

Comune di Palata - Montecilfone,
Provincia di Campobasso, Regione Molise



ARNG SOLAR III S.R.L.

Viale Giorgio Ribotta, 21 Eurosky Tower - Interno 0B3

ROMA (RM), 00144

PEC: arngsolar3@pec.it

Impianto Ivoltaico "PALATA 21.0" PD01_21 – SIMULAZIONE ENERGETICA (PVSYSY)

| PROGETTISTI | | IL PROPONENTE |
|--|---|---|
| Coordinamento tecnico di progetto | | ARNG SOLAR III S.R.L. Sede legale: Viale Giorgio Ribotta, 21 Eurosky Tower – Interno 0B3 ROMA (RM), 00144 pec: arngsolar3@pec.it Numero REA RM - 1678430 P.IVA 02332900683 |
| Michele Di stefano Ordine Ingegneri della Provincia di Chieti - n. 1463 mdistefano@nrgplus.global |  | |
| RESPONSABILE TECNICO NRG+ | | |
| Maurizio DE DONNO Ordine Ingegneri della Provincia di Torino - n. 10258 H mddonno@nrgplus.global |  | |

DICEMBRE 2022



PVsyst - Simulation report

Grid-Connected System

Project: ITS2PA-Palata

Variant: Palata_Tracker 1P(15-30)_670Wp_Pitch=4.5m

Tracking system with backtracking

System power: 25.99 MWp

Palata - Italy



Project: ITS2PA-Palata

Variant: Palata_Tracker 1P(15-30)_670Wp_Pitch=4.5m

PVsyst V7.2.8

VCO, Simulation date:
13/12/22 08:28
with v7.2.8

Project summary

| | | | | | |
|---|-------|------------------|----------|-------------------------|------|
| Geographical Site | | Situation | | Project settings | |
| Palata | Italy | Latitude | 41.88 °N | Albedo | 0.20 |
| | | Longitude | 14.80 °E | | |
| | | Altitude | 513 m | | |
| | | Time zone | UTC+1 | | |
| Meteo data | | | | | |
| Palata | | | | | |
| Meteonorm 8.0 (1997-2015), 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, tilted axis | | Backtracking activated | | Electrical effect | 100 % |
| Avg axis tilt | -0.1 ° | | | | |
| Avg axis azim. | 0.0 ° | | | | |
| System information | | | | | |
| PV Array | | | | | |
| Nb. of modules | 38790 units | Inverters | | | |
| Pnom total | 25.99 MWp | Nb. of units | 82 units | | |
| | | Pnom total | 27.06 MWac | | |
| | | Grid power limit | 21.00 MWac | | |
| | | Grid lim. Pnom ratio | 1.238 | | |
| User's needs | | | | | |
| Unlimited load (grid) | | | | | |

Results summary

| | | | | | |
|-----------------|----------------|---------------------|-------------------|----------------|---------|
| Produced Energy | 38476 MWh/year | Specific production | 1480 kWh/kWp/year | Perf. Ratio PR | 81.38 % |
|-----------------|----------------|---------------------|-------------------|----------------|---------|

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General parameters

| Grid-Connected System | | Tracking system with backtracking | |
|--------------------------------|--------------------------------------|--|------------|
| PV Field Orientation | | Tracking algorithm | |
| Orientation | | Irradiance optimization | |
| Tracking plane, tilted axis | | Backtracking activated | |
| Avg axis tilt | -0.1 ° | | |
| Avg axis azim. | 0.0 ° | | |
| | | Backtracking strategy | |
| | | Nb. of trackers | 1424 units |
| | | Sizes | |
| | | Tracker Spacing | 4.50 m |
| | | Collector width | 2.38 m |
| | | Ground Cov. Ratio (GCR) | 53.0 % |
| | | Phi min / max. | -/+ 60.0 ° |
| | | Backtracking limit angle | |
| | | Phi limits | +/- 57.8 ° |
| Models used | | Near Shadings | |
| Transposition | Perez | According to strings | |
| Diffuse | Perez, Meteonorm | Electrical effect | 100 % |
| Circumsolar | separate | | |
| Horizon | | User's needs | |
| Average Height | 2.6 ° | Unlimited load (grid) | |
| Bifacial system | | | |
| Model | 2D Calculation unlimited trackers | | |
| Bifacial model geometry | | Bifacial model definitions | |
| Tracker Spacing | 4.50 m | Ground albedo | 0.30 |
| Tracker width | 2.38 m | Bifaciality factor | 70 % |
| GCR | 53.0 % | Rear shading factor | 5.0 % |
| Axis height above ground | 2.48 m | Rear mismatch loss | 10.0 % |
| | | Shed transparent fraction | 0.0 % |
| Grid power limitation | | | |
| Active Power | 21.00 MWac | | |
| Pnom ratio | 1.238 | | |

