PVGIS, AS A HELP TOOL FOR THE DESIGN OF PHOTOVOLTAIC INSTALLATIONS

Prof. Sergio Valero Verdú

ISEC 2023

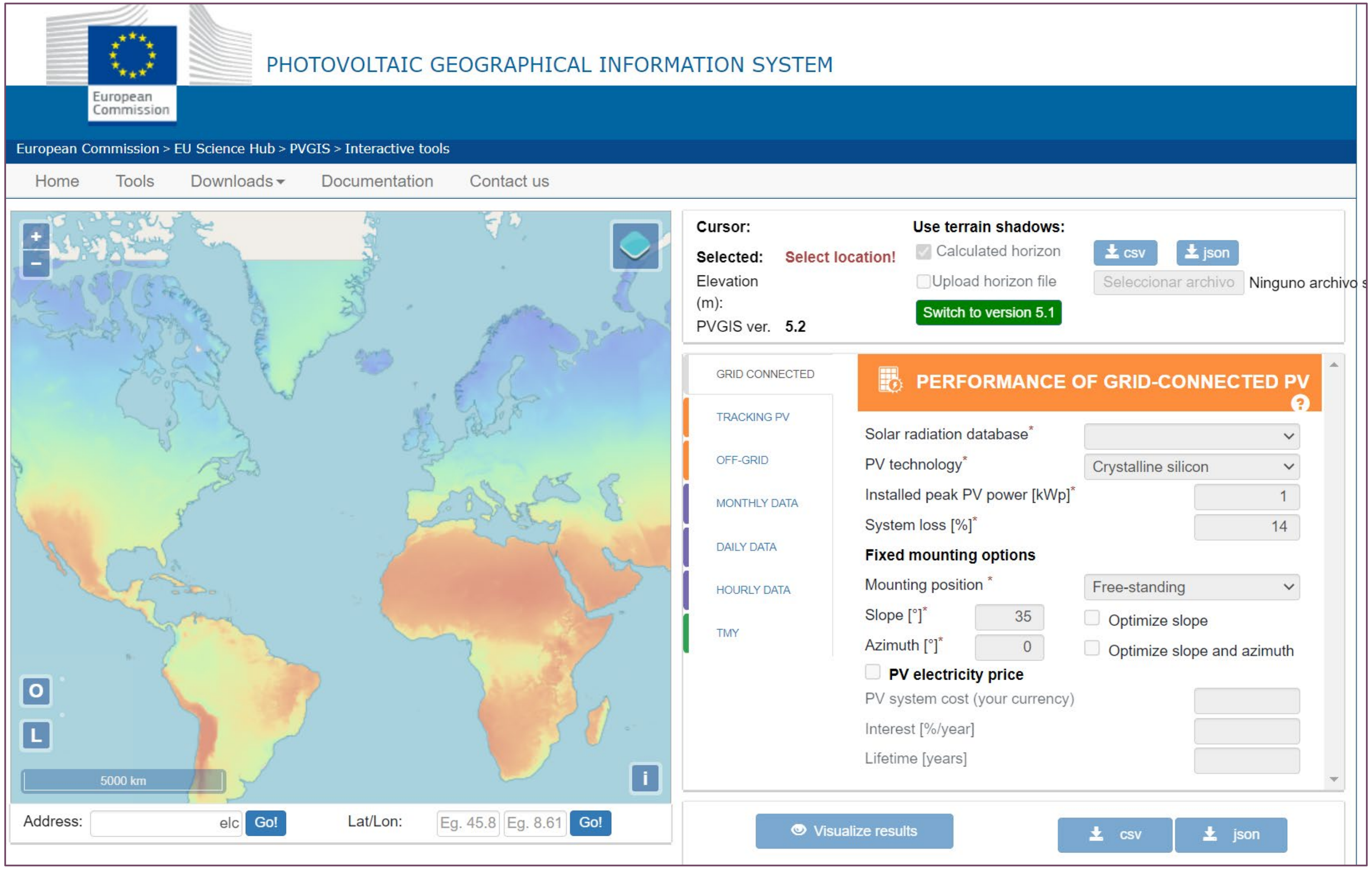
INTERNATIONAL SOLAR ENERGY CONFERENCE

GENERALITAT VALENCIANA

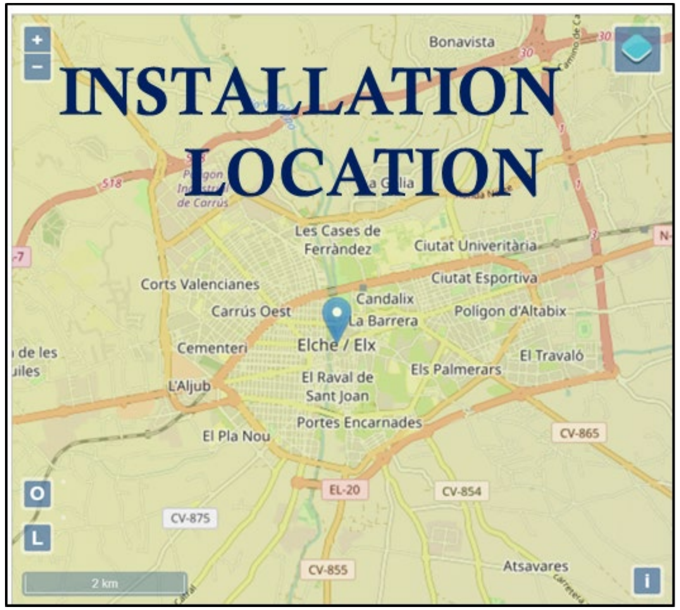
CÁTEDRA DEMESOL
ENERGÍA SOLAR FOTOVOLTAICA

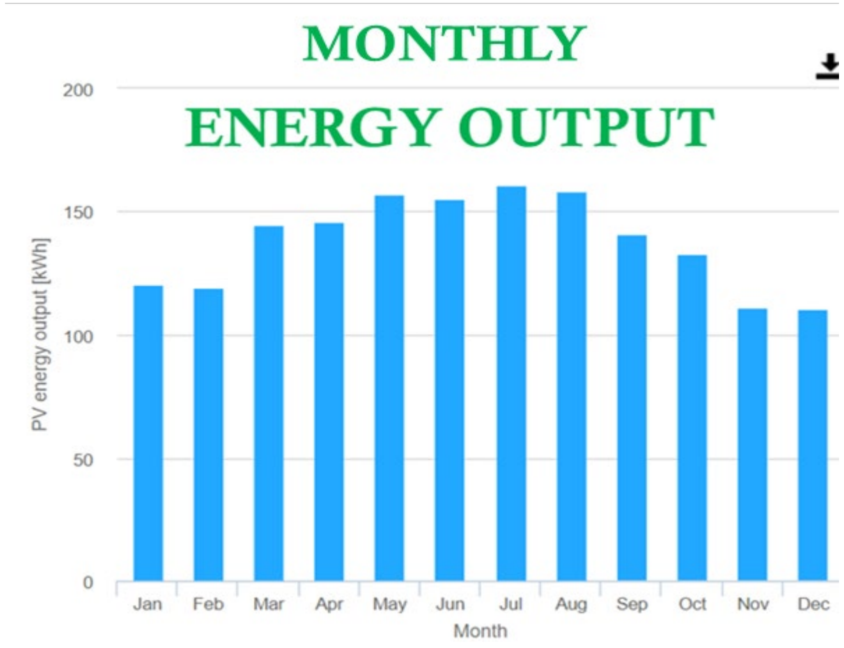
ISEC2023.UMH.ES

The first question would be: What is PVGIS?



