



Comune di Velletri,
Provincia di Roma, Regione Lazio

RNE4 S.R.L.

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Impianto Agrivoltaico VELLETRI 19.2
PD01_21 – SIMULAZIONE ENERGETICA (PVSYST)

IL TECNICO	IL PROPONENTE
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FEBBRAIO 2023

PVsyst - Simulation report

Grid-Connected System

Project: ITS2VE - Velletri 19.2

Variant: Velletri_Tracker.2P(12-24-48)_620Wp.Bif_Pitch=8.0

Tracking system with backtracking

System power: 23.21 MWp

Carano - Italy

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Project summary

Geographical Site		Situation		Project settings	
Carano		Latitude	41.58 °N	Albedo	0.20
Italy		Longitude	12.74 °E		
		Altitude	53 m		
		Time zone	UTC+1		
Meteo data					
Carano					
Meteonorm 8.0 (1996-2015), Sat=100% - Sintético					

System summary

Grid-Connected System		Tracking system with backtracking			
Simulation for year no 1					
PV Field Orientation		Tracking algorithm		Near Shadings	
Orientation		Irradiance optimization		According to strings	
Tracking plane, horizontal N-S axis		Backtracking activated		Electrical effect	
Avg axis azim. 0 °				100 %	
System information					
PV Array					
Nb. of modules	37440 units	Inverters		Nb. of units	
Pnom total	23.21 MWp			20 units	
				Pnom total	
				19.15 MWac	
				Grid power limit	
				19.20 MWac	
				Grid lim. Pnom ratio	
				1.209	
User's needs					
Unlimited load (grid)					

Results summary

Produced Energy	36050 MWh/year	Specific production	1553 kWh/kWp/year	Perf. Ratio PR	84.27 %
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General parameters**Grid-Connected System****PV Field Orientation****Orientation**

Tracking plane, horizontal N-S axis
Avg axis azim. 0 °

Models used

Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon

Average Height 1.1 °

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing 8.00 m
Tracker width 5.03 m
GCR 62.9 %
Axis height above ground 2.73 m

Grid power limitation

Active Power 19.20 MWac
Pnom ratio 1.209

Tracking system with backtracking**Tracking algorithm**

Irradiance optimization
Backtracking activated

Near Shadings

According to strings
Electrical effect 100 %

Backtracking array

Nb. of trackers 470 units

Sizes

Tracker Spacing 8.00 m
Collector width 5.03 m
Ground Cov. Ratio (GCR) 62.9 %
Phi min / max. -/+ 60.0 °

Backtracking strategy

Phi limits for BT -/+ 79.9 °
Backtracking pitch 8.00 m
Backtracking width 5.02 m

User's needs

Unlimited load (grid)

Bifacial model definitions

Ground albedo 0.20
Bifaciality factor 50 %
Rear shading factor 5.0 %
Rear mismatch loss 10.0 %
Shed transparent fraction 0.0 %

PV Array Characteristics**Array #1 - Conjunto FV 1****PV module**

Manufacturer Suntech_Mod.
Model STP620S-C78/Nmh+
(Custom parameters definition)

Unit Nom. Power 620 Wp
Number of PV modules 24960 units
Nominal (STC) 15.48 MWp
Modules 1040 Strings x 24 In series

At operating cond. (48°C)

Pmpp 14.39 MWp
U mpp 1010 V
I mpp 14250 A

Inverter

Manufacturer Santerno
Model SUNWAY TG 900 1500V TE - 610 EV
(Custom parameters definition)

Unit Nom. Power 951 kWac
Number of inverters 12 units
Total power 11412 kWac
Operating voltage 870-1300 V
Pnom ratio (DC:AC) 1.36



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PV Array Characteristics

Array #2 - Conjunto FV 2			
PV module		Inverter	
Manufacturer	Suntech_Mod.	Manufacturer	Santerno
Model	STP620S-C78/Nmh+	Model	SUNWAY TG 900 1500V TE - 620 EV
(Custom parameters definition)		(Custom parameters definition)	
Unit Nom. Power	620 Wp	Unit Nom. Power	967 kWac
Number of PV modules	12480 units	Number of inverters	8 units
Nominal (STC)	7738 kWp	Total power	7736 kWac
Modules	520 Strings x 24 In series	Operating voltage	880-1300 V
At operating cond. (48°C)		Pnom ratio (DC:AC)	1.00
Pmpp	7194 kWp		
U mpp	1010 V		
I mpp	7125 A		
Total PV power		Total inverter power	
Nominal (STC)	23213 kWp	Total power	19148 kWac
Total	37440 modules	Number of inverters	20 units
Module area	103637 m ²	Pnom ratio	1.21
Cell area	90530 m ²		