PV Array Characteristics

| PV module | | Inverter | |
|----------------------------------|-----------------------------|--------------------------------|------------------------------------|
| Manufacturer | Trina Solar | Manufacturer | Huawei Technologies |
| Model | TSM-670DEG21C.20 | Model | SUN2000-330KTL-H1-Preliminary V0.1 |
| (Custom parameters definition) | | (Custom parameters definition) | |
| Unit Nom. Power | 670 Wp | Unit Nom. Power | 330 kWac |
| Number of PV modules | 38790 units | Number of inverters | 82 units |
| Nominal (STC) | 25.99 MWp | Total power | 27060 kWac |
| Modules | 1293 Strings x 30 In series | Operating voltage | 500-1500 V |
| At operating cond. (47°C) | | Pnom ratio (DC:AC) | 0.96 |
| Pmpp | 24.08 MWp | | |
| U mpp | 962 V | | |
| I mpp | 25042 A | | |
| Total PV power | | Total inverter power | |
| Nominal (STC) | 25989 kWp | Total power | 27060 kWac |
| Total | 38790 modules | Nb. of inverters | 82 units |
| Module area | 121998 m² | Pnom ratio | 0.96 |
| Cell area | 112646 m² | | |



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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/m²K

Uv (wind) 0.0 W/m²K/m/s

DC wiring losses

Global array res. 0.62 mΩ

Loss Fraction 1.5 % at STC

Serie Diode Loss

Voltage drop 0.7 V

Loss Fraction 0.1 % at STC

LID - Light Induced Degradation

Loss Fraction 0.2 %

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 1

Loss factor 0.45 %/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 |

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage 800 Vac tri

Loss Fraction 1.22 % at STC

Inverter: SUN2000-330KTL-H1-Preliminary V0.1

Wire section (82 Inv.) Alu 82 x 3 x 185 mm²

Average wires length 147 m

MV line up to Injection

MV Voltage 30 kV

Wires Alu 3 x 1000 mm²

Length 4680 m

Loss Fraction 0.42 % at STC

AC losses in transformers

MV transfo

Grid voltage 30 kV

Operating losses at STC

Nominal power at STC 25537 kVA

Iron loss (24/24 Connexion) 25.54 kW

Loss Fraction 0.10 % at STC

Coils equivalent resistance 3 x 0.25 mΩ

Loss Fraction 1.00 % at STC



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Horizon definition

Horizon from PVGIS website API, Lat=41°53'0', Long=14°48'16', Alt=513m

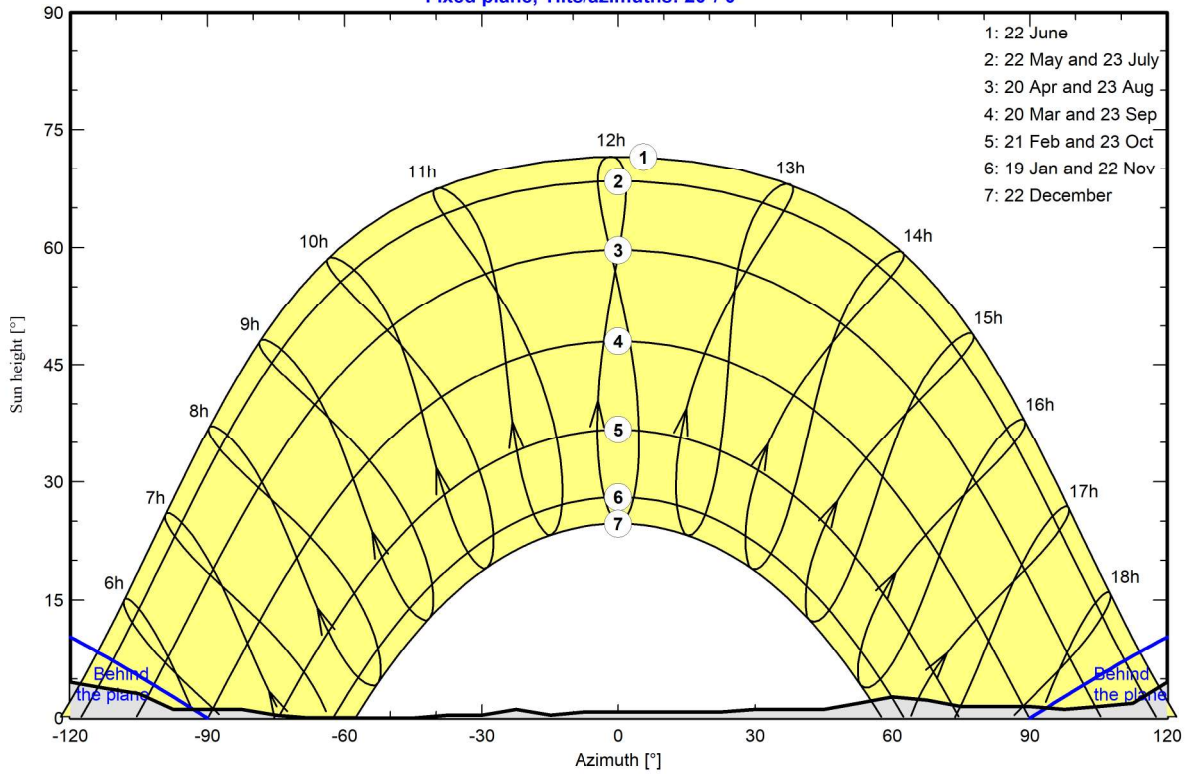
| | | | |
|----------------|-------|-----------------|-------|
| Average Height | 2.6 ° | Albedo Factor | 0.87 |
| Diffuse Factor | 0.96 | Albedo Fraction | 100 % |