PVGIS is a web site that gives you information about solar radiation and PhotoVoltaic (PV) system performance. **You can use PVGIS to calculate how much energy output you can get from different kinds of PV systems at nearly any place in the world.**





Example:

Yearly PV energy production:

1658,12 kWh

(In this case for 1 kW of installed peak power)

And…..two more questions:

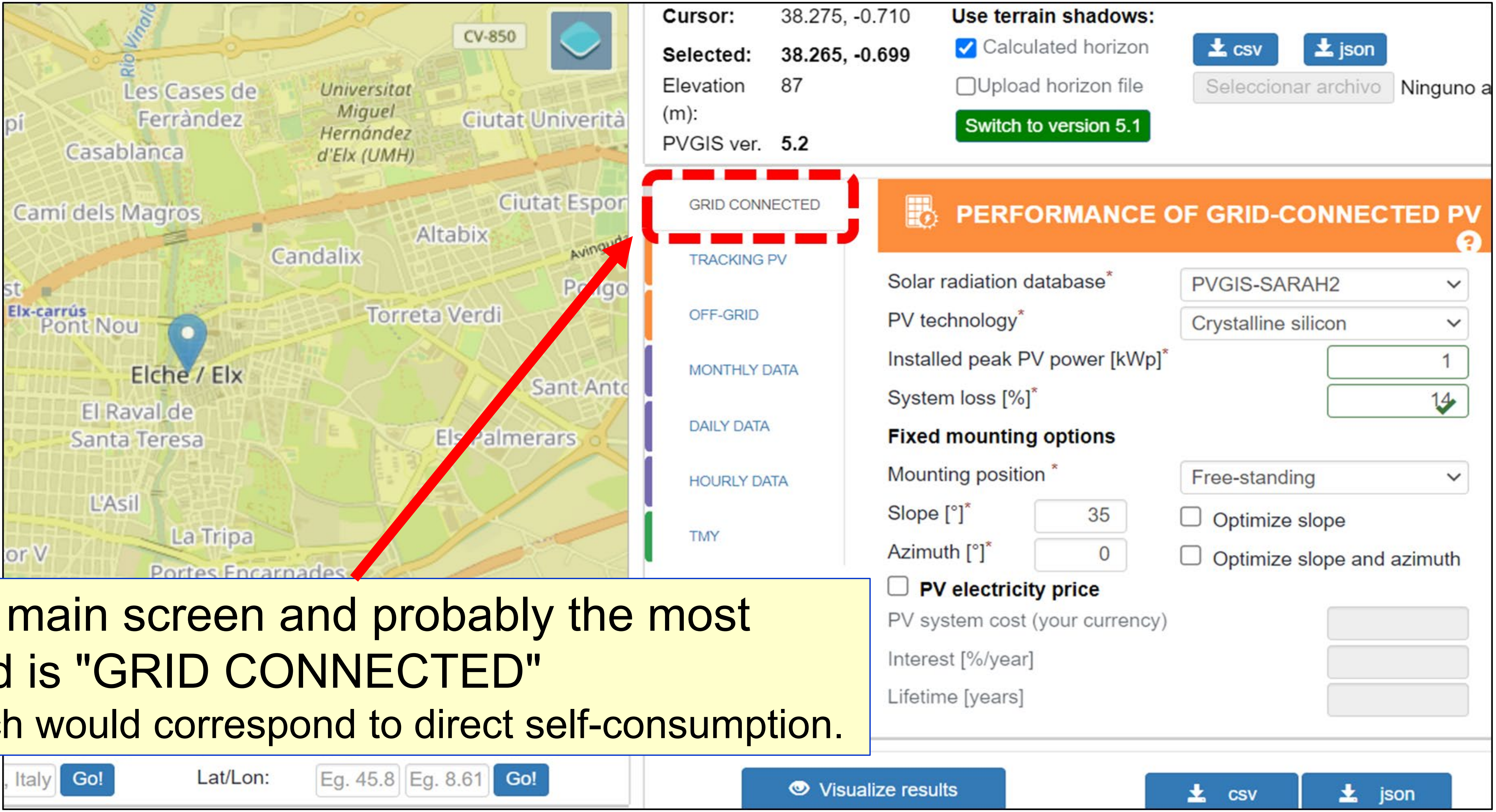
Where can I consult it?

