Regione Emilia Romagna
Comune di Alfonsine (RA)

IMPIANTO FOTOVOLTAICO E OPERE CONNESSE

Potenza Impianto 37,492 MWp

PROPONENTE

LIGHTSOURCE RENEWABLE ENERGY ITALY SPV 8 S.R.L.

VIA G. LEOPARDI, 7 - 20123 MILANO (MI) - P.IVA: 12593780963 – PEC: lightsourcespv_8@legalmail.it

PROGETTAZIONE

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COORDINAMENTO PROGETTUALE

SOLAR IT S.R.L.

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Tel.: +390425 072 257– email: info@solaritglobal.com

TITOLO ELABORATO

Relazione Calcoli Producibilità

LIVELLO DI PROGETTAZIONE	CODICE ELABORATO	FILE NAME	DATA
DEFINITIVO	PI-R04	LS15781-PI-R04_1	21/12/2022

REVISIONI

REV.	DATA	DESCRIZIONE	ESEGUITO	VERIFICATO	APPROVATO
0	21/12/2022	PERMITTING	MCA	MLA	ARI
1	15/11/2023	INTEGRAZIONE VOLONTARIA	MCA	LST	ARU
2	12/12/2023	RICHIESTA INTEGRAZIONI	MCA	LST	ARU

RELAZIONE CALCOLI DI PRODUCIBILITA’

INDICE

Contenuto del documento

1. PREMESSA

La società proponente nell'ambito del proprio piano di sviluppo delle fonti energetiche rinnovabili prevede di realizzare un impianto di produzione da fonte rinnovabile - fotovoltaica - nel Comune di Alfonsine (RA) (nel seguito "Impianto FV").

2. CALCOLI DI PRODUCIBILITA'

Nel seguito si riportano i calcoli relativi alla producibilità del sito fotovoltaico di cui il presente progetto, per i quali ci si è avvalsi del software PVSyst il quale calcolerà l'energia prodotta, su base mensile ed annuale.

2.1. SITO DI SANT'ANNA

Project summary

Geographical Site
Chiesa Nuova
Italy

Situation

Latitude	44.55 °N
Longitude	11.96 °E
Altitude	10 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Chiesa Nuova
Meteonorm 8.1 (1991-2012), Sat=100% - Sintetico

System summary

Grid-Connected System

Tracking system with backtracking

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

Tracking algorithm
Irradiance optimization
Backtracking activated

Near Shadings
Linear shadings : Slow (simul.)
Diffuse shading Automatic

System information

PV Array

Nb. of modules	25272 units
Pnom total	17.69 MWp

Inverters

Nb. of units	5 units
Pnom total	17.19 MWac
Pnom ratio	1.029

User's needs
Unlimited load (grid)

Results summary

Produced Energy	26998968 kWh/year	Specific production	1526 kWh/kWp/year	Perf. Ratio PR	90.82 %

General parameters

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

PV Field Orientation

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

Tracking algorithm
Irradiance optimization
Backtracking activated

Backtracking array
Nb. of trackers 987 units

Sizes
Tracker Spacing 8.70 m
Collector width 4.79 m
Ground Cov. Ratio (GCR) 55.0 %
Phi min / max. -/+ 60.0 °

Backtracking strategy
Phi limits for BT -/+ 56.5 °
Backtracking pitch 8.70 m
Backtracking width 4.79 m
Mode Automatic

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Free Horizon

Near Shadings
Linear shadings : Slow (simul.)
Diffuse shading Automatic

User's needs
Unlimited load (grid)

Bifacial system
Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	8.70 m
Tracker width	4.79 m
GCR	55.0 %
Axis height above ground	2.10 m

Bifacial model definitions

Ground albedo	0.30
Bifaciality factor	80 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Risen Solar
Model	RSM132-8-700BHDG
(Custom parameters definition)	
Unit Nom. Power	700 Wp
Number of PV modules	25272 units
Nominal (STC)	17.69 MWp
Modules	972 string x 26 In series
At operating cond. (50°C)	
Pmpp	16.73 MWp
U mpp	1023 V
I mpp	16361 A

Inverter

Manufacturer	Sungrow
Model	SG3400-HV-20
(Custom parameters definition)	
Unit Nom. Power	3437 kWac
Number of inverters	10 * MPPT 50% 5 units
Total power	17185 kWac
Operating voltage	875-1300 V
Max. power (=>25°C)	3593 kWac
Pnom ratio (DC:AC)	1.03
No power sharing between MPPTs	

Total PV power

Nominal (STC)	17690 kWp
Total	25272 modules
Module area	78504 m²

Total inverter power

Total power	17185 kWac
Number of inverters	5 units
Pnom ratio	1.03

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 29.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 1.0 mΩ
Loss Fraction 1.5 % at STC

LID - Light Induced Degradation
Loss Fraction 1.4 %

Module Quality Loss
Loss Fraction -0.4 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.2 %

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

AC wiring losses

Inv. output line up to MV transfo
Inverter voltage 600 Vac tri
Loss Fraction 0.11 % at STC
Inverter: SG3400-HV-20
Wire section (5 Inv.) Copper 5 x 3 x 2500 mm²
Average wires length 15 m

MV line up to Injection
MV Voltage 20 kV
Average each inverter
Wires Copper 3 x 120 mm²
Length 3700 m
Loss Fraction 0.51 % at STC

AC losses in transformers

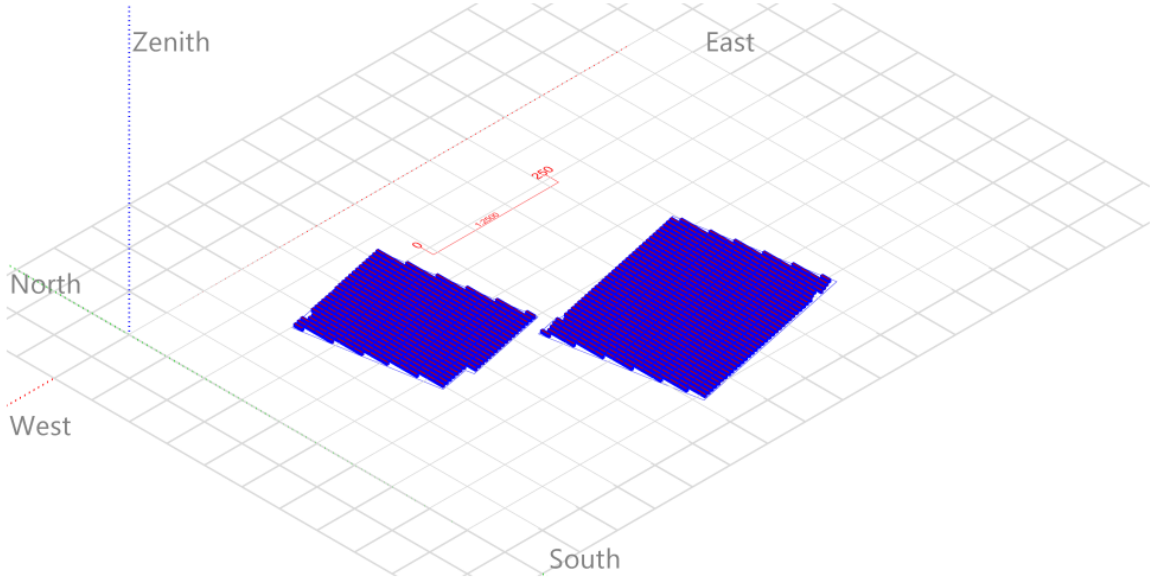
MV transfo
Medium voltage 20 kV

One transfo parameters
Nominal power at STC 3.50 MVA
Iron Loss (24/24 Connexion) 3.56 kVA
Iron loss fraction 0.10 % at STC
Copper loss 34.53 kVA
Copper loss fraction 0.99 % at STC
Coils equivalent resistance 3 x 1.01 mΩ

Operating losses at STC (full system)
Nb. identical MV transfos 5
Nominal power at STC 17.51 MVA
Iron loss (24/24 Connexion) 17.78 kVA
Copper loss 172.65 kVA

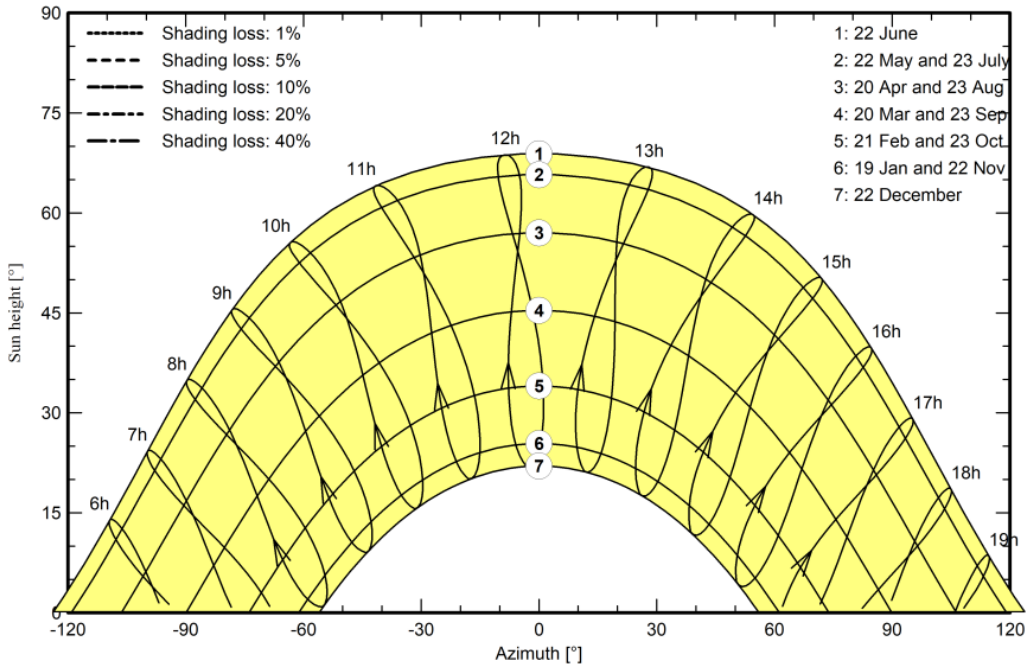
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

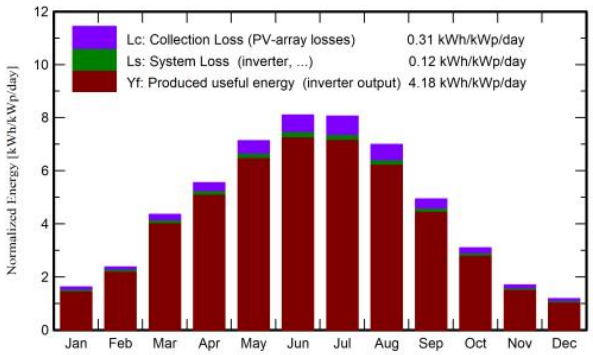


Main results

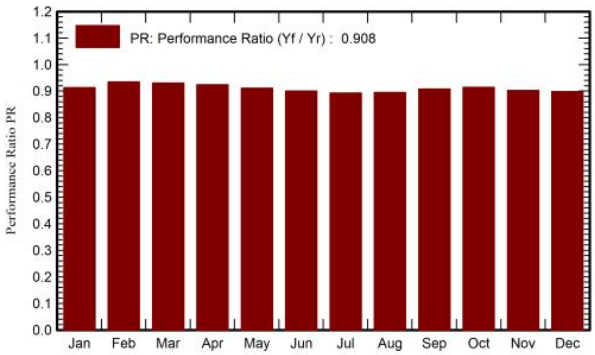
System Production

Produced Energy	26998968 kWh/year	Specific production	1526 kWh/kWp/year
		Perf. Ratio PR	90.82 %