Horizon profile

| | | | | | | | | | | | | | |
|-------------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|
| Azimuth [°] | -180 | -173 | -165 | -150 | -143 | -120 | -113 | -105 | -98 | -83 | -75 | -68 | -45 |
| Height [°] | 6.1 | 6.1 | 5.0 | 5.0 | 4.6 | 4.6 | 3.8 | 3.1 | 1.1 | 1.1 | 0.4 | 0.0 | 0.0 |
| Azimuth [°] | -38 | -30 | -23 | -15 | -8 | 23 | 30 | 45 | 53 | 60 | 68 | 75 | 90 |
| Height [°] | 0.4 | 0.4 | 1.1 | 0.4 | 0.8 | 0.8 | 1.1 | 1.1 | 1.9 | 2.7 | 2.3 | 1.5 | 1.5 |
| Azimuth [°] | 98 | 105 | 113 | 120 | 128 | 135 | 143 | 150 | 165 | 173 | 180 | | |
| Height [°] | 1.1 | 1.5 | 1.9 | 4.6 | 4.6 | 5.3 | 5.3 | 6.5 | 6.5 | 6.1 | 6.1 | | |

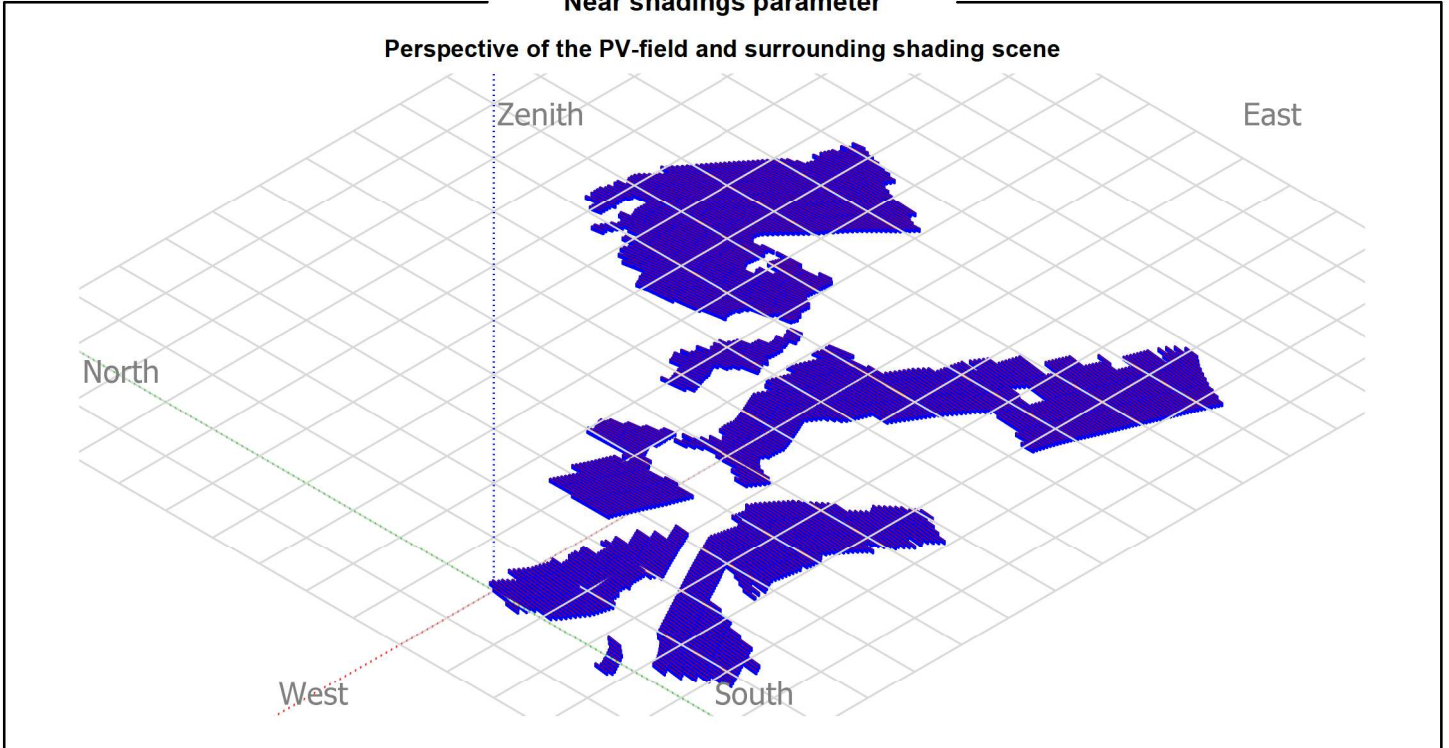
Sun Paths (Height / Azimuth diagram)