It is on the following website online:

https://re.jrc.ec.europa.eu/pvg_tools/es/

Is free? YES

Description and explanation of the some screens and menus



The main screen and probably the most used is "GRID CONNECTED"

Which would correspond to direct self-consumption.

How much will a PHOTOVOLTAIC SOLAR INSTALLATION produce annually?

We need to know the following starting data:

- Installation location.
- Solar radiation database to consult.
- PV technology.
- Peak Power to Install (kWp)
- System losses (%)
- Installation Type
  - Free layout or Integrated in building?
- Angle of inclination of the modules.
- Orientation angle of the modules.
- Possible shadows
  - None, of the relief, of nearby obstacles...?

VERY IMPORTANT !!! Therefore, you need to collect all this data before consulting PVGIS

Installation location.

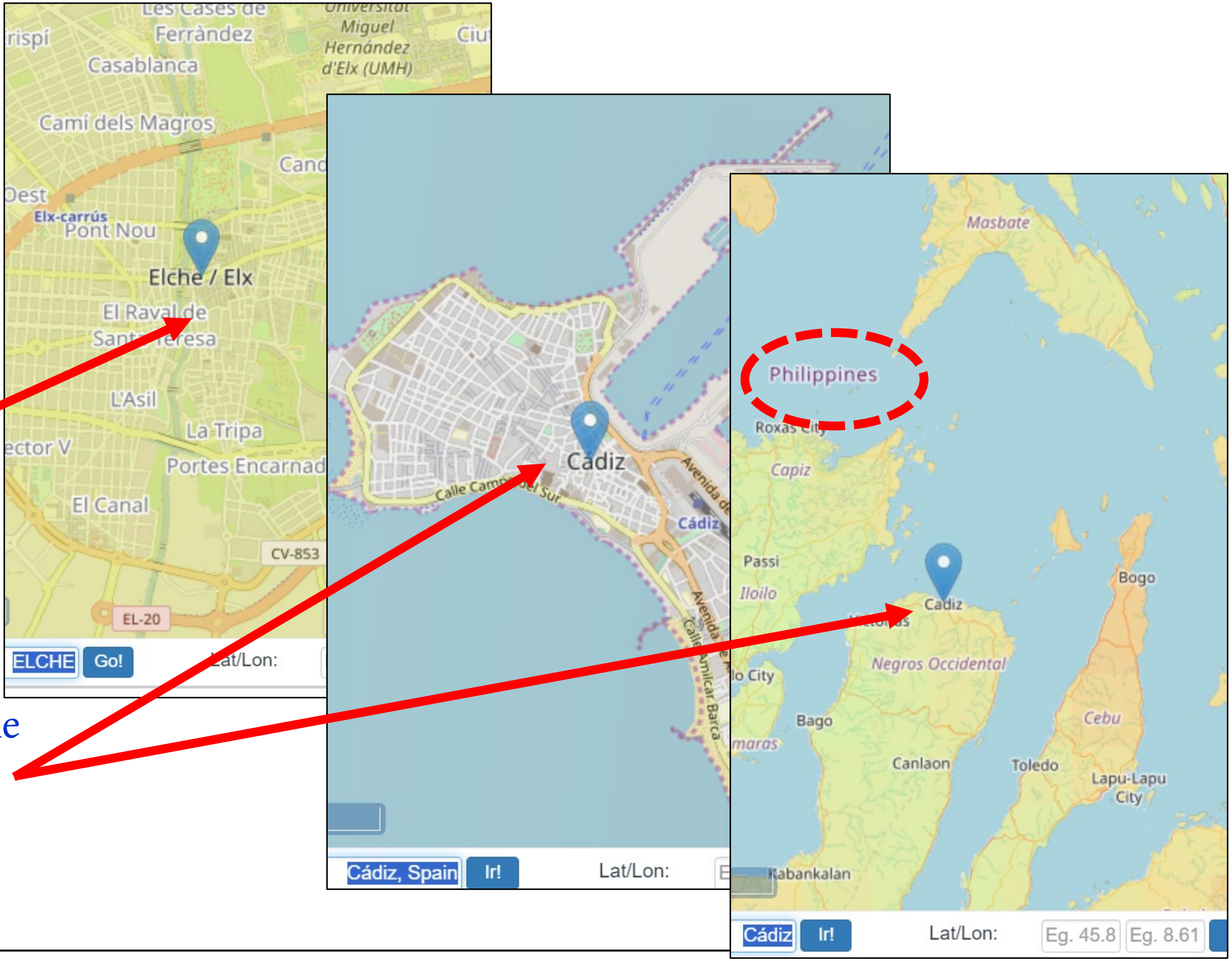
You can select the city, or the city and the country.

