



IMPIANTO FOTOVOLTAICO GREENHUB 2 S.R.L. E OPERE DI CONNESSIONE

POTENZA IMPIANTO 18,29 MW - COMUNE DI BENTIVOGLIO (BO)

Proponente



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Progettazione



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Titolo Elaborato

STIMA DI PRODUCIBILITA' DELL'IMPIANTO

| LIVELLO PROGETTAZIONE | COD. ELABORATO | FILE NAME | DATA | SCALA |
|-----------------------|----------------|-----------|----------|-------|
| DEFINITIVO | PD_REL.4 | - | 05/08/24 | |

Revisioni

| REV. | DATA | DESCRIZIONE | ESEGUITO | VERIFICATO | APPROVATO |
|------|----------|-------------|--------------|------------|-----------|
| 0 | 05/08/24 | | FB - GB - SC | EF | DZ |



COMUNE DI BENTIVOGLIO (BO)
REGIONE EMILIA-ROMAGNA





STIMA DI PRODUCIBILITÀ



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1. STIMA PRODUCIBILITÀ

Project: 1750507_Bentivoglio

Variant: Bentivoglio_Solar Plant

QuattroE S.r.l. (Italy)

Project summary

Geographical Site

Bentivoglio

Italy

Situation

Latitude 44.64 °N

Longitude 11.42 °E

Altitude 15 m

Time zone UTC+1

Project settings

Albedo 0.20

Weather data

Bentivoglio

Meteonorm 8.1 (1991-2012), Sat=100% - Synthetic

System summary

Grid-Connected System

Simulation for year no 10

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

25402 units

Pnom total

18.29 MWp

Inverters

Nb. of units

42 units

Pnom total

14.78 MWac

Pnom ratio

1.237

User's needs

Unlimited load (grid)

Results summary

Produced Energy 24343198 kWh/year Specific production 1331 kWh/kWp/year Perf. Ratio PR 81.58 %

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Project: 1750507_Bentivoglio

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QuattroE S.r.l. (Italy)

General parameters

Grid-Connected System

PV Field Orientation

Orientation

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

Models used

Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon

Free Horizon

Bifacial system

Model 2D Calculation
unlimited trackers

Bifacial model geometry

Tracker Spacing 8.00 m
Tracker width 4.92 m
GCR 61.5 %
Axis height above ground 2.70 m

Tracking system with backtracking

Tracking algorithm

Astronomic calculation
Backtracking activated

Near Shadings

Linear shadings : Fast (table)
Diffuse shading Automatic

Backtracking array

Nb. of trackers 977 units

Sizes

Tracker Spacing 8.00 m
Collector width 4.92 m
Ground Cov. Ratio (GCR) 61.5 %
Phi min / max. +/- 60.0 °

Backtracking strategy

Phi limits for BT +/- 52.0 °
Backtracking pitch 8.00 m
Backtracking width 4.92 m

User's needs

Unlimited load (grid)

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 CanadianSolar
Model Bifacial TOPBiHiKu7 CS7N-720TB-AG

(Custom parameters definition)

Unit Nom. Power 720 Wp
Number of PV modules 25402 units
Nominal (STC) 18.29 MWp

Array #1 - Sottocampo 1

Number of PV modules 8008 units
Nominal (STC) 5766 kWp
Modules 308 string x 26 In series

At operating cond. (50°C)

Pmpp 5193 kWp
U mpp 944 V
I mpp 5504 A

Inverter

Manufacturer Sungrow
Model SG350-HX

(Custom parameters definition)

Unit Nom. Power 352 kWac
Number of inverters 42 units
Total power 14784 kWac

Number of inverters 13 units
Total power 4576 kWac

Operating voltage 500-1450 V

Pnom ratio (DC:AC) 1.26

Power sharing within this inverter

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PV Array Characteristics

Array #2 - Sottocampo 2

| | | | |
|----------------------------------|---------------------------|------------------------------------|------------|
| Number of PV modules | 7410 units | Number of inverters | 12 units |
| Nominal (STC) | 5335 kWp | Total power | 4224 kWac |
| Modules | 285 string x 26 In series | | |
| At operating cond. (50°C) | | Operating voltage | 500-1450 V |
| P _{mpp} | 4805 kWp | P _{nom} ratio (DC:AC) | 1.26 |
| U _{mpp} | 944 V | Power sharing within this inverter | |
| I _{mpp} | 5093 A | | |