Normalized productions (per installed kWp)



Performance Ratio PR



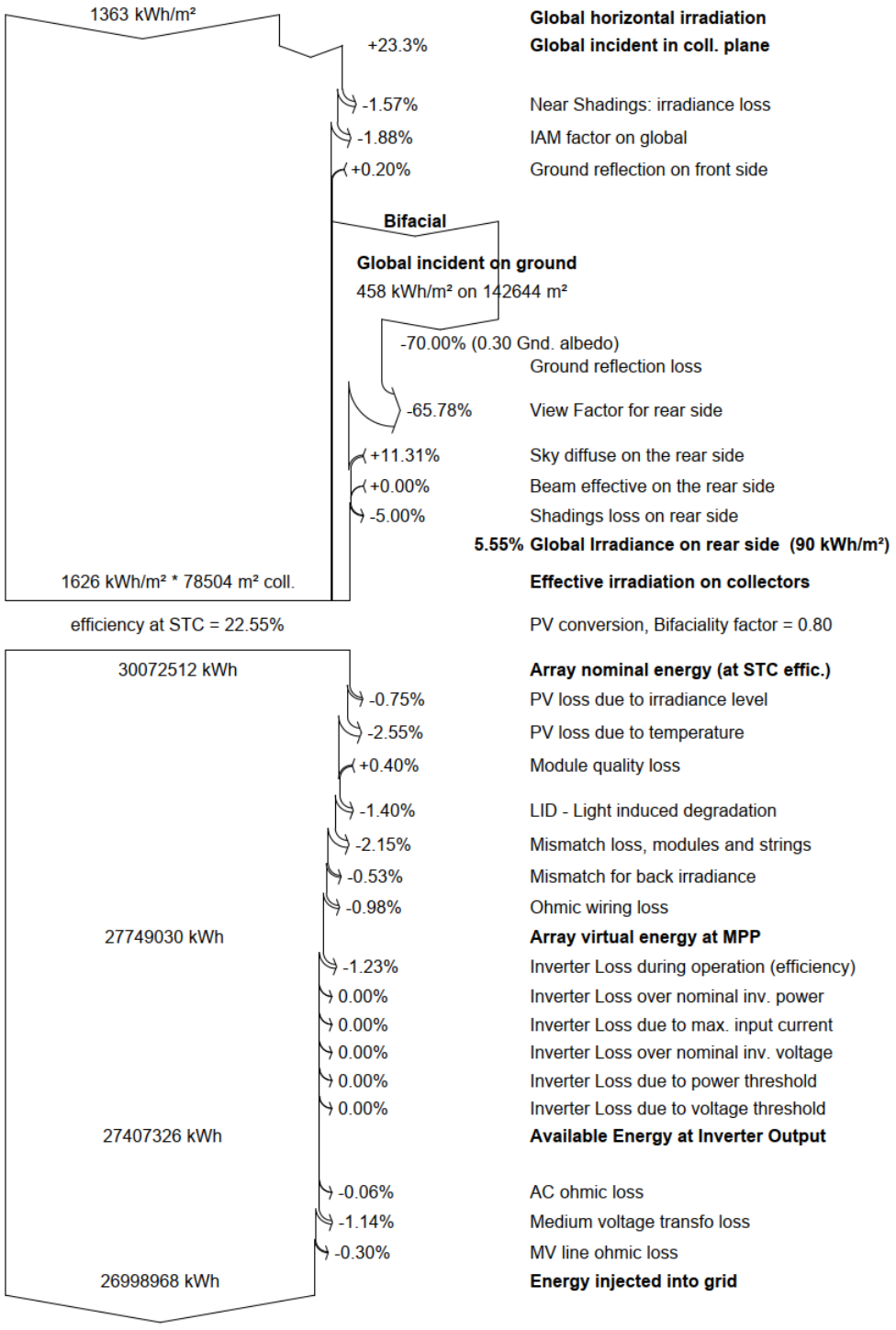
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	41.3	22.44	2.92	50.3	47.1	844964	813359	0.914
February	55.9	33.19	5.13	66.6	63.6	1136679	1101291	0.935
March	108.1	51.97	10.02	134.8	130.1	2280250	2220530	0.931
April	136.0	67.92	14.40	166.5	161.5	2792428	2720843	0.924
May	180.7	82.30	19.65	221.2	215.3	3660289	3567796	0.912
June	196.8	85.26	24.33	243.0	236.9	3972348	3872199	0.901
July	199.7	79.00	26.67	249.7	243.4	4046036	3943738	0.893
August	173.2	70.77	25.98	216.8	211.1	3521148	3432585	0.895
September	120.2	54.88	20.36	148.1	143.4	2444497	2380983	0.909
October	78.8	44.10	15.85	95.8	91.6	1594406	1549391	0.914
November	41.4	24.25	10.01	50.9	48.1	845352	813301	0.903
December	31.2	21.02	4.26	36.7	34.0	610633	582951	0.899
Year	1363.2	637.12	15.02	1680.5	1626.3	27749030	26998968	0.908

Legends

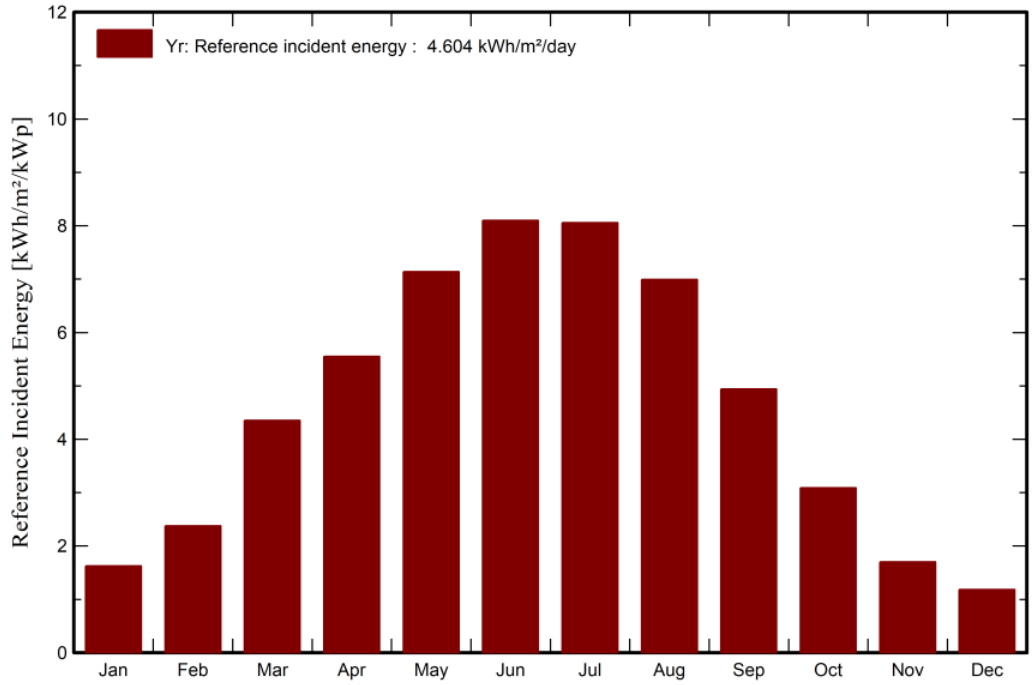
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Loss diagram