Array losses

Array Soiling Losses		Thermal Loss factor		Serie Diode Loss				
Loss Fraction	3.0 %	Module temperature according to irradiance		Voltage drop	0.7 V			
		Uc (const)	29.0 W/m ² K	Loss Fraction	0.1 % at STC			
		Uv (wind)	0.0 W/m ² K/m/s					
LID - Light Induced Degradation		Module Quality Loss		Module mismatch losses				
Loss Fraction	1.5 %	Loss Fraction	-0.8 %	Loss Fraction	2.0 % at MPP			
Strings Mismatch loss		Module average degradation						
Loss Fraction	0.1 %	Year no	1					
		Loss factor	0.4 %/year					
		Mismatch due to degradation						
		Imp RMS dispersion	0.4 %/year					
		Vmp RMS dispersion	0.4 %/year					
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

DC wiring losses

Global wiring resistance	0.77 mΩ		
Loss Fraction	1.5 % at STC		
Array #1 - Conjunto FV 1		Array #2 - Conjunto FV 2	
Global array res.	1.2 mΩ	Global array res.	2.3 mΩ
Loss Fraction	1.5 % at STC	Loss Fraction	1.5 % at STC

System losses

Auxiliaries loss	
constant (fans)	25.0 kW
1500.0 kW from Power thresh.	



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AC wiring losses

Inv. output line up to MV transfo

Inverter voltage 610 Vac tri
Loss Fraction 0.14 % at STC

Inverters: SUNWAY TG 900 1500V TE - 610 EV, SUNWAY TG 900 1500V TE - 620 EV

Wire section (20 Inv.) Alu 20 x 3 x 1000 mm²
Average wires length 12 m

MV line up to Injection

MV Voltage 20 kV
Wires Alu 3 x 2000 mm²
Length 11000 m
Loss Fraction 0.99 % at STC

AC losses in transformers

MV transfo

Medium voltage 20 kV

Transformer parameters

Nominal power at STC 22.85 MVA
Iron Loss (24/24 Connexion) 21.77 kVA
Iron loss fraction 0.10 % at STC
Copper loss 239.87 kVA
Copper loss fraction 1.05 % at STC
Coils equivalent resistance 3 x 0.17 mΩ



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Horizon definition

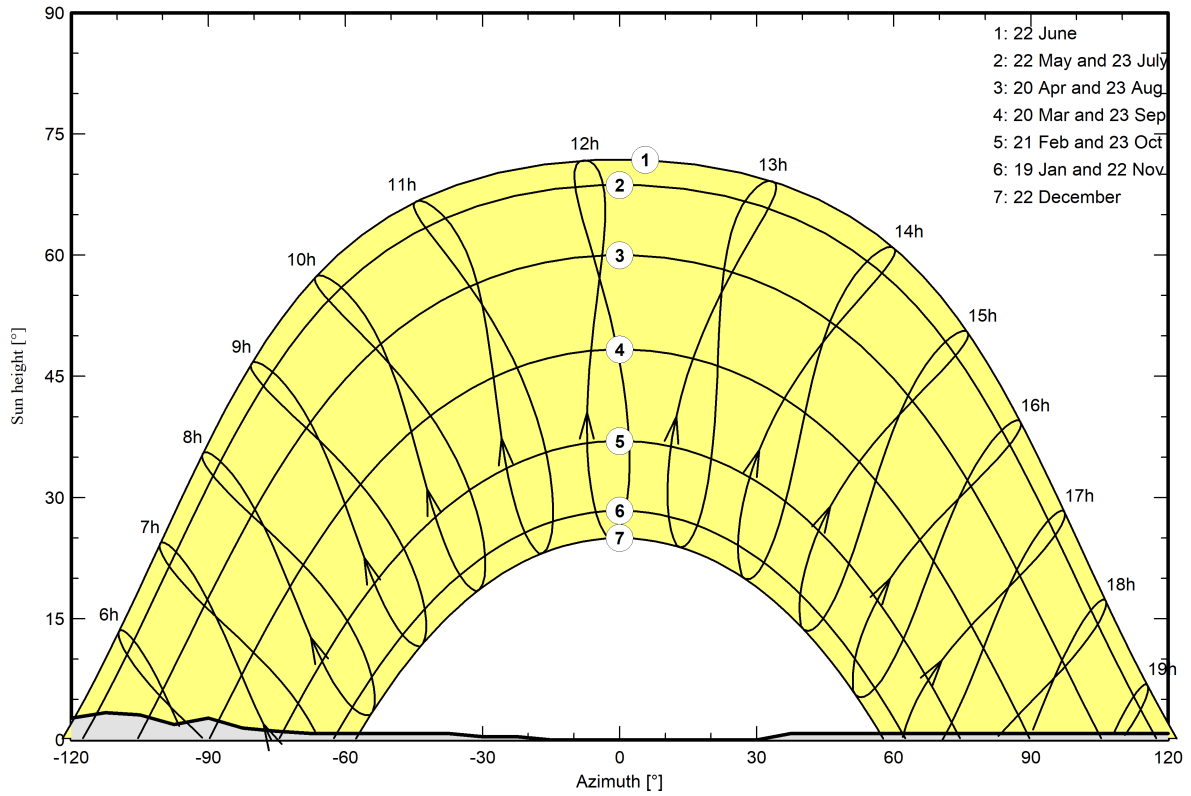
Horizon from PVGIS website API, Lat=41°34'53', Long=12°44'31', Alt=53m

