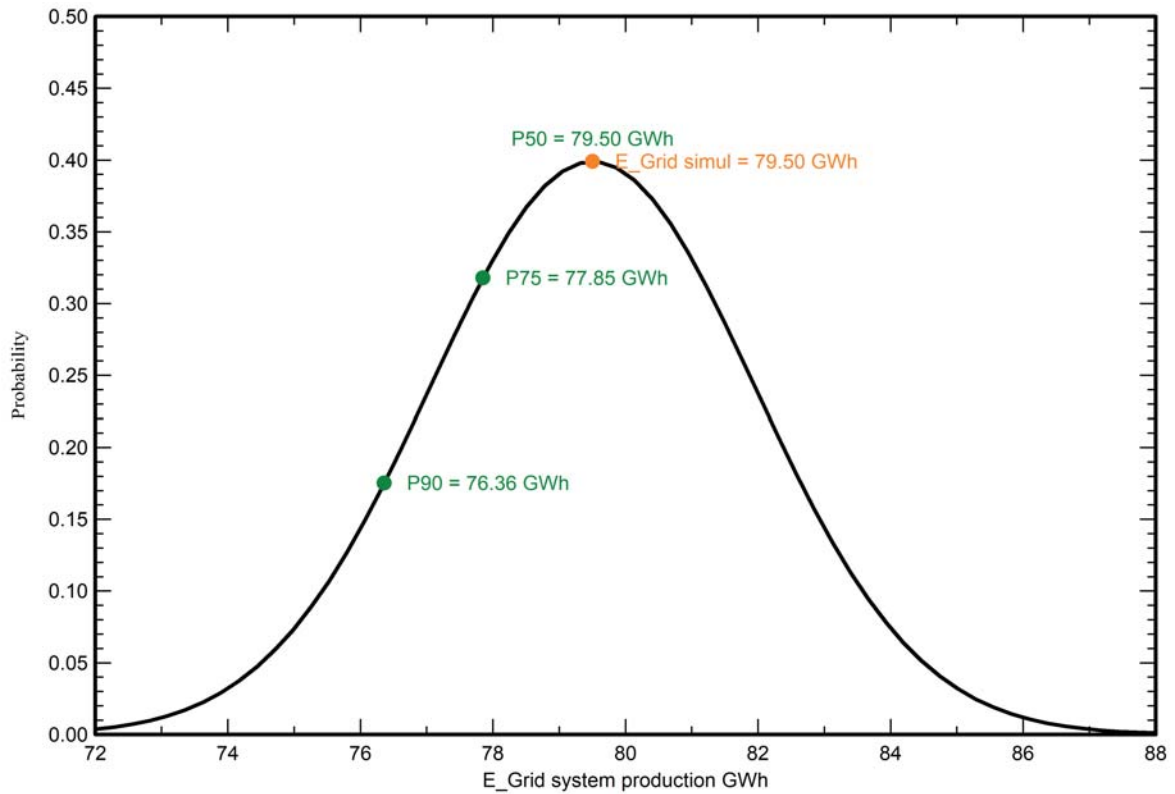
#### Simulation and parameters uncertainties

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	2.45 GWh
P50	79.50 GWh
P75	77.85 GWh
P90	76.36 GWh

### Probability distribution



# PVsyst - Simulation report

## Grid-Connected System

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Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS, pitch 7.4m Flat Terrain

Tracking system with backtracking

System power: 40.57 MWp

PetraliaSottana - Italia

**Autore**

Tozzi Green Spa (Italy)



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## PVsyst V7.4.6

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### Project summary

<b>Geographical Site</b> PetraliaSottana Italia	<b>Situation</b> Latitude 37.64 °N Longitude 13.99 °E Altitude 705 m Time zone UTC	<b>Project settings</b> Albedo 0.20
<b>Weather data</b> PetraliaSottana SolarGIS Monthly aver. , period not spec. - Sintetico		

### System summary

<b>Grid-Connected System</b>	<b>Tracking system with backtracking</b>	
<b>PV Field Orientation</b> <b>Orientation</b> Tracking plane, horizontal N-S axis Axis azimuth 180 °	<b>Tracking algorithm</b> Irradiance optimization Backtracking activated	<b>Near Shadings</b> Linear shadings : Slow (simul.) Diffuse shading Automatic
<b>System information</b> <b>PV Array</b> Nb. of modules 55580 units Pnom total 40.57 MWp	<b>Inverters</b> Nb. of units 123 units Pnom total 36.90 MWac Pnom ratio 1.100	
<b>User's needs</b> Unlimited load (grid)		

### Results summary

Produced Energy 85282474 kWh/year	Specific production 2102 kWh/kWp/year	Perf. Ratio PR 90.05 %
Apparent energy 88118400 kVAh/year		

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Tozzi Green Spa (Italy)

### General parameters

#### Grid-Connected System

#### PV Field Orientation

##### Orientation

Tracking plane, horizontal N-S axis  
Axis azimuth 180 °

#### Models used

Transposition Perez  
Diffuse Perez, Meteonorm  
Circumsolar separate

#### Horizon

Free Horizon

#### Bifacial system

Model 2D Calculation  
unlimited trackers

#### Bifacial model geometry

Tracker Spacing 7.40 m  
Tracker width 2.38 m  
GCR 32.2 %  
Axis height above ground 2.10 m

#### Grid injection point

##### Power factor

Cos(phi) (lagging) 0.970

#### Tracking system with backtracking

##### Tracking algorithm

Irradiance optimization  
Backtracking activated

#### Near Shadings

Linear shadings : Slow (simul.)  
Diffuse shading Automatic

##### Backtracking array

Nb. of trackers 992 units

##### Sizes

Tracker Spacing 7.40 m  
Collector width 2.38 m  
Ground Cov. Ratio (GCR) 32.2 %  
Phi min / max. -/+ 50.0 °

##### Backtracking strategy

Phi limits for BT -/+ 71.1 °  
Backtracking pitch 7.40 m  
Backtracking width 2.38 m

#### User's needs

Unlimited load (grid)

#### Bifacial model definitions

Ground albedo 0.23  
Bifaciality factor 88 %  
Rear shading factor 1.0 %  
Rear mismatch loss 2.0 %  
Shed transparent fraction 0.0 %

### PV Array Characteristics

#### PV module

Manufacturer Tongwei Solar  
Model TWMHF-66HD695-730-GG-Bifacial (TG)  
(Custom parameters definition)

Unit Nom. Power 730 Wp  
Number of PV modules 55580 units  
Nominal (STC) 40.57 MWp  
Modules 1985 string x 28 In series

#### At operating cond. (50°C)

Pmpp 38.18 MWp  
U mpp 1114 V  
I mpp 34287 A

#### Inverter

Manufacturer Huawei Technologies  
Model SUN2000-330KTL-H1- (TG)  
(Custom parameters definition)

Unit Nom. Power 300 kWac  
Number of inverters 123 units  
Total power 36900 kWac  
Operating voltage 500-1500 V  
Max. power (=>30°C) 330 kWac  
Pnom ratio (DC:AC) 1.10  
Power sharing within this inverter



# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

## PVsyst V7.4.6

VDB, Simulation date:  
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with V7.4.6

Tozzi Green Spa (Italy)

### PV Array Characteristics

Total PV power		Total inverter power	
Nominal (STC)	40573 kWp	Total power	36900 kWac
Total	55580 modules	Max. power	40590 kWac
Module area	172651 m <sup>2</sup>	Number of inverters	123 units
		Pnom ratio	1.10
		PNom limit forced to active power	

### Array losses

Array Soiling Losses		Thermal Loss factor		DC wiring losses				
Loss Fraction	2.5 %	Module temperature according to irradiance		Global array res.	0.38 mΩ			
		Uc (const)	29.0 W/m <sup>2</sup> K	Loss Fraction	1.1 % at STC			
		Uv (wind)	0.0 W/m <sup>2</sup> K/m/s					
Serie Diode Loss		LID - Light Induced Degradation		Module Quality Loss				
Voltage drop	0.7 V	Loss Fraction	2.0 %	Loss Fraction	-0.2 %			
Loss Fraction	0.1 % at STC							
Module mismatch losses		Strings Mismatch loss						
Loss Fraction	2.0 % at MPP	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

### System losses

Unavailability of the system		Auxiliaries loss	
Time fraction	0.8 %	constant (fans)	5.00 kW
	2.9 days,	0.0 kW from Power thresh.	
	3 periods	Night aux. cons.	10.00 kW

### AC wiring losses

Inv. output line up to MV transfo	
Inverter voltage	800 Vac tri
Loss Fraction	1.59 % at STC
Inverter: SUN2000-330KTL-H1- (TG)	
Wire section (123 Inv.)	Alu 123 x 3 x 240 mm <sup>2</sup>
Average wires length	225 m
MV line up to Injection	
MV Voltage	36 kV
Average each inverter	
Wires	Alu 3 x 700 mm <sup>2</sup>
Length	16450 m
Loss Fraction	0.40 % at STC



## Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

### PVsyst V7.4.6

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### AC losses in transformers

#### MV transfo

Medium voltage 36 kV

#### One transfo parameters

Nominal power at STC 6.64 MVA  
Iron Loss (24/24 Connexion) 6.18 kVA  
Iron loss fraction 0.09 % at STC  
Copper loss 71.75 kVA  
Copper loss fraction 1.08 % at STC  
Coils equivalent resistance 3 x 1.04 mΩ

#### Operating losses at STC (full system)

Nb. identical MV transfos 6  
Nominal power at STC 39.86 MVA  
Iron loss (24/24 Connexion) 37.07 kVA  
Copper loss 430.50 kVA



# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

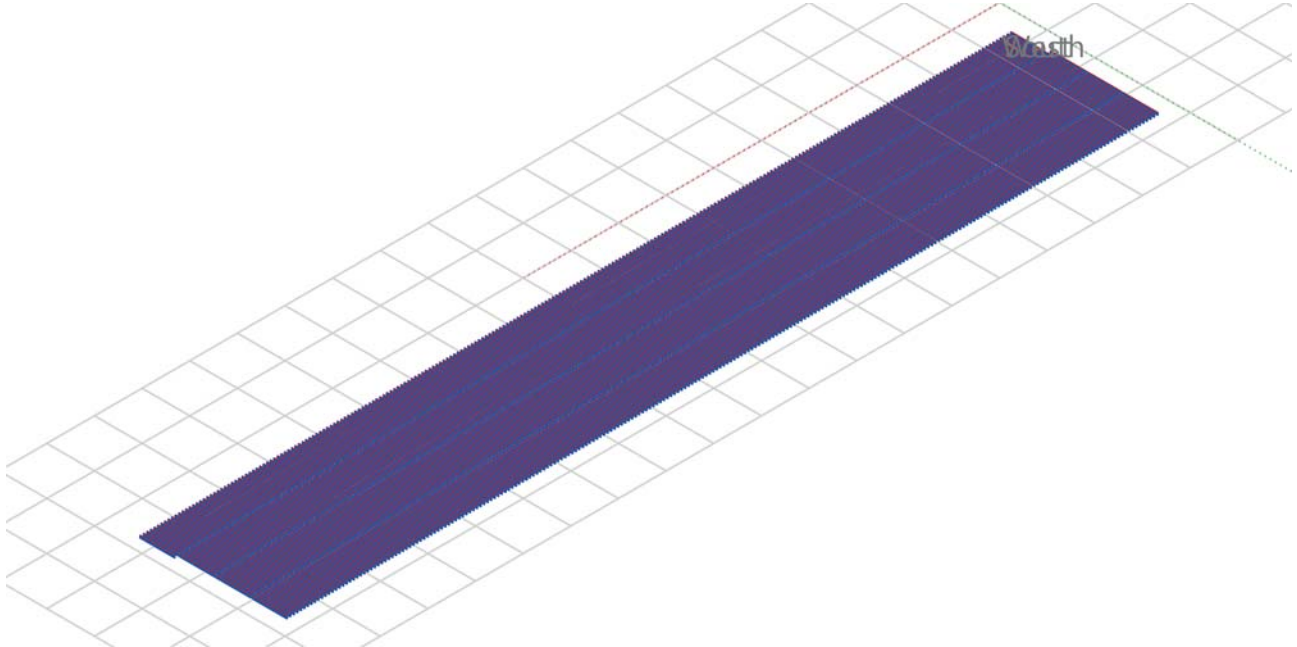
PVsyst V7.4.6

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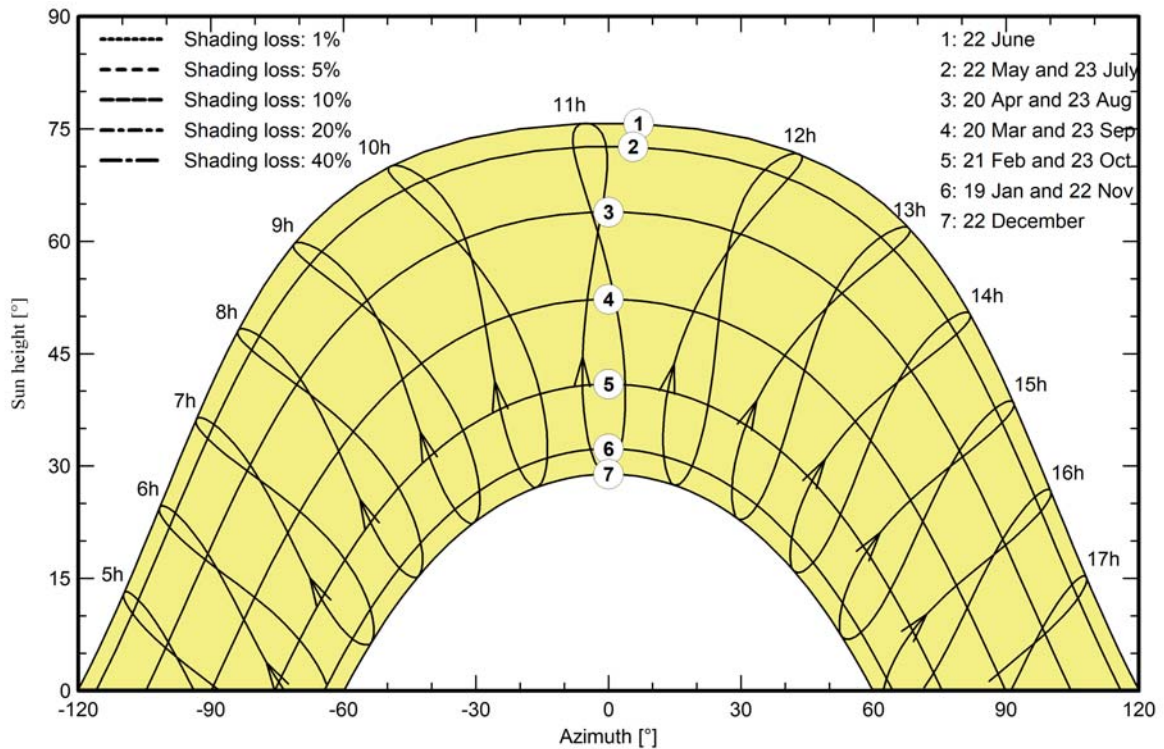
## Near shadings parameter

Perspective of the PV-field and surrounding shading scene



## Iso-shadings diagram

Orientation #1





# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

PVsyst V7.4.6

VDB, Simulation date:  
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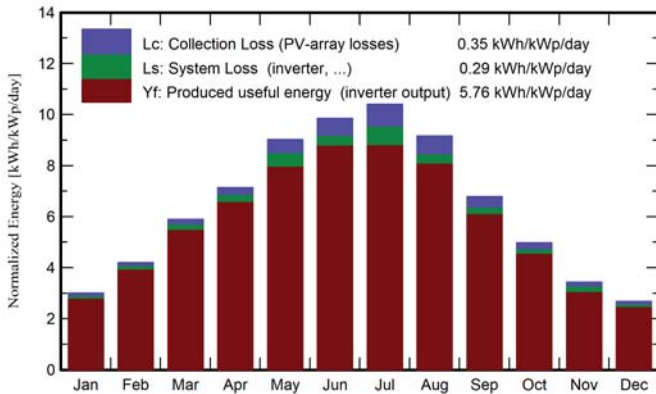
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## Main results

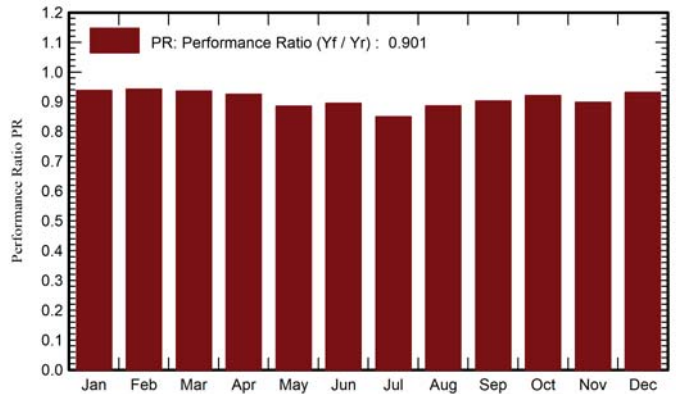
### System Production

Produced Energy	85282474 kWh/year	Specific production	2102 kWh/kWp/year
Apparent energy	88118400 kVAh/year	Perf. Ratio PR	90.05 %

Normalized productions (per installed kWp)



Performance Ratio PR



## Balances and main results

	GlobHor kWh/m <sup>2</sup>	DiffHor kWh/m <sup>2</sup>	T_Amb °C	GlobInc kWh/m <sup>2</sup>	GlobEff kWh/m <sup>2</sup>	EArray kWh	E_Grid kWh	PR ratio
January	68.1	29.40	6.30	93.2	87.8	3678347	3548520	0.938
February	86.6	35.80	6.20	117.7	111.6	4661725	4499595	0.942
March	135.9	52.40	8.20	182.8	174.5	7211424	6944174	0.936
April	163.4	63.90	10.80	214.4	205.3	8379440	8048026	0.925
May	210.0	72.90	16.30	279.7	268.1	10714092	10053412	0.886
June	221.8	71.10	21.60	295.7	283.9	11194454	10735792	0.895
July	240.2	66.00	24.60	322.5	309.8	12036106	11115616	0.850
August	210.1	61.70	24.60	284.0	272.8	10650692	10210851	0.886
September	150.9	55.50	20.10	203.8	194.8	7767413	7466944	0.903
October	114.4	45.90	16.30	154.2	146.7	5976039	5764045	0.921
November	74.8	33.60	11.30	102.9	97.0	4013918	3752276	0.899
December	61.0	28.20	7.69	83.2	78.2	3259583	3143223	0.932
Year	1737.2	616.40	14.55	2334.1	2230.5	89543234	85282474	0.901

### 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: Petralia Sottana

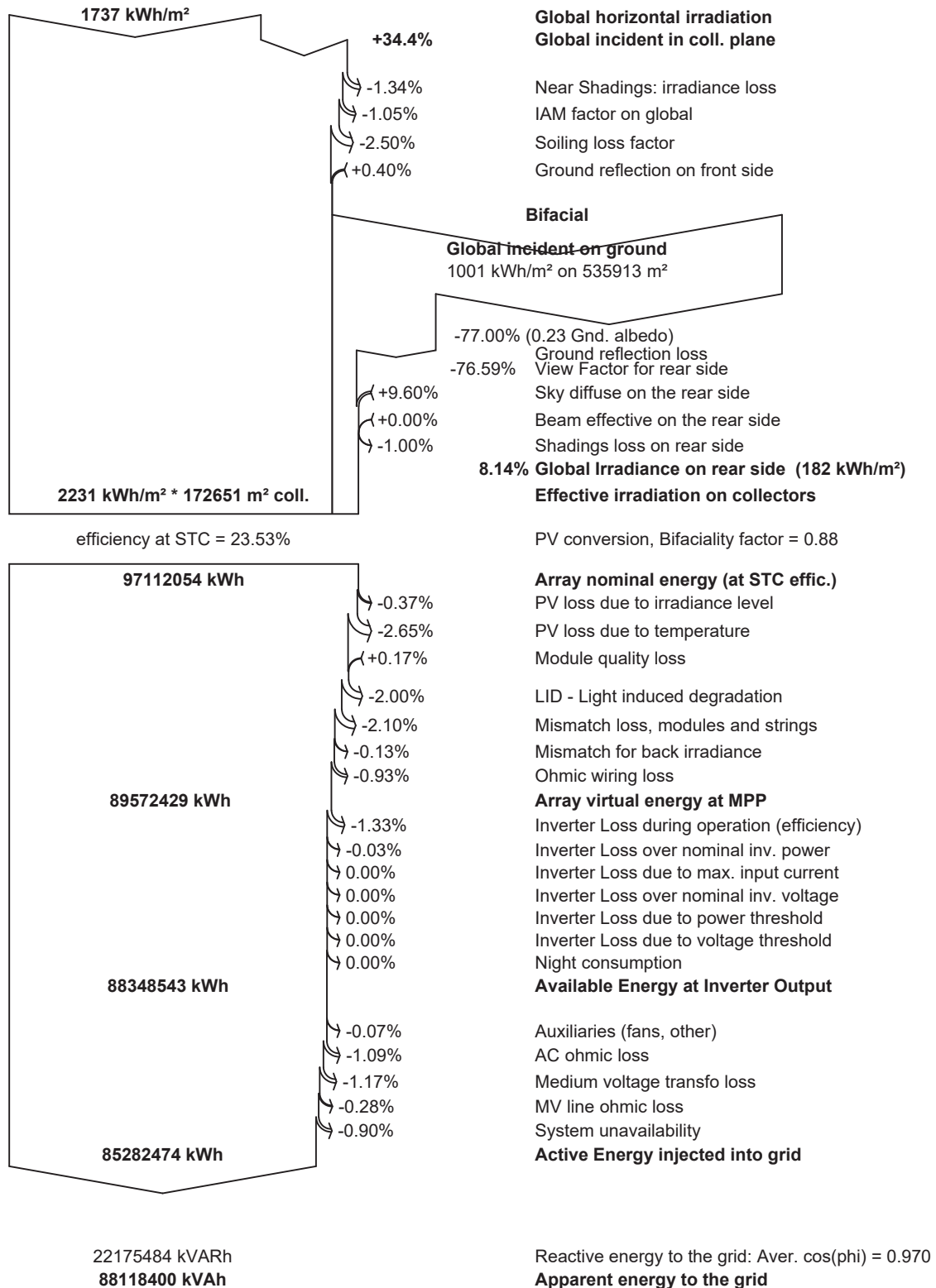
Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

PVsyst V7.4.6

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## Loss diagram





# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

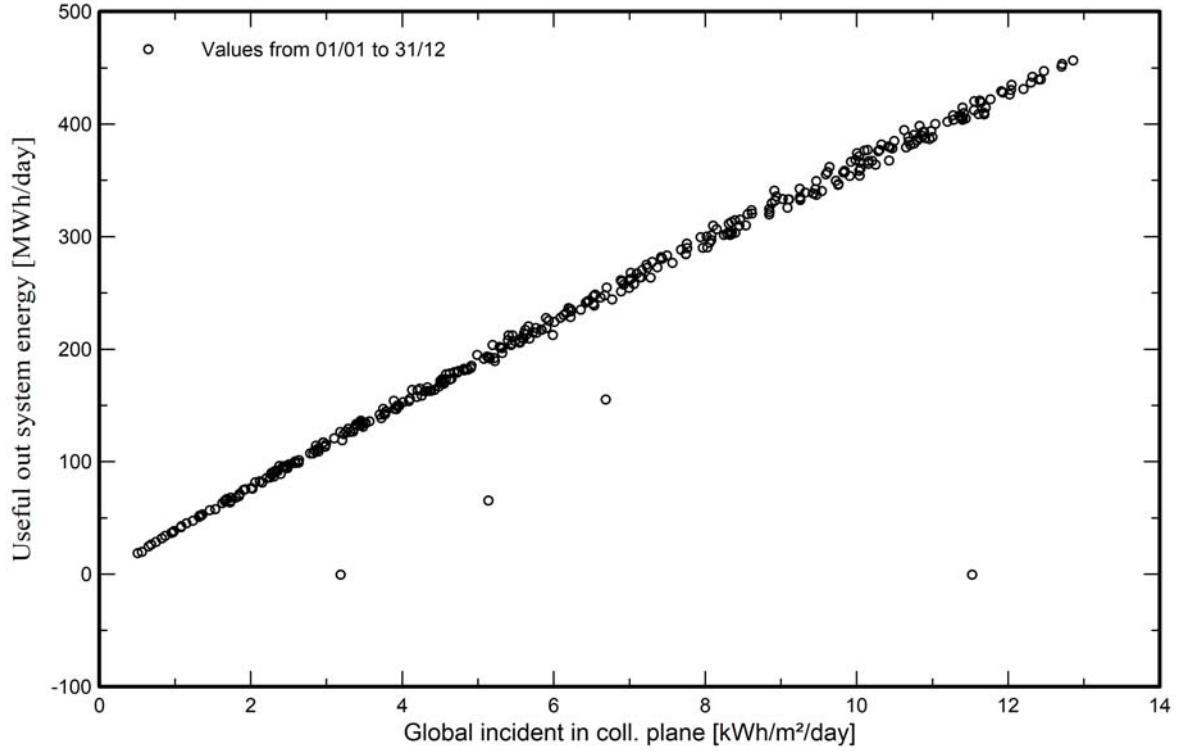
PVsyst V7.4.6

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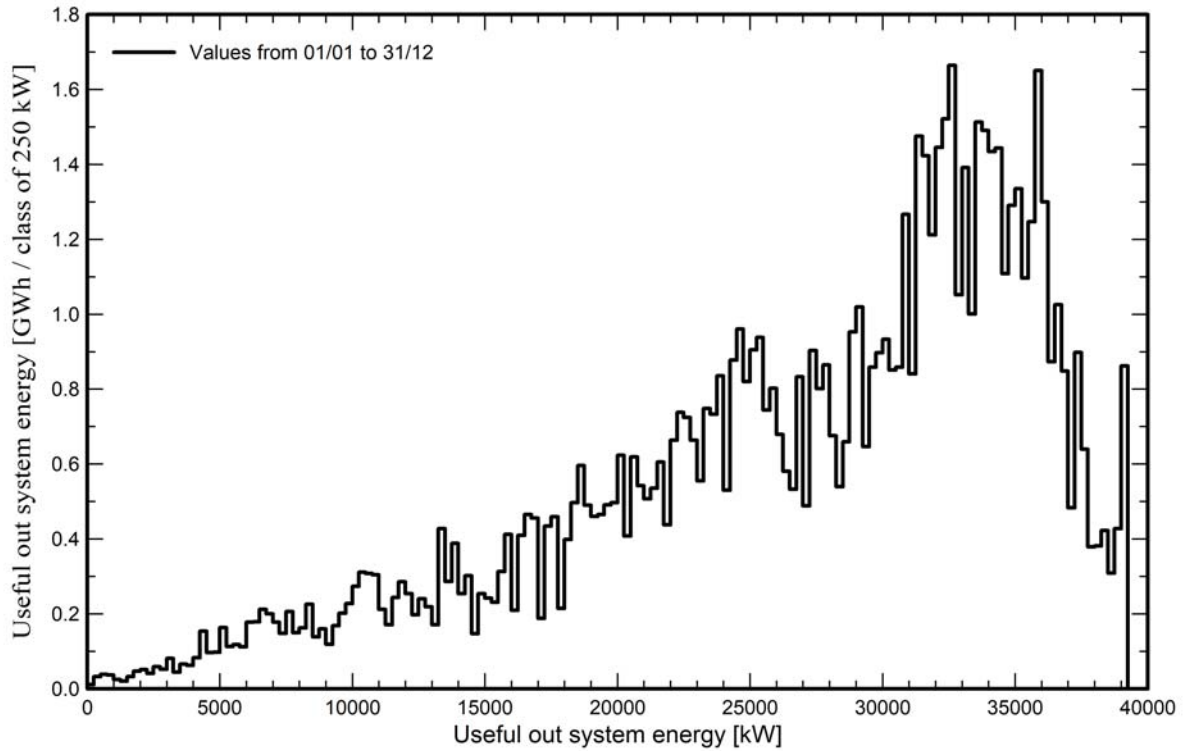
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## Predef. graphs

### Diagramma giornaliero entrata/uscita



### Distribuzione potenza in uscita sistema





# Project: Petralia Sottana

Variant: 40.560 kWp Petralia Sottana Mono Bifacial panel 1V Tracker NS,  
pitch 7.4m Flat Terrain

## PVsyst V7.4.6

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### P50 - P90 evaluation

#### Weather data

Source SolarGIS Monthly aver. , period not spec.  
Kind TMY, multi-year  
Year-to-year variability(Variance) 2.5 %

#### Specified Deviation

Climate change 0.0 %

#### Global variability (weather data + system)

Variability (Quadratic sum) 3.1 %

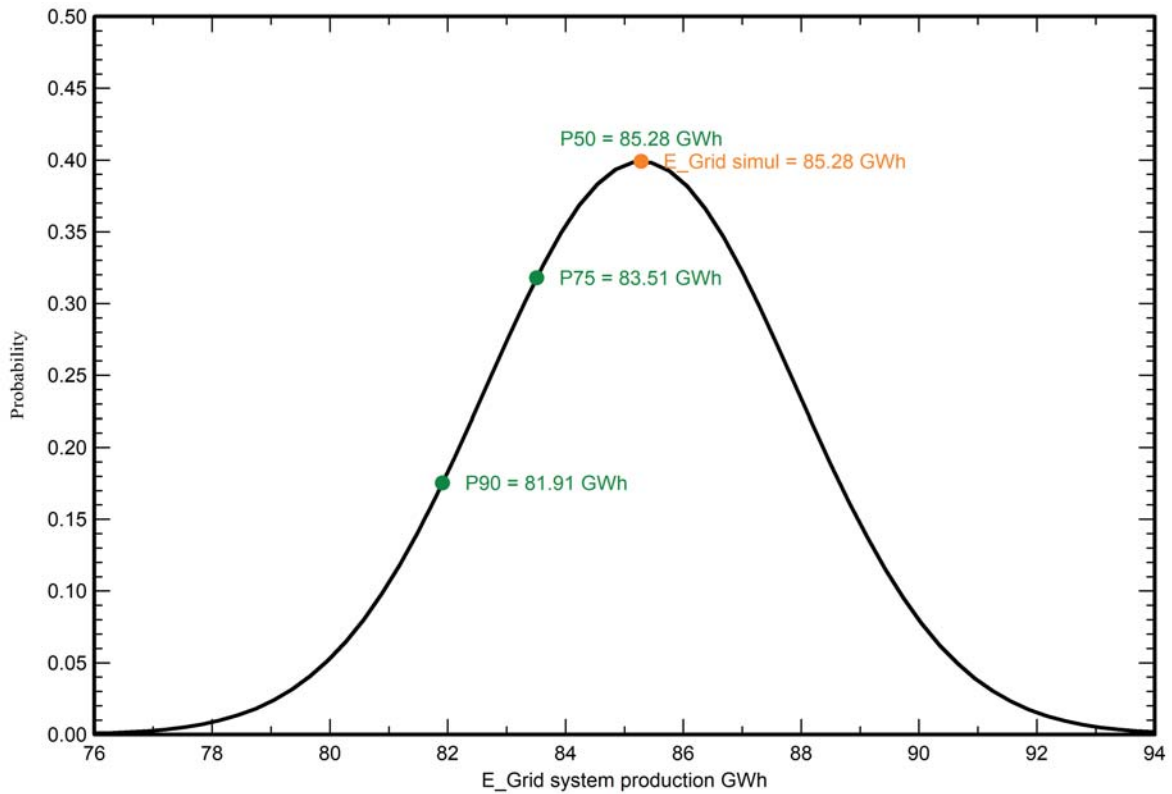
#### Simulation and parameters uncertainties

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	2.63 GWh
P50	85.28 GWh
P75	83.51 GWh
P90	81.91 GWh

### Probability distribution





# PVsyst - Simulation report

## Grid-Connected System

---

Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground  
toward North

Tracking system with backtracking

System power: 40.57 MWp

PetraliaSottana - Italy

**Autore**

Tozzi Green Spa (Italy)



# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

## PVsyst V7.4.6

VDA, Simulation date:  
26/03/24 14:54  
with V7.4.6

Tozzi Green Spa (Italy)

### Project summary

<b>Geographical Site</b>		<b>Situation</b>		<b>Project settings</b>	
PetraliaSottana		Latitude	37.64 °N	Albedo	0.20
Italy		Longitude	13.99 °E		
		Altitude	705 m		
		Time zone	UTC		
<b>Weather data</b>					
PetraliaSottana					
SolarGIS Monthly aver. , period not spec. - Sintetico					

### System summary

<b>Grid-Connected System</b>		<b>Tracking system with backtracking</b>			
<b>PV Field Orientation</b>		<b>Tracking algorithm</b>		<b>Near Shadings</b>	
<b>Orientation</b>		Irradiance optimization		Linear shadings : Slow (simul.)	
Tracking plane, tilted axis		Backtracking activated		Diffuse shading Automatic	
Axis Tilt	9 °				
Azimuth	180 °				
<b>System information</b>					
<b>PV Array</b>					
Nb. of modules	55580 units	<b>Inverters</b>		Nb. of units 123 units	
Pnom total	40.57 MWp	Pnom total		36.90 MWac	
		Pnom ratio		1.100	
<b>User's needs</b>					
Unlimited load (grid)					

### Results summary

Produced Energy	75071817 kWh/year	Specific production	1850 kWh/kWp/year	Perf. Ratio PR	83.84 %
Apparent energy	77560462 kVAh/year				

### Table of contents

Project and results summary	2
General parameters, PV Array Characteristics, System losses	3
Near shading definition - Iso-shadings diagram	5
Main results	6
Loss diagram	7
Predef. graphs	8
P50 - P90 evaluation	9



# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

## PVsyst V7.4.6

VDA, Simulation date:  
26/03/24 14:54  
with V7.4.6

Tozzi Green Spa (Italy)

### General parameters

<b>Grid-Connected System</b>		<b>Tracking system with backtracking</b>	
<b>PV Field Orientation</b>		<b>Tracking algorithm</b>	<b>Backtracking array</b>
<b>Orientation</b>		Irradiance optimization	Nb. of trackers 992 units
Tracking plane, tilted axis		Backtracking activated	<b>Sizes</b>
Axis Tilt	9 °		Tracker Spacing 7.40 m
Azimuth	180 °		Collector width 2.38 m
			Ground Cov. Ratio (GCR) 32.2 %
			Phi min / max. -/+ 50.0 °
			<b>Backtracking strategy</b>
			Phi limits for BT -/+ 71.1 °
			Backtracking pitch 7.40 m
			Backtracking width 2.38 m
<b>Models used</b>		<b>Near Shadings</b>	<b>User's needs</b>
Transposition	Perez	Linear shadings : Slow (simul.)	Unlimited load (grid)
Diffuse	Perez, Meteonorm	Diffuse shading Automatic	
Circumsolar	separate		
<b>Horizon</b>			
Free Horizon			
<b>Grid injection point</b>			
<b>Power factor</b>			
Cos(phi) (lagging)	0.970		

### PV Array Characteristics

<b>PV module</b>		<b>Inverter</b>	
Manufacturer	Tongwei Solar	Manufacturer	Huawei Technologies
Model	TWMHF-66HD695-730-GG-Bifacial (TG)	Model	SUN2000-330KTL-H1- (TG)
(Custom parameters definition)		(Custom parameters definition)	
Unit Nom. Power	730 Wp	Unit Nom. Power	300 kWac
Number of PV modules	55580 units	Number of inverters	123 units
Nominal (STC)	40.57 MWp	Total power	36900 kWac
Modules	1985 string x 28 In series	Operating voltage	500-1500 V
<b>At operating cond. (50°C)</b>		Max. power (=>30°C)	330 kWac
Pmpp	38.18 MWp	Pnom ratio (DC:AC)	1.10
U mpp	1114 V	Power sharing within this inverter	
I mpp	34287 A		
<b>Total PV power</b>		<b>Total inverter power</b>	
Nominal (STC)	40573 kWp	Total power	36900 kWac
Total	55580 modules	Max. power	40590 kWac
Module area	172651 m²	Number of inverters	123 units
		Pnom ratio	1.10
		PNom limit forced to active power	



# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

## PVsyst V7.4.6

VDA, Simulation date:  
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with V7.4.6

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### Array losses

#### Array Soiling Losses

Loss Fraction 2.5 %

#### Thermal Loss factor

Module temperature according to irradiance

Uc (const) 29.0 W/m<sup>2</sup>K

Uv (wind) 0.0 W/m<sup>2</sup>K/m/s

#### DC wiring losses

Global array res. 0.38 mΩ

Loss Fraction 1.1 % at STC

#### 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 -0.2 %

#### 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

### System losses

#### Unavailability of the system

Time fraction 0.8 %

2.9 days,

3 periods

#### Auxiliaries loss

constant (fans) 5.00 kW

0.0 kW from Power thresh.

Night aux. cons. 10.00 kW

### AC wiring losses

#### Inv. output line up to MV transfo

Inverter voltage 800 Vac tri

Loss Fraction 1.59 % at STC

#### Inverter: SUN2000-330KTL-H1- (TG)

Wire section (123 Inv.) Alu 123 x 3 x 240 mm<sup>2</sup>

Average wires length 225 m

#### MV line up to Injection

MV Voltage 36 kV

Average each inverter

Wires Alu 3 x 700 mm<sup>2</sup>

Length 16450 m

Loss Fraction 0.40 % at STC

### AC losses in transformers

#### MV transfo

Medium voltage 36 kV

#### One transfo parameters

Nominal power at STC 6.64 MVA

Iron Loss (24/24 Connexion) 6.18 kVA

Iron loss fraction 0.09 % at STC

Copper loss 71.76 kVA

Copper loss fraction 1.08 % at STC

Coils equivalent resistance 3 x 1.04 mΩ

#### Operating losses at STC (full system)

Nb. identical MV transfos 6

Nominal power at STC 39.86 MVA

Iron loss (24/24 Connexion) 37.07 kVA

Copper loss 430.54 kVA



# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

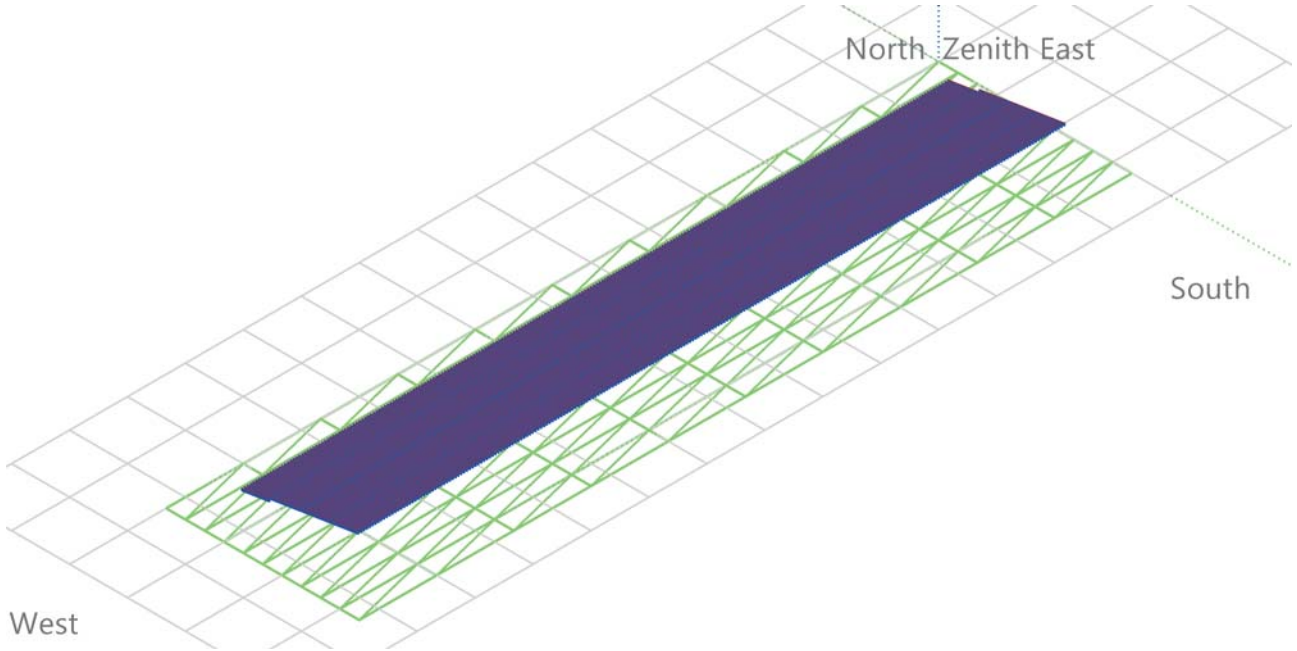
PVsyst V7.4.6

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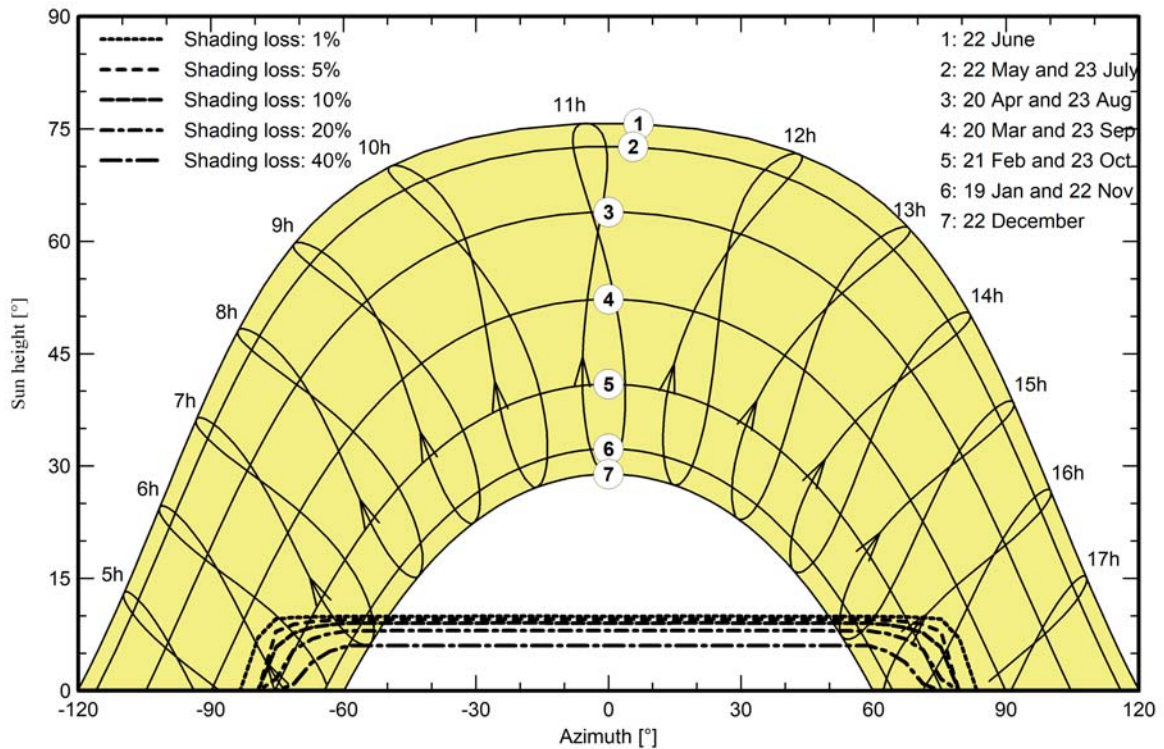
## Near shadings parameter

Perspective of the PV-field and surrounding shading scene



## Iso-shadings diagram

Orientation #1





# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

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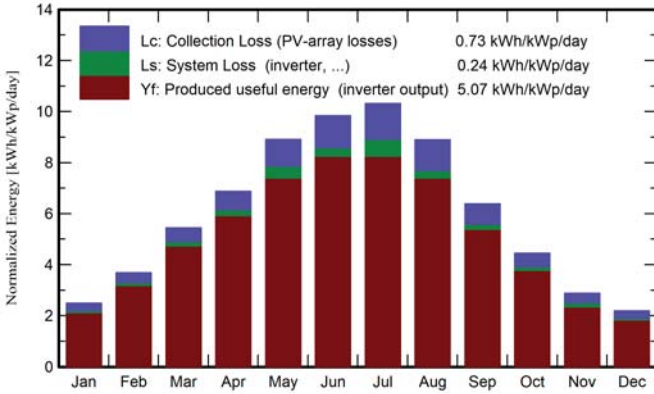
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## Main results

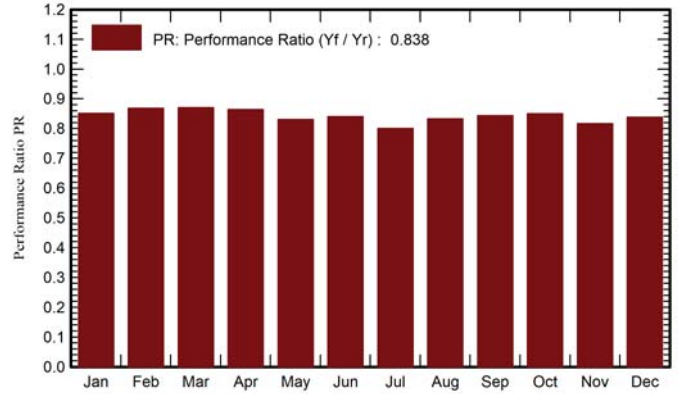
### System Production

Produced Energy	75071817 kWh/year	Specific production	1850 kWh/kWp/year
Apparent energy	77560462 kVAh/year	Perf. Ratio PR	83.84 %

Normalized productions (per installed kWp)



Performance Ratio PR



## Balances and main results

	GlobHor kWh/m <sup>2</sup>	DiffHor kWh/m <sup>2</sup>	T_Amb °C	GlobInc kWh/m <sup>2</sup>	GlobEff kWh/m <sup>2</sup>	EArray kWh	E_Grid kWh	PR ratio
January	68.1	29.40	6.30	77.3	70.9	2767573	2670119	0.851
February	86.6	35.80	6.20	103.1	96.4	3757606	3632570	0.868
March	135.9	52.40	8.20	168.9	160.0	6181377	5966998	0.871
April	163.4	63.90	10.80	206.2	196.7	7505820	7226958	0.864
May	210.0	72.90	16.30	276.3	264.3	9892683	9310158	0.831
June	221.8	71.10	21.60	295.1	282.9	10461599	10058498	0.840
July	240.2	66.00	24.60	319.9	306.9	11222900	10390588	0.800
August	210.1	61.70	24.60	275.9	264.2	9695158	9319807	0.832
September	150.9	55.50	20.10	191.7	182.2	6808130	6561492	0.843
October	114.4	45.90	16.30	138.1	129.8	4931037	4764798	0.850
November	74.8	33.60	11.30	86.3	79.4	3059115	2861505	0.817
December	61.0	28.20	7.69	67.9	61.7	2395031	2308325	0.838
Year	1737.2	616.40	14.55	2206.8	2095.2	78678030	75071817	0.838

### 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: Petralia Sottana

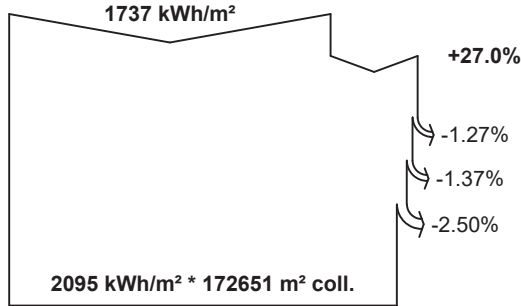
Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

PVsyst V7.4.6

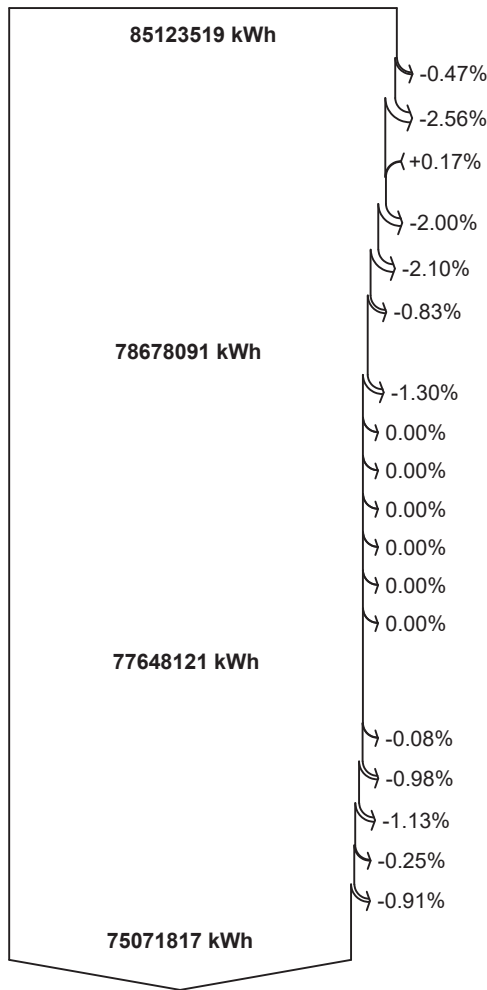
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Tozzi Green Spa (Italy)

## Loss diagram



efficiency at STC = 23.53%



19489678 kVARh  
77560462 kVAh

**Global horizontal irradiation**  
**Global incident in coll. plane**

Near Shadings: irradiance loss  
IAM factor on global  
Soiling loss factor

**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

LID - Light induced degradation

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**

Auxiliaries (fans, other)

AC ohmic loss

Medium voltage transfo loss

MV line ohmic loss

System unavailability

**Active Energy injected into grid**

Reactive energy to the grid: Aver. cos(phi) = 0.970

**Apparent energy to the grid**



# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch 7.4m 9° Sloped Ground toward North

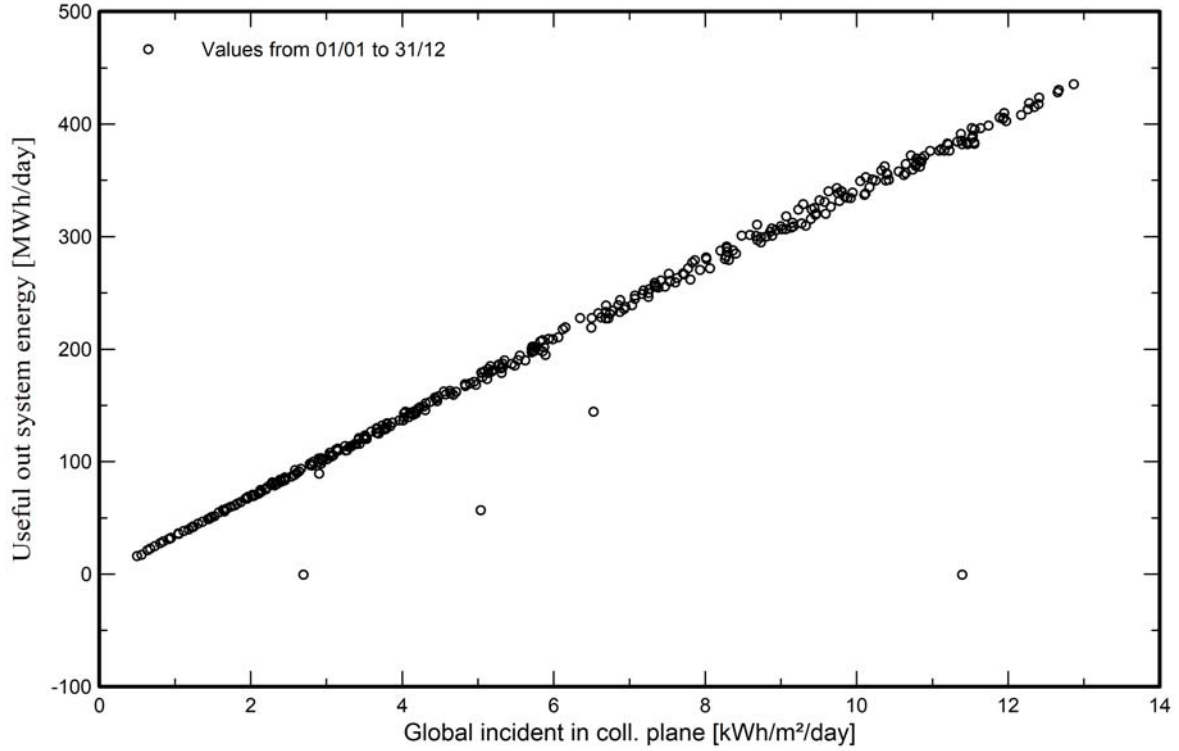
PVsyst V7.4.6

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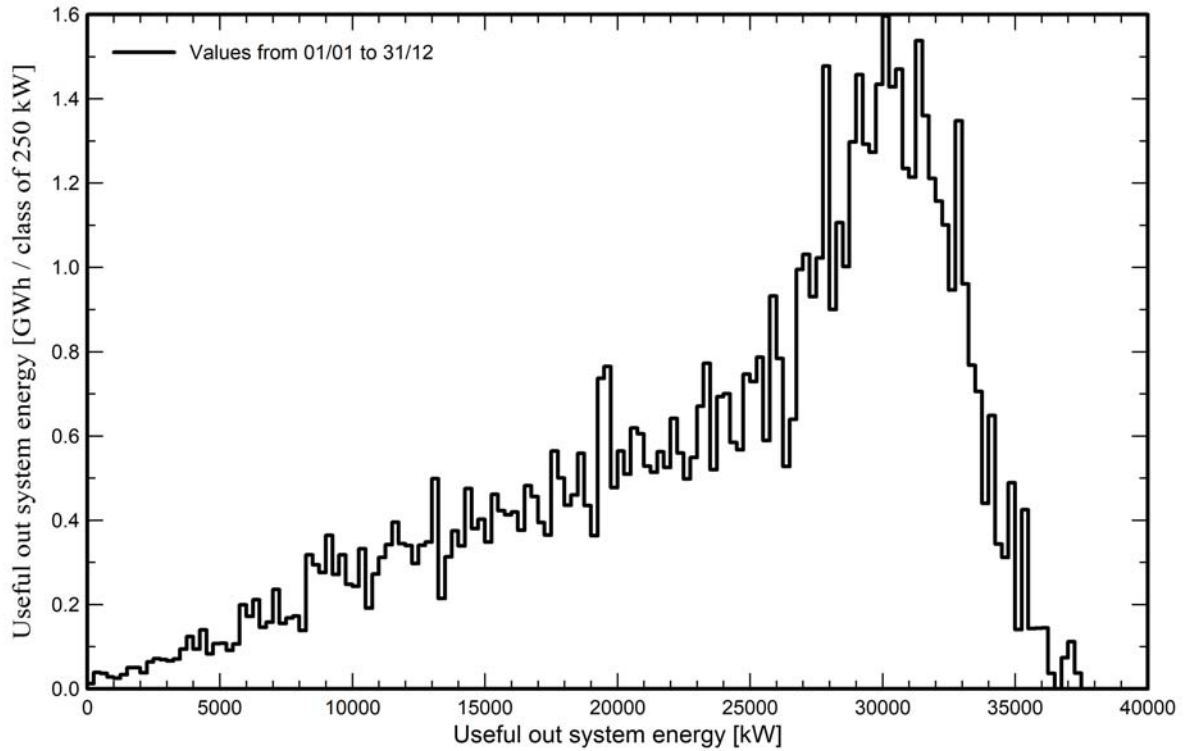
Tozzi Green Spa (Italy)

## Predef. graphs

### Diagramma giornaliero entrata/uscita



### Distribuzione potenza in uscita sistema







# Project: Petralia Sottana

Variant: 40.570 kWp Petralia Sottana Mono Panel 1V Tracker NS, pitch  
7.4m 9° Sloped Ground toward North

## PVsyst V7.4.6

VDA, Simulation date:  
26/03/24 14:54  
with V7.4.6

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### P50 - P90 evaluation

#### Weather data

Source SolarGIS Monthly aver. , period not spec.  
Kind TMY, multi-year  
Year-to-year variability(Variance) 2.5 %

#### Specified Deviation

Climate change 0.0 %

#### Global variability (weather data + system)

Variability (Quadratic sum) 3.1 %

#### 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 2.31 GWh  
P50 75.07 GWh  
P75 73.51 GWh  
P90 72.10 GWh

### Probability distribution