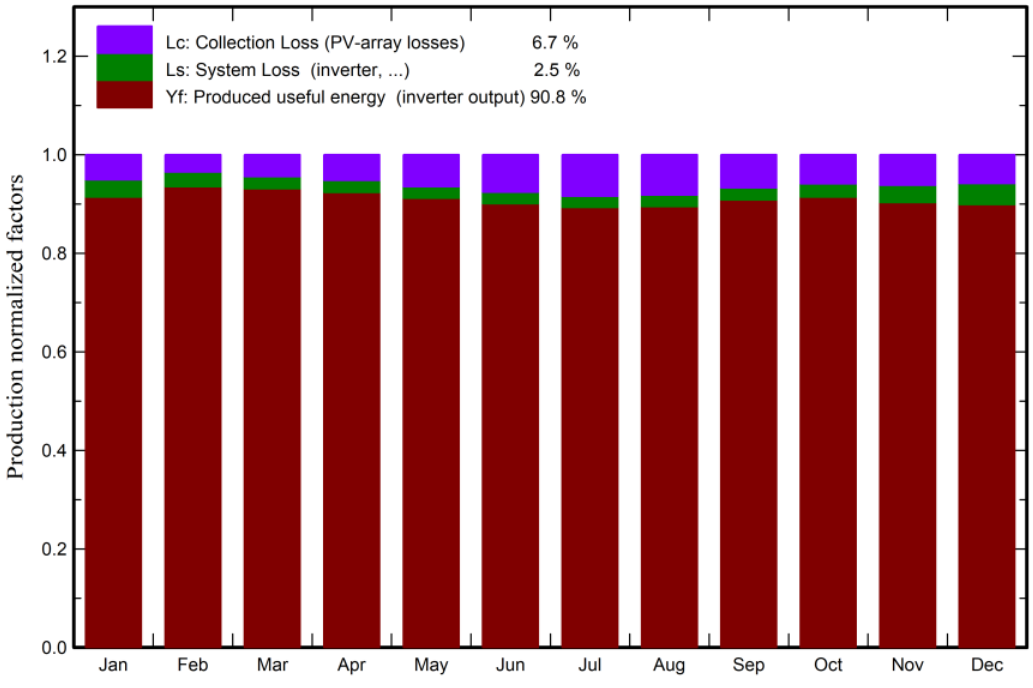


Predef. graphs

Energia incidente di riferimento su piano collettori

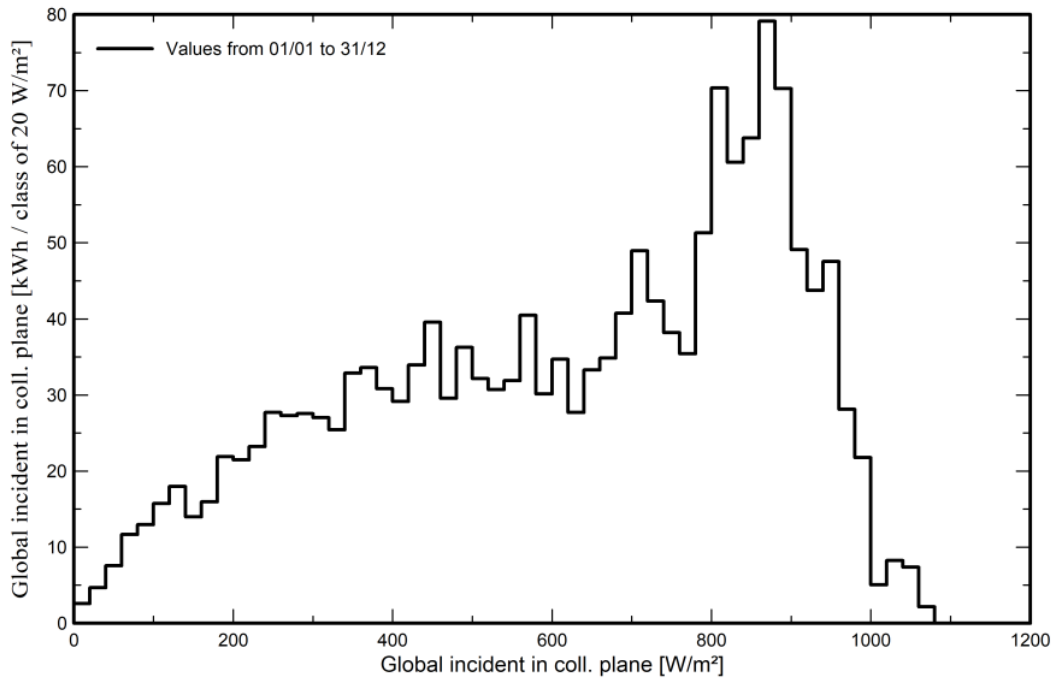


Fattori normalizzati di produzione e di perdita

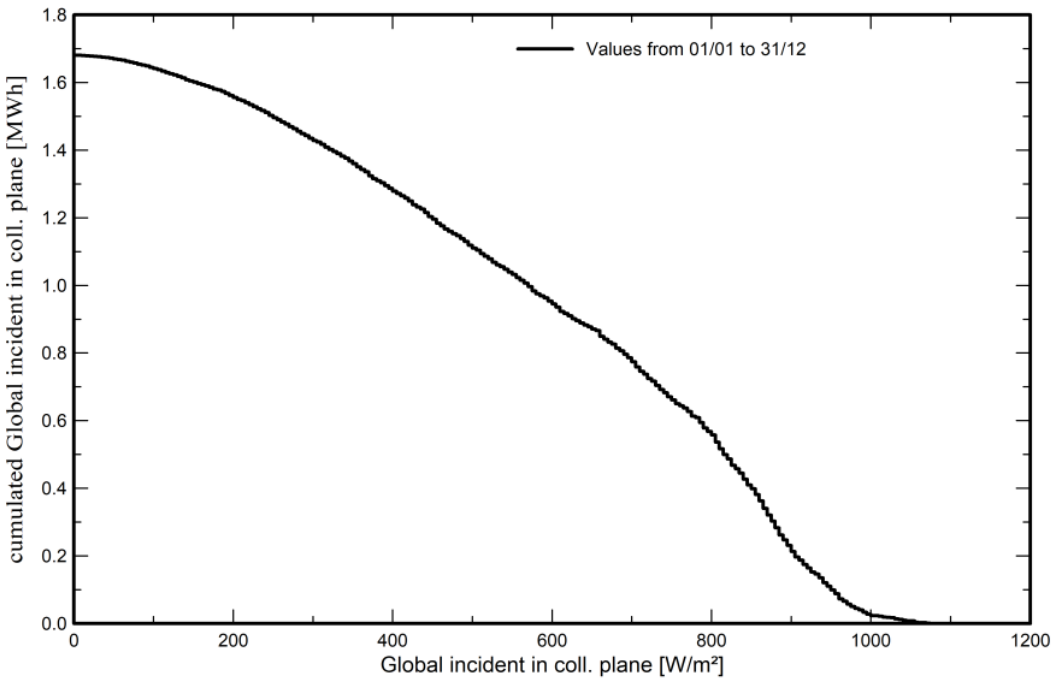


Predef. graphs

Distribuzione irraggiamento incidente



Coda della distribuzione di irradiazione incidente



Predef. graphs

Temperatura del campo vs.irradiazione efficace

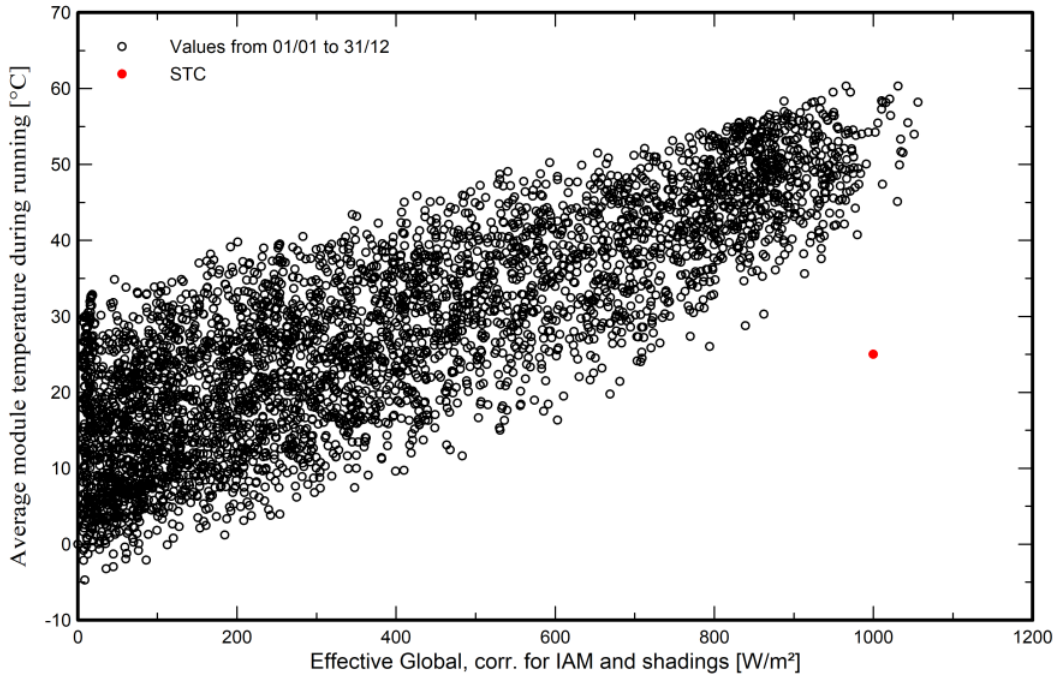
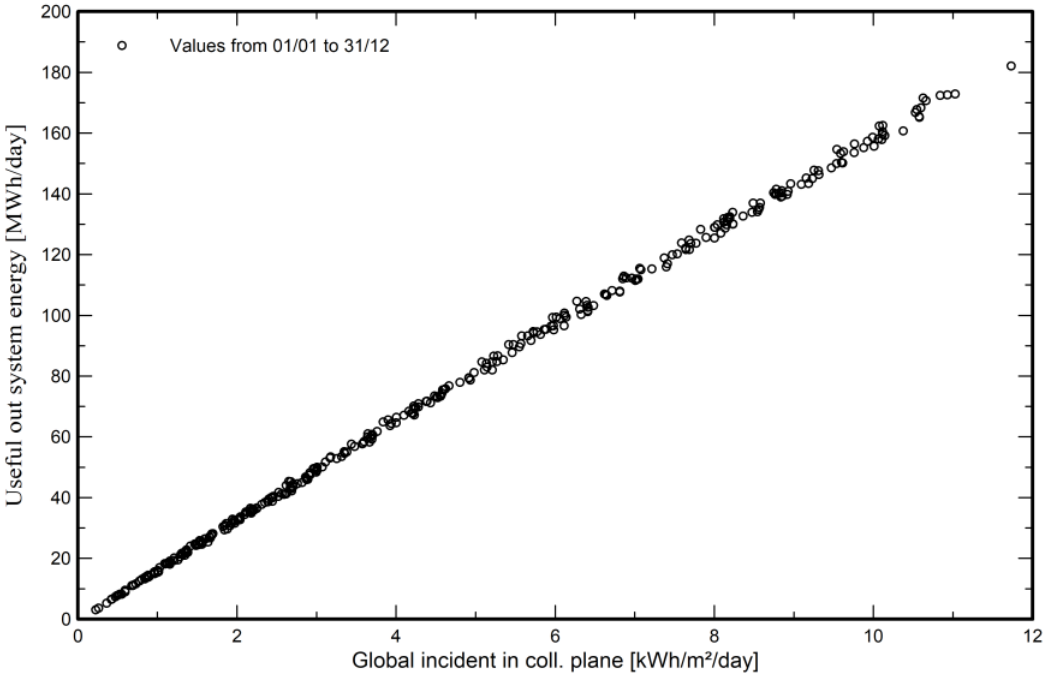
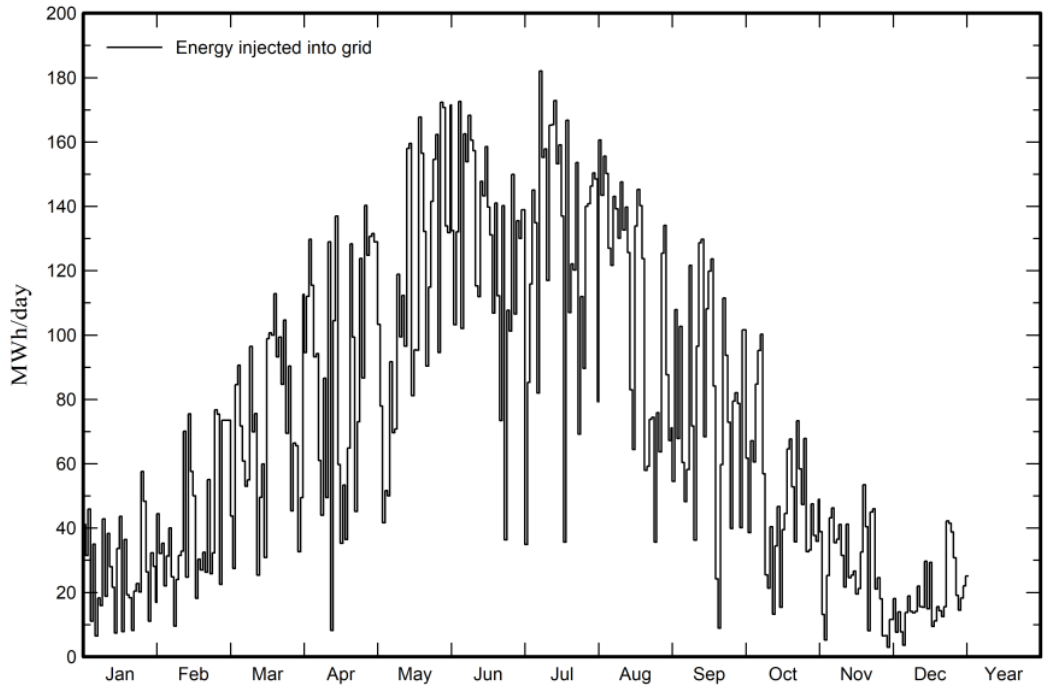