Average Height	1.1 °	Albedo Factor	0.96
Diffuse Factor	1.00	Albedo Fraction	100 %

Horizon profile

Azimuth [°]	-180	-173	-165	-158	-150	-143	-135	-128	-120	-113	-105	-98	-90	-83
Height [°]	2.7	3.1	2.3	1.5	1.1	1.1	1.5	1.9	2.7	3.4	3.1	1.9	2.7	1.5
Azimuth [°]	-75	-68	-38	-30	-23	-15	30	38	150	158	165	173	180	
Height [°]	1.1	0.8	0.8	0.4	0.4	0.0	0.0	0.8	0.8	1.1	1.5	2.3	2.7	

Sun Paths (Height / Azimuth diagram)



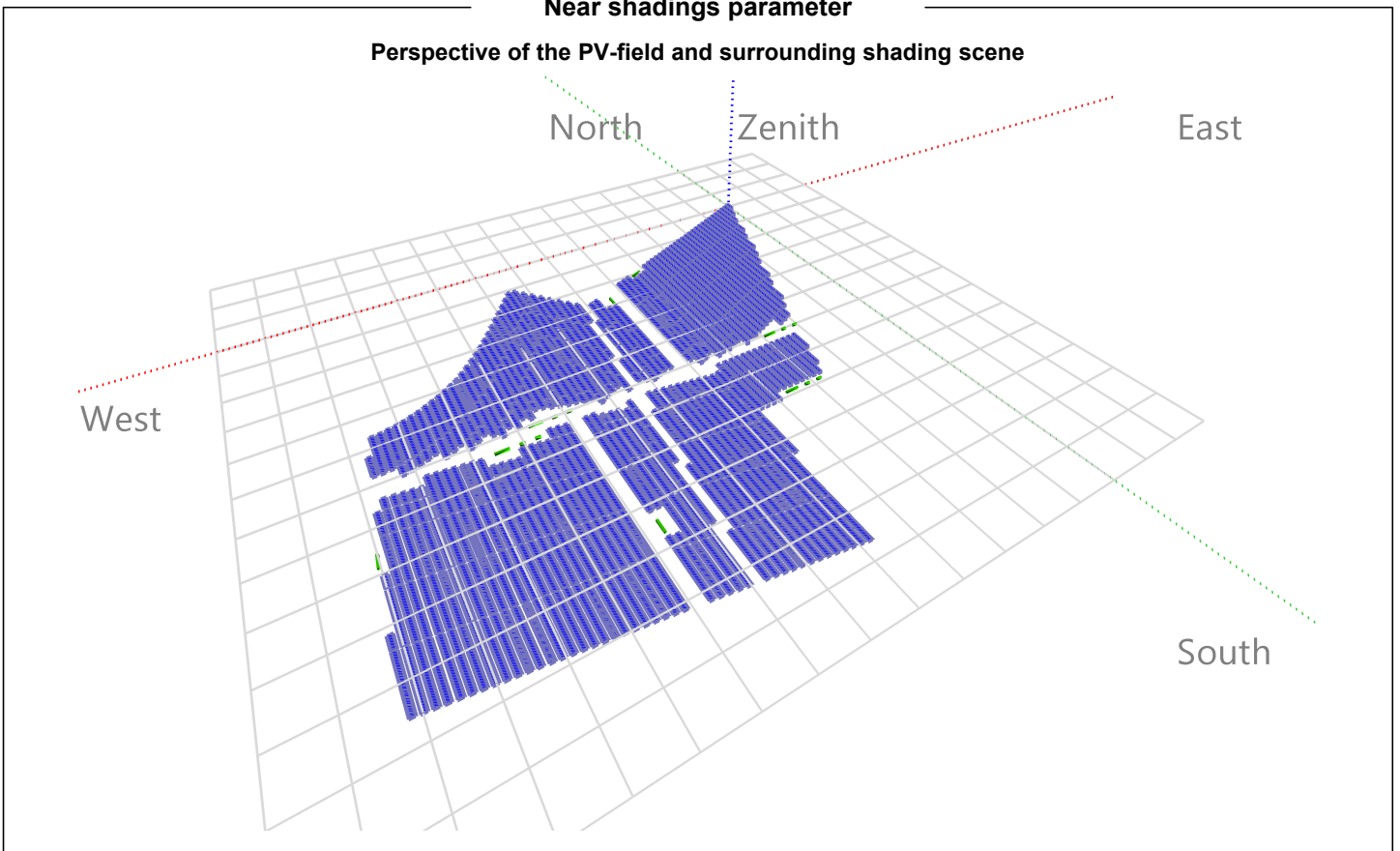


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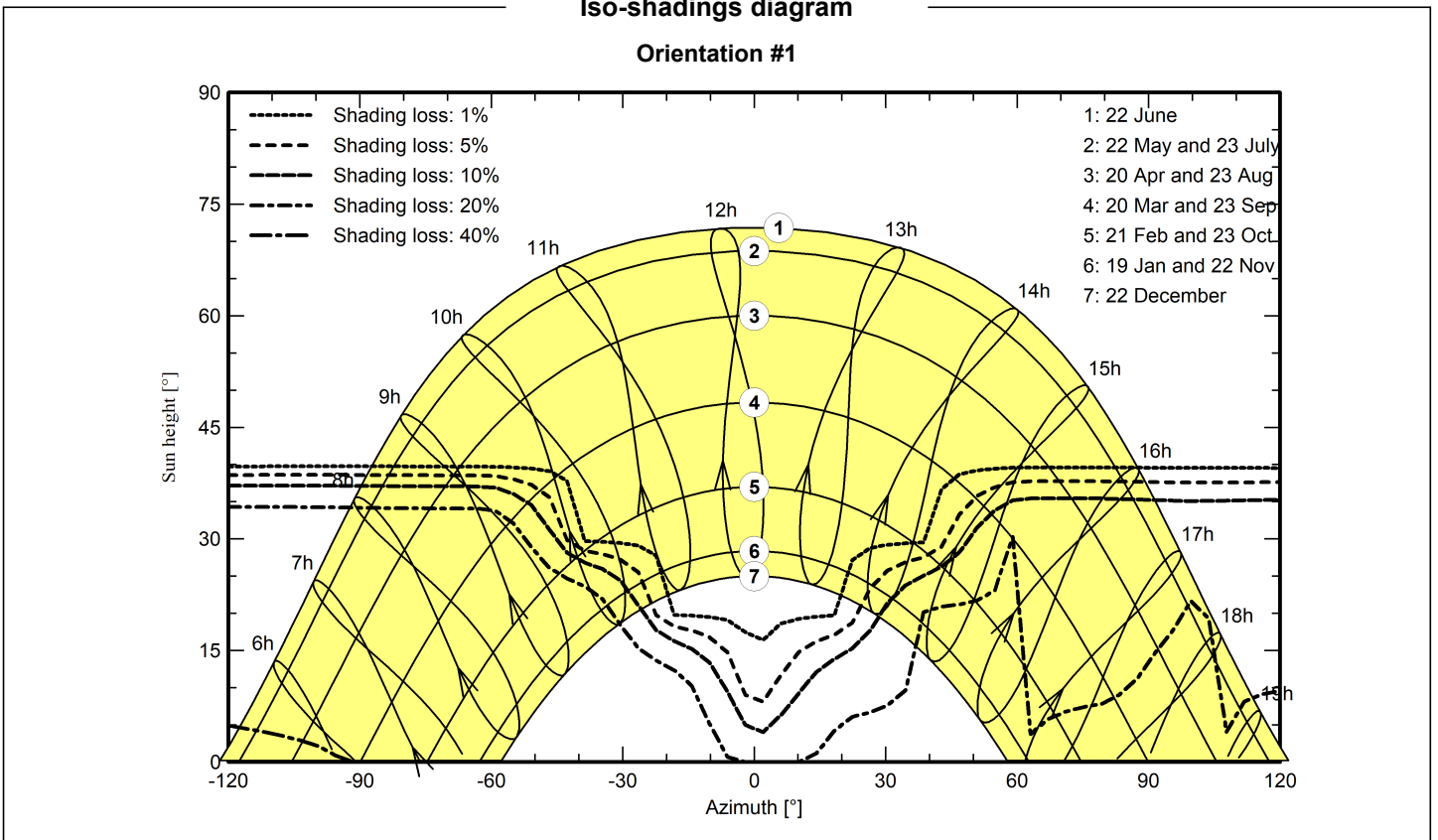
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1