Fixed plane, Tilts/azimuths: 20°/ 0°

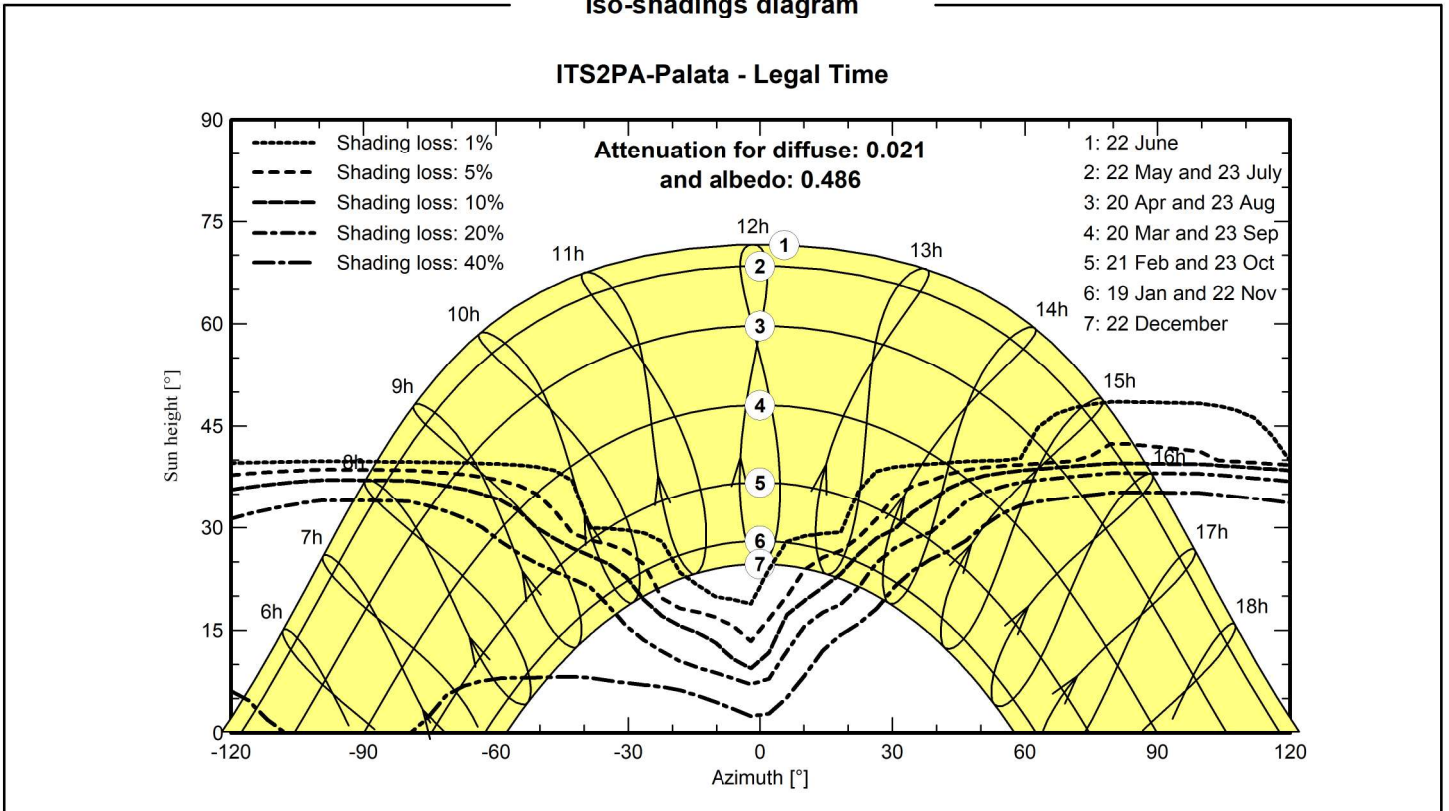




Near shadings parameter



Iso-shadings diagram





Project: ITS2PA-Palata

Variant: Palata_Tracker 1P(15-30)_670Wp_Pitch=4.5m

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Main results

System Production

Produced Energy 38476 MWh/year

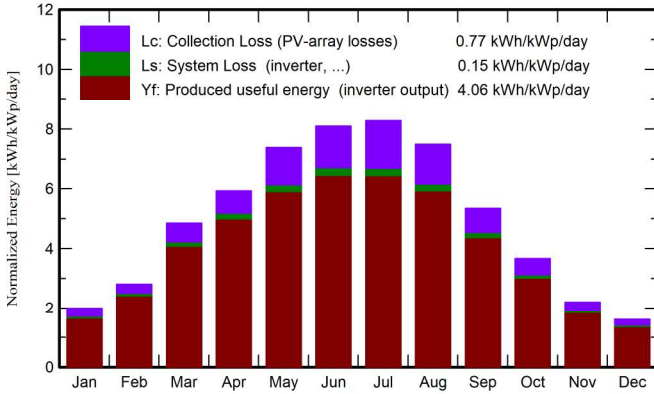
Specific production

1480 kWh/kWp/year

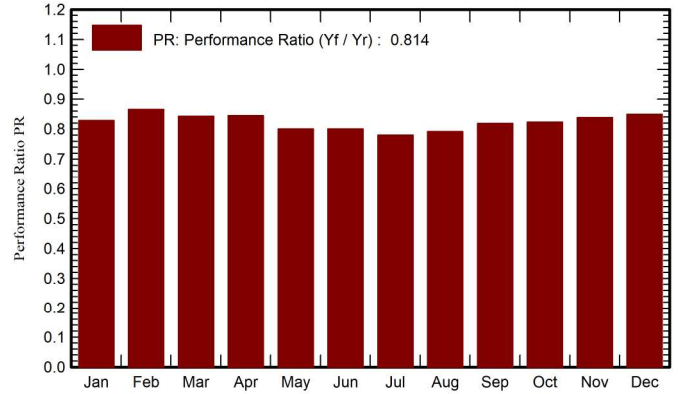
Performance Ratio PR

81.38 %

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 | 48.4 | 22.66 | 5.11 | 61.9 | 56.4 | 1386 | 1333 | 0.828 |
| February | 64.5 | 36.60 | 5.50 | 78.5 | 72.2 | 1829 | 1765 | 0.865 |
| March | 120.5 | 48.59 | 8.79 | 150.4 | 140.5 | 3417 | 3294 | 0.842 |
| April | 145.3 | 70.94 | 12.16 | 177.7 | 166.2 | 4046 | 3901 | 0.845 |
| May | 184.4 | 75.24 | 16.53 | 229.1 | 214.8 | 4948 | 4766 | 0.801 |
| June | 195.8 | 83.36 | 21.03 | 243.0 | 228.5 | 5247 | 5053 | 0.800 |