Array #3 - Sottocampo 3.1

| | | | |
|----------------------------------|---------------------------|------------------------------------|------------|
| Number of PV modules | 7826 units | Number of inverters | 13 units |
| Nominal (STC) | 5635 kWp | Total power | 4576 kWac |
| Modules | 301 string x 26 In series | | |
| At operating cond. (50°C) | | Operating voltage | 500-1450 V |
| P _{mpp} | 5075 kWp | P _{nom} ratio (DC:AC) | 1.23 |
| U _{mpp} | 944 V | Power sharing within this inverter | |
| I _{mpp} | 5379 A | | |

Array #4 - Sottocampo 3.2

| | | | |
|----------------------------------|--------------------------|------------------------------------|------------|
| Number of PV modules | 2158 units | Number of inverters | 4 units |
| Nominal (STC) | 1554 kWp | Total power | 1408 kWac |
| Modules | 83 string x 26 In series | | |
| At operating cond. (50°C) | | Operating voltage | 500-1450 V |
| P _{mpp} | 1399 kWp | P _{nom} ratio (DC:AC) | 1.10 |
| U _{mpp} | 944 V | Power sharing within this inverter | |
| I _{mpp} | 1483 A | | |

Total PV power

| | |
|---------------|---------------|
| Nominal (STC) | 18289 kWp |
| Total | 25402 modules |
| Module area | 78908 m² |
| Cell area | 75444 m² |

Total inverter power

| | |
|------------------------|------------|
| Total power | 14784 kWac |
| Number of inverters | 42 units |
| P _{nom} ratio | 1.24 |

Array losses

Array Soiling Losses

| | |
|---------------|-------|
| Loss Fraction | 3.0 % |
|---------------|-------|

Thermal Loss factor

| | |
|--|---------------|
| Module temperature according to irradiance | |
| U _c (const) | 29.0 W/m²K |
| U _v (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 % |
|---------------|-------|

Module average degradation

| | |
|------------------------------------|------------|
| Year no | 10 |
| 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): Fresnel smooth glass, n = 1.526

| 0° | 30° | 50° | 60° | 70° | 75° | 80° | 85° | 90° |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1.000 | 0.998 | 0.981 | 0.948 | 0.862 | 0.776 | 0.636 | 0.403 | 0.000 |

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QuattroE S.r.l. (Italy)

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 0.91 mΩ

Loss Fraction 1.5 % at STC

Array #1 - Sottocampo 1

Global array res.

2.9 mΩ

Loss Fraction

1.5 % at STC

Array #3 - Sottocampo 3.1

Global array res.

3.0 mΩ

Loss Fraction

1.5 % at STC

Array #2 - Sottocampo 2

Global array res.

3.1 mΩ

Loss Fraction

1.5 % at STC

Array #4 - Sottocampo 3.2

Global array res.

11 mΩ

Loss Fraction

1.5 % at STC

System losses

Auxiliaries loss

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage

800 Vac tri

Loss Fraction

0.70 % at STC

Inverter: SG350-HX

Wire section (38 Inv.)

Copper 38 x 3 x 185 mm²

Average wires length

100 m

Inverter: SG350-HX

Wire section (4 Inv.)

Copper 4 x 3 x 150 mm²

Average wires length

100 m

MV line up to Injection

MV Voltage

30 kV

Average each inverter

Wires

Copper 3 x 120 mm²

Length

50 m

Loss Fraction

0.01 % at STC

AC losses in transformers

MV transfo

Medium voltage

30 kV

One transfo parameters

Nominal power at STC

6.05 MVA

Iron Loss (24/24 Connexion)

6.05 kVA

Iron loss fraction

0.10 % at STC

Copper loss

60.48 kVA

Copper loss fraction

1.00 % at STC

Coils equivalent resistance

3 x 1.06 mΩ

Operating losses at STC (full system)

Nb. identical MV transfos

3

Nominal power at STC

18.14 MVA

Iron loss (24/24 Connexion)