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Main results

System Production

Produced Energy 36050 MWh/year

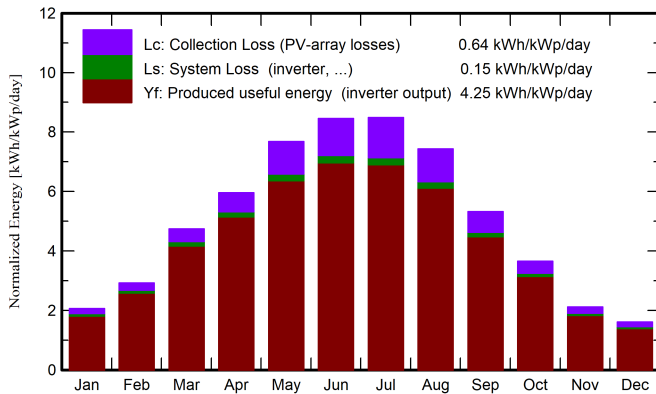
Specific production

1553 kWh/kWp/year

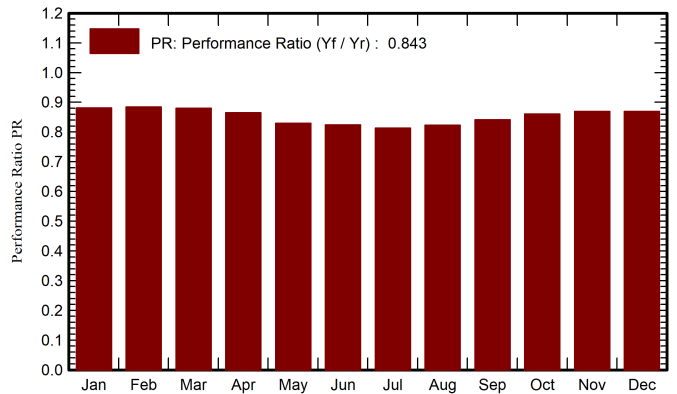
Performance Ratio PR

84.27 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

	GlobHor kWh/m ²	DiffHor kWh/m ²	T_Amb °C	GlobInc kWh/m ²	GlobEff kWh/m ²	EArray MWh	E_Grid MWh	PR ratio
January	52.1	24.27	8.55	64.0	60.5	1364	1309	0.881
February	68.5	34.55	9.18	81.9	77.6	1744	1680	0.884
March	122.6	57.99	12.23	146.9	139.5	3107	3002	0.880
April	149.8	72.33	15.17	178.6	169.8	3710	3584	0.864
May	195.7	80.02	19.78	238.0	226.3	4745	4584	0.830
June	210.5	86.29	24.14	253.7	241.4	5025	4856	0.824
July	215.3	81.56	27.14	263.0	250.3	5142	4968	0.814