Diagramma giornaliero entrata/uscita

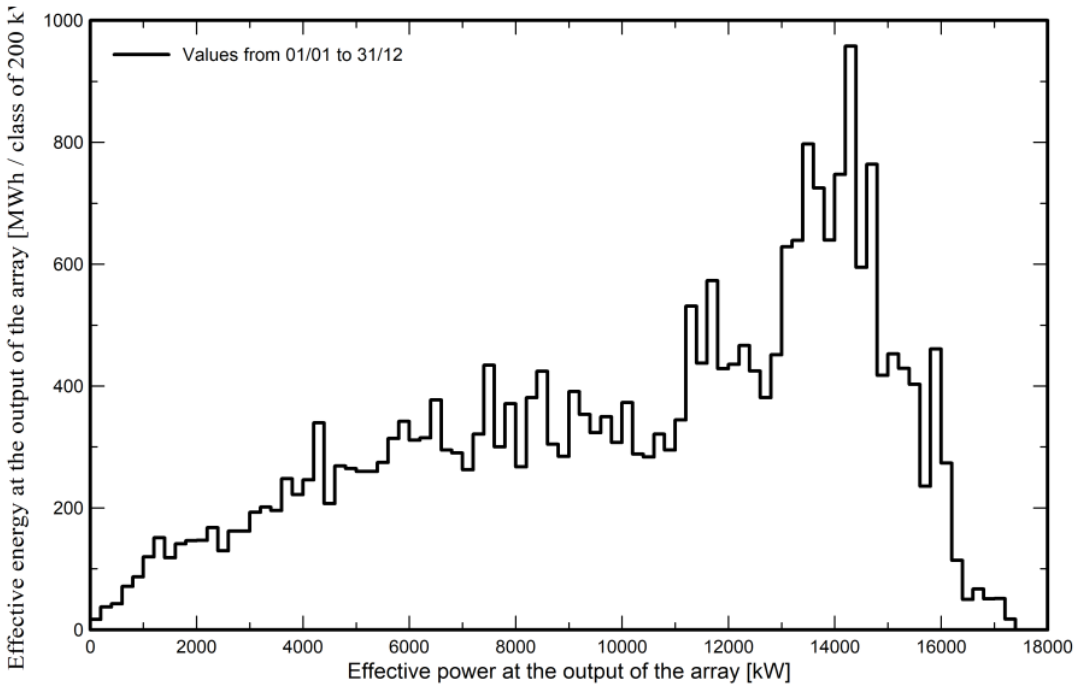


Predef. graphs

Energia giornaliera in uscita sistema

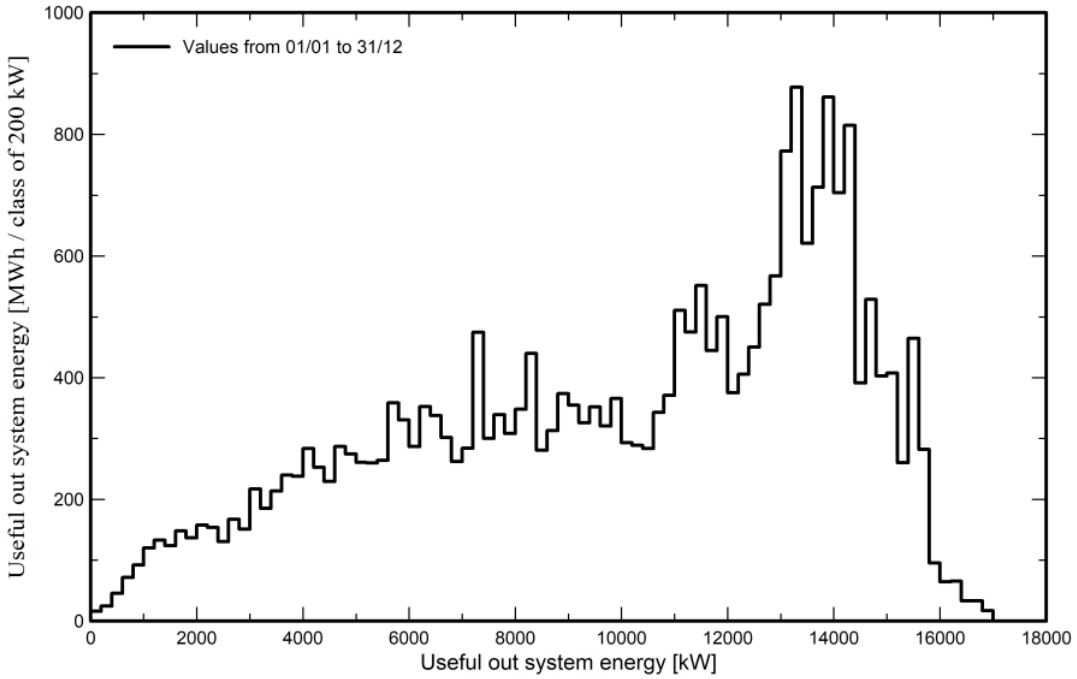


Distribuzione potenza dell'impianto

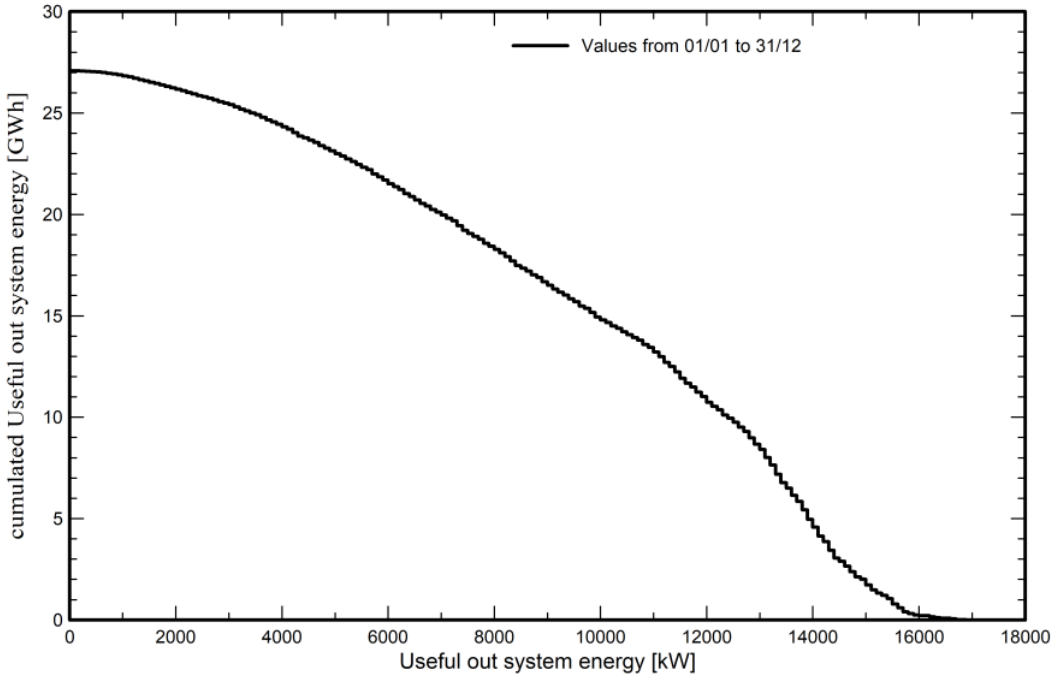


Predef. graphs

Distribuzione potenza in uscita sistema

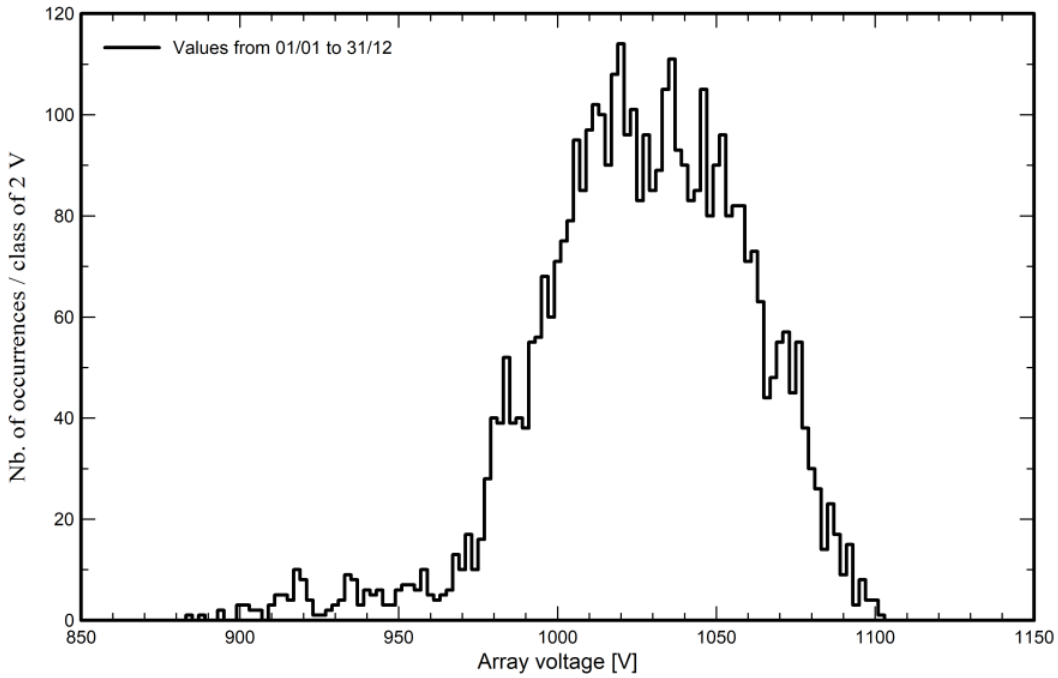


Coda della distribuzione della potenza in uscita

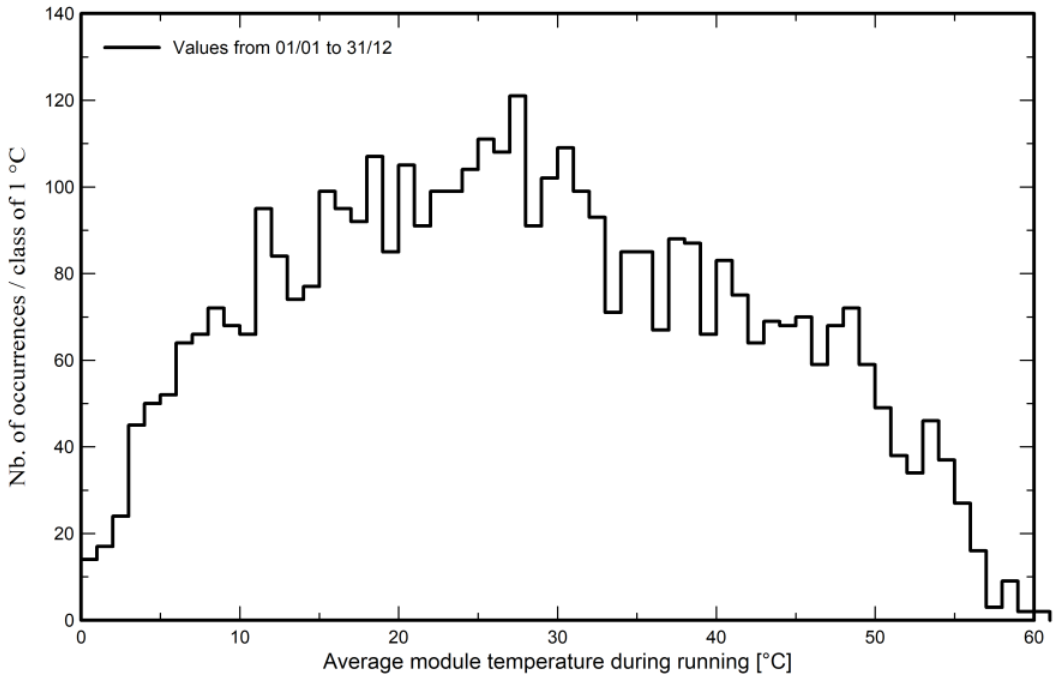


Predef. graphs

Distribuzione tensione impianto



Distribuzione temperatura impianto



2.2. SITO DI CAMPEGGIA

Project summary

Geographical Site
Chiesa Nuova
Italia

Situation

Latitude	44.55 °N
Longitude	11.96 °E
Altitude	10 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
Chiesa Nuova
Meteonorm 8.1 (1991-2012), Sat=100% - Sintetico