For example:

Elche

or

Cádiz, Spain (In the case that the same name of the city is repeated or coincides with other places in the world)



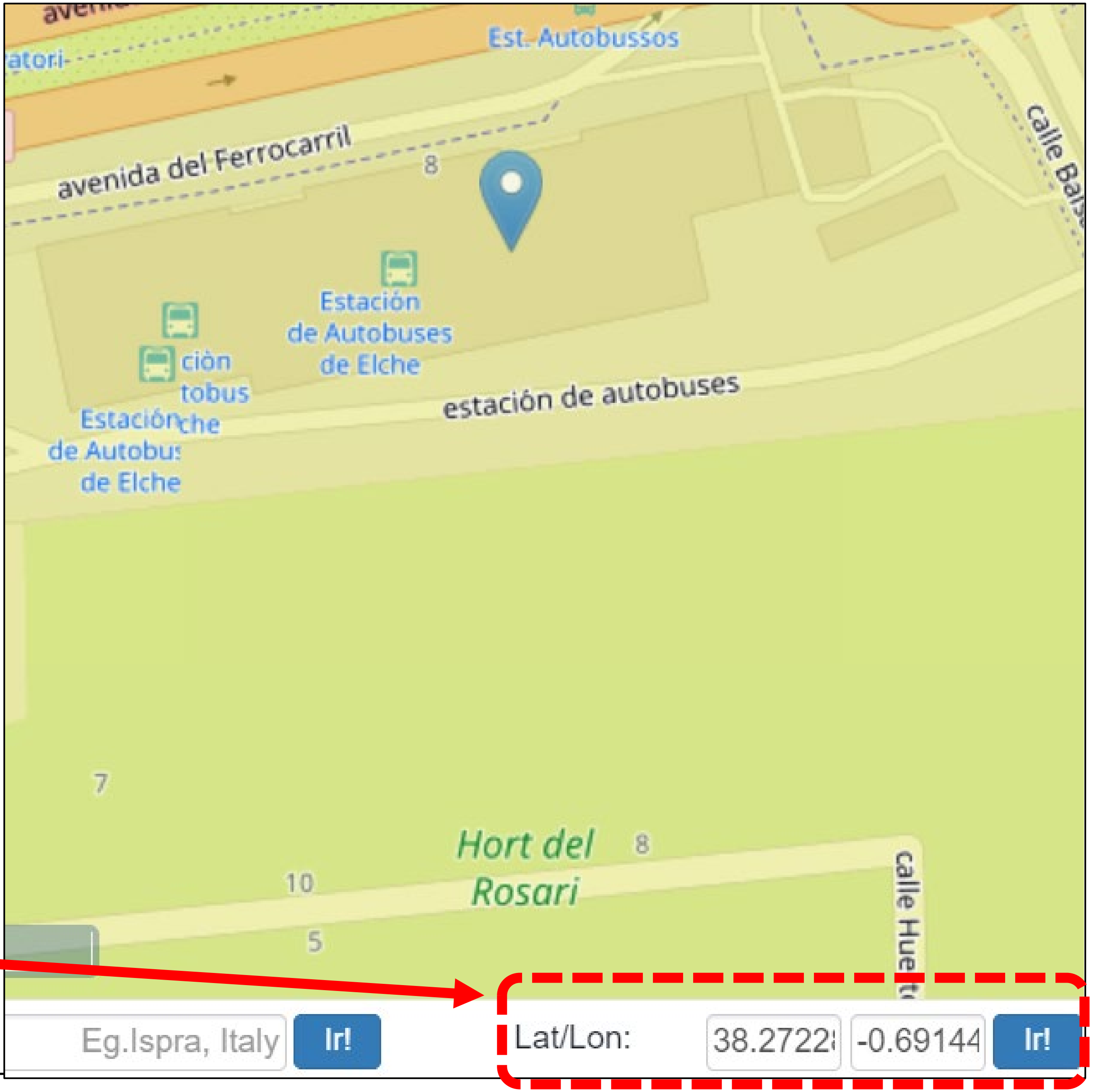
Installation location.

Also, you can enter the latitude and longitude of the place.

For example: Consulting it in GoogleMaps:

38.272282535772504

-0.6914480930091893



Solar radiation database to consult

PERFORMANCE OF GRID-CONNECTED PV

Solar radiation database*

- PVGIS-SARAH2
- PVGIS-SARAH2
- PVGIS-SARAH
- PVGIS-ERA5

Solar radiation databases

PVGIS offers four different solar radiation databases with hourly time resolution. At the moment, there are three satellite-based databases:

- **PVGIS-SARAH2** (0.05º x 0.05º) Database produced by CM SAF to replace SARAH-1 (PVGIS-SARAH). It covers Europe, Africa, most of Asia, and parts of South America. Temporal range: 2005-2020.
- **PVGIS-SARAH*** (0.05º x 0.05º) Database produced using the CM SAF algorithm. Similar coverage to SARAH-2. Temporal range: 2005-2016.
- **PVGIS-NSRDB** (0.04º x 0.04º) Result of a collaboration with NREL (USA) under which the NSRDB solar radiation database was made available for PVGIS. Temporal range: 2005-2015.