August	187.6	68.58	27.12	230.5	219.6	4557	4402	0.823
September	132.5	55.19	22.36	159.8	152.0	3231	3120	0.841
October	94.5	48.39	18.72	113.2	107.2	2343	2262	0.861
November	53.2	29.29	13.80	63.4	60.0	1334	1279	0.869
December	41.5	21.89	9.89	49.8	47.0	1053	1004	0.869
Year	1523.7	660.34	17.39	1842.9	1751.1	37355	36050	0.843

Legends

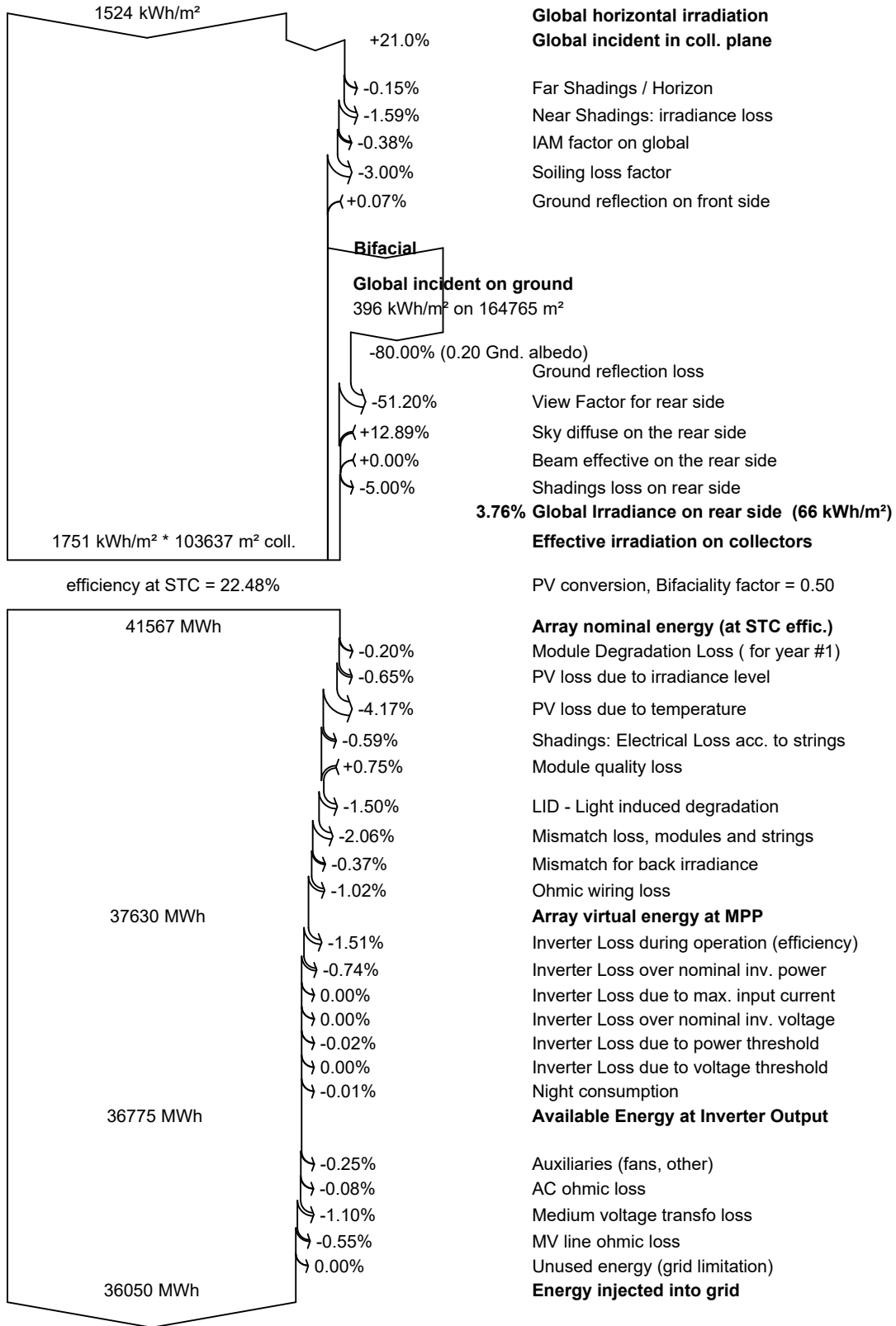
- GlobHor Global horizontal irradiation
- DiffHor Horizontal diffuse irradiation
- T_Amb Ambient Temperature
- GlobInc Global incident in coll. plane
- GlobEff Effective Global, corr. for IAM and shadings
- EArray Effective energy at the output of the array
- E_Grid Energy injected into grid
- PR Performance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