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
Linear shadings : Fast (table)
Diffuse shading Automatic

System information

PV Array

Nb. of modules	28288 units
Pnom total	19.80 MWp

Inverters

Nb. of units	5 units
Pnom total	17.19 MWac
Pnom ratio	1.152

User's needs
Unlimited load (grid)

Results summary

Produced Energy	29858009 kWh/year	Specific production	1508 kWh/kWp/year	Perf. Ratio PR	90.19 %

General parameters

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

Backtracking array

Nb. of trackers 1115 units

Sizes

Tracker Spacing	8.70 m
Collector width	4.79 m
Ground Cov. Ratio (GCR)	55.0 %
Phi min / max.	-/+ 60.0 °

Backtracking strategy

Phi limits for BT	-/+ 56.5 °
Backtracking pitch	8.70 m
Backtracking width	4.79 m
Mode	Automatic

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon

Free Horizon

Near Shadings

Linear shadings : Fast (table)
Diffuse shading Automatic

User's needs

Unlimited load (grid)

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing	8.70 m
Tracker width	4.79 m
GCR	55.0 %
Axis height above ground	2.10 m

Bifacial model definitions

Ground albedo	0.30
Bifaciality factor	80 %
Rear shading factor	5.0 %
Rear mismatch loss	10.0 %
Shed transparent fraction	0.0 %

PV Array Characteristics

PV module

Manufacturer	Risen Solar
Model	RSM132-8-700BHDG
(Custom parameters definition)	
Unit Nom. Power	700 Wp
Number of PV modules	28288 units
Nominal (STC)	19.80 MWp
Modules	1088 string x 26 In series
At operating cond. (50°C)	
Pmpp	18.73 MWp
U mpp	1023 V
I mpp	18314 A

Inverter

Manufacturer	Sungrow
Model	SG3400-HV-20
(Custom parameters definition)	
Unit Nom. Power	3437 kWac
Number of inverters	10 * MPPT 50% 5 units
Total power	17185 kWac
Operating voltage	875-1300 V
Max. power (=>25°C)	3593 kWac
Pnom ratio (DC:AC)	1.15
No power sharing between MPPTs	

Total PV power

Nominal (STC)	19802 kWp
Total	28288 modules
Module area	87872 m²

Total inverter power

Total power	17185 kWac
Number of inverters	5 units
Pnom ratio	1.15

Array losses

Thermal Loss factor

Module temperature according to irradiance

Uc (const)	29.0 W/m²K
Uv (wind)	0.0 W/m²K/m/s

DC wiring losses

Global array res.	0.90 mΩ
Loss Fraction	1.5 % at STC

LID - Light Induced Degradation

Loss Fraction	1.4 %

Module Quality Loss

Loss Fraction	-0.4 %

Module mismatch losses

Loss Fraction	2.0 % at MPP

Strings Mismatch loss

Loss Fraction	0.2 %

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

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage	600 Vac tri
Loss Fraction	0.12 % at STC

Inverter: SG3400-HV-20

Wire section (5 Inv.)	Copper 5 x 3 x 2500 mm²
Average wires length	15 m

MV line up to Injection

MV Voltage	20 kV
Average each inverter	
Wires	Copper 3 x 120 mm²
Length	5700 m
Loss Fraction	0.88 % at STC

AC losses in transformers

MV transfo

Medium voltage 20 kV

One transfo parameters

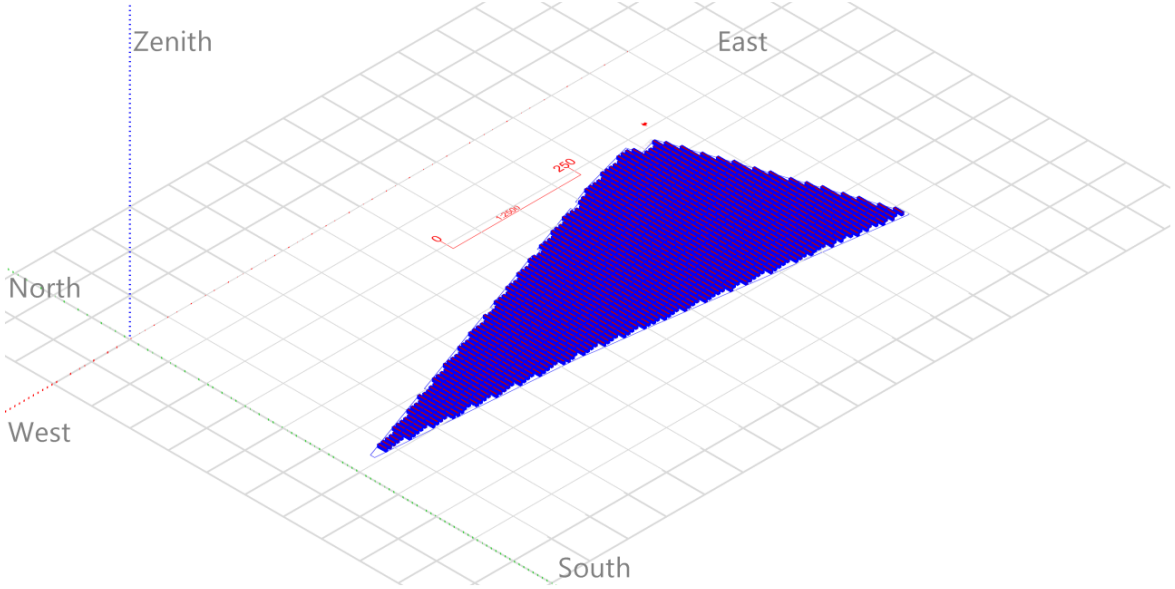
Nominal power at STC	3.92 MVA
Iron Loss (24/24 Connexion)	3.58 kVA
Iron loss fraction	0.09 % at STC
Copper loss	43.27 kVA
Copper loss fraction	1.10 % at STC
Coils equivalent resistance	3 x 1.01 mΩ

Operating losses at STC (full system)

Nb. identical MV transfos	5
Nominal power at STC	19.60 MVA
Iron loss (24/24 Connexion)	17.88 kVA
Copper loss	216.35 kVA

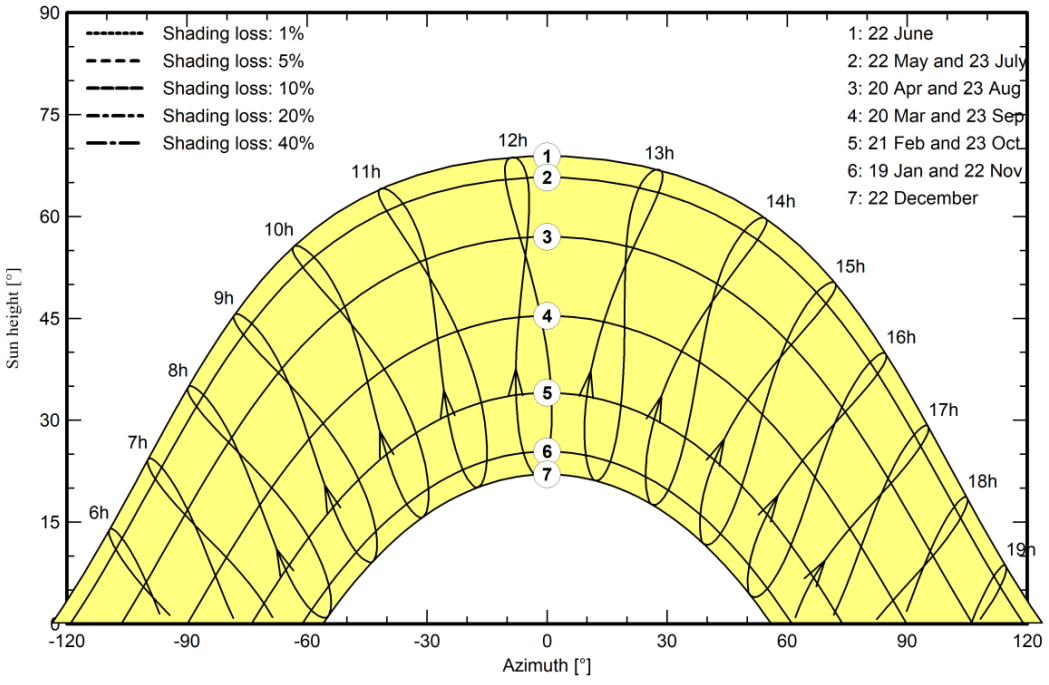
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram

Orientation #1

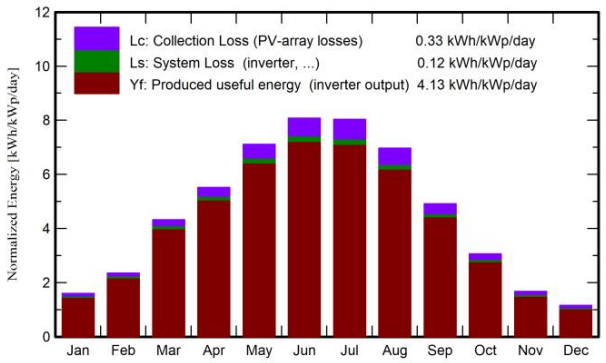


Main results

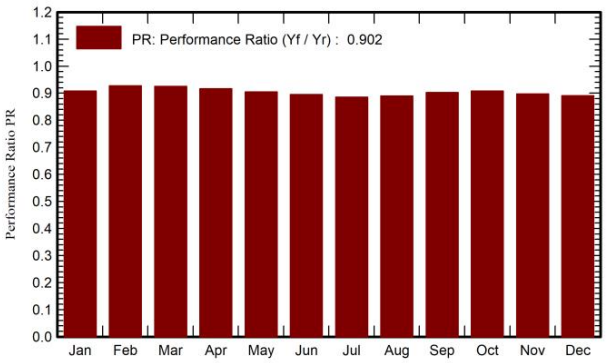
System Production

Produced Energy	29858009 kWh/year	Specific production	1508 kWh/kWp/year
		Perf. Ratio PR	90.19 %

Normalized productions (per installed kWp)