18.14 kVA

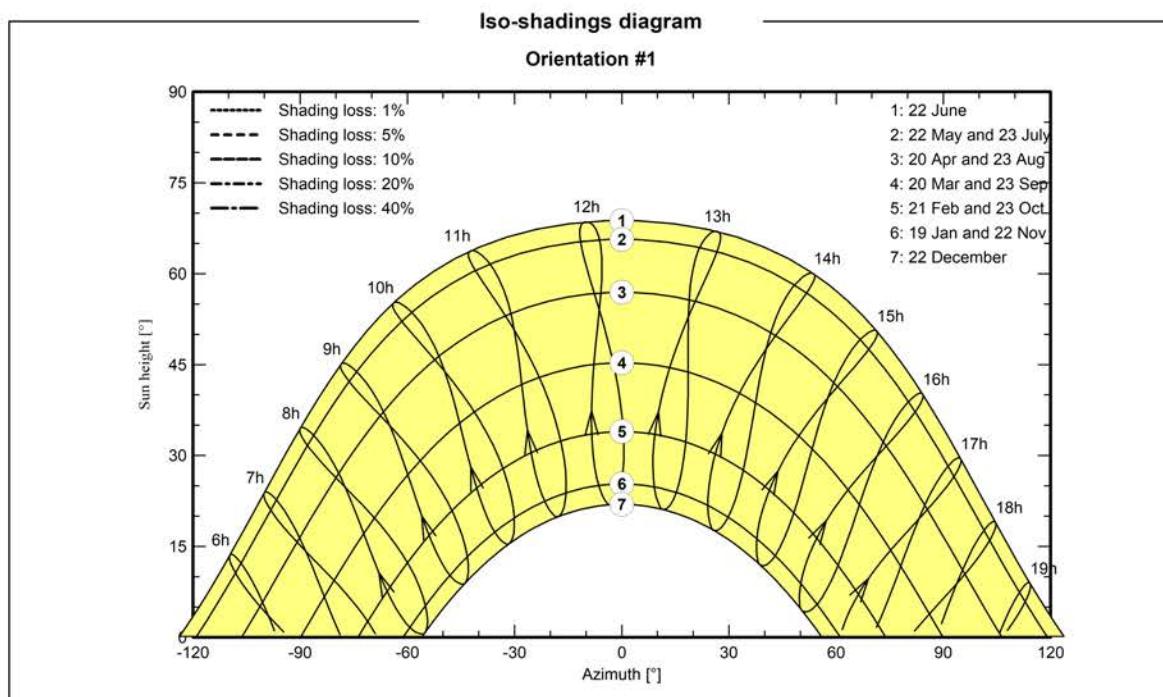
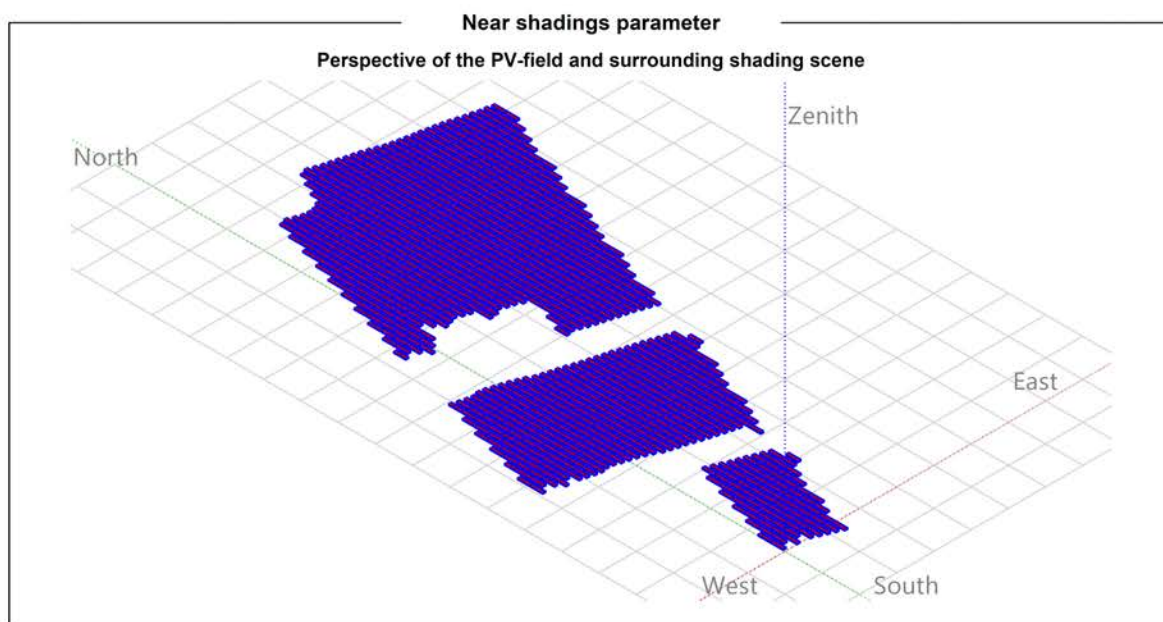
Copper loss