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Loss diagram



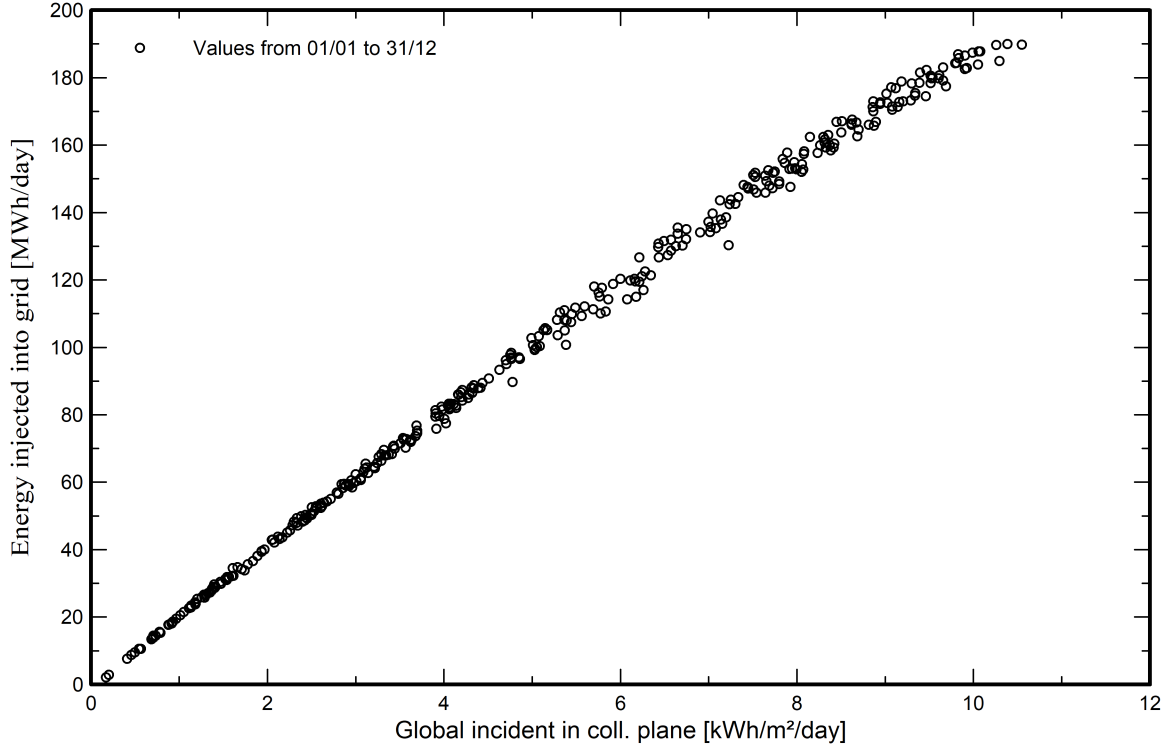


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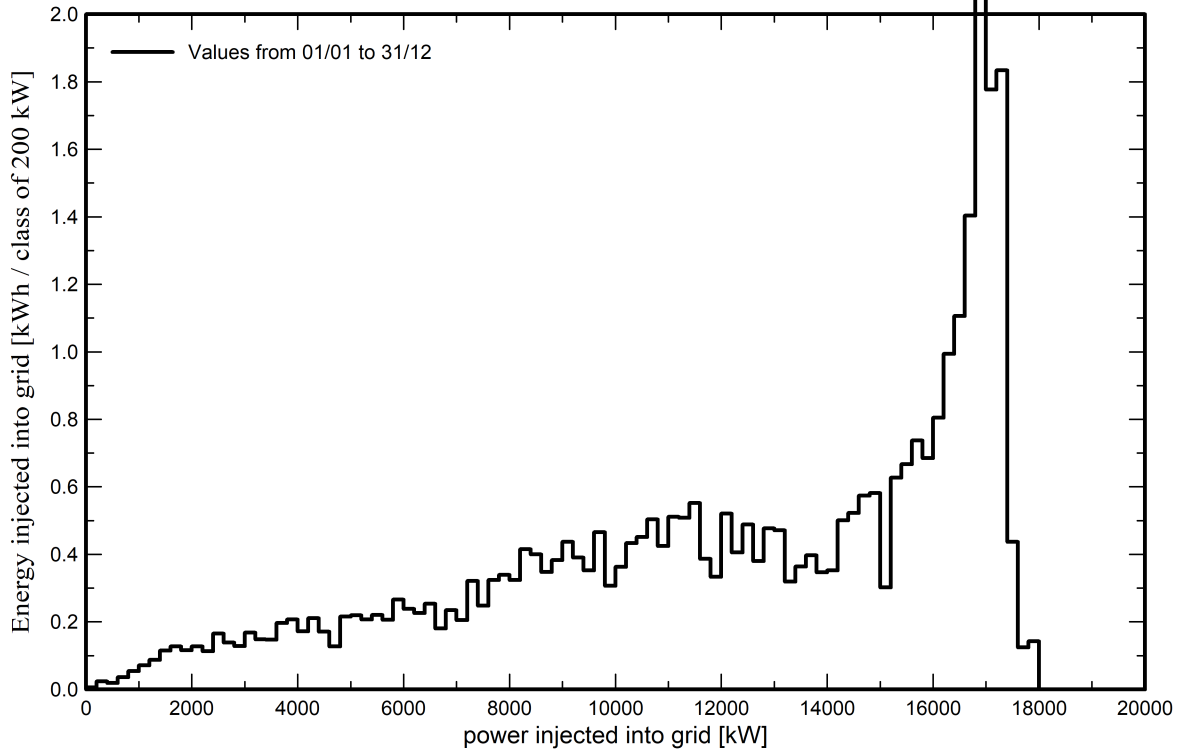
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Predef. graphs