| July | 203.9 | 77.58 | 24.05 | 256.7 | 241.2 | 5409 | 5206 | 0.780 |
| August | 183.7 | 67.76 | 23.98 | 232.3 | 218.2 | 4968 | 4780 | 0.792 |
| September | 128.1 | 57.61 | 18.41 | 160.4 | 149.6 | 3543 | 3415 | 0.819 |
| October | 91.4 | 46.17 | 15.05 | 113.6 | 105.0 | 2519 | 2431 | 0.823 |
| November | 54.0 | 30.26 | 10.16 | 66.0 | 60.2 | 1492 | 1437 | 0.838 |
| December | 40.9 | 23.29 | 6.45 | 49.7 | 45.2 | 1142 | 1096 | 0.849 |
| Year | 1460.8 | 640.08 | 13.99 | 1819.3 | 1697.9 | 39945 | 38476 | 0.814 |

Legends

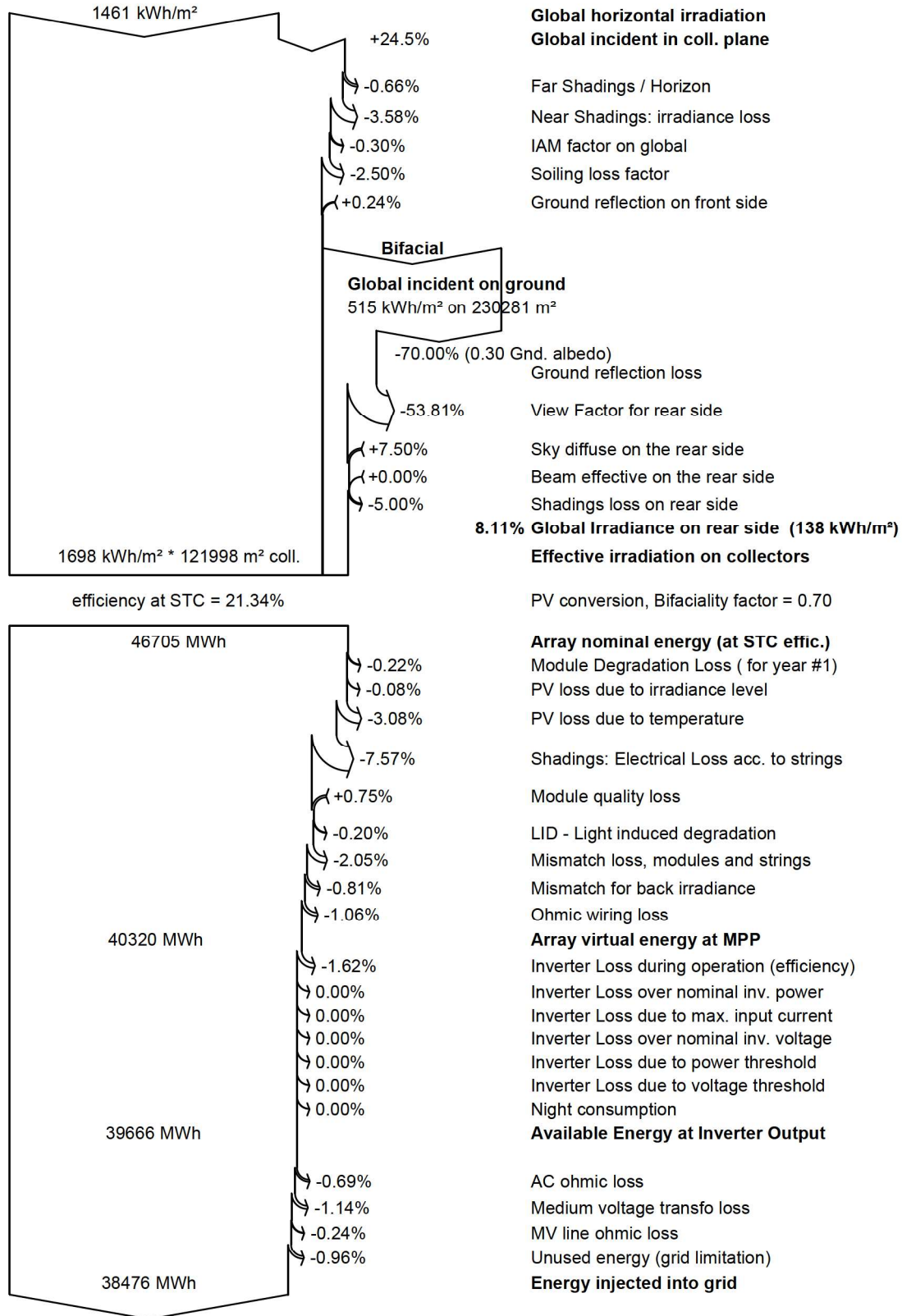
| | | | |
|---------|--|--------|---|
| GlobHor | Global horizontal irradiation | EArray | Effective energy at the output of the array |
| DiffHor | Horizontal diffuse irradiation | E_Grid | Energy injected into grid |
| T_Amb | Ambient Temperature | PR | Performance Ratio |
| GlobInc | Global incident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