In addition to these, there is also a reanalysis database available worldwide.

- **PVGIS-ERA5** (0.25º x 0.25º) Latest global reanalysis of the ECMWF (ECMWF). Temporal range: 2005-2020.

Reanalyses solar radiation data generally have larger uncertainty than satellite-based databases. Therefore, we recommend using reanalysis data only where satellite-based data are missing or outdated. For more information about the databases and the accuracy, see the PVGIS web page on the calculation methods.

* PVGIS-SARAH will be removed by the end of 2022.

The most updated database is "PVGIS-SARAH2". With a range of historical data from 2005 to 2020. So, It is the most up-to-date database

Note that the data range of the PVGIS-SARAH database is only from 2005 to 2016.

PV technology

PERFORMANCE OF GRID-CONNECTED PV

PV technology*

Crystalline silicon

- Crystalline silicon
- CIS
- CdTe
- Unknown

PV technology

The performance of PV modules depends on the temperature and on the solar irradiance, as well as on the spectrum of the sunlight, but the exact dependence varies between different types of PV modules. At the moment we can estimate the losses due to temperature and irradiance effects for the following types of modules:

- crystalline silicon cells
- thin film modules made from CIS or CIGS
- thin film modules made from Cadmium Telluride (CdTe)

For other technologies (especially various amorphous technologies), this correction cannot be calculated here. If you choose one of the first three options here the calculation of performance will take into account the temperature dependence of the performance of the chosen technology. If you choose the other option (other/unknown), the calculation will assume a loss of 8% of power due to temperature effects (a generic value which was found to be reasonable for temperate climates). Note that the calculation of the effect of spectral variations is at the moment only available for crystalline silicon and for CdTe. The spectral effect cannot be considered yet for the areas only covered by the PVGIS-NSRDB database.

The cell technology, that most current photovoltaic modules have, is crystalline silicon technology.

Therefore, in most cases we will choose this option.

Peak Power to Install (kWp)

PERFORMANCE OF GRID-CONNECTED PV

Installed peak PV power [kWp]* 1

Installed peak PV power [kWp] - Peak power

This is the power that the manufacturer declares that the PV array can produce under standard test conditions, which are a constant 1000W of solar irradiance per square meter in the plane of the array, at an array temperature of 25°C. The peak power should be entered in kilowatt-peak (kWp). If you do not know the declared peak power of your modules but instead know the area of the modules (in m^2) and the declared conversion efficiency (in percent), you can calculate the peak power as *power (kWp) = 1 kW/m² * area * efficiency / 100*. See more explanation in the FAQ

It is the power provided by the photovoltaic module under standard testing conditions.

With an irradiance of 1000 W/m² and a cell temperature of 25° C

For example:

If your installation consists of 2 modules of 500 W power (according to the module's technical sheet).

Your installation has a peak power of 1 kW

System losses (%)

System loss [%]* 14

Estimated system losses

The estimated system losses are all the losses in the system, which cause the power actually delivered to the electricity grid to be lower than the power produced by the PV modules. There are several causes for this loss, such as losses in cables, power inverters, dirt (sometimes snow) on the modules and so on. Over the years the modules also tend to lose a bit of their power, so the average yearly output over the lifetime of the system will be a few percent lower than the output in the first years.

We have given a default value of 14% for the overall losses. If you have a good idea that your value will be different (maybe due to a really high-efficiency inverter) you may reduce this value a little.

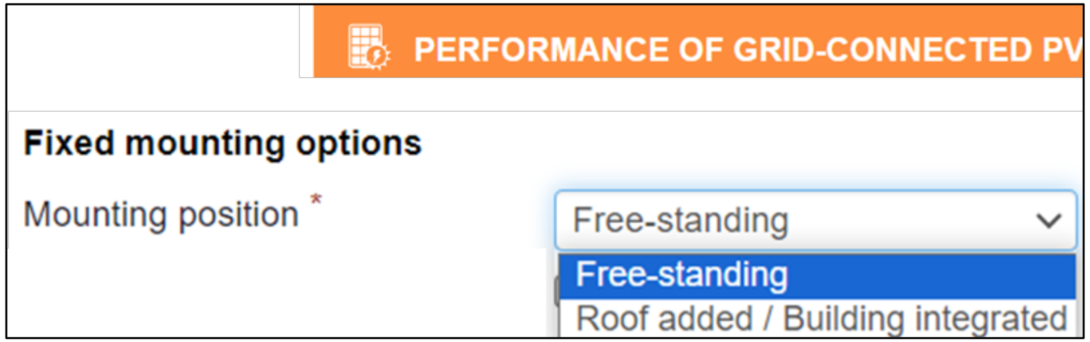
VERY IMPORTANT:

These system losses (14%) do not take into account losses due to:

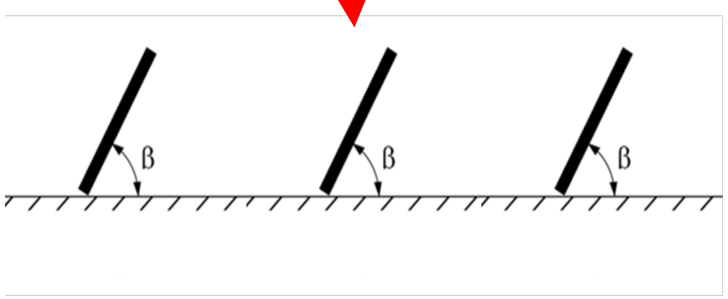
- Angle of incidence
- Spectral effects
- Temperature and low irradiance