181.43 kVA

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Main results

System Production

Produced Energy

24343198 kWh/year

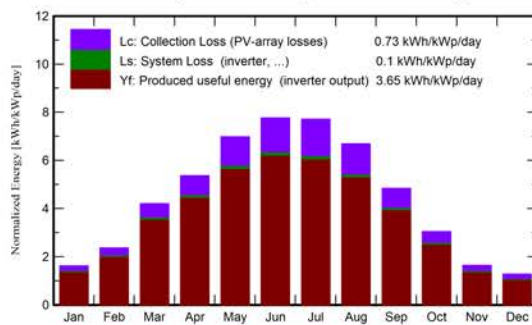
Specific production

1331 kWh/kWp/year

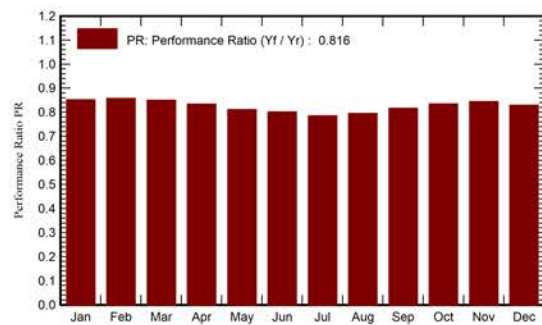
Perf. Ratio PR

81.58 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

| | GlobHor | DiffHor | T_Amb | GlobInc | GlobEff | EArray | E_Grid | PR |
|-----------|--------------------|--------------------|-------|--------------------|--------------------|----------|----------|-------|
| | kWh/m ² | kWh/m ² | °C | kWh/m ² | kWh/m ² | kWh | kWh | ratio |
| January | 43.1 | 26.15 | 2.79 | 50.3 | 44.3 | 813150 | 783464 | 0.852 |
| February | 55.6 | 30.50 | 4.88 | 66.1 | 59.8 | 1069437 | 1036450 | 0.857 |
| March | 107.9 | 50.77 | 9.87 | 130.2 | 120.3 | 2074707 | 2023620 | 0.850 |
| April | 134.6 | 65.79 | 13.91 | 160.9 | 149.7 | 2515296 | 2454267 | 0.834 |
| May | 178.5 | 77.81 | 18.82 | 216.5 | 202.4 | 3290564 | 3213452 | 0.812 |
| June | 193.8 | 84.80 | 23.12 | 233.0 | 218.5 | 3494857 | 3414165 | 0.801 |
| July | 196.4 | 75.19 | 25.76 | 239.3 | 224.7 | 3518515 | 3436519 | 0.785 |
| August | 171.9 | 73.29 | 25.26 | 207.3 | 194.0 | 3086794 | 3015545 | 0.796 |
| September | 120.3 | 53.62 | 19.91 | 145.1 | 134.3 | 2222521 | 2168500 | 0.817 |
| October | 79.6 | 46.79 | 15.26 | 94.2 | 85.5 | 1479329 | 1439222 | 0.835 |
| November | 43.3 | 28.34 | 9.25 | 49.1 | 43.7 | 787563 | 758285 | 0.844 |
| December | 33.4 | 19.10 | 3.95 | 39.5 | 34.3 | 627306 | 599709 | 0.829 |
| Year | 1358.5 | 632.15 | 14.45 | 1631.5 | 1511.3 | 24980038 | 24343198 | 0.816 |

