PVsyst - Simulation report

Grid-Connected System

Project: REN176 Poirino

Variant: Layout Ottobre 2022 - 46,7 MWp 36 kV SMA 4,6 MVA x 10

Tracking system with backtracking

System power: 46.72 MWp

Ternavasso - Italy

Author

Renergetica S.p.a. (Italy)

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Project summary

Geographical Site
Ternavasso

Italy

Situation			Project settings	
Latitude	44.85 °N		Albedo	0.20
Longitude	7.86 °E			
Altitude	282 m			
Time zone	UTC+1			

Meteo data
Ternavasso

PVGIS api TMY

System summary

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

PV Field Orientation
Orientation

Tracking plane, horizontal N-S axis

Axis azimuth   0 °

Tracking algorithm

Astronomic calculation

Backtracking activated

Near Shadings

According to strings

Electrical effect	100 %

System information
PV Array

Nb. of modules	67228 units
Pnom total	46.72 MWp

Inverters

Nb. of units	10 units
Pnom total	46.00 MWac
Grid power limit	60.00 MWac
Grid lim. Pnom ratio	0.779

User's needs
Unlimited load (grid)

Results summary

Produced Energy	81.11 GWh/year	Specific production	1736 kWh/kWp/year	Perf. Ratio PR	86.88 %

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General parameters

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

PV Field Orientation

Orientation		Tracking algorithm		Backtracking array	
Tracking plane, horizontal N-S axis		Astronomic calculation		Nb. of trackers	880 units
Axis azimuth	0 °	Backtracking activated		Identical arrays	
				Sizes	
				Tracker Spacing	12.0 m
				Collector width	4.79 m
				Ground Cov. Ratio (GCR)	39.9 %
				Phi min / max.	-/+ 55.0 °
				Backtracking strategy	
				Phi limits	+/- 66.4 °
				Backtracking pitch	12.0 m
				Backtracking width	4.79 m

Models used

Transposition	Perez
Diffuse	Imported
Circumsolar	separate

Horizon		**Near Shadings**		**User's needs**	
Average Height	1.1 °	According to strings		Unlimited load (grid)	
		Electrical effect	100 %		

Bifacial system

Model	2D Calculation
	unlimited trackers

Bifacial model geometry		**Bifacial model definitions**	
Tracker Spacing	12.00 m	Ground albedo	0.20
Tracker width	4.79 m	Bifaciality factor	75 %
GCR	39.9 %	Rear shading factor	5.0 %
Axis height above ground	2.10 m	Rear mismatch loss	10.0 %
		Shed transparent fraction	0.0 %

Grid power limitation

Active Power	60.00 MWac
Pnom ratio	0.779

PV Array Characteristics

PV module		**Inverter**	
Manufacturer	Jolywood	Manufacturer	SMA
Model	JW-HD132N	Model	Sunny Central 4600 UP
(Custom parameters definition)		(Original PVsyst database)	
Unit Nom. Power	695 Wp	Unit Nom. Power	4600 kWac
Number of PV modules	67228 units	Number of inverters	10 units
Nominal (STC)	46.72 MWp	Total power	46000 kWac
Modules	2401 Strings x 28 In series	Operating voltage	1003-1325 V
At operating cond. (50°C)		Pnom ratio (DC:AC)	1.02
Pmpp	43.60 MWp		
U mpp	1011 V		
I mpp	43142 A		

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PV Array Characteristics

Total PV power		**Total inverter power**	
Nominal (STC)	46723 kWp	Total power	46000 kWac
Total	67228 modules	Number of inverters	10 units
Module area	208834 m²	Pnom ratio	1.02
Cell area	195674 m²		

Array losses

Array Soiling Losses		**Thermal Loss factor**		**DC wiring losses**	
Loss Fraction	2.0 %	Module temperature according to irradiance		Global array res.	0.38 mΩ
		Uc (const)	20.0 W/m²K	Loss Fraction	1.5 % at STC
		Uv (wind)	0.0 W/m²K/m/s		

LID - Light Induced Degradation		**Module Quality Loss**		**Module mismatch losses**	
Loss Fraction	0.5 %	Loss Fraction	-0.2 %	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

Auxiliaries loss
constant (fans)   20.0 kW
20.0 kW from Power thresh.