Performance Ratio PR



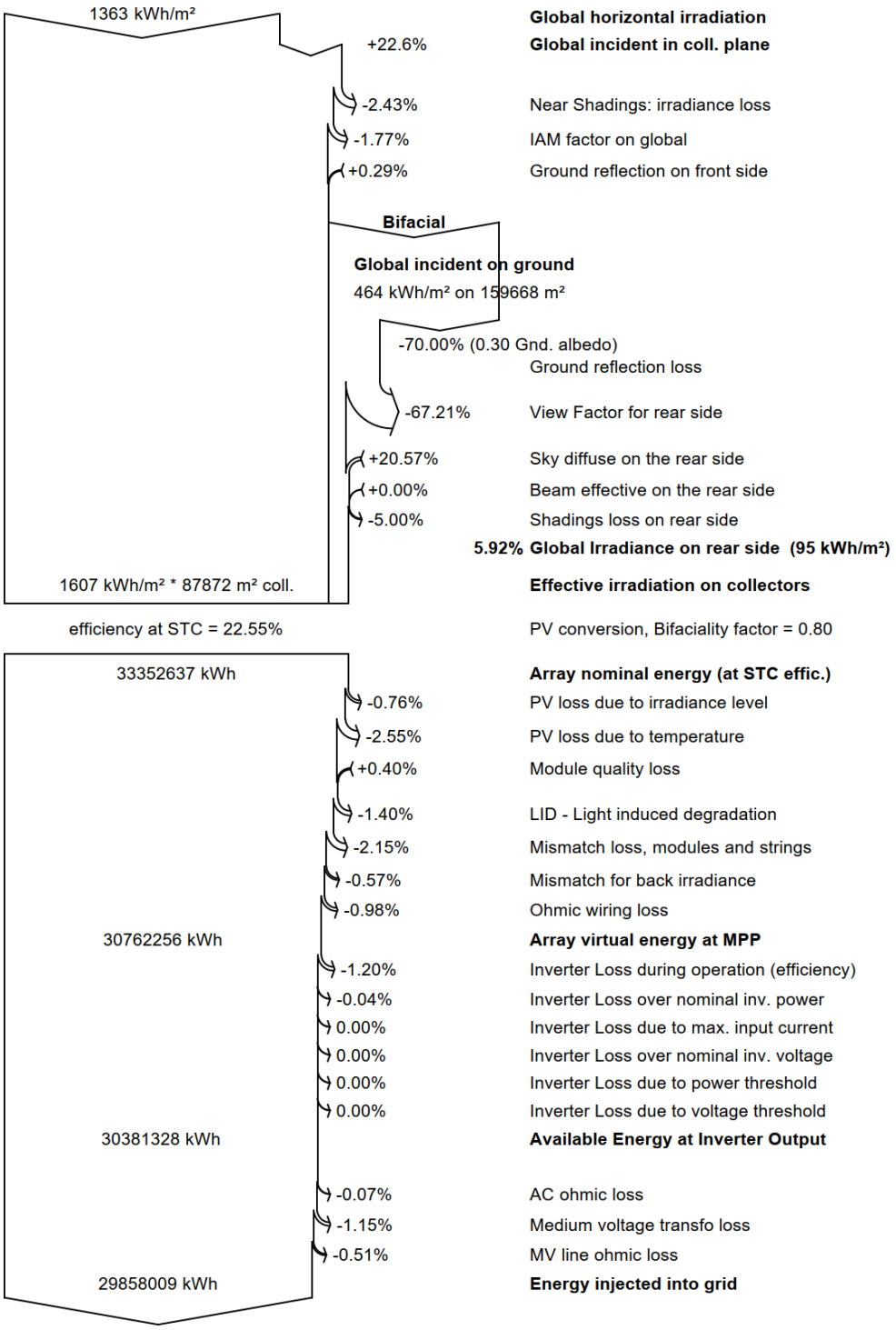
Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	41.3	22.44	2.92	49.6	45.9	926476	892577	0.908
February	55.9	33.19	5.13	65.8	62.2	1248745	1209575	0.928
March	108.1	51.97	10.02	134.1	128.5	2526893	2456536	0.925
April	136.0	67.92	14.40	165.6	159.4	3092908	3006944	0.917
May	180.7	82.30	19.65	220.3	213.1	4060468	3946998	0.905
June	196.8	85.26	24.33	242.4	235.2	4418705	4294962	0.895
July	199.7	79.00	26.67	249.1	241.7	4494952	4368846	0.886
August	173.2	70.77	25.98	216.2	209.5	3917490	3809029	0.890
September	120.2	54.88	20.36	147.4	141.8	2711148	2635637	0.903
October	78.8	44.10	15.85	95.0	89.9	1758678	1707816	0.908
November	41.4	24.25	10.01	50.3	46.9	927791	893350	0.897
December	31.2	21.02	4.26	36.0	32.9	664773	635740	0.891
Year	1363.2	637.12	15.02	1671.8	1606.9	30749028	29858009	0.902

Legends

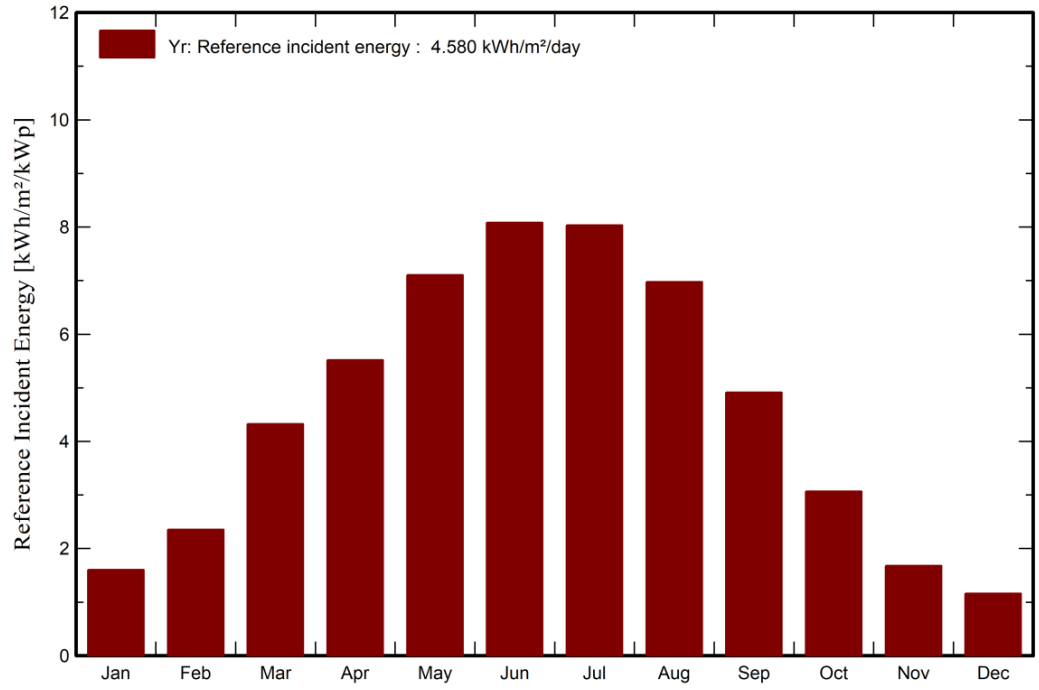
GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Loss diagram