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

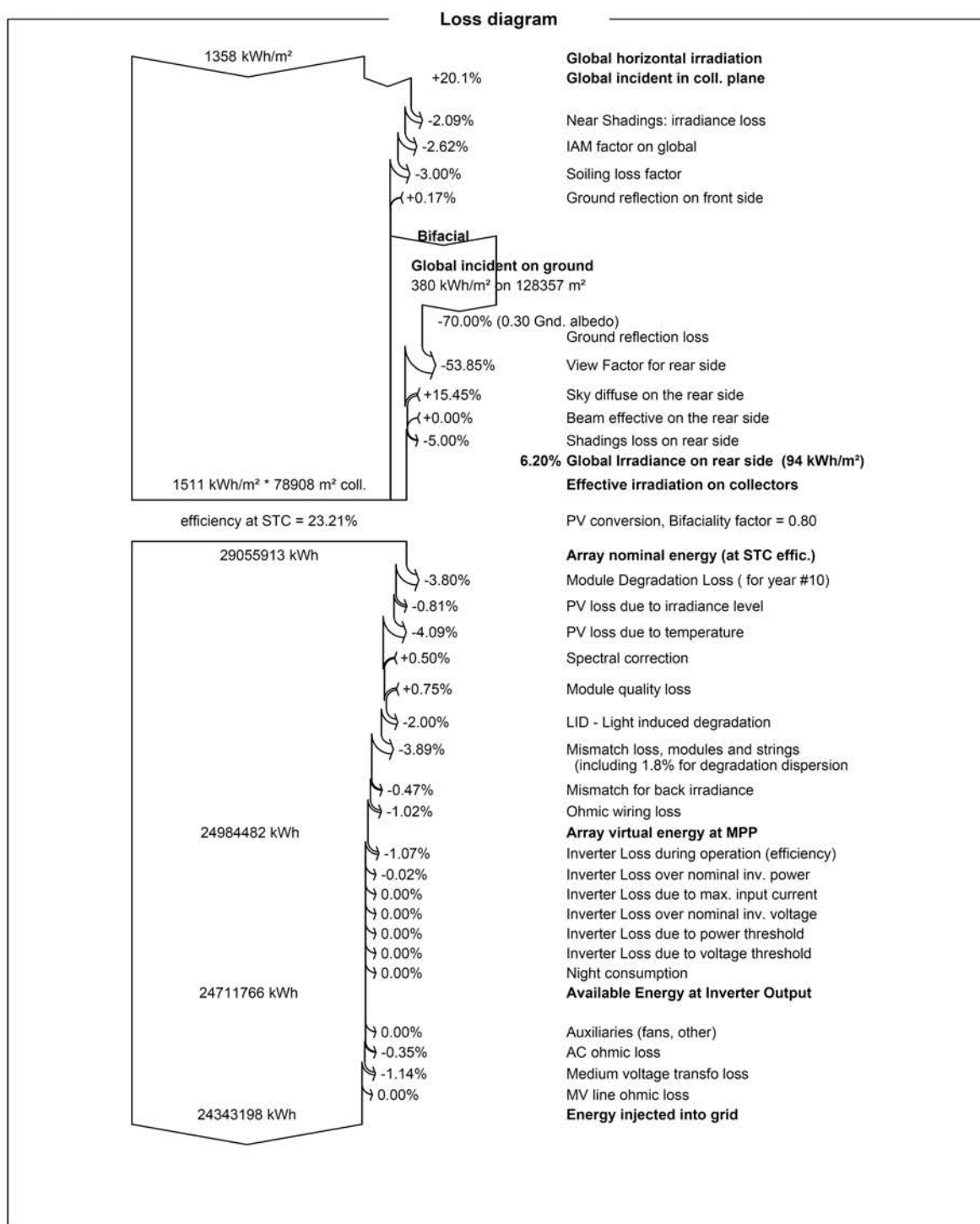
E_Grid Energy injected into grid

PR Performance Ratio

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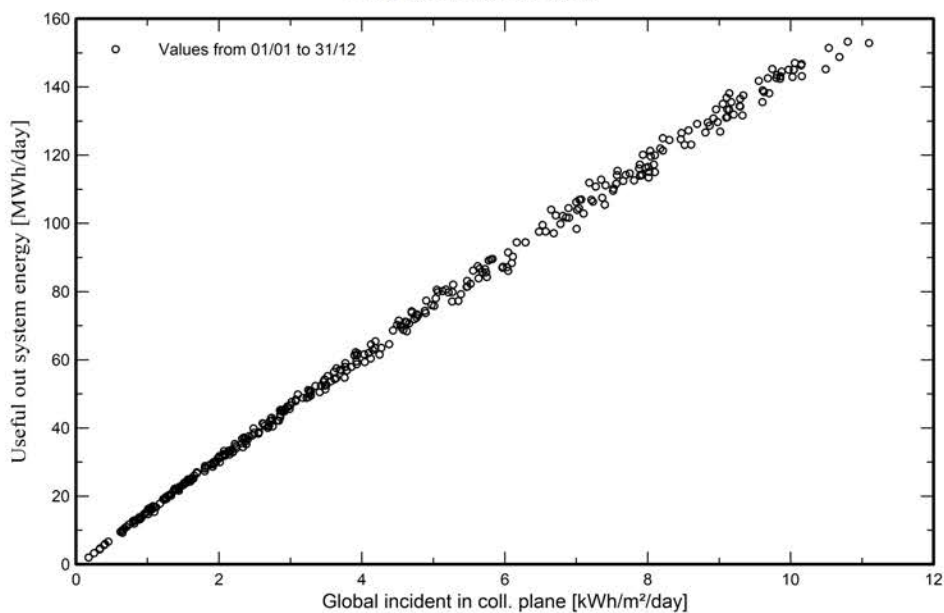
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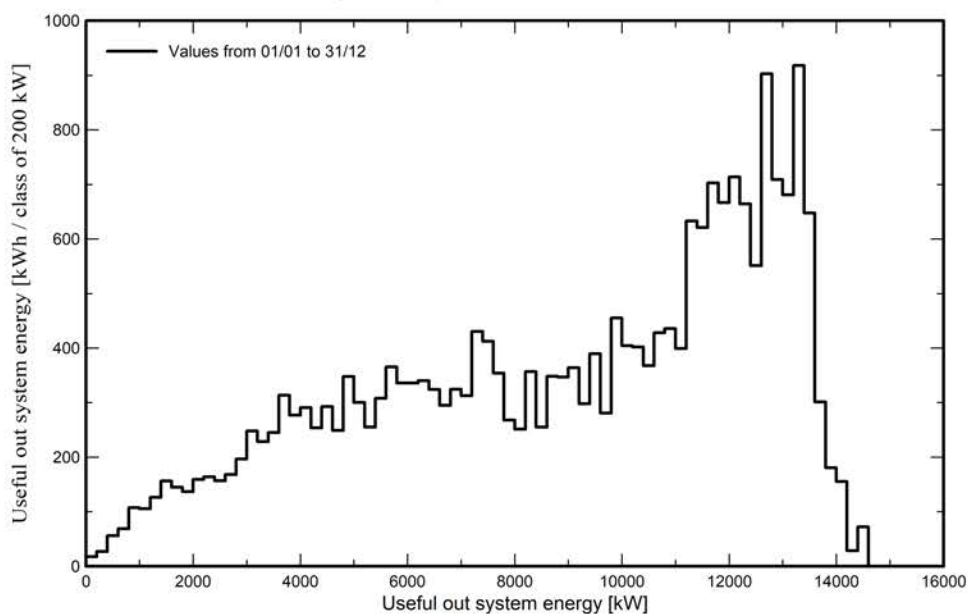
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Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



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P50 - P90 evaluation

Weather data

Source Meteonorm 8.1 (1991-2012), Sat=100%
 Kind Monthly averages
 Synthetic - Multi-year average
 Year-to-year variability(Variance) 8.8 %
Specified Deviation
 Climate change 0.0 %

Global variability (weather data + system)

Variability (Quadratic sum) 8.9 %

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 2.18 GWh
 P50 24.34 GWh
 P90 21.55 GWh
 P95 20.77 GWh

Probability distribution