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage	690 Vac tri
Loss Fraction	0.11 % at STC

Inverter: Sunny Central 4600 UP

Wire section (10 Inv.)	Copper 10 x 3 x 2500 mm²
Average wires length	15 m

MV line up to Injection

MV Voltage	36 kV
Average each inverter	
Wires	Copper 3 x 700 mm²
Length	10000 m
Loss Fraction	0.10 % at STC

AC losses in transformers

MV transfo

Grid voltage	36 kV

Operating losses at STC

Nominal power at STC	45939 kVA
Iron loss (night disconnect)	4.59 kW/Inv.
Loss Fraction	0.10 % at STC
Coils equivalent resistance	3 x 1.04 mΩ/inv.
Loss Fraction	1.00 % at STC

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Horizon definition

Horizon from PVGIS website API, Lat=44°50"58', Long=7°51"25', Alt=282m

Average Height	1.1 °	Albedo Factor	0.91
Diffuse Factor	0.97	Albedo Fraction	100 %

Horizon profile

Azimuth [°]	-180	-173	-165	-158	-150	-128	-120	-68	-60	0	8	15	23	30
Height [°]	1.5	0.8	0.4	0.4	0.0	0.0	0.4	0.4	1.1	1.1	1.5	1.1	1.1	1.5
Azimuth [°]	60	68	75	83	90	113	120	128	135	143	165	173	180	
Height [°]	1.5	1.9	2.3	1.5	1.9	1.9	1.5	2.3	1.9	1.5	1.5	1.1	1.5	