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Loss diagram



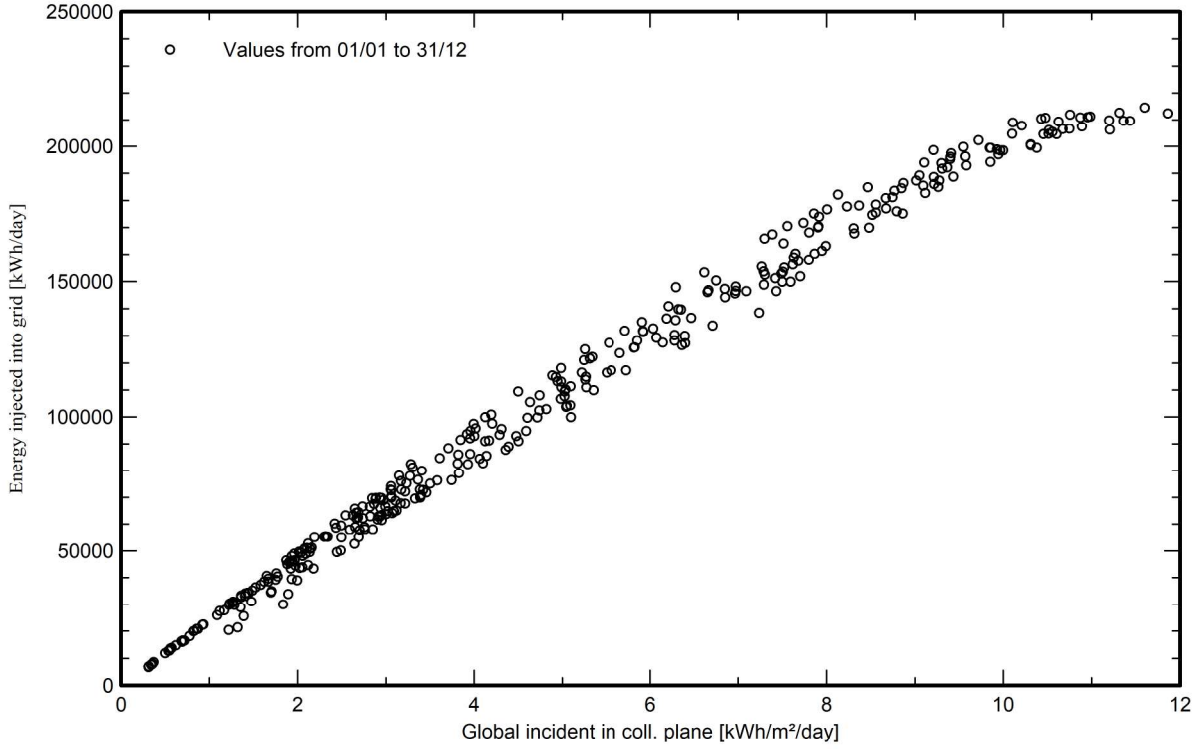


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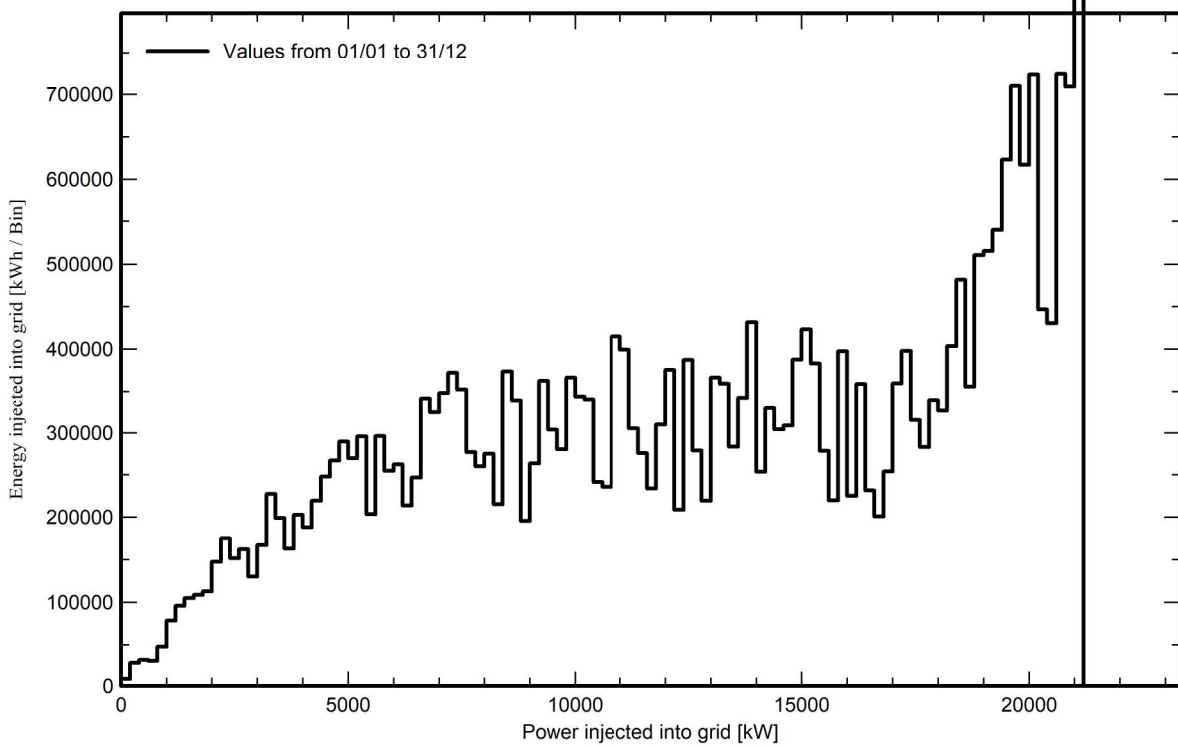
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Special graphs

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 0.45 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

Vmp RMS dispersion 0.4 %/year

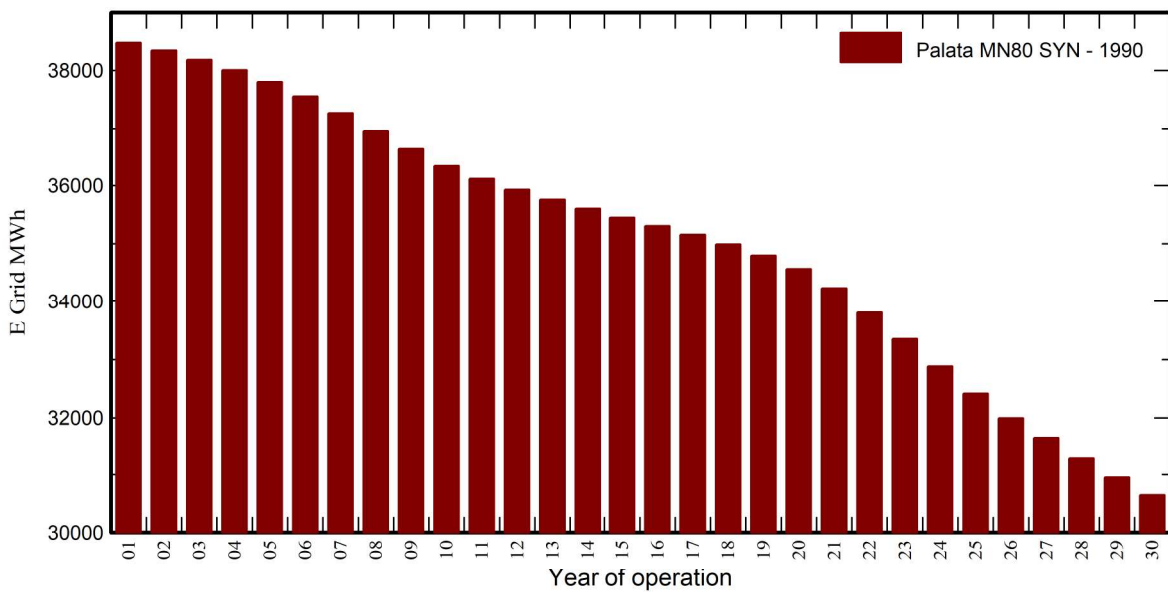
Meteo used in the simulation

#1 Palata MN80 SYN

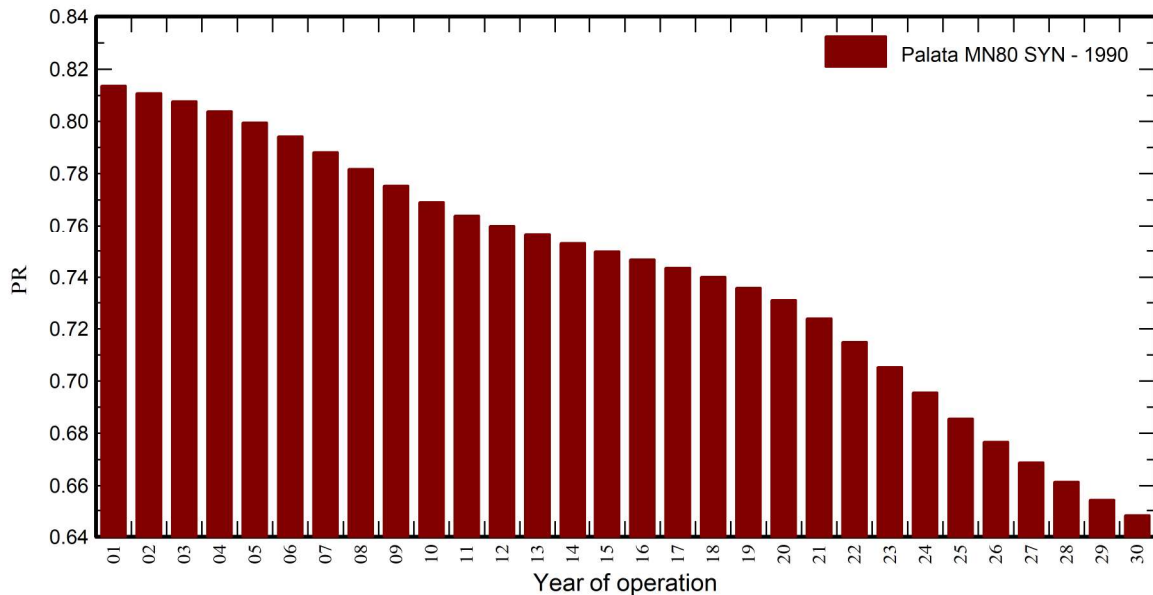
Years 1990 (reference year)

Years simulated 1-30

Energy injected into grid



Performance Ratio





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Variant: Palata_Tracker 1P(15-30)_670Wp_Pitch=4.5m

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Aging Tool

Aging Parameters

Time span of simulation 30 years

Module average degradation

Loss factor 0.45 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

Vmp RMS dispersion 0.4 %/year

Meteo used in the simulation

#1 Palata MN80 SYN

Years 1990 (reference year)

Years simulated 1-30

Palata MN80 SYN

| Year | E Grid MWh | PR | PR loss % |
|------|---------------|-------|--------------|
| 1 | 38476 | 0.814 | 0% |
| 2 | 38342 | 0.811 | -0.3% |
| 3 | 38185 | 0.808 | -0.8% |
| 4 | 38005 | 0.804 | -1.2% |
| 5 | 37800 | 0.799 | -1.8% |
| 6 | 37551 | 0.794 | -2.4% |