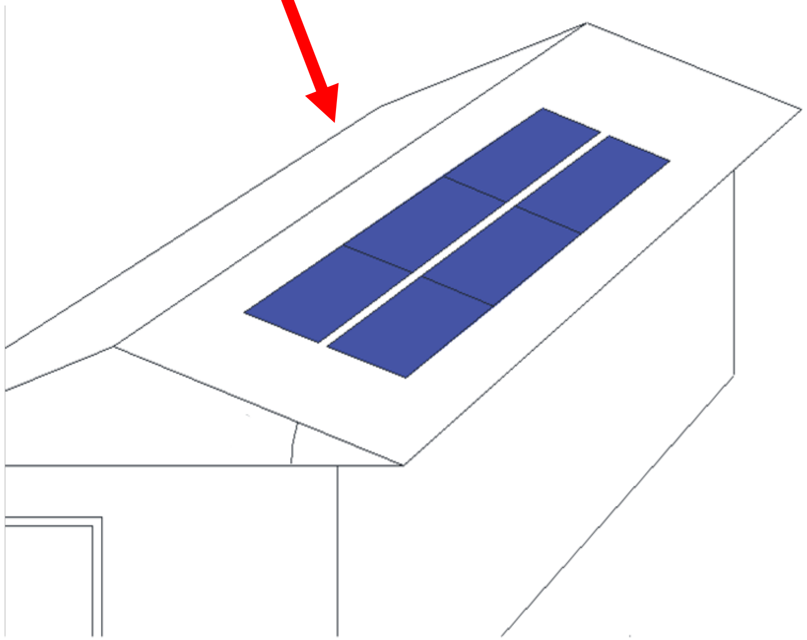
These others will be added by PVGIS after completing the query and viewing the results.

Installation Type



Free layout or Integrated in building?





PVGIS asks us for this information, because if we were to install the modules "on the Roof", PVGIS would add more losses due to temperature.

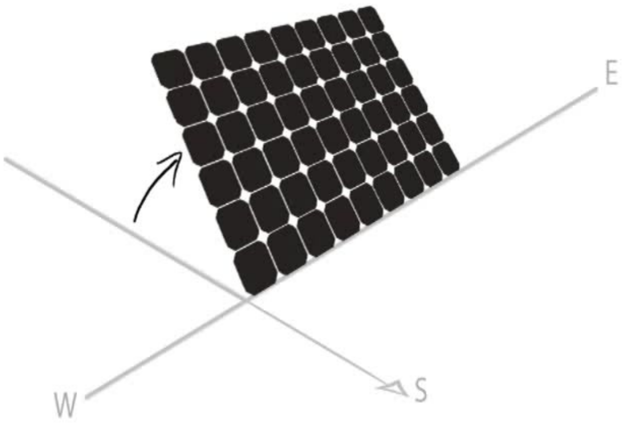
This is because the modules are less ventilated when they are installed in “Roof or building integrated”