Sun Paths (Height / Azimuth diagram)
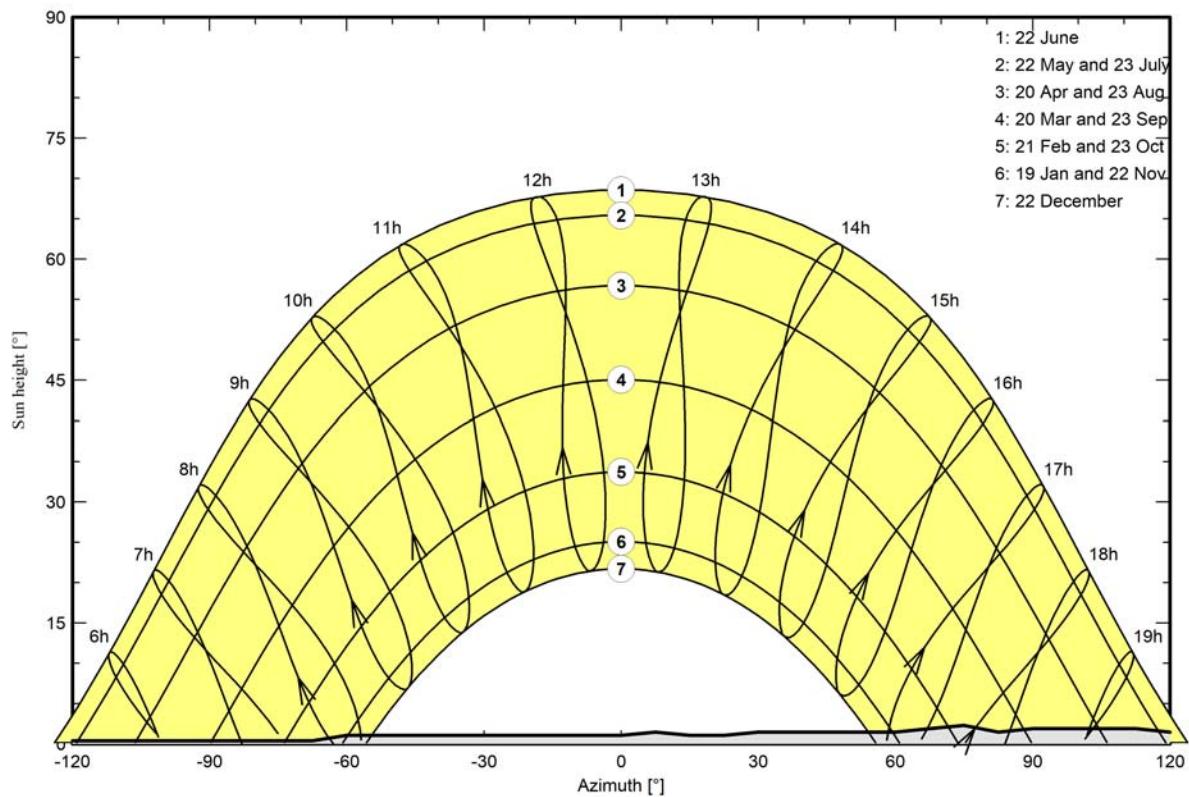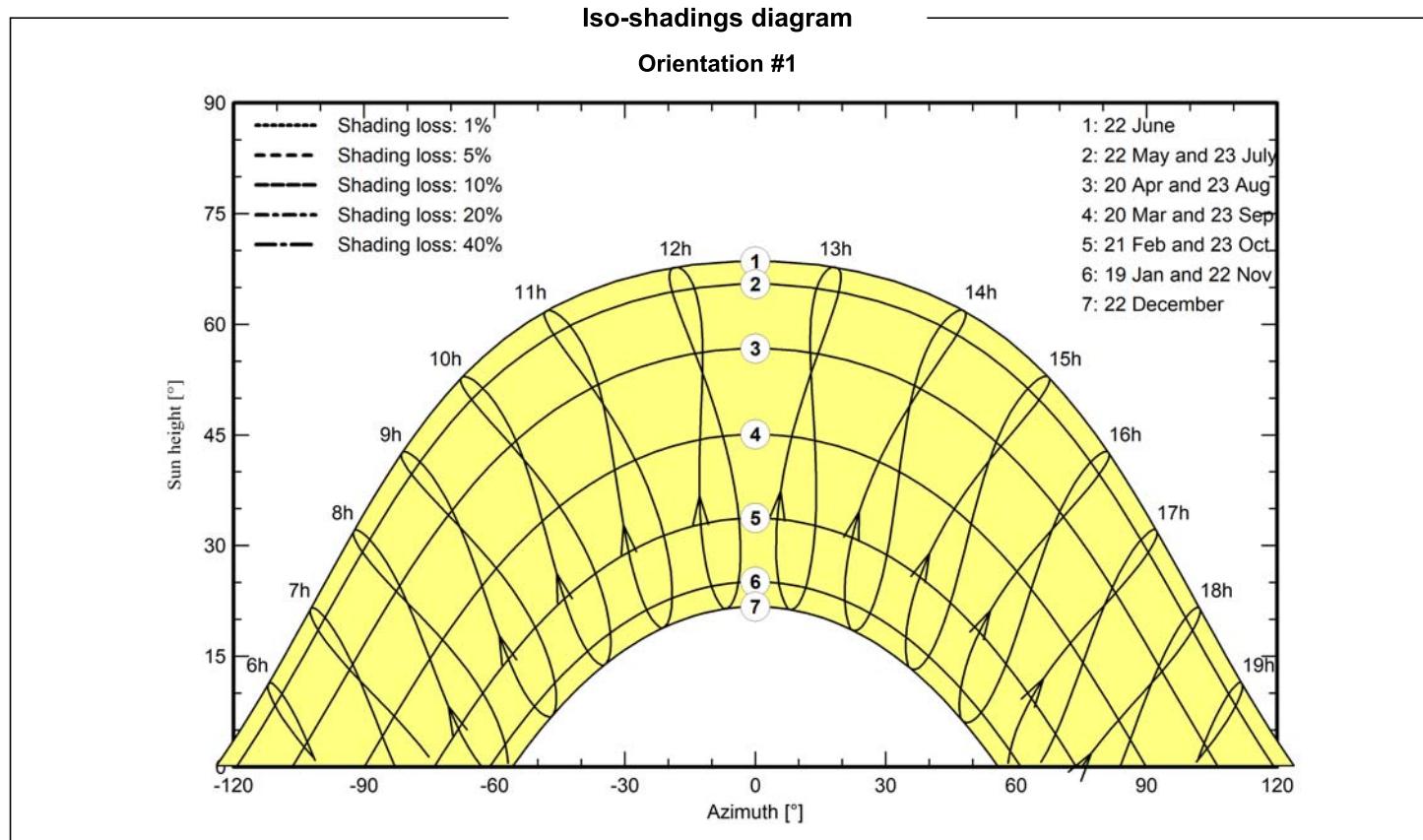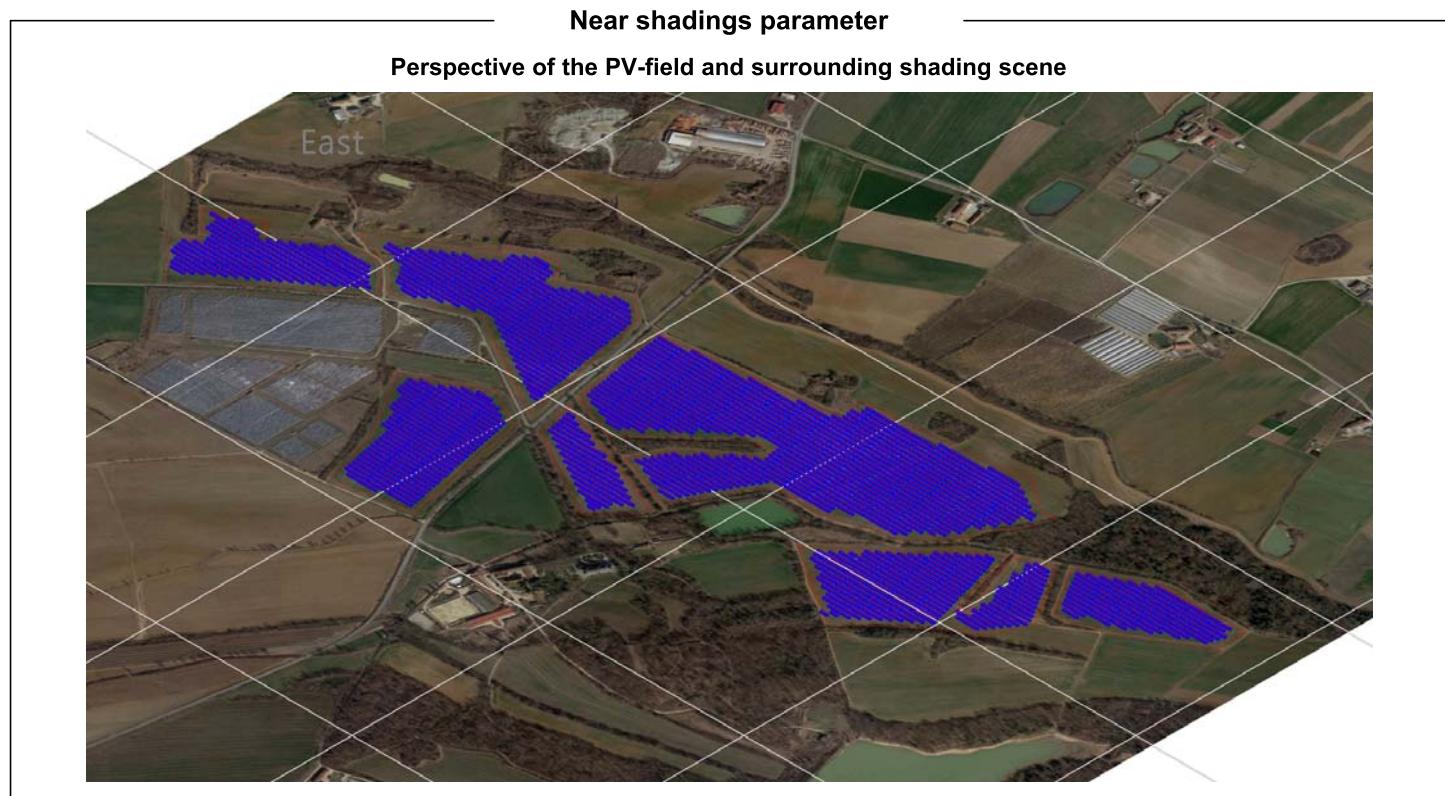
1: 22 June
2: 22 May and 23 July
3: 20 Apr and 23 Aug.
4: 20 Mar and 23 Sep
5: 21 Feb and 23 Oct
6: 19 Jan and 22 Nov.
7: 22 December