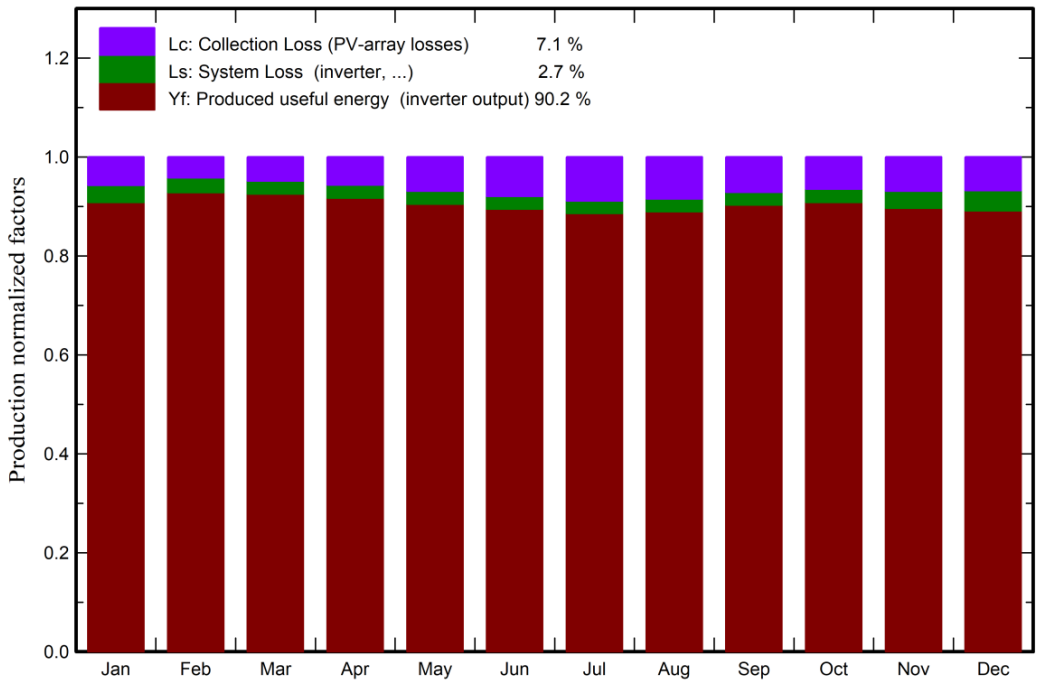


Predef. graphs

Energia incidente di riferimento su piano collettori

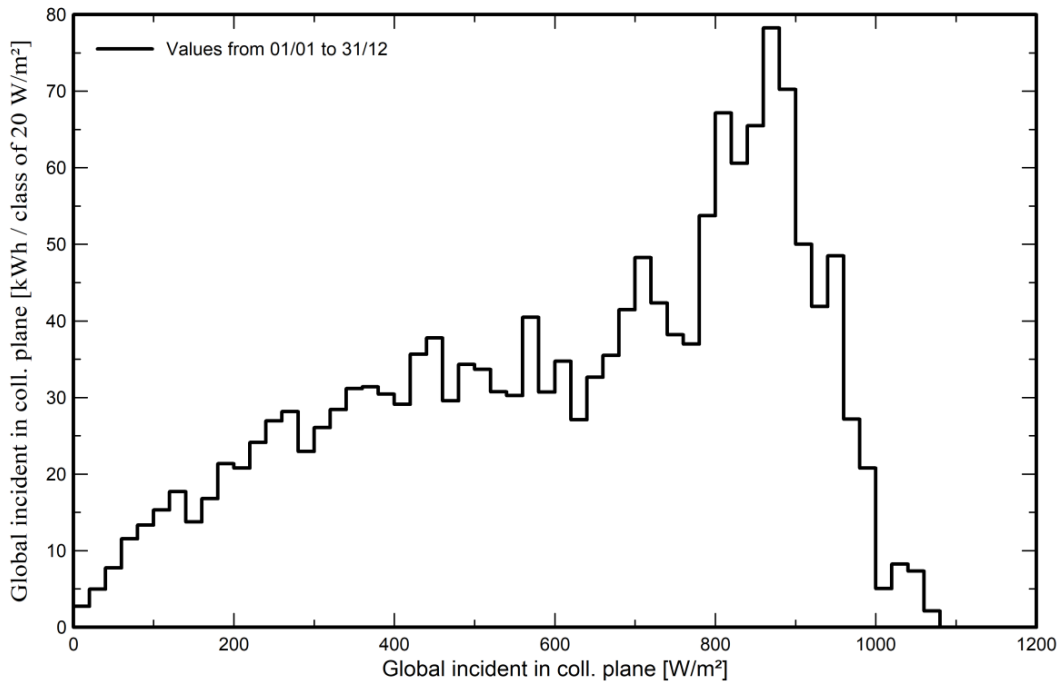


Fattori normalizzati di produzione e di perdita

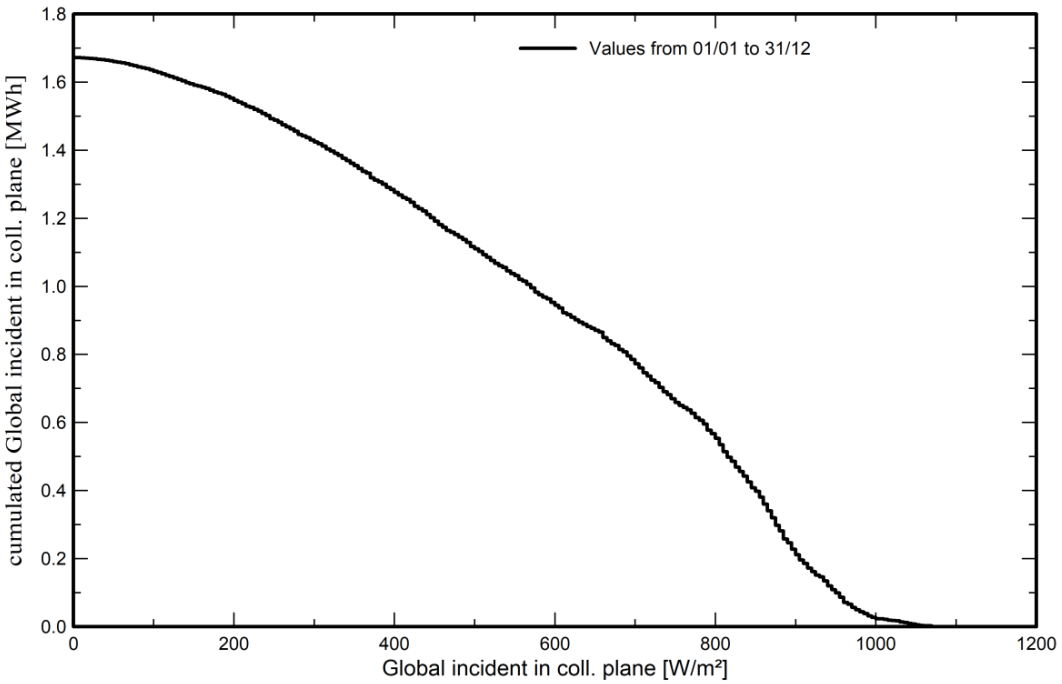


Predef. graphs

Distribuzione irraggiamento incidente



Coda della distribuzione di irradiazione incidente



Predef. graphs

Temperatura del campo vs.irradiazione efficace

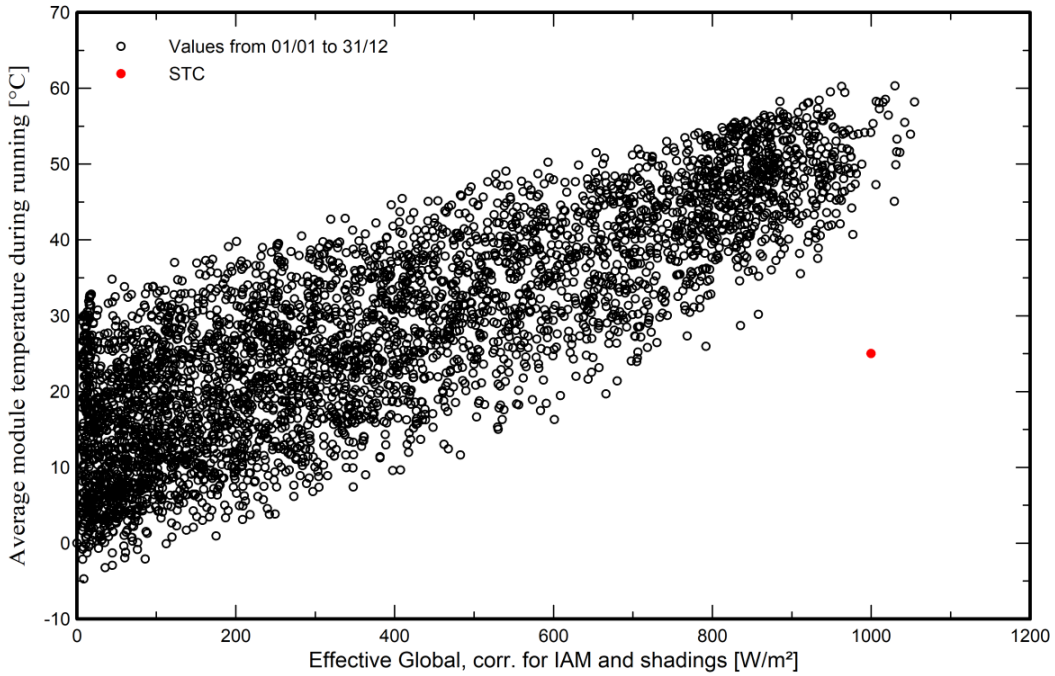
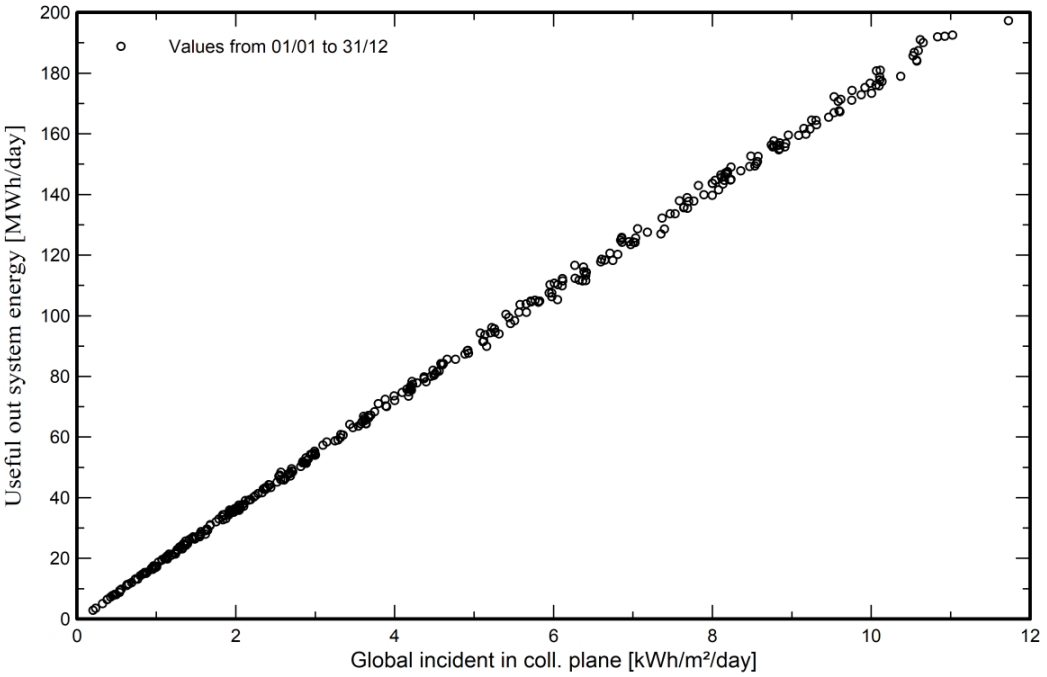
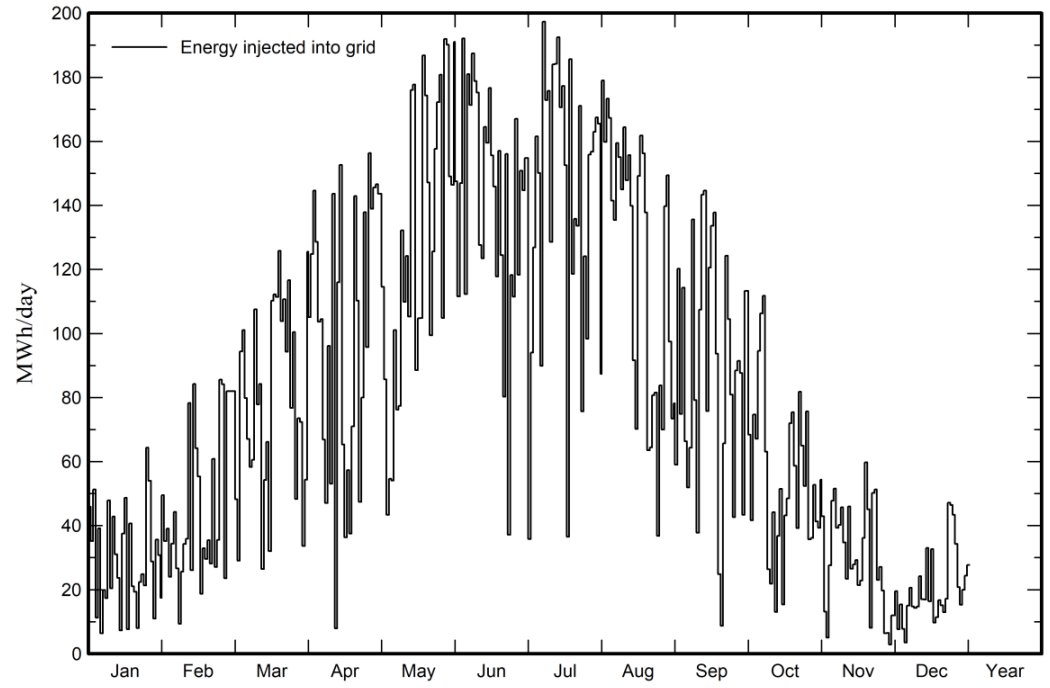