Diagrama entrada/salida diaria



Distribución de potencia de salida del sistema





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Aging Tool

Aging Parameters

Time span of simulation 30 years

Module average degradation

Loss factor 0.4 %/year

Mismatch due to degradation

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

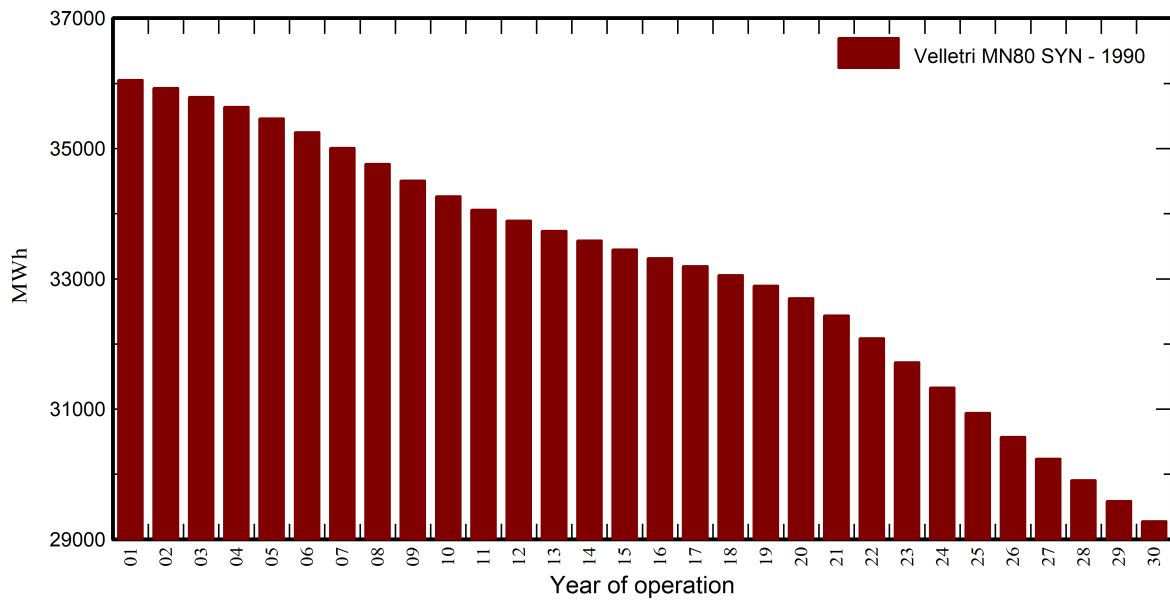
Meteo used in the simulation

#1 Velletri MN80 SYN

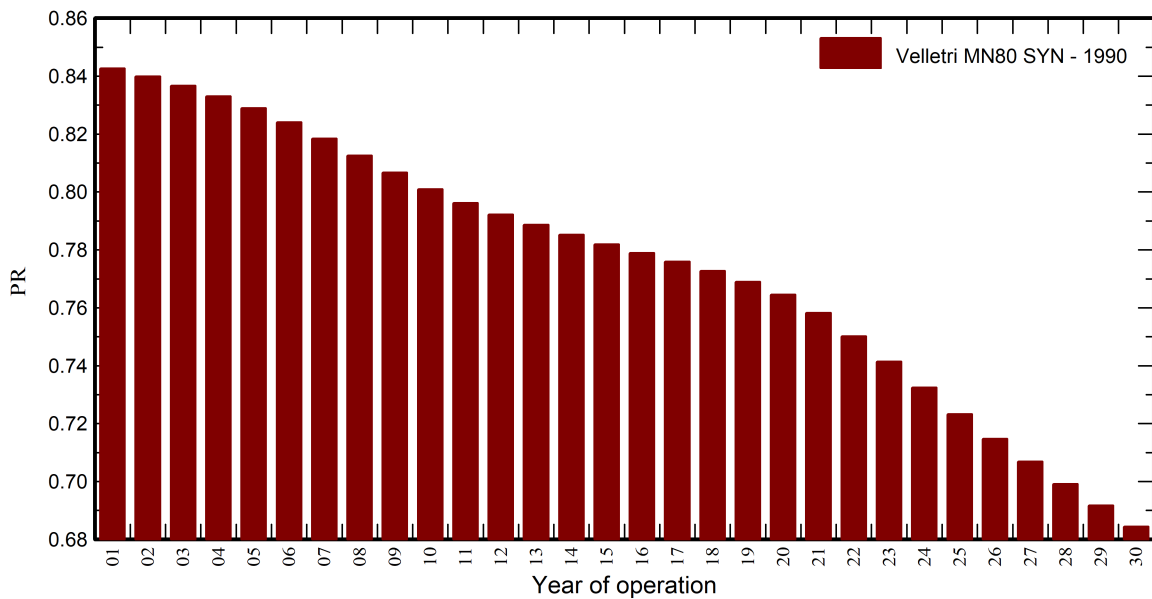
Years 1990 (reference year)

Years simulated 1-30

System output energy



Performance Ratio





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Aging Tool

Aging Parameters

Time span of simulation 30 years

Module average degradation

Loss factor 0.4 %/year

Mismatch due to degradation

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

Meteo used in the simulation

#1 Velletri MN80 SYN

Years 1990 (reference year)

Years simulated 1-30

Velletri MN80 SYN

Year	System output	PR	PR loss
	MWh		%
1	36050	0.843	0%
2	35929	0.84	-0.3%
3	35792	0.837	-0.7%
4	35636	0.833	-1.1%
5	35462	0.829	-1.6%
6	35252	0.824	-2.2%
7	35011	0.818	-2.9%
8	34761	0.813	-3.6%
9	34510	0.807	-4.3%
10	34265	0.801	-5%
11	34058	0.796	-5.5%
12	33890	0.792	-6%
13	33736	0.789	-6.4%
14	33590	0.785	-6.8%
15	33449	0.782	-7.2%
16	33319	0.779	-7.6%
17	33194	0.776	-7.9%
18	33055	0.773	-8.3%
19	32895	0.769	-8.8%
20	32704	0.764	-9.3%
21	32435	0.758	-10%
22	32090	0.75	-11%
23	31719	0.741	-12%
24	31332	0.732	-13.1%
25	30940	0.723	-14.2%
26	30573	0.715	-15.2%
27	30237	0.707	-16.1%
28	29910	0.699	-17%
29	29591	0.692	-17.9%
30	29280	0.684	-18.8%



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P50 - P90 evaluation

Meteo data

Source Meteororm 8.0 (1996-2015), Sat=100%
Kind Monthly averages
Sintético - Multi-year average
Year-to-year variability(Variance) 3.0 %

Specified Deviation

Climate change 0.0 %

Global variability (meteo + system)

Variability (Quadratic sum) 3.5 %

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 1.26 GWh
P50 36.05 GWh
P90 34.43 GWh
P95 33.98 GWh

Probability distribution