Inclination angle

PERFORMANCE OF GRID-CONNECTED PV

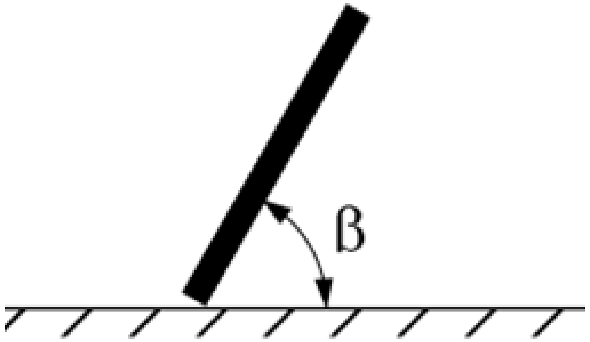
Slope [°]* 35

- [ ] Optimize slope
- [ ] Optimize slope and azimuth



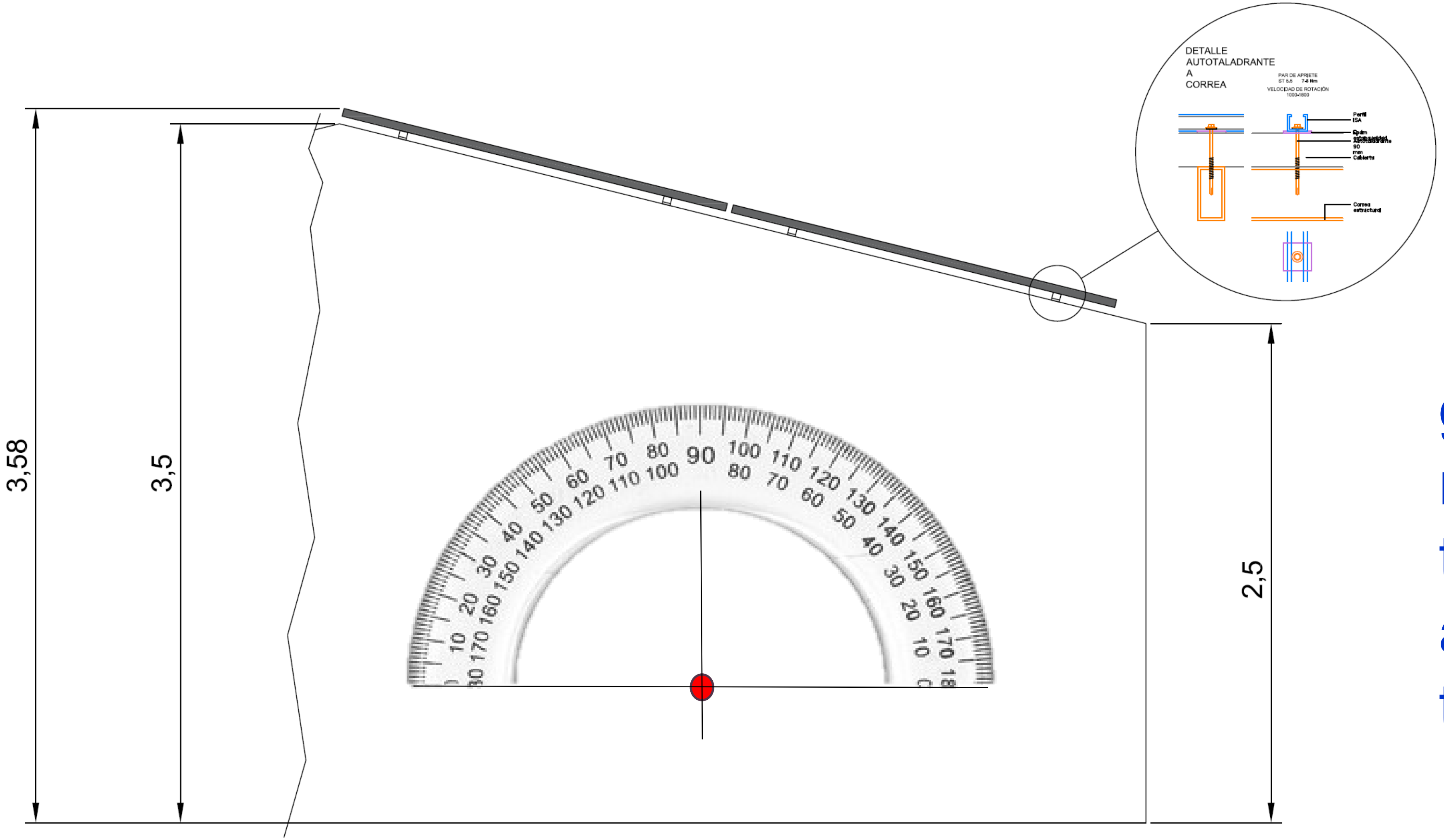
This is the angle of the PV modules from the horizontal plane, for a fixed (non-tracking) mounting.

For some applications the slope and orientation angles will already be known, for instance if the PV modules are to be built into an existing roof. However, if you have the possibility to choose the slope and/or azimuth (orientation), this application can also calculate for you the optimal values for slope and orientation (assuming fixed angles for the entire year).



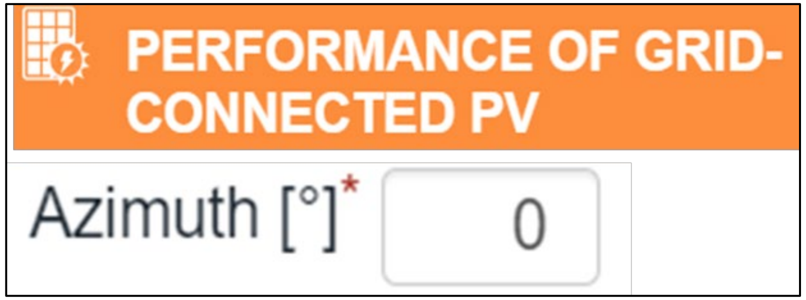
Depending on the angle of inclination, our installation will capture more or less solar irradiation in each of the different months of the year.

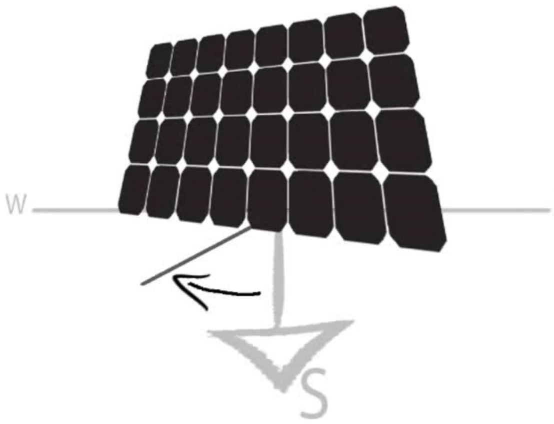
Inclination angle

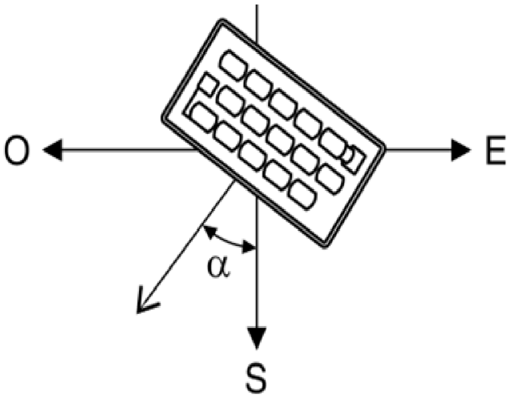


If our installation is going to be mounted on a roof, the inclination angle will be that of the roof.

Orientation angle







The azimuth, or orientation, is the angle of the PV modules relative to the direction due South. -90° is East, 0° is South and 90° is West.

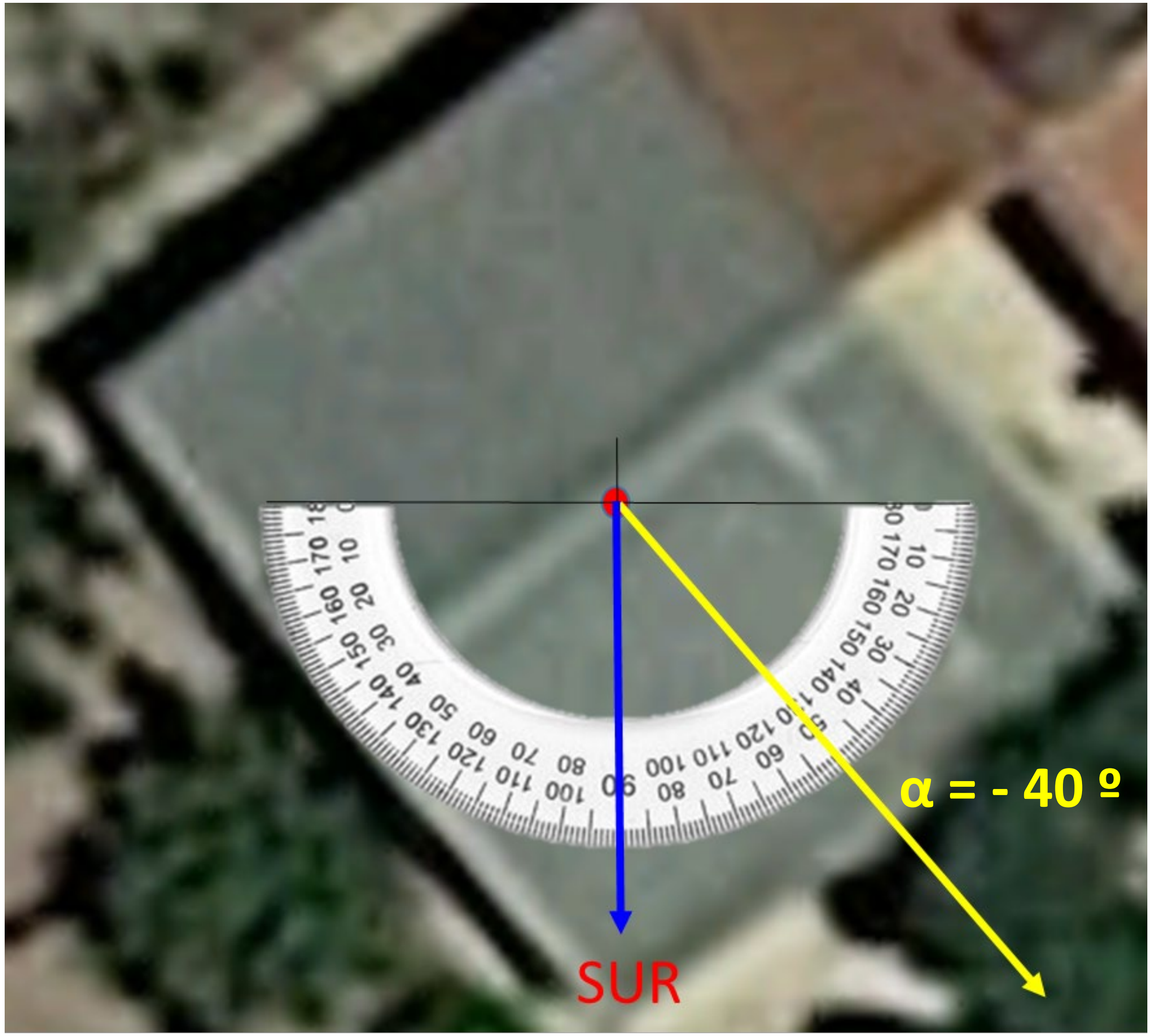
For some applications the slope and azimuth angles will already be known, for instance if the PV modules are to be built into an existing roof. However, if you have the possibility to choose the inclination and/or orientation, this application can also calculate for you the optimal values for inclination and orientation (assuming fixed angles for the entire year).

Example:

For our geographical area, a fairly good azimuth angle would be an angle of approximately 0º.

That is, with the modules facing the SOUTH, to maximize annual solar gain

Orientation angle



Example:

Aerial view of a roof, and an approximate orientation angle of 40º with respect to the SOUTH.

Relief shadows

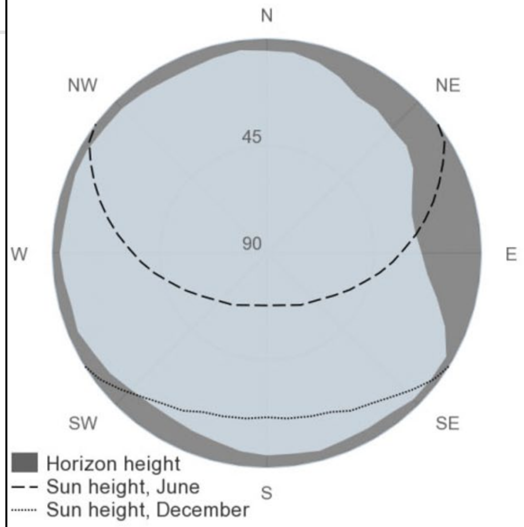
Use terrain shadows:

