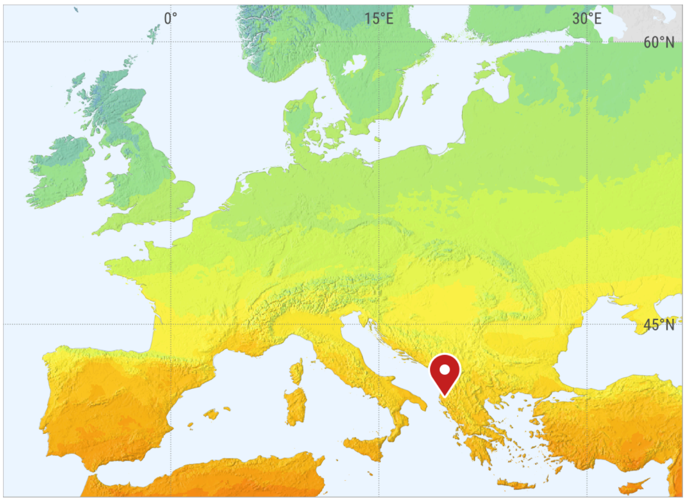
Solargis Evaluate Report

Full Evaluation of Photovoltaic Energy Project

Mallakastër, Fier, ALB

PV system

PROJECT LOCATION
Mallakastër, Albania



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21 September 2025

DATA
Time series
01/1994 to 08/2025

SOURCE OF DATA
Solargis v2025.09.19-2.2.65

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1 Summary

This report evaluates the solar power production potential of a photovoltaic (PV) project. It also examines solar resource, climate, and environmental factors that influence the operation and performance efficiency of the power plant. The power production is calculated by the Solargis PV simulator using high-resolution time series (TS) data. The Solargis time series data represents a historical period from 1 January 1994 to 31 December 2024 and it is calculated by models using satellite, atmospheric, meteorological, and environmental inputs.

1.1 Solar resource

Global horizontal irradiation (GHI) and Direct normal irradiation (DNI) describe the primary solar resource for calculating Global tilted irradiation (GTI, plane-of-array irradiation) received by PV modules. The long-term average yearly value is often referred to as P50, which represents 50% probability of exceedance. Considering the long-term average to be equal to P50 (median) is a simplification, assuming normal distribution of annual values of solar resource, but it is widely accepted in the industry.

Table 1.1 summarizes the long-term average values (represented by a P50 value) of solar resource parameters. The values are shown with and without shading by the terrain horizon. Solar resource with terrain shading is considered in the PV energy simulation across the entire report. The values without shading are shown only for a reference as they are often used as an input to other PV simulation software.

Table 1.1 Solar resource: Long-term average yearly values at P50, calculated from Solargis time series data

	Acronym	Unit	Terrain shading considered	Terrain shading not considered
Global horizontal irradiation	GHI	[kWh/m²]	1,631.4	1,640.5
Direct normal irradiation	DNI	[kWh/m²]	1,722.9	1,746.7
Global tilted irradiation	GTI	[kWh/m²]	2,133.1	-

Notes: For the sake of simplification, long-term average is considered as equal to P50

1.2 Climate and environment

Local climate and environment have an impact on the operation of the PV power plant and degradation of the long-term performance. Some factors have a direct impact on the quantity of electricity generated (air temperature, wind speed, soiling, snow, ground surface albedo and precipitation) or they affect the operation (wind gust and humidity). Table 1.2 shows long-term yearly average values of the meteorological and environmental parameters important for a PV project.

Table 1.2 Meteorological and environmental parameters: Long-term average yearly values

	Acronym	Unit	Yearly average
Air temperature at 2 m	TEMP	[°C]	15.6
Wind speed at 10 m	WS	[m/s]	1.7
Wind gust at 10 m	WG	[-]	
Relative humidity at 2 m	RH	[-]	
Atmospheric pressure	AP	[-]	
Precipitation (rainfall)	PREC	[-]	
Ground surface albedo	ALB	[-]	0.15
Precipitable water	PWAT	[kg/m²]	17.8

1.3 Photovoltaic power generation

The electrical output from the photovoltaic power plant is calculated from a time series of solar radiation, meteorological and environmental parameters . Assuming global tilted irradiation and 100 % technical availability, PV power production is calculated. When considering the reduction of conversion efficiency of PV modules, the life time yearly PV power production is calculated as follows: 2.0 % performance reduction for the first year and 0.5 % for a period of 25 years. Table 1.4 shows the estimates of the long-term average values, or P50.

Table 1.3 Energy system properties

Nominal DC capacity	31,980 kWp
Nominal AC output power	27,000 kW

Table 1.4 Long-term average yearly values of PV power production

	PVOUT specific	PVOUT total	PR
	kWh/kWp	GWh	%
Total system performance considering technical availability and losses due to snow	1,434	45.85	69.1
Power generation in the first year	1,405	44.93	67.8
Yearly power generation, average over 25 years	1,324	42.33	63.8

Notes: For the sake of simplification, long-term average is considered as equal to P50

1.4 Note on climate change and large volcano eruptions

The estimates in this study are based on the analysis of the long history of data. However, the effects of possible man-induced climate change or natural events such as large volcano eruptions may not be represented in this data. Solar resource trends can be analyzed in a separate study.

2 Project site

Site name	**Mallakastër, Fier, ALB**
Geographical coordinates	40.604252°, 019.756840°
Elevation above sea level	170m
Terrain slope inclination:	2°
Terrain azimuth:	quasi flat

Location on the map (Solargis Prospect):
https://apps.solargis.com/prospect/map?center=40.604252,19.756840,15&layer=mapbox-satellite&location=40.604252,19.756840

Details of this data and report can be accessed from Solargis Evaluate:
https://apps.solargis.com/evaluate

2.1 Geographical context

Figure 2.1 Detailed position of the project site

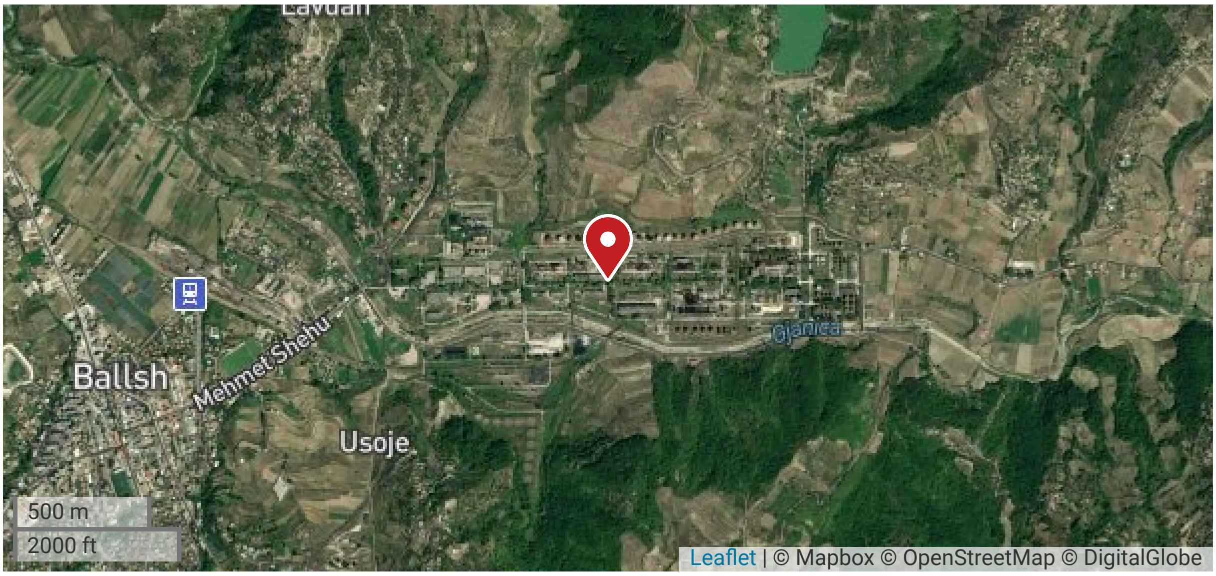
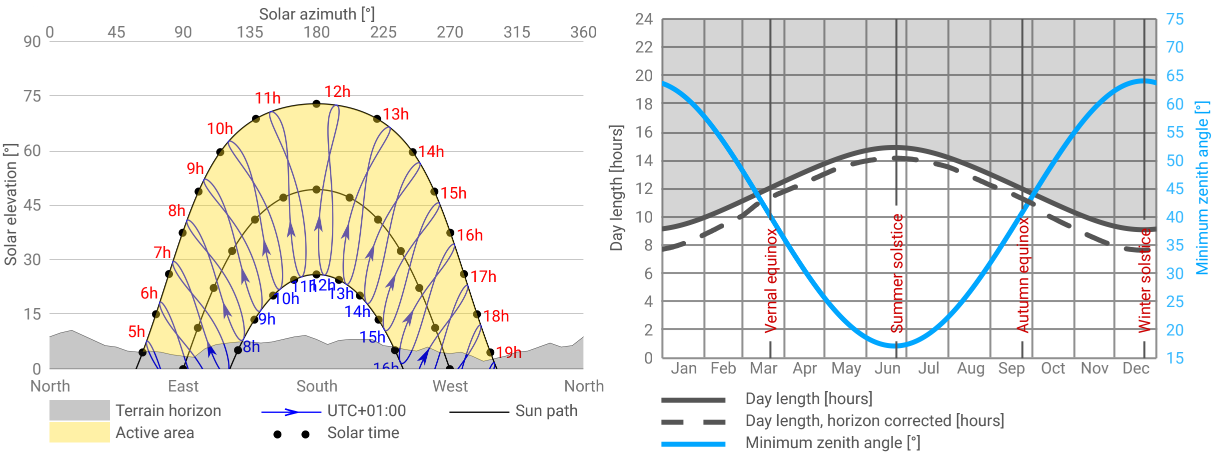


Figure 2.2 Position of the site in the context of a Global horizontal irradiation map

2.2 Terrain and astronomic conditions

Terrain properties (elevation, slope, azimuth, and horizon) are derived from the SRTM3 digital elevation model, unless customized.

Figure 2.3 Project horizon, sunpath, day length, and solar zenith angle



2.3 Configuration of photovoltaic power plant

Table 2.1 General

Nominal DC capacity	31,980 kWp
Nominal AC output power	27,000 kW
Grid power limitation	unlimited
Power factor (cos phi)	1
Segment count	5

Table 2.2 Buildable area 14

Mounting type	Ground segment, Fixed one angle, Azimuth (specific / effective) 180° / 180.78°, Tilt (specific / effective) 33.21° / 34.06°, Row spacing (relative • GCR • absolute) 1.5 • 67 % • 3.7 m
PV modules	JA Solar, JAM72D42-640/LB, 78% (bifacial), modules: 5454 pcs, installed DC capacity 3,491 kWp
Inverters	Inverter setup (E) - Power-One, ULTRA-750-TL-OUTD-4-US-690-x-y-z [690V], 36 unit(s), installed AC capacity 27,000 kW
LV/MV Transformers	Inverter transformer 690 / 22,000 V, Apparent rated power 3500 kVA, 1 unit(s), Inverter setup (E)

Table 2.3 Segment 1

Mounting type	Ground segment, Fixed one angle, Azimuth (specific / effective) 180° / 181.09°, Tilt (specific / effective) 33.21° / 33.9°, Row spacing (relative • GCR • absolute) 1.4 • 71 % • 3.45 m
PV modules	JA Solar, JAM72D42-640/LB, 78% (bifacial), modules: 12240 pcs, installed DC capacity 7,834 kWp
Inverters	Inverter setup (A) - Power-One, ULTRA-750-TL-OUTD-4-US-690-x-y-z [690V], 36 unit(s), installed AC capacity 27,000 kW
LV/MV Transformers	Inverter transformer 690 / 22,000 V, Apparent rated power 10000 kVA, 2 unit(s), Inverter setup (A)

Table 2.4 Segment 2

Mounting type	Ground segment, Fixed one angle, Azimuth (specific / effective) 180° / 181.37°, Tilt (specific / effective) 33.21° / 33.63°, Row spacing (relative • GCR • absolute) 1.5 • 67 % • 3.7 m
PV modules	JA Solar, JAM72D42-640/LB, 78% (bifacial), modules: 8352 pcs, installed DC capacity 5,345 kWp
Inverters	Inverter setup (B) - Power-One, ULTRA-750-TL-OUTD-4-US-690-x-y-z [690V], 36 unit(s), installed AC capacity 27,000 kW
LV/MV Transformers	Inverter transformer 690 / 22,000 V, Apparent rated power 6300 kVA, 1 unit(s), Inverter setup (B)

Table 2.5 Segment 3

Mounting type	Ground segment, Fixed one angle, Azimuth (specific / effective) 180° / 179.64°, Tilt (specific / effective) 33.21° / 36.2°, Row spacing (relative • GCR • absolute) 1.5 • 67 % • 3.7 m
PV modules	JA Solar, JAM72D42-640/LB, 78% (bifacial), modules: 16920 pcs, installed DC capacity 10,829 kWp
Inverters	Inverter setup (C) - Power-One, ULTRA-750-TL-OUTD-4-US-690-x-y-z [690V], 36 unit(s), installed AC capacity 27,000 kW
LV/MV Transformers	Inverter transformer 690 / 22,000 V, Apparent rated power 10000 kVA, 2 unit(s), Inverter setup (C)

Table 2.6 Segment 4

Mounting type	Ground segment, Fixed one angle, Azimuth (specific / effective) 180° / 181.73°, Tilt (specific / effective) 33.21° / 34.83°, Row spacing (relative • GCR • absolute) 1.5 • 67 % • 3.7 m
PV modules	JA Solar, JAM72D42-640/LB, 78% (bifacial), modules: 7002 pcs, installed DC capacity 4,481 kWp
Inverters	Inverter setup (D) - Power-One, ULTRA-750-TL-OUTD-4-US-690-x-y-z [690V], 36 unit(s), installed AC capacity 27,000 kW
LV/MV Transformers	Inverter transformer 690 / 22,000 V, Apparent rated power 4000 kVA, 1 unit(s), Inverter setup (D)

Annex 1 shows the full description of parameters used in the simulation

3 Data description

This report is based on the use of time series (TS) data with 15-minute temporal resolution, derived from the Solargis models. These models are optimized for all geographic regions, with the satellite, meteorological and environmental input data harmonized to achieve the best possible geographical representation and long-term performance estimates. The models are validated by ground measurements acquired at meteorological stations worldwide.

Due to the limited spatial and temporal resolution of the models and their input data, the solar resource, climate and environmental parameters may characterize a larger area that may exceed limits of the project. Especially, the extreme values may be smoothed, thus not always sufficiently representing the local conditions. To achieve higher accuracy and lower uncertainty, enhanced calculation or adaptation of the Solargis models to the project site, based on local measurements, is offered as a separate service.

3.1 Time series data properties

Table 3.1 Global characteristics of solar resource parameters

Data originator	Solargis
Version	2.2.65 (19 September 2025)
Type of data	Time series
Geographical representation	Grid resolution depends on the input data and geographical site. Terrain and clouds: between ~2.5 km and 8 km, PWAT and aerosols: ~30 km to 125 km
Time resolution	15-minute
Data aggregation	Long-term yearly, monthly and hourly averages
Period of time represented	1 Jan 1994 to 31 Dec 2024 (complete calendar years are used in this report)
Time zone	UTC+01
Method	Solargis solar models characterizing state of the atmosphere, cloud transmittance, and terrain conditions. Data from geostationary meteorological satellites Meteosat, GOES, Himawari, global meteorological data MACC-II, CAMS, MERRA-2, CFSR, GFS and digital terrain model SRTM3 are used as inputs.
Parameters	GHI, DNI, DIF, GTI , SUN_AZIMUTH, SUN_ELEVATION
Terrain shading	Terrain shading is considered in all calculations. Typically calculated from the SRTM3 data set. Depending on a specific data product/format the solar parameters may be provided with or without consideration of the terrain horizon shading.

Table 3.2 Global characteristics of meteorological and environmental parameters

Data originator	Solargis
Version	2.2.65 (19 September 2025)
Type of data	Time series
Geographical representation	Grid resolution depends on the input data and geographical site. TEMP and AP: ~1km, other parameters: between ~9 km and 25 km
Time resolution	15-minute (recalculated from hourly)
Data aggregation	Long-term yearly, monthly and hourly averages
Period of time represented	1 Jan 1994 to 31 Dec 2024 (complete calendar years are used in this report)
Time zone	UTC+01
Method	Processing of ERA5, ERA5-Land and IFS global meteorological model outputs
Parameters	TEMP, RH, TD, WBT, WS, WD, WG, AP, PREC, SDWE, PWAT

Table 3.3 Ground surface albedo

Type of data	Long-term yearly and monthly averages
Geographical representation	Grid resolution ~1km
Time resolution	Long-term averages
Period of time represented	1 Jan 2006 to 31 Dec 2015
Time zone	N/A
Method	Processing based on the input data from MODIS database, global meteorological models, and Solargis time series
Parameters	ALB

3.2 Primary data parameters

Although the delivered data cover the entire period until the last available calendar month, the calculation of long-term statistics in this report is limited to the complete calendar years.

Table 3.4 Data parameters analyzed in this report

Parameter	Acronym	Monthly and yearly	Daily	Hourly	15-minute	Uncertainty
Global horizontal irradiance	GHI	Yes	-	-	-	-
Direct normal irradiance	DNI	Yes	-	-	-	-
Diffuse horizontal irradiance	DIF	Yes	-	-	-	-
Global horizontal irradiance, no shading	GHI	Yes	-	-	-	-
Direct normal irradiance, no shading	DNI	Yes	-	-	-	-
Diffuse horizontal irradiance, no shading	DIF	Yes	-	-	-	-
Global tilted irradiance	GTI	Yes	-	-	-	-
Cloud identification quality flag	CI_FLAG	-	-	-	-	N/A
Sun elevation	SUN_ELEVATION	-	-	-	-	N/A
Sun azimuth	SUN_AZIMUTH	-	-	-	-	N/A
Air temperature at 2 meters	TEMP	Yes	-	-	-	-
Relative humidity at 2 meters	RH	Yes	-	-	-	-
Dew point temperature at 2 meters	TD	Yes	-	-	-	-
Wet bulb temperature at 2 meters	WBT	Yes	-	-	-	-
Wind speed at 10 meters	WS	Yes	-	-	-	-
Wind direction at 10 meters	WD	-	-	-	-	-
Wind gust at 10 meters	WG	-	-	-	-	-
Atmospheric pressure	AP	Yes	-	-	-	-
Precipitation rate/total	PREC	Yes	-	-	-	-
Precipitable water	PWAT	Yes	-	-	-	-
Snow depth water equivalent	SDWE	Yes	-	-	-	-
Snowfall rate water equivalent	SFWE	-	-	-	-	-

Table 3.5 Customized parameters

Parameter	Acronym	Monthly and yearly	Daily	Hourly	15-minute	Uncertainty
Ground surface albedo	ALB	Yes	-	-	-	-

3.3 Simulation results

Table 3.6 Calculated PV power output

Parameter	Acronym	Monthly and yearly	Daily	Hourly	15-minute	Uncertainty
PV electricity output specific	PVOUT specific	Yes	Yes	Yes	Yes	-
PV electricity output total	PVOUT total	Yes	Yes	Yes	Yes	-
Performance ratio	PR	Yes	-	-	-	-

4 Solar resource

This chapter shows solar energy potential of the site as calculated from the Solargis time series data. Global horizontal irradiation (GHI) represents the total amount of direct and diffuse radiation received on a horizontal surface. GHI is used to compare solar energy potential of different sites, as it is independent of any solar technology. Understanding Direct normal irradiation (DNI) helps optimize PV systems' performance, especially those utilizing sun trackers. Accurate DNI is complementary to GHI and helps fine-tune the PV design, enhancing its overall efficiency. A ratio of diffuse to global irradiation (DIF/GHI or D2G) is important for understanding the efficiency of PV modules and solar trackers. Global tilted irradiation (GTI) is the technology-specific energy that is converted into electricity in the PV array. It is a key parameter used in the simulation of photovoltaic power output. GTI is calculated from GHI and DIF for a specified technical configuration of the PV power plant. Note that in Table 4.1 the monthly extremes do not sum to the annual extremes.

All data shown here consider solar radiation losses due to terrain shading calculated from SRTM3, if not changed by the user. The only exception is Table 4.2, which shows theoretical GHI, DNI and DIF values without consideration of terrain shading. While these values have no practical meaning in this report, they are shown here for reference, as they are often used as an input into PV energy simulation software, which calculates terrain shading internally.

GTI is calculated for the project system configuration defined in the Annex 1 of this report. All GTI values, incorporate shading effects caused by default terrain horizon of the project reference point or of the individual segments of the PV power plant. The default horizon could have been customized by Customer. For multi-segment PV systems, Solargis Evaluate calculates GTI as a weighted average of GTI values calculated for individual segments. The weight is represented by the surface area of solar cells installed in each segment. In the GTI hourly statistics, we omit nighttime values, concentrating solely on data recorded during daylight hours (i.e. with the Sun above horizon).

The GTI values in Table 4.1 include terrain horizon shading and summarize GTI input from both front and rear side of PV modules.

Table 4.1 Solar resource parameters calculated from time series: Long-term averages and extreme values of monthly and yearly sums. Terrain shading is considered

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
GHI	kWh/m²	Average	63.0	78.9	126.2	150.2	192.9	217.8	233.0	201.9	142.2	106.1	66.1	53.1	1,631.4
		Min	49.5	52.3	98.3	125.6	158.2	181.4	207.9	173.6	115.7	88.6	56.3	37.4	1,526.4
		Max	75.4	96.1	159.9	171.8	228.4	246.8	248.5	217.4	163.9	129.3	80.3	70.7	1,720.7
DNI	kWh/m²	Average	100.5	103.0	134.9	130.6	166.1	201.2	232.2	201.4	145.1	129.5	92.2	86.2	1,722.9
		Min	56.0	47.2	85.3	85.6	115.4	148.9	173.4	158.4	90.0	92.0	65.2	34.1	1,442.8
		Max	143.9	154.3	205.1	171.1	230.9	273.2	268.7	231.1	193.5	179.4	140.6	142.0	1,907.4
DIF	kWh/m²	Average	25.6	32.5	51.7	66.3	78.3	75.6	71.2	68.2	56.9	42.3	29.3	23.2	621.2
		Min	21.7	25.0	42.4	57.4	69.7	57.2	62.2	61.6	51.4	35.3	24.1	19.5	581.0
		Max	31.1	37.1	59.1	74.3	84.8	85.8	84.9	79.8	64.3	47.7	32.8	26.0	664.3
GTI	kWh/m²	Average	114.4	125.9	176.8	186.0	220.9	239.7	258.8	243.3	191.7	162.8	113.5	99.4	2,133.1
		Min	82.0	77.8	134.4	154.8	181.1	199.3	230.9	206.7	152.6	130.4	92.6	59.8	1,953.9
		Max	145.3	159.6	230.7	213.9	261.5	269.8	275.9	262.7	224.6	202.9	146.2	142.7	2,255.6
D2G		Average	0.407	0.412	0.410	0.442	0.406	0.347	0.305	0.338	0.400	0.399	0.443	0.437	0.381

Table 4.2 Solar resource parameters: Long-term average values of monthly sums. Terrain shading is not considered

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
GHI	kWh/m²	Average	64.0	79.7	126.9	150.8	193.6	218.4	233.6	202.6	142.9	106.9	66.9	54.1	1,640.5
DNI	kWh/m²	Average	105.5	105.8	136.2	131.2	166.7	202.0	233.0	202.3	146.0	131.6	95.3	91.1	1,746.7
DIF	kWh/m²	Average	26.2	33.1	52.4	66.9	78.9	76.2	71.7	68.9	57.6	43.0	29.9	23.8	628.6
D2G		Average	0.409	0.415	0.413	0.444	0.408	0.349	0.307	0.340	0.403	0.402	0.446	0.439	0.383

Figure 4.1 Global horizontal irradiation (GHI, left) and Direct normal irradiation (DNI, right). Long-term averages of monthly sums and minimum/maximum monthly values. Terrain shading is considered

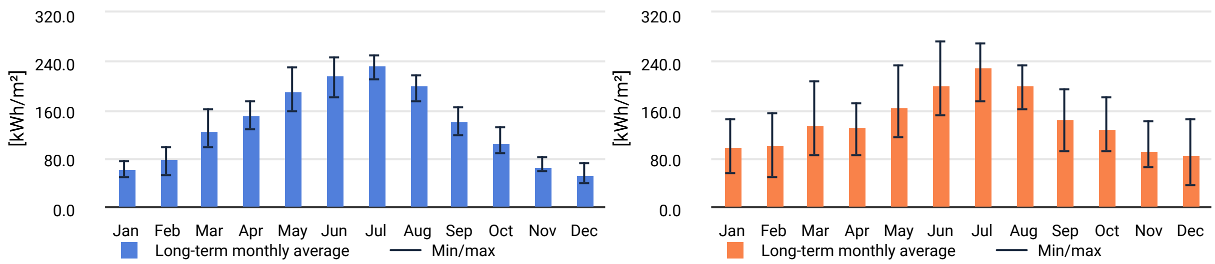


Figure 4.2 Ratio of diffuse to global horizontal irradiation (DIF/GHI, left) and Global tilted irradiation (GTI, right): Long-term monthly averages of monthly sums and minimum/maximum monthly values. Terrain shading is considered

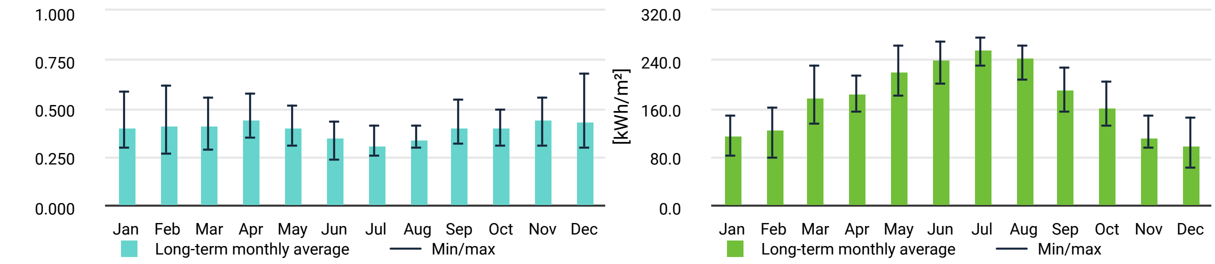
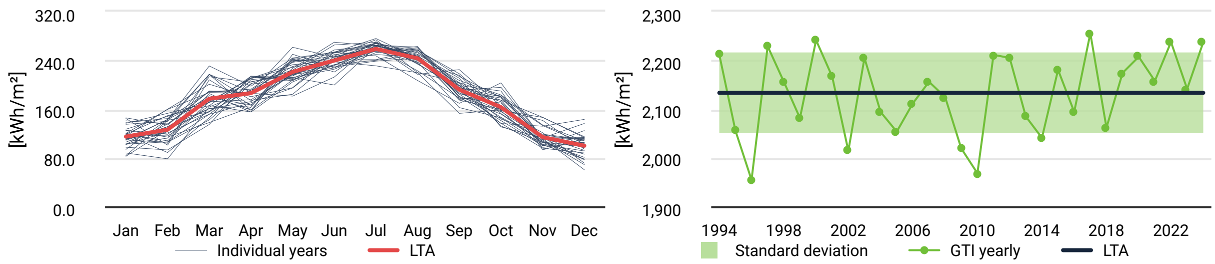


Figure 4.3 Global tilted irradiation - interannual variability: Time series of monthly sums (left) and yearly sums (right) compared to long-term average values (LTA). Terrain shading is considered



5 Climate

Meteorological parameters, representing climate of the site, are used in evaluating the operation conditions of a PV project and for optimizing the PV design and energy production. Data is derived from meteorological models and processed by Solargis algorithms.

Conversion efficiency of PV modules is influenced by air temperature (TEMP). Extreme temperature increases long-term thermal degradation of PV modules, and this data is important for optimizing the design of PV strings matching to inverters. Relative humidity (RH) affects the efficiency of a PV system, high humidity contributes to increased degradation of PV system. Dew point temperature (TD) and Wet bulb temperature (WBT) provide insights into atmospheric moisture conditions, which are important for the design and energy performance estimation of PV power plants. TEMP, RH, TD and WBT are referenced to 2 meters above ground.

Wind speed (WS) and Wind direction (WD) contribute to the cooling of photovoltaic modules, enhancing their efficiency. However, strong wind poses a risk of damage to the mounting structures and PV modules. High Wind gust (WG) indicates the need for extra safety and stability measures, especially for trackers. WD, WS and WG parameters are referenced to 10 meters above ground.

Precipitation (rainfall, PREC) impacts the soiling of PV modules. In a season of low rainfall, dust and soiling can significantly reduce the efficiency of converting solar radiation into electricity. Snow cover on PV modules, represented by Snow depth water equivalent (SDWE), blocks solar radiation, reducing their conversion efficiency and energy yield. The mounting and PV modules have to withstand the weight of the accumulated snow. Snow on the ground increases albedo.

Table 5.1 summarizes monthly and yearly statistics: long-term averages, and minimum and maximum averages for each month or year. Table 5.2 shows monthly and yearly long-term averages of Air temperature at 2 meters. Table 5.3 shows occurrence statistics of Wind gust.

Figure 5.1 Air temperature at 2 m (TEMP, left) and Relative humidity at 2 m (RH, right): Long-term monthly averages (LTA), minimum/maximum monthly average values

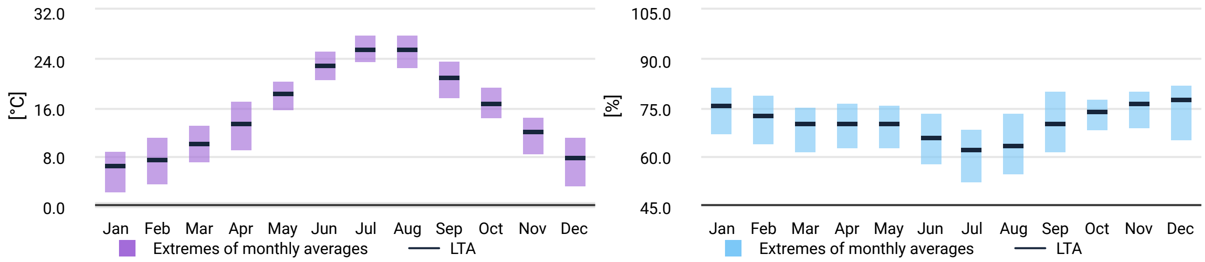


Figure 5.2 Dew point temperature at 2 m (TD, left) and Wet bulb temperature at 2 m (WBT, right): Long-term monthly averages (LTA), minimum/maximum monthly average values

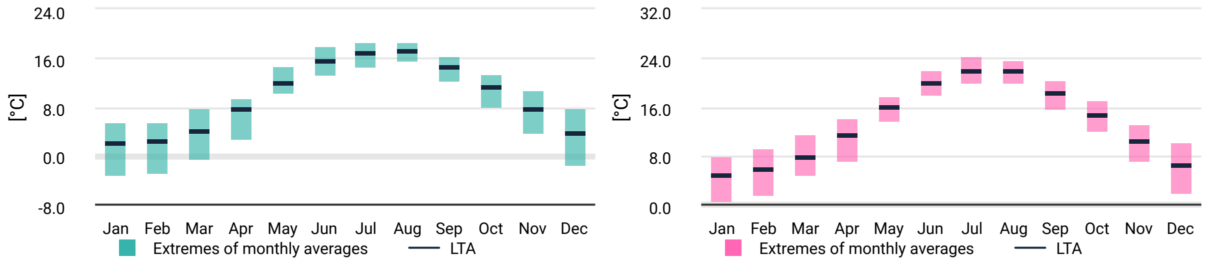


Figure 5.3 Wind speed at 10 m (WS, left) and Atmospheric pressure (AP, right): Long-term monthly averages (LTA), minimum/maximum monthly average values

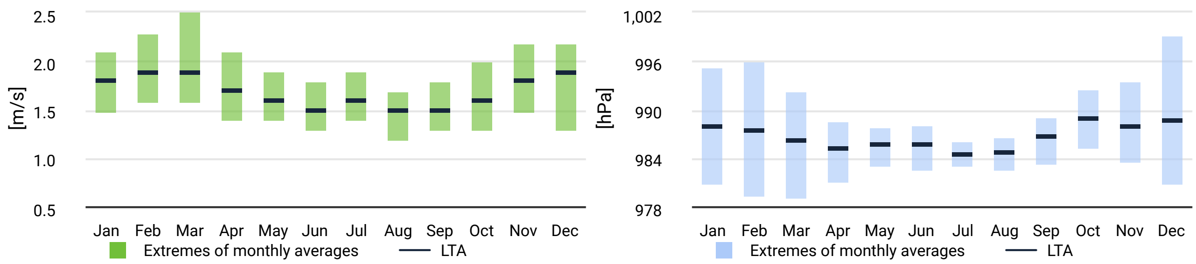


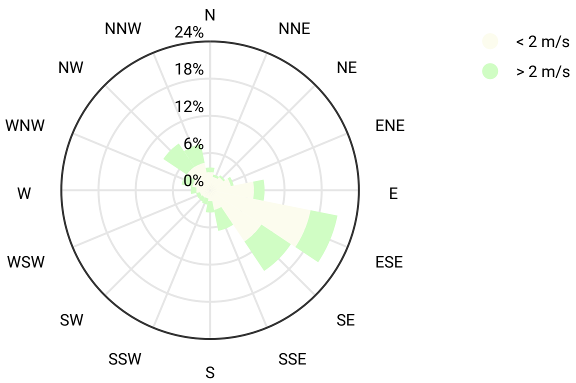
Table 5.1 Monthly and yearly statistics of meteorological parameters

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMP	°C	Average	6.3	7.4	9.9	13.5	18.3	22.9	25.6	25.6	20.9	16.5	12.0	7.7	15.6
		Min	2.3	3.6	7.1	9.2	15.9	20.9	23.7	22.7	17.8	14.5	8.7	3.4	14.5
		Max	8.8	11.1	13.3	17.2	20.3	25.5	28.2	28.0	23.8	19.6	14.5	11.1	17.0
RH	%	Average	75.4	72.3	69.8	69.8	69.9	66.0	61.9	63.1	70.2	73.9	76.0	77.4	70.4
		Min	67.4	64.1	61.9	62.8	62.9	57.9	52.6	54.7	61.6	68.3	69.3	65.7	66.8
		Max	81.4	79.3	75.3	76.4	76.1	73.5	68.4	73.2	80.4	78.0	80.2	82.3	73.8
TD	°C	Average	2.0	2.3	4.1	7.6	12.1	15.5	16.9	17.2	14.7	11.4	7.6	3.7	9.6
		Min	-2.9	-2.6	-0.4	3.0	10.4	13.6	14.9	15.9	12.6	8.3	3.9	-1.3	8.5
		Max	5.6	5.6	8.0	9.6	14.8	17.9	18.8	18.6	16.4	13.5	10.9	8.0	10.8
WBT	°C	Average	4.9	5.7	7.9	11.4	15.9	19.8	22.0	22.1	18.4	14.6	10.5	6.4	13.3
		Min	0.6	1.5	4.8	7.1	13.9	18.2	20.2	20.1	15.9	12.3	7.1	1.9	12.4
		Max	7.8	9.2	11.4	14.1	17.8	22.2	24.3	23.9	20.4	17.1	13.3	10.1	14.6
WS	m/s	Average	1.8	1.9	1.9	1.7	1.6	1.5	1.6	1.5	1.5	1.6	1.8	1.9	1.7
		Min	1.5	1.6	1.6	1.4	1.4	1.3	1.4	1.2	1.3	1.3	1.5	1.3	1.6
		Max	2.1	2.3	2.5	2.1	1.9	1.8	1.9	1.7	1.8	2.0	2.2	2.2	1.8
AP	hPa	Average	988	988	986	985	986	986	985	985	987	989	988	989	987
		Min	981	979	979	981	983	983	983	983	983	985	984	981	985
		Max	995	996	992	989	988	988	986	987	989	993	994	999	988
PREC	mm	Average	106.8	95.5	112.2	100.2	91.0	61.0	38.0	46.2	112.0	114.8	137.1	128.8	1,143.6
		Min	38.8	20.2	13.9	32.4	27.9	7.0	2.8	5.5	9.2	2.9	11.9	0.4	777.2
		Max	320.2	252.9	267.1	180.0	191.1	174.3	111.9	159.9	320.8	261.9	266.4	252.4	1,704.2
SDWE	kg/m²	Average	0.4	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
		Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Max	3.7	1.6	1.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.2	0.3

Table 5.2 Air temperature at 2 m: Monthly and yearly long-term averages (LTA) [°C]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1994	8.5	7.5	11.2	13.4	18.9	21.8	25.8	26.3	22.5	16.9	10.8	6.4	15.9
1995	6.0	9.0	8.7	11.7	17.0	21.7	25.5	22.7	19.2	15.5	8.7	9.4	14.6
1996	6.7	6.6	7.2	12.1	18.3	22.6	23.9	24.1	17.8	14.6	11.9	8.5	14.5
1997	7.9	7.0	8.9	9.2	18.2	23.3	24.1	23.0	21.2	14.5	11.7	7.6	14.8
1998	7.4	8.2	7.1	13.9	17.5	22.7	25.5	26.5	19.8	16.5	10.3	4.7	15.1
1999	5.9	5.0	9.1	13.2	19.3	22.8	24.4	25.7	20.9	17.0	11.7	8.9	15.4
2000	2.3	6.3	8.3	14.5	19.2	23.6	24.7	25.5	20.4	16.8	13.6	8.4	15.3
2001	8.8	7.4	13.3	12.6	19.0	21.3	25.0	26.5	19.7	17.4	10.7	3.4	15.5
2002	4.6	9.4	11.6	13.3	18.0	23.4	25.1	23.2	18.7	15.4	12.7	8.1	15.3
2003	7.8	3.6	8.1	12.1	20.3	25.4	26.2	27.1	20.2	16.2	12.9	7.3	15.7
2004	5.2	6.6	9.7	14.4	16.0	21.9	24.9	23.8	20.7	17.7	11.4	8.9	15.1
2005	4.8	4.7	9.1	12.4	18.9	21.7	24.8	23.3	20.7	15.3	10.6	7.1	14.5
2006	4.4	6.0	9.4	14.0	18.2	21.7	25.1	23.8	20.9	16.9	9.3	7.4	14.8
2007	7.0	8.4	11.1	14.1	18.9	23.7	27.0	25.9	19.6	15.9	10.5	5.8	15.7
2008	6.6	6.5	10.8	13.6	18.3	22.7	25.3	26.0	20.2	16.2	12.8	7.7	15.6
2009	7.7	6.0	8.6	14.3	19.3	21.5	24.8	25.9	21.5	15.5	11.4	9.6	15.6
2010	7.2	7.8	9.7	14.2	17.8	21.8	25.0	25.5	19.8	15.4	13.9	8.3	15.6
2011	6.6	7.6	9.7	13.8	17.7	22.4	24.7	26.1	23.8	14.6	9.7	7.5	15.4
2012	3.8	5.1	10.6	13.8	17.7	24.3	27.6	27.1	22.6	18.0	13.5	7.0	16.0
2013	6.8	7.8	10.5	15.2	19.1	21.7	25.2	26.5	20.8	16.9	12.9	6.5	15.9
2014	8.8	9.8	10.7	13.3	16.5	22.1	23.7	24.6	19.9	16.2	13.1	8.3	15.6
2015	6.0	6.6	9.7	12.9	19.4	22.1	27.5	26.1	22.7	17.1	12.3	6.5	15.8
2016	6.8	11.1	10.5	16.2	17.1	22.9	25.9	25.3	20.7	16.6	11.6	5.0	15.8
2017	3.6	9.2	11.5	13.5	17.9	24.5	26.7	27.4	20.3	15.4	11.4	7.2	15.8
2018	7.3	7.8	11.1	17.2	19.9	22.2	24.7	25.6	21.7	18.3	13.4	7.1	16.4
2019	4.0	7.2	11.4	14.1	15.9	24.4	25.4	27.0	22.1	18.1	14.5	9.2	16.2
2020	5.4	8.1	10.5	13.3	18.9	20.9	25.5	25.9	23.0	16.5	11.8	10.3	15.9
2021	7.8	8.6	8.8	12.2	18.5	23.8	27.1	27.3	21.5	15.5	14.2	7.4	16.1
2022	5.4	7.7	7.4	13.2	19.6	25.4	27.4	25.8	21.1	17.0	13.1	11.1	16.2
2023	7.9	6.6	10.9	12.3	18.1	22.5	27.6	25.8	23.5	19.6	13.3	9.2	16.5
2024	7.8	9.7	11.9	15.9	19.0	25.5	28.2	28.0	21.5	17.6	11.5	7.8	17.0
2025	9.4	8.4	12.1	14.1	17.9	25.7	27.3	26.0					
	6.3	7.4	9.9	13.5	18.3	22.9	25.6	25.6	20.9	16.5	12.0	7.7	15.6

Figure 5.4 Wind speed (WS) and Wind direction (WD) at 10 m: Statistics of hourly values [m/s]

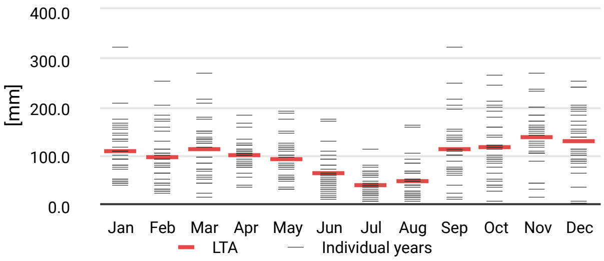


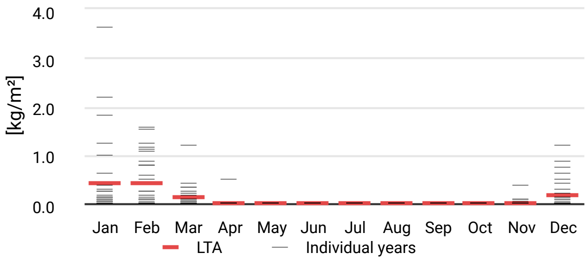
The length of the segments in Figure 5.4 represents the relative frequency [%] of wind blowing from the respective direction. Colors represent wind speed categories.

Table 5.3 Wind gust at 10 meters (WG), hourly values per month: Long-term averages, minimum/maximum, and percentiles [m/s]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	5.9	6.2	6.1	5.8	5.2	5.0	5.1	4.8	5.0	5.1	6.0	6.0
Min	1.2	1.0	1.2	1.0	1.0	1.2	1.1	1.2	1.1	0.9	1.2	1.1
Max	24.2	22.4	23.8	22.2	21.8	16.1	20.9	16.1	21.0	20.8	23.0	25.0
p01	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.8	1.9	2.0	2.0
p05	2.8	2.8	2.7	2.5	2.4	2.4	2.4	2.3	2.3	2.5	2.6	2.7
p10	3.2	3.2	3.2	2.9	2.7	2.7	2.7	2.6	2.6	2.8	3.0	3.1
p25	4.0	4.1	4.0	3.7	3.4	3.3	3.3	3.2	3.3	3.5	3.8	4.0
p50	5.2	5.4	5.4	5.1	4.6	4.4	4.4	4.1	4.4	4.5	5.1	5.2
p75	7.1	7.5	7.6	7.2	6.7	6.5	6.7	6.2	6.2	6.0	7.3	7.4
p90	9.8	10.4	10.2	9.5	8.6	8.2	8.7	8.2	8.0	8.3	10.3	10.3
p95	11.6	12.5	12.0	11.2	9.9	9.2	9.6	9.1	9.3	10.1	12.3	12.0
p99	15.1	15.7	15.9	14.6	13.3	11.3	11.4	10.6	12.4	13.7	15.9	15.3

Figure 5.5 Precipitation (PREC, left) and Snow depth water equivalent of accumulated snow (SDWE, right): Totals for individual months (black lines) and long-term monthly averages (red line)





6 Atmospheric and environmental conditions

6.1 Precipitable water

Precipitable water (PWAT) refers to the total amount of water in a column from the Earth's surface to the top of the atmosphere, and this parameter is used to model PV module spectral losses.

Figure 6.1 and Table 6.1 show long-term average values.

Figure 6.1 Precipitable water: Long-term monthly averages

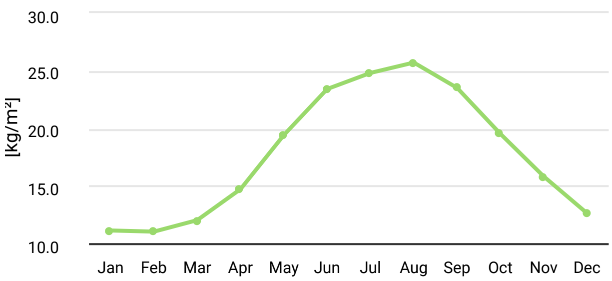


Table 6.1 Precipitable water: Long-term average values

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	kg/m²	11.1	11.0	12.0	14.7	19.4	23.4	24.8	25.7	23.5	19.5	15.8	12.6	17.8

6.2 Ground surface albedo

Ground surface albedo (ALB) refers to the fraction of solar radiation that is reflected off the ground, and it is important for modelling energy output from bifacial PV modules.

Figure 6.2 and Table 6.2 show long-term average values.

Figure 6.2 Ground surface albedo: Long-term monthly averages

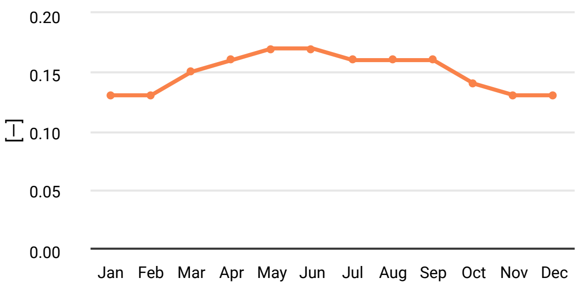


Table 6.2 Ground surface albedo: Long-term average values

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	0.13	0.13	0.15	0.16	0.17	0.17	0.16	0.16	0.16	0.14	0.13	0.13	0.15

7 Photovoltaic power generation

The conversion losses and the long-term average yearly and monthly electricity output from the photovoltaic power plant is calculated from the solar radiation, meteorological and environmental parameters included in the Solargis time series. Monthly average values of GTI and PV system losses due to soiling and snow are estimated by user.

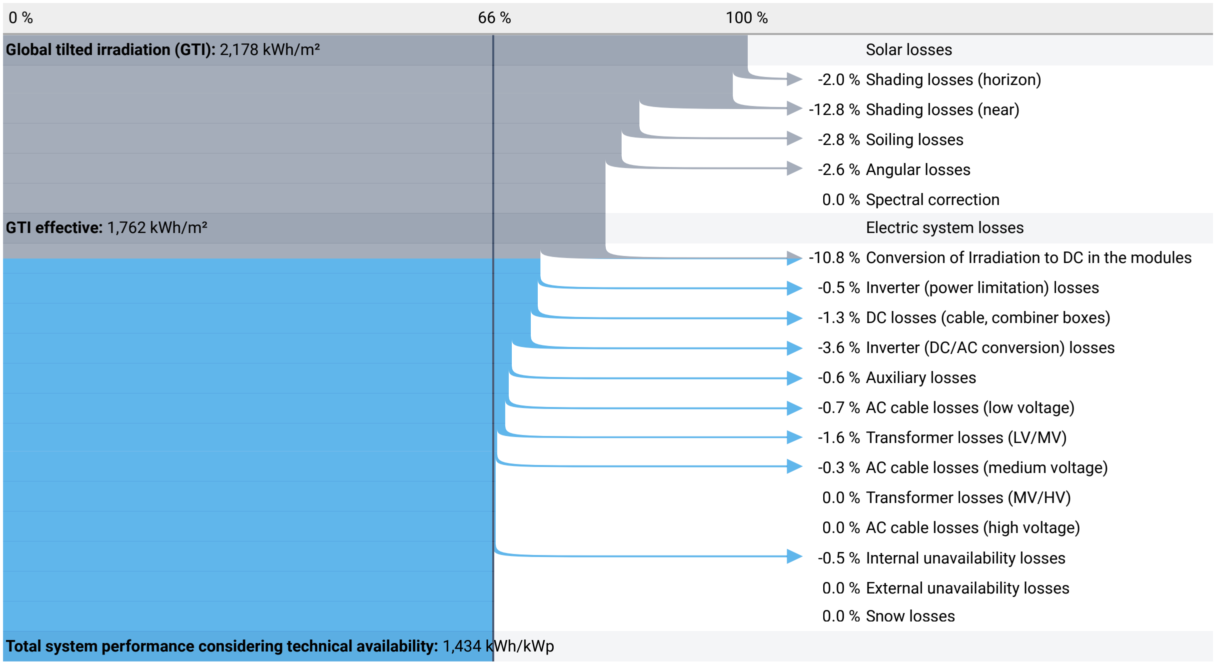
The GTI, PVOUT and PR results are calculated for the PV system configuration as fully described in the Annex 1 of this report.

In GTI values, we show the contribution of shading losses, caused by the default terrain horizon of the project reference point or of the individual segments of the PV power plant. The default horizon could have been customized by the customer. For PV systems with multi-segment, Solargis Evaluate calculates GTI as a weighted average of the GTI values calculated for individual segments. The weight is represented by the surface area of solar cells installed in each segment. In case of bifacial PV modules, the GTI values are shown separately for both the front and the rear side of the PV modules. These two GTI values, together with the consideration of the terrain horizon are shown as a summarized values in Table 4.1.

Power generation of the PV power plant does not consider degradation (aging) of nominal power (conversion efficiency) of PV modules. This factor is discussed in Chapter 8.

7.1 PV system losses and performance ratio

Figure 7.1 Summary of yearly losses at the level of a PV system



Most energy losses are variable in time. They change during the seasons of a year, and they are variable between the years (interannual variability). This is typically visible in power limitation losses and energy conversion losses, where impact of changing conditions is the strongest, mainly due to solar radiation and air temperature. Figure 7.2 shows seasonal and interannual variability of energy losses in each type of the conversion stage.

Table 7.1 shows yearly breakdown of energy losses, providing an insight into the power plant performance. Degradation of conversion efficiency of PV modules is not considered here.

Table 7.1 Conversion stages, energy losses, and performance ratio at the level of the PV system.

Energy input	kWh/m²
Global horizontal irradiation	1,641
Global horizontal irradiation after shading	1,631

Optical losses	Energy output	Energy loss	Energy loss	Energy loss	Energy loss	Performance loss
			Partial	Relative to previous	Relative to input	Cumulative
	kWh/m²	kWh/m²	%	%	%	%
Front side						
Global tilted irradiation	1,897	–	100.0	–	–	100.0
Shading losses (horizon)	1,862	-35	98.2	-1.8	-1.8	98.2
Shading losses (near)	1,743	-119	93.6	-6.4	-8.1	91.9
Soiling losses	1,691	-52	97.0	-3.0	-10.9	89.1
Angular losses	1,656	-35	97.9	-2.1	-12.7	87.3
Spectral correction	1,657	1	100.0	0.0	-12.7	87.3
Rear side						
Global tilted irradiation	280	–	100.0	–	–	100.0
Shading losses (horizon)	271	-10	96.5	-3.5	-3.5	96.5
Shading losses (near)	117	-154	43.3	-56.7	-58.2	41.8
Soiling losses	117	-1	99.5	-0.5	-58.4	41.6
Angular losses	105	-11	90.3	-9.7	-62.4	37.6
Spectral correction	106	0	100.2	0.2	-62.4	37.6
GTI effective	1,762					80.9

Conversion losses	kWh/kWp	kWh/kWp	%	%	%	%
Conversion of Irradiation to DC in the modules	1,572	-190	89.2	-10.8	0.0	75.8

Electrical losses	PVOUT specific	Energy loss	Energy loss	Energy loss	Energy loss	Performance ratio
			Partial	Relative to previous	Relative to input	Cumulative
	kWh/kWp	kWh/kWp	%	%	%	%
Inverter (power limitation) losses	1,564	-8	99.5	-0.5	-0.4	75.4
DC losses (cable, combiner boxes)	1,544	-20	98.7	-1.3	-0.9	74.5
Inverter (DC/AC conversion) losses	1,488	-56	96.4	-3.6	-2.6	71.8
Auxiliary losses	1,479	-10	99.4	-0.6	-0.4	71.3
AC cable losses (low voltage)	1,469	-10	99.3	-0.7	-0.5	70.8
Transformer losses (LV/MV)	1,446	-23	98.4	-1.6	-1.1	69.7
AC cable losses (medium voltage)	1,441	-5	99.7	-0.3	-0.2	69.5
Transformer losses (MV/HV)	1,441	0	100.0	0.0	0.0	69.5
AC cable losses (high voltage)	1,441	0	100.0	0.0	0.0	69.5
Internal unavailability losses	1,434	-7	99.5	-0.5	-0.3	69.1
External unavailability losses	1,434	0	100.0	0.0	0.0	69.1
Snow losses	1,434	0	100.0	0.0	0.0	69.1
Total system performance considering technical availability and losses due to snow	1,434	-744	65.8	-34.2	-34.2	69.1

Capacity factor	%
Capacity factor considering technical availability and losses due to snow	16.4

Figure 7.2 Statistics of interannual variability for monthly losses considered in PV simulation

In the results of PV power simulation, shown in Chapters below, the terrain shading of the individual segments and near shading by objects are considered.

7.2 Monthly and yearly PV power generation

Long-term average photovoltaic power generation (under simplified assumptions considered equal to P50, i.e., 50% probability of exceedance) is complemented with absolute minimum and maximum monthly sums, identified in the Solargis time series. These values are not symmetric, and they depend on real weather conditions. Furthermore, almost all months show higher deviations from the long-term average values (see Table 7.2).

Yearly sum of solar radiation can deviate from the long-term average in the range of a few percent, and this applies also to meteorological parameters (air temperature, snow, etc.) as they influence PV power generation. Figure 7.3, Figure 7.4, and Table 7.3 show variability of PV power output (PVOUT, including internal, external unavailability and snow losses) at yearly and monthly level.

Figure 7.3 Specific power generation and Performance ratio with internal, external unavailability and snow losses: Monthly statistics (left) and interannual variability (right)

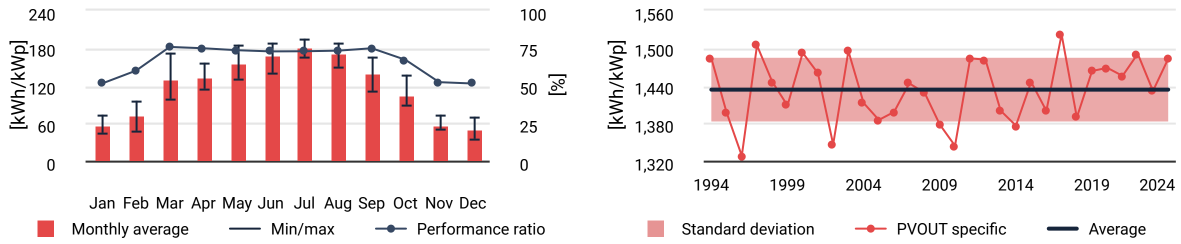


Table 7.2 PV power generation (PVOUT) and Performance ratio (PR) with internal, external unavailability and snow losses: Long-term monthly and yearly statistics

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
PVOUT specific	kWh/kWp	Average	57.9	74.1	130.6	135.2	157.1	168.3	182.2	173.0	139.8	107.1	58.2	50.2	1,433.6
		Min	44.4	46.0	98.7	112.8	129.0	140.4	163.3	148.0	111.4	88.5	49.6	33.1	1,327.8
		Max	70.9	92.9	170.3	154.5	185.0	187.7	193.3	186.5	164.4	134.8	72.0	68.5	1,521.8
PVOUT total	MWh	Average	1,851	2,369	4,178	4,322	5,023	5,381	5,828	5,533	4,469	3,425	1,862	1,604	45,846
		Min	1,421	1,470	3,155	3,608	4,125	4,491	5,221	4,734	3,562	2,829	1,586	1,058	42,463
		Max	2,269	2,970	5,446	4,942	5,916	6,002	6,182	5,966	5,257	4,312	2,302	2,190	48,668
PR	%	Average	51.5	60.0	75.8	74.9	73.6	72.8	72.9	73.3	74.9	67.2	52.3	51.4	69.1
		Min	49.3	57.3	75.0	74.1	72.9	72.1	72.3	72.6	74.4	64.7	49.4	48.7	68.1
		Max	55.8	66.6	76.6	75.9	74.7	73.7	73.5	74.2	75.7	69.5	54.6	56.5	70.3

Figure 7.4 Specific power generation (PVOUT specific) with internal, external unavailability and snow losses: Time series of monthly sums

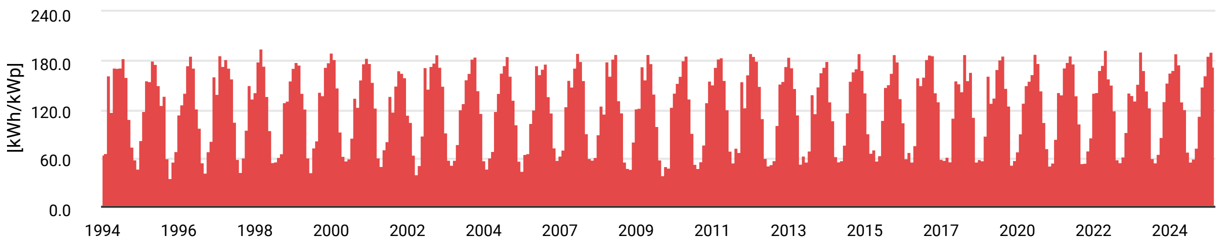


Table 7.3 Specific power generation (PVOUT specific) with internal, external unavailability and snow losses: Monthly and yearly sums and long-term averages (LTA) [kWh/kWp]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1994	62.2	64.0	160.1	114.8	169.7	169.4	169.8	181.4	158.1	106.2	72.0	56.2	1,483.9
1995	44.7	80.0	116.0	153.9	152.9	178.4	174.3	148.0	123.5	134.8	57.6	33.1	1,397.2
1996	53.4	66.4	111.7	124.2	138.6	172.6	184.4	169.6	119.2	95.3	52.6	39.8	1,327.8
1997	66.3	79.1	158.9	137.2	185.0	171.8	180.2	169.6	156.3	102.7	56.7	40.6	1,504.3
1998	58.5	92.9	148.1	131.5	139.3	177.3	193.3	172.0	134.6	92.4	52.8	53.6	1,446.2
1999	59.2	63.7	126.9	128.8	153.8	169.4	176.6	173.4	138.5	119.0	58.5	40.3	1,408.2
2000	70.9	79.7	139.8	135.6	170.6	176.3	188.2	180.2	145.1	90.6	60.5	54.8	1,492.4
2001	57.4	83.0	132.4	121.2	155.0	175.0	181.8	175.4	152.0	120.2	58.5	48.0	1,459.9
2002	68.7	78.7	134.7	115.3	147.5	166.4	163.3	157.8	111.4	102.5	62.0	37.8	1,345.9
2003	49.1	85.7	170.3	143.6	171.7	175.9	186.2	170.7	147.3	89.5	55.7	49.5	1,495.2
2004	55.6	75.1	118.1	125.8	155.2	163.1	180.8	183.2	141.7	113.6	55.1	44.8	1,412.2
2005	58.5	66.6	116.0	138.4	163.4	172.7	183.9	159.7	129.9	99.6	54.5	42.0	1,385.1
2006	62.9	63.9	101.2	117.8	172.7	161.6	168.2	174.6	134.4	114.2	71.0	55.5	1,397.9
2007	60.8	68.3	121.9	154.5	146.2	169.7	187.9	177.8	154.2	88.5	57.8	55.8	1,443.5
2008	59.1	87.2	122.7	112.8	177.4	159.7	180.7	186.5	129.3	114.3	53.4	45.6	1,428.8
2009	44.4	78.2	119.3	120.0	171.3	155.1	186.5	175.2	137.5	97.4	56.1	36.6	1,377.8
2010	47.9	46.0	121.2	138.7	150.8	159.5	178.7	184.5	131.5	89.0	50.6	45.5	1,343.8
2011	53.9	74.5	126.9	153.6	148.9	170.6	181.0	182.5	154.4	118.1	67.0	52.4	1,483.7
2012	70.6	65.3	152.9	120.6	161.3	187.7	184.1	178.2	147.0	107.2	58.0	48.7	1,481.5
2013	50.3	55.2	98.7	149.9	153.1	171.6	183.1	170.1	144.4	111.7	50.9	60.9	1,399.9
2014	53.4	67.1	136.8	113.3	146.4	164.0	170.6	177.9	127.9	104.6	60.2	53.7	1,376.0
2015	55.2	74.4	114.3	153.4	165.0	168.9	187.5	166.8	139.0	88.5	64.3	68.5	1,445.7
2016	54.7	61.4	105.0	145.8	149.1	163.2	186.4	177.3	131.9	102.0	57.6	65.3	1,399.6
2017	53.4	73.8	157.7	148.0	158.4	180.2	185.8	185.0	139.2	128.0	56.8	55.5	1,521.8
2018	59.4	53.8	107.7	153.8	150.3	140.4	186.4	154.2	164.4	108.8	53.5	56.5	1,389.2
2019	55.0	85.5	159.6	126.1	132.6	167.9	179.8	184.5	144.6	122.7	49.6	55.3	1,463.4
2020	66.1	88.4	126.3	148.0	153.5	161.6	186.7	175.4	141.5	102.4	70.1	48.5	1,468.5
2021	52.2	81.6	139.4	136.6	169.9	176.7	184.7	174.8	135.4	100.7	51.6	52.0	1,455.6
2022	67.2	83.4	138.6	139.4	166.7	173.0	191.6	156.4	148.7	116.8	56.3	52.7	1,490.9
2023	59.8	90.1	138.9	135.8	129.0	149.6	189.6	166.7	141.4	120.5	57.7	52.5	1,431.5
2024	63.0	83.9	128.2	151.1	163.5	166.8	187.4	173.7	127.9	118.3	65.8	53.5	1,483.0
2025	57.2	70.6	110.1	146.3	160.2	184.3	189.3	171.0					
	57.9	74.1	130.6	135.2	157.1	168.3	182.2	173.0	139.8	107.1	58.2	50.2	1,433.6

7.3 Daily PV power generation

Figure 7.5 shows histograms of daily sums of specific PV power generation (PVOUT specific, without internal, external unavailability and snow losses) for each month. The distribution of daily values is not symmetric: median is drawn as a grey vertical line. The area between percentiles p10 and p90 (light grey range) shows 80% occurrence of daily values within each month and the area between percentiles p25 and p75 (dark grey range) shows 50% occurrence. PVOUT is variable throughout the year: narrower groups indicate more stable weather with lower influence of clouds. Table 7.4 shows the occurrence statistics of daily sums of theoretical PV power generation per month.

Figure 7.5 Specific power generation (PVOUT specific), without internal, external unavailability and snow losses, daily sums: Relative occurrence and percentiles p10, p25, p50, p75 and p90 [kWh/kWp]. Y-axes: (left) - occurrence, (right) - cumulative distribution

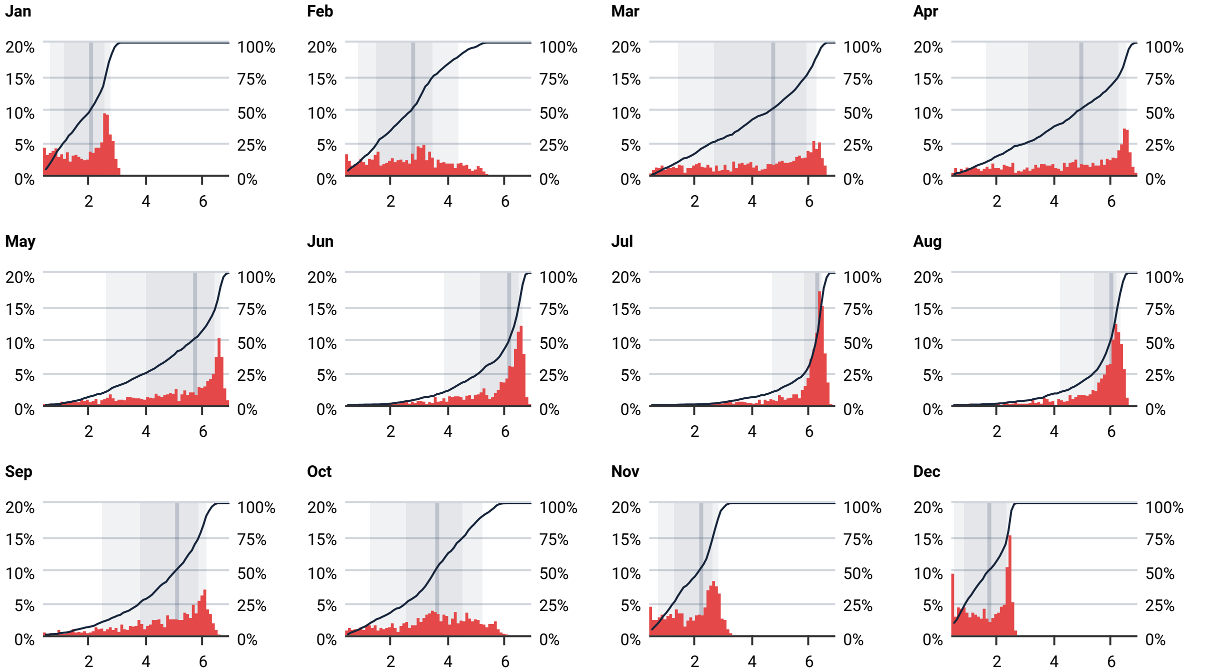


Table 7.4 Specific power generation (PVOUT specific), without internal, external unavailability and snow losses, daily sums: Relative occurrence and percentiles p01, p05, p10, p25, p50, p75, p90, p95 and p99 [Wh/kWp]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	1.876	2.635	4.235	4.528	5.092	5.637	5.908	5.609	4.682	3.472	1.950	1.627
Min	0.210	0.228	0.277	0.264	0.482	0.741	0.594	0.685	0.341	0.386	0.152	0.094
Max	3.096	5.357	6.537	6.822	6.868	6.844	6.709	6.591	6.509	6.059	3.258	2.665
p01	0.351	0.401	0.605	0.571	1.025	2.033	2.597	1.990	0.940	0.558	0.270	0.254
p05	0.554	0.593	0.958	1.147	1.854	3.029	3.754	3.453	1.737	0.944	0.558	0.384
p10	0.692	0.918	1.414	1.655	2.602	3.873	4.750	4.224	2.470	1.327	0.756	0.528
p25	1.151	1.528	2.703	3.124	4.067	5.126	5.869	5.406	3.812	2.557	1.274	0.914
p50	2.090	2.757	4.709	4.932	5.690	6.150	6.238	5.984	5.083	3.583	2.188	1.756
p75	2.584	3.497	5.887	6.244	6.438	6.461	6.409	6.217	5.865	4.556	2.630	2.367
p90	2.771	4.398	6.269	6.526	6.609	6.591	6.513	6.353	6.099	5.198	2.841	2.465
p95	2.859	4.705	6.381	6.598	6.676	6.657	6.580	6.418	6.220	5.510	2.936	2.508
p99	3.000	5.159	6.510	6.730	6.780	6.713	6.638	6.512	6.368	5.793	3.112	2.585

7.4 Hourly PV power generation

Figure 7.6 shows distribution of hourly sums of specific PV power generation (PVOUT specific) statistics per month. The graphs show average, and percentiles p10 - p90 and p01 - p99 as calculated from PVOUT time series. Table 7.5 is complementary, and it shows distribution of hourly PVOUT averages per month. Both figures show the power generation without internal, external unavailability and snow losses.

Figure 7.6 Specific power generation (PVOUT specific), without internal, external unavailability and snow losses, hourly profiles: Average values, percentiles p01, p10, p90, and p99 [Wh/kWp]

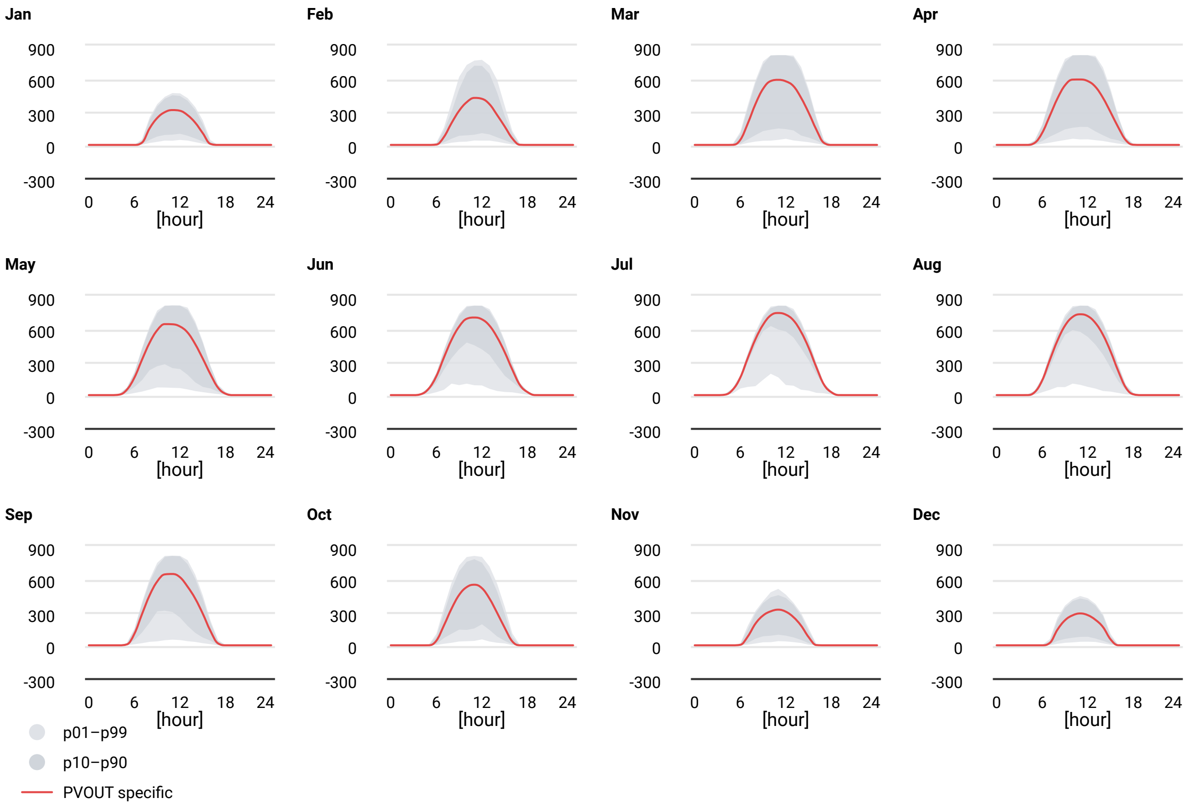


Table 7.5 Specific power generation (PVOUT specific), without internal, external unavailability and snow losses, hourly averages per month [Wh/kWp]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1	-	-	-	-	-	-	-	-	-	-	-	-
1 - 2	-	-	-	-	-	-	-	-	-	-	-	-
2 - 3	-	-	-	-	-	-	-	-	-	-	-	-
3 - 4	-	-	-	-	-	-	-	-	-	-	-	-
4 - 5	-	-	-	-	2	7	2	-	-	-	-	-
5 - 6	-	-	-	16	47	57	47	24	6	-	-	-
6 - 7	-	1	44	108	157	170	157	133	103	40	2	-
7 - 8	19	70	195	263	320	340	338	317	281	179	79	20
8 - 9	148	196	370	420	474	500	507	493	452	331	195	140
9 - 10	242	309	508	540	587	621	638	630	578	456	269	226
10 - 11	295	386	578	591	643	691	722	708	642	527	306	270
11 - 12	314	425	589	592	641	703	744	732	646	548	322	287
12 - 13	308	416	575	577	621	686	728	715	616	517	303	271
13 - 14	268	367	531	525	566	628	676	653	530	422	253	229
14 - 15	200	269	425	424	461	523	571	545	422	292	176	163
15 - 16	104	164	290	294	329	387	427	393	284	156	71	51
16 - 17	7	57	138	158	188	229	252	217	129	33	0	-
17 - 18	-	-	17	41	66	89	94	65	16	-	-	-
18 - 19	-	-	-	-	10	25	23	5	-	-	-	-
19 - 20	-	-	-	-	-	-	-	-	-	-	-	-
20 - 21	-	-	-	-	-	-	-	-	-	-	-	-
21 - 22	-	-	-	-	-	-	-	-	-	-	-	-
22 - 23	-	-	-	-	-	-	-	-	-	-	-	-
23 - 24	-	-	-	-	-	-	-	-	-	-	-	-
Sum	1,876	2,635	4,235	4,528	5,092	5,637	5,908	5,609	4,682	3,472	1,950	1,627

7.5 15-minute PV power generation

Figure 7.7 shows monthly histograms, representing the occurrence of 15-minute specific PV power output values (PVOUT specific, without internal, external unavailability and snow losses) within 50 W/kWp bins. Figure 7.8 shows monthly histograms of 15-minute PVOUT specific variability (ramps, signed values).

Figure 7.7 Specific power generation (PVOUT specific), without internal, external unavailability and snow losses, 15-minute values: Relative occurrence and percentiles p10, p25, p50, p75 and p90. Y-axes: (left) - occurrence, (right) - cumulative distribution

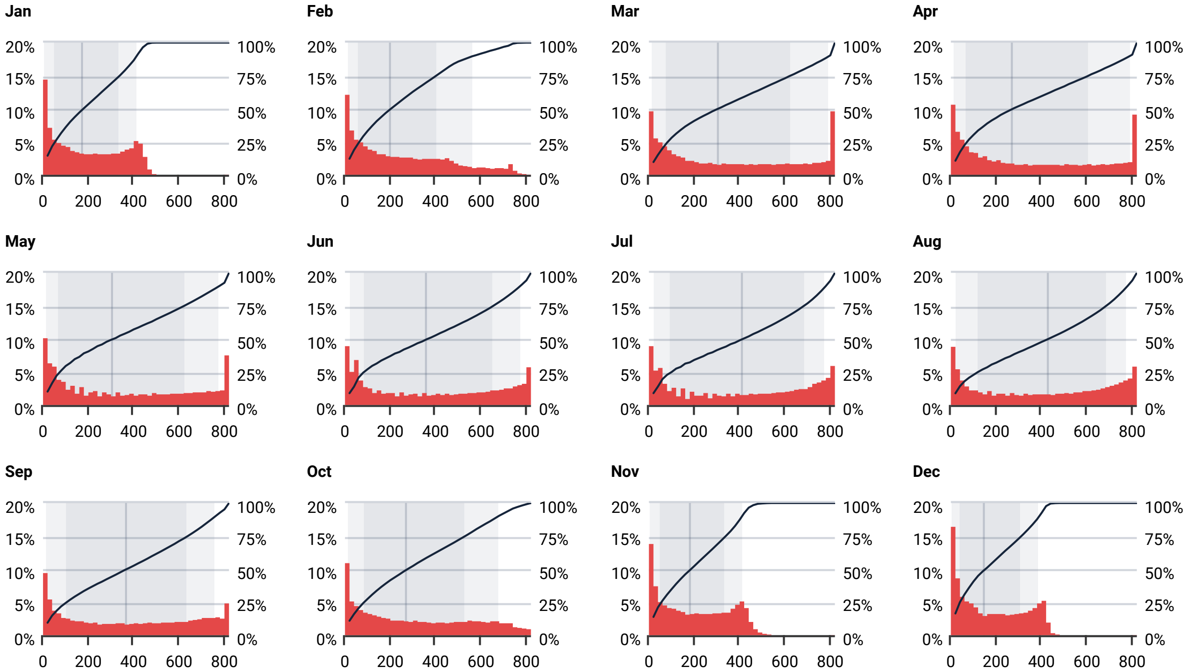
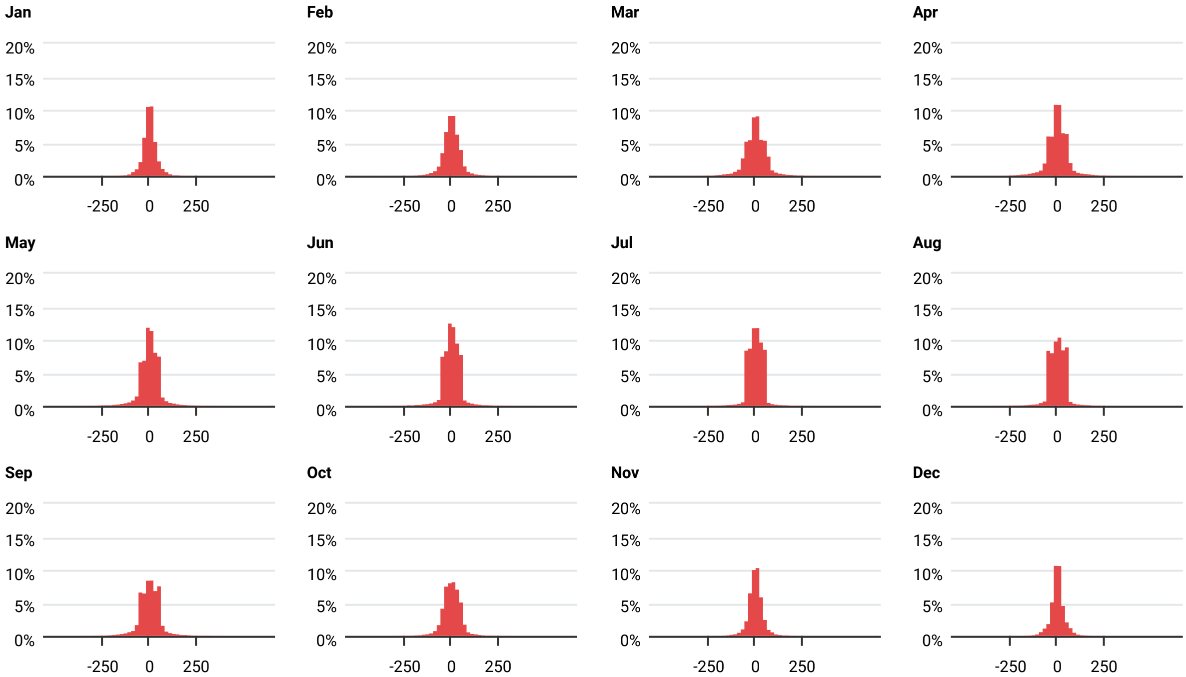


Figure 7.8 Specific power generation (PVOUT specific), 15-minute values: Occurrence of signed ramps [W/kWp]



Note: Bin size: 50 W/kWp

8 Photovoltaic power generation for next 25 years

To estimate power generation of the PV power plant (PVOUT) and the Performance ratio (PR) for 25 years, degradation (aging) of nominal power (conversion efficiency) of PV modules must be considered. Not only are the modules subject to aging, but the overall performance of the power plant also depends on the performance degradation effects in cabling and inverters during the planned 25 years. Another source of uncertainty is the non-uniform degradation of individual modules, which results in higher mismatch losses. The calculation below is built on the results of Chapter 7.1, and it considers a simplified assumption of yearly linear degradation rate of 2.0 % in the first year and 0.5 % in the following years.

Figure 8.1 Specific PV power generation (PVOUT specific) [kWh/kWp] and Performance ratio (PR) [%] for next 25 years

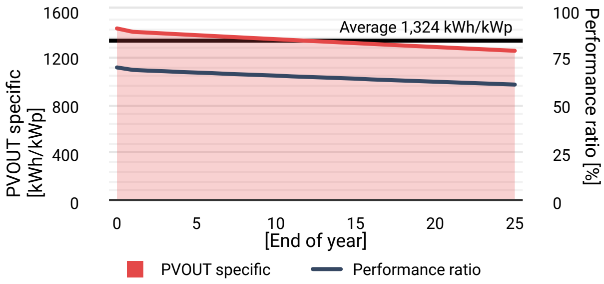


Table 8.1 Power generation over lifetime of PV power plant

End of year	Degradation rate	PVOUT specific	PVOUT total	PR
	%	kWh/kWp	GWh	%
0	-	1,434	45.85	69.1
1	2.0	1,405	44.93	67.8
2	0.5	1,398	44.70	67.4
3	0.5	1,391	44.48	67.1
4	0.5	1,384	44.26	66.7
5	0.5	1,377	44.04	66.4
6	0.5	1,370	43.82	66.1
7	0.5	1,363	43.60	65.7
8	0.5	1,356	43.38	65.4
9	0.5	1,350	43.16	65.1
10	0.5	1,343	42.95	64.8
11	0.5	1,336	42.73	64.4
12	0.5	1,330	42.52	64.1
13	0.5	1,323	42.31	63.8
14	0.5	1,316	42.09	63.5
15	0.5	1,310	41.88	63.2
16	0.5	1,303	41.67	62.8
17	0.5	1,297	41.47	62.5
18	0.5	1,290	41.26	62.2
19	0.5	1,284	41.05	61.9
20	0.5	1,277	40.85	61.6
21	0.5	1,271	40.64	61.3
22	0.5	1,265	40.44	61.0
23	0.5	1,258	40.24	60.7
24	0.5	1,252	40.04	60.4
25	0.5	1,246	39.84	60.1
Average	0.6	1,324	42.33	63.8
Cumulative	13.1	-	1,058.34	-

9 Acronyms

ALB	Ground surface albedo
AP	Atmospheric pressure
CFSR	National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis
D2G, DIF/GHI	Ratio of diffuse to global horizontal irradiation
DIF	Diffuse horizontal irradiation, if integrated solar energy is assumed. Diffuse horizontal irradiance, if solar power values are discussed
DNI	Direct normal irradiation, if integrated solar energy is assumed. Direct normal irradiance, if solar power values are discussed
ERA5, ERA5 Land	Climate reanalysis data, providing atmospheric, land-surface and sea-state parameters. Service operated by ECMWF
GFS	Global Forecast System. Service operated by NOAA
GHI	Global horizontal irradiation, if integrated solar energy is assumed. Global horizontal irradiance, if solar power values are discussed
GTI	Global tilted (global in-plane) irradiation, if integrated solar energy is assumed. Global tilted irradiance, if solar power values are discussed
LTA	Long-term average values
MACC-II/CAMS	Monitoring Atmospheric Composition and Climate - Interim Implementation of the Copernicus Atmosphere Monitoring Service operated by ECMWF
MERRA-2	Modern Era Reanalysis for Research and Applications operated by NASA
Meteosat	Meteosat satellites operated by EUMETSAT organization
MODIS	MODerate resolution Imaging Spectroradiometer operated by NASA
p01, p10, ... pxx	Calculated percentile values, pxx stands for the x-th percentile, p50 is median
PREC	Precipitation total
PVOUT Specific	AC energy delivered by a PV system and normalized to 1 kWp of installed capacity
PVOUT Total	AC energy delivered by the total installed capacity of a PV system
PWAT	Precipitable water. The total amount of vapor in a column of the atmosphere
RH	Relative humidity at 2 meters
SDWE	Snow depth water equivalent
SRTM3	Global digital elevation model prepared by the Shuttle Radar Topography Mission at the spatial resolution of 3 arc-second
SUN_AZIMUTH	Sun azimuth angle
SUN_ELEVATION	Sun elevation angle
TD	Dew point temperature at 2 meters
TEMP	Air temperature at 2 meters
WBT	Wet bulb temperature at 2 meters
WD	Wind direction at 10 meters
WG	Wind gust at 10 meters
WS	Wind speed at 10 meters

10 Glossary

P50 value	Best estimate or median value represents 50% probability of exceedance. For annual and monthly solar irradiation summaries it is close to average, since multiyear distribution of solar radiation is (in a simplified approach) considered to be a normal distribution.
Solar irradiance	Solar power (instantaneous energy) falling on a unit area per unit time [W/m²]. Terms solar resource or solar radiation are used when considering both irradiance and irradiation.
Solar irradiation	Amount of solar energy falling on a unit area over a stated time interval [Wh/m²].

11 References

11.1 Solargis methodology

[1] Solargis digital terrain models: https://kb.solargis.com/docs/geospatial-mapping-1

[2] Solargis solar, meteorological, and environmental database: methods, inputs, numerical models, validation, data parameters, and properties: https://kb.solargis.com/docs/solar-meteorological-and-environmental-data

[3] Validation of Solargis model parameters: https://kb.solargis.com/docs/accuracy-validation

[4] Geographical representation of Solargis model data: https://kb.solargis.com/docs/geospatial-mapping

[5] Solargis PV simulation chain: https://kb.solargis.com/docs/pv-energy-yield-simulation#the-solargis-approach

[6] Solar resource uncertainty: https://kb.solargis.com/docs/uncertainty

[7] Solargis Analyst software: https://kb.solargis.com/docs/analyst

11.2 Data sources from third parties

CFSR	© 2025 National Oceanic and Atmospheric Administration (NOAA)
ERA5	© 2025 European Centre for Medium-range Weather Forecasts (ECMWF)
ERA5 Land	© 2025 European Centre for Medium-range Weather Forecasts (ECMWF)
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