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## Near shadings parameter

Perspective of the PV-field and surrounding shading scene

Iso-shadings diagram

Orientation #1

	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
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Main results

System Production

Produced Energy	81.11 GWh/year		Specific production	1736 kWh/kWp/year
			Performance Ratio PR	86.88 %

Normalized productions (per installed kWp)

Lc: Collection Loss (PV-array losses)	0.6 kWh/kWp/day
Ls: System Loss (inverter, ...)	0.12 kWh/kWp/day
Yf: Produced useful energy (inverter output)	4.76 kWh/kWp/day

Performance Ratio PR

PR: Performance Ratio (Yf / Yr) : 0.869
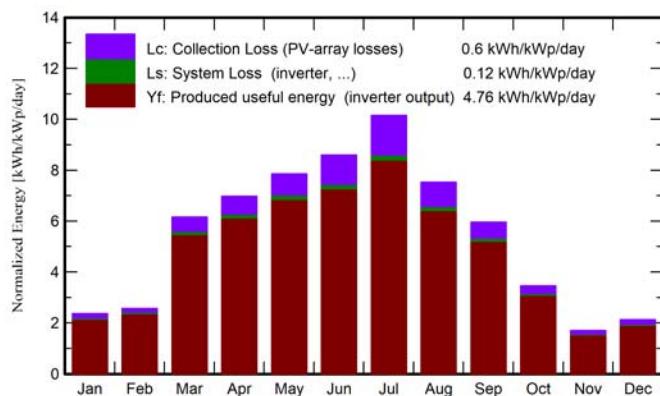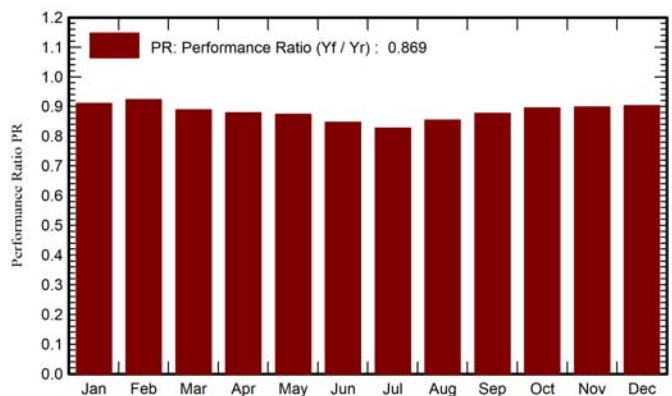
Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	GWh	GWh	ratio
January	52.8	21.46	4.26	73.3	67.9	3.19	3.12	0.911
February	56.9	31.90	2.35	71.8	67.0	3.18	3.10	0.923
March	138.2	42.24	9.84	191.0	182.2	8.12	7.93	0.889
April	157.9	58.17	12.98	209.2	200.1	8.81	8.60	0.879
May	190.4	76.12	15.64	243.6	233.3	10.19	9.94	0.873
June	203.4	75.43	21.68	258.0	247.5	10.46	10.20	0.846
July	235.6	64.26	23.24	314.9	303.3	12.48	12.18	0.828
August	178.5	68.52	21.95	233.4	223.3	9.54	9.31	0.854
September	135.3	53.08	17.82	178.7	170.4	7.49	7.32	0.877
October	81.0	39.52	14.43	107.1	100.9	4.59	4.48	0.896
November	39.8	21.55	9.02	51.2	47.5	2.21	2.15	0.899
December	46.8	19.05	2.06	65.8	60.1	2.84	2.78	0.903
Year	1516.6	571.30	13.00	1998.1	1903.5	83.09	81.11	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			

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Loss diagram

1517 kWh/m²	**Global horizontal irradiation**
+31.8%	**Global incident in coll. plane**
-0.27%	Far Shadings / Horizon
-1.63%	Near Shadings: irradiance loss
-1.36%	IAM factor on global
-2.00%	Soiling loss factor
+0.46%	Ground reflection on front side

Bifacial

Global incident on ground
738 kWh/m² on 523397 m²

-80.00% (0.20 Gnd. albedo)	Ground reflection loss
-81.56%	View Factor for rear side
+34.05%	Sky diffuse on the rear side
+0.00%	Beam effective on the rear side
-5.00%	Shadings loss on rear side
4.56%	**Global Irradiance on rear side (87 kWh/m²)**

1904 kWh/m² * 208834 m² coll.   **Effective irradiation on collectors**

efficiency at STC = 22.44%   PV conversion, Bifaciality factor = 0.75

92.3 GWh	**Array nominal energy (at STC effic.)**
-0.20%	PV loss due to irradiance level
-5.30%	PV loss due to temperature
0.00%	Shadings: Electrical Loss acc. to strings
+0.17%	Module quality loss
-0.50%	LID - Light induced degradation
-2.10%	Mismatch loss, modules and strings
-0.44%	Mismatch for back irradiance
-1.12%	Ohmic wiring loss
83.8 GWh	**Array virtual energy at MPP**
-1.31%	Inverter Loss during operation (efficiency)
0.00%	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
-0.81%	Inverter Loss due to voltage threshold
0.00%	Night consumption
82.0 GWh	**Available Energy at Inverter Output**
-0.10%	Auxiliaries (fans, other)
-0.07%	AC ohmic loss
-0.86%	Medium voltage transfo loss
-0.06%	MV line ohmic loss
0.00%	Unused energy (grid limitation)
81.1 GWh	**Energy injected into grid**

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## Special graphs

Daily Input/Output diagram
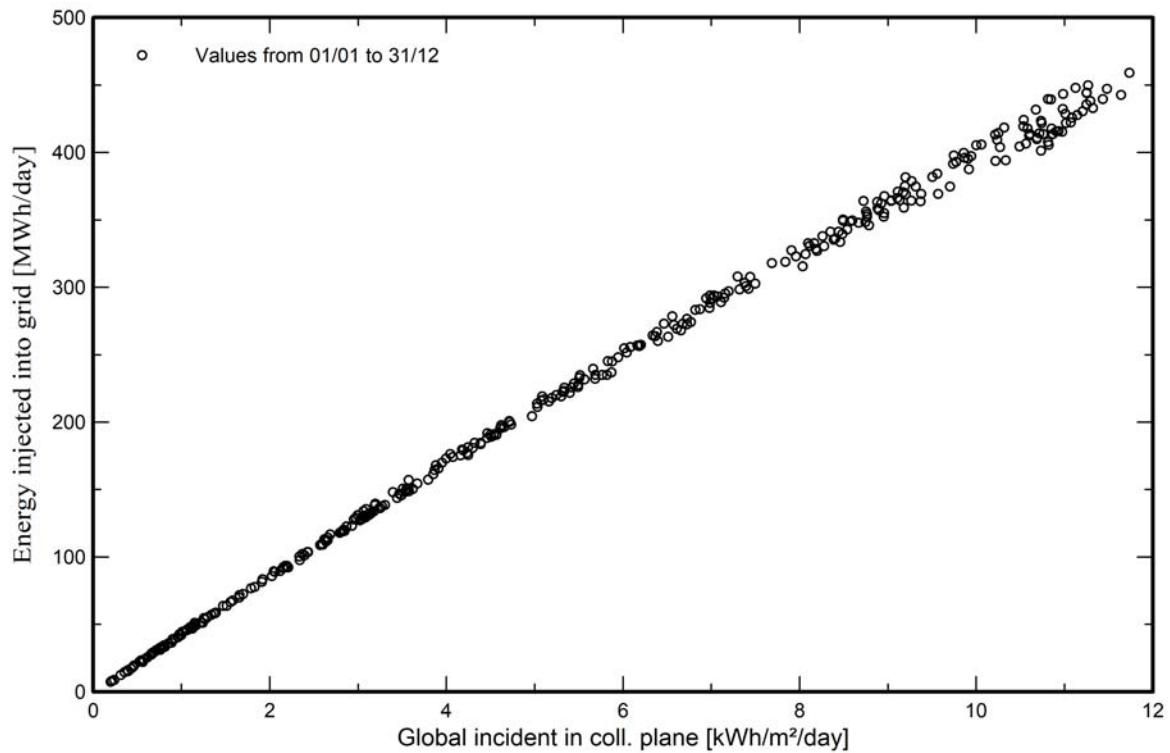
System Output Power Distribution
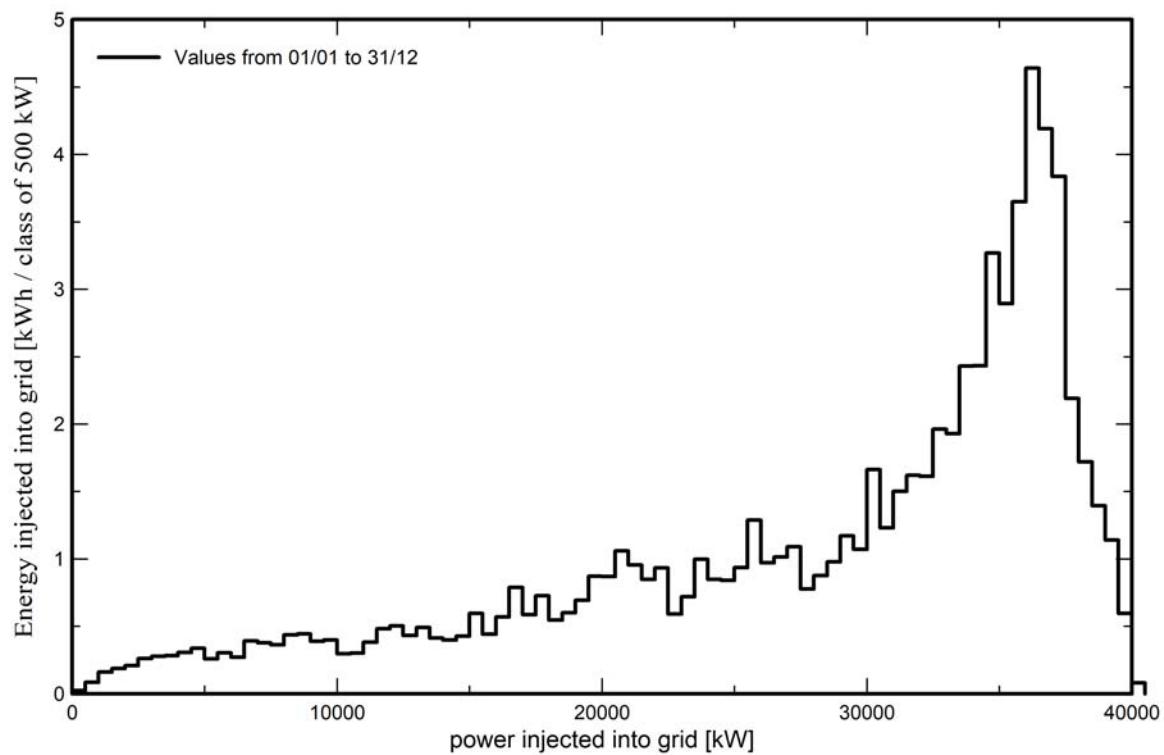
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CO_2 Emission Balance