| 7 | 37262 | 0.788 | -3.2% |
| 8 | 36961 | 0.782 | -3.9% |
| 9 | 36657 | 0.775 | -4.7% |
| 10 | 36360 | 0.769 | -5.5% |
| 11 | 36117 | 0.764 | -6.1% |
| 12 | 35930 | 0.76 | -6.6% |
| 13 | 35760 | 0.756 | -7.1% |
| 14 | 35602 | 0.753 | -7.5% |
| 15 | 35449 | 0.75 | -7.9% |
| 16 | 35303 | 0.747 | -8.2% |
| 17 | 35155 | 0.744 | -8.6% |
| 18 | 34989 | 0.74 | -9.1% |
| 19 | 34794 | 0.736 | -9.6% |
| 20 | 34561 | 0.731 | -10.2% |
| 21 | 34231 | 0.724 | -11% |
| 22 | 33805 | 0.715 | -12.1% |
| 23 | 33351 | 0.705 | -13.3% |
| 24 | 32884 | 0.695 | -14.5% |
| 25 | 32417 | 0.686 | -15.7% |
| 26 | 31996 | 0.677 | -16.8% |
| 27 | 31626 | 0.669 | -17.8% |
| 28 | 31278 | 0.662 | -18.7% |
| 29 | 30951 | 0.655 | -19.6% |
| 30 | 30645 | 0.648 | -20.4% |



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P50 - P90 evaluation

Meteo data

Source Meteonorm 8.0 (1997-2015), 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 1.35 GWh
P50 38.48 GWh
P90 36.75 GWh
P95 36.26 GWh

Probability distribution