Diagramma giornaliero entrata/uscita

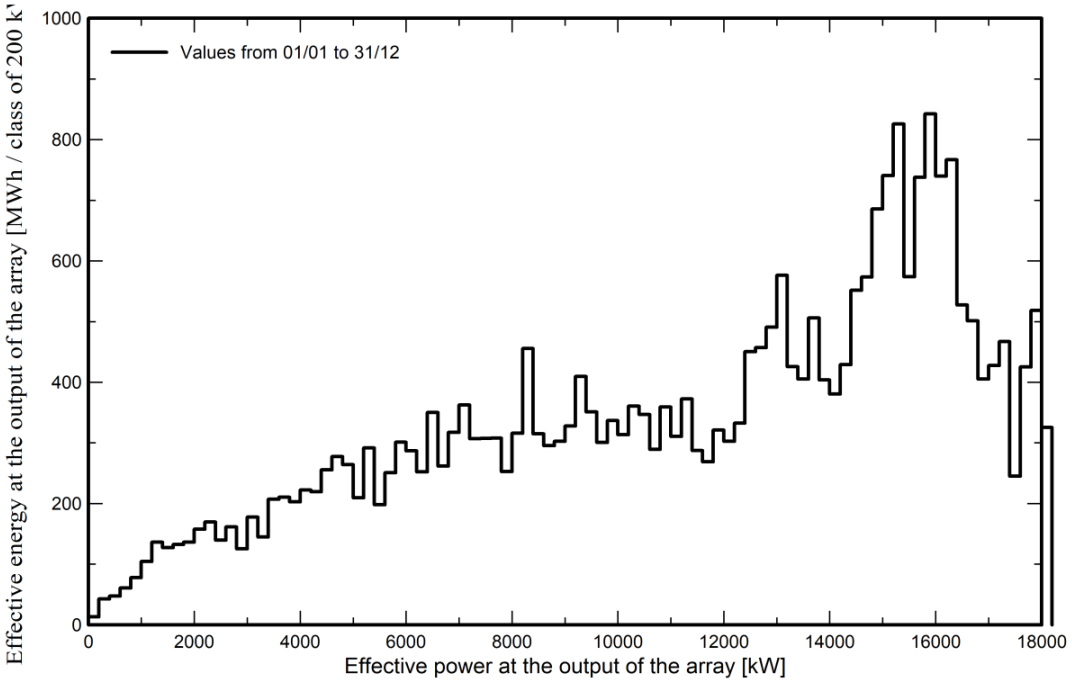


Predef. graphs

Energia giornaliera in uscita sistema

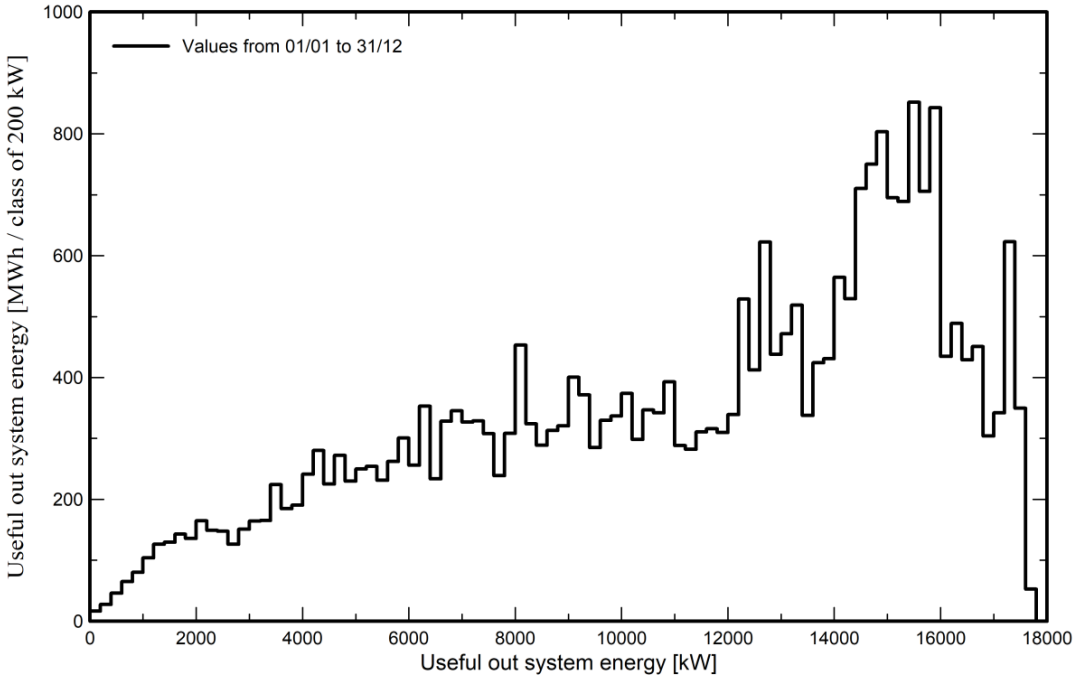


Distribuzione potenza dell'impianto

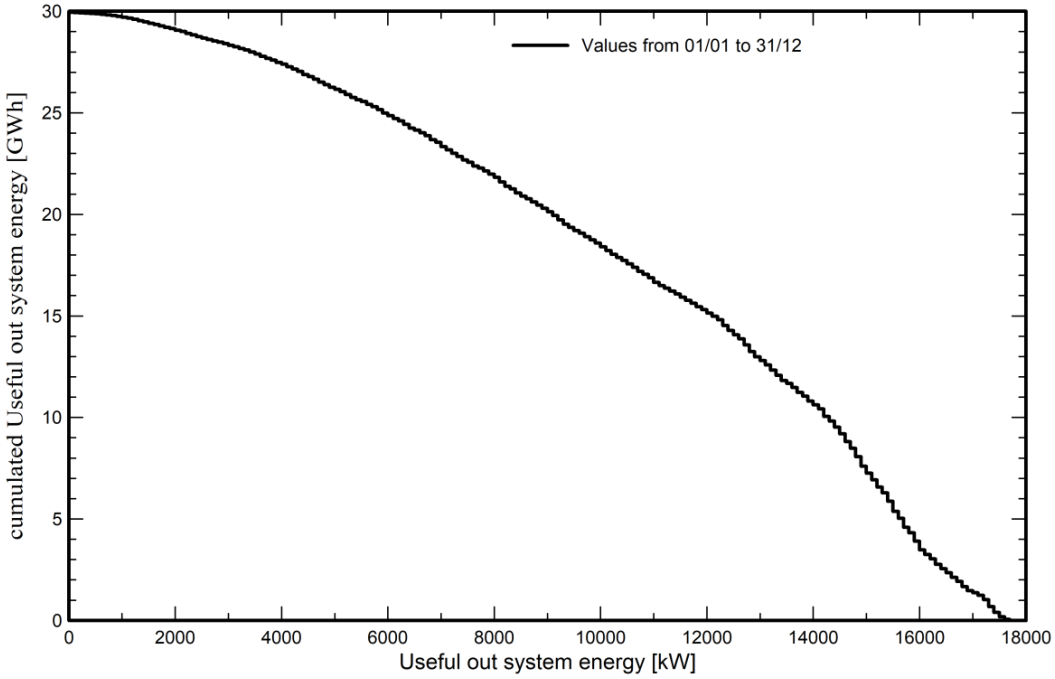


Predef. graphs

Distribuzione potenza in uscita sistema

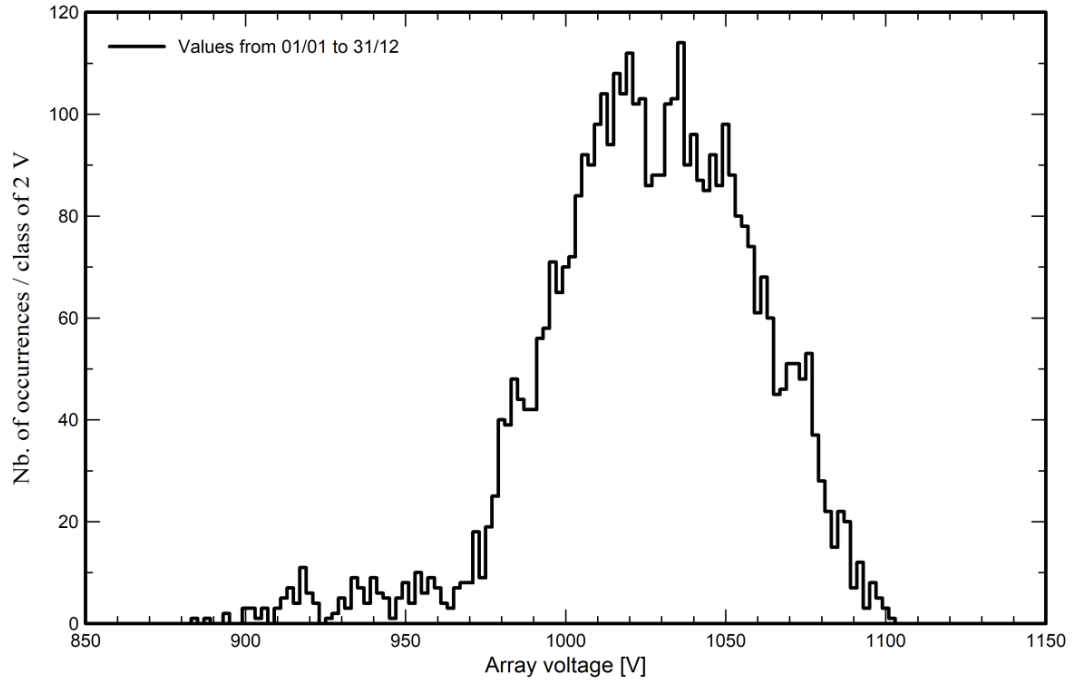


Coda della distribuzione della potenza in uscita

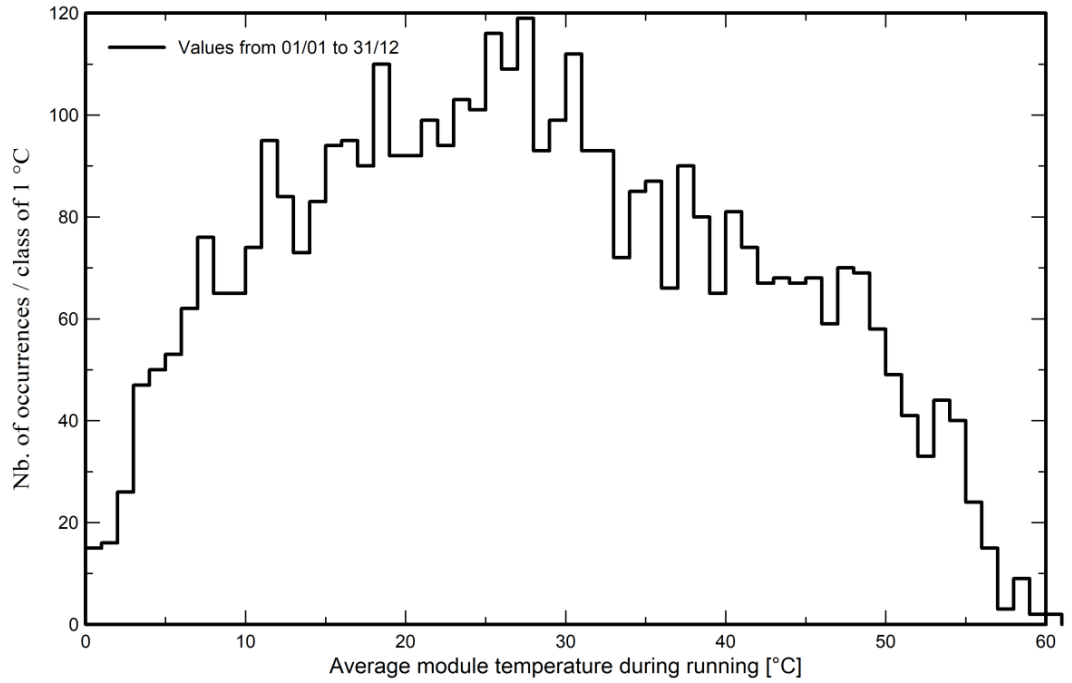


Predef. graphs

Distribuzione tensione impianto



Distribuzione temperatura impianto



3. EMISSIONI EVITATE

L'impianto fotovoltaico, per sua natura, non comporta emissioni in atmosfera in quanto si basa, per definizione, sulla produzione di energia elettrica per mezzo della radiazione luminosa non impattando in alcun modo su quella che è la qualità dell'aria. La produzione di energia per mezzo di fonti rinnovabili consente una minor dipendenza da fonti fossili la cui combustione è responsabile dell'immissione di inquinanti in atmosfera.

Grazie ai calcoli sovra riportati si è in grado di determinare per ogni sito l'energia prodotta annualmente.

In base ai dati più aggiornati in termini di emissioni specifiche in atmosfera e di fattore di conversione di energia primaria, forniti dal Rapporto ISPRA si è determinata una stima di inquinanti non emessi in atmosfera e di risparmi in termini di energia primaria (TEP) ottenibili grazie alla realizzazione dell'impianto in studio:

Emissioni specifiche in atmosfera (Rapporto ISPRA 2018)	**Inquinante [g/kWh]**			
	CO_2	SO_2	NO_X	Polveri
	492	0,0636	0,227	0,0054

Tabella 1 - Fattori di emissione

Periodo di tempo considerato	**Inquinante [ton]**			
	CO_2	SO_2	NO_X	Polveri
Emissioni evitate in 1 anno	27 973,63	3,62	12,91	0,31
Emissioni evitate in 30 anni	839 208,98	108,48	387,20	9,21

Tabella 2 - Emissioni evitate

Valore di Energia primaria risparmiata per ogni MWh prodotto dall'impianto FTV	**TEP/MWh**
	0,187

Tabella 3 - Fattore di conversione dell'energia primaria

Periodo di tempo considerato	**TEP**
Emissioni evitate in 1 anno	10 632,25
Emissioni evitate in 30 anni	318 968

Tabella 4 - Energia primaria risparmiata