Total: 803514.7 tCO_2

Generated emissions
Total: 89510.89 tCO_2
Source: Detailed calculation from table below:

Replaced Emissions
Total: 1029228.0 tCO_2
System production: 81105.44 MWh/yr
Grid Lifecycle Emissions: 423 gCO_2/kWh
Source: IEA List
Country: Italy
Lifetime: 30 years
Annual degradation: 1.0 %

Saved CO_2 Emission vs. Time
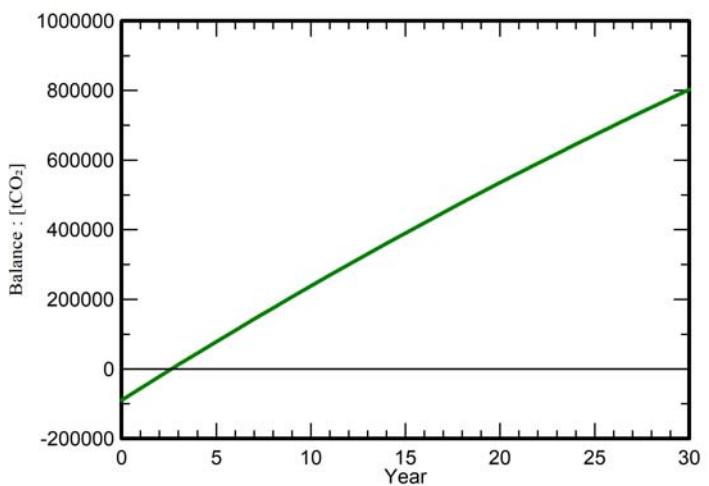
System Lifecycle Emissions Details

Item	LCE	Quantity	Subtotal
			[$kgCO_2$]
Modules	1713 kgCO2/kWp	46723 kWp	80024204
Supports	2.82 kgCO2/kg	3361400 kg	9483888
Inverters	280 kgCO2/units	10.00 units	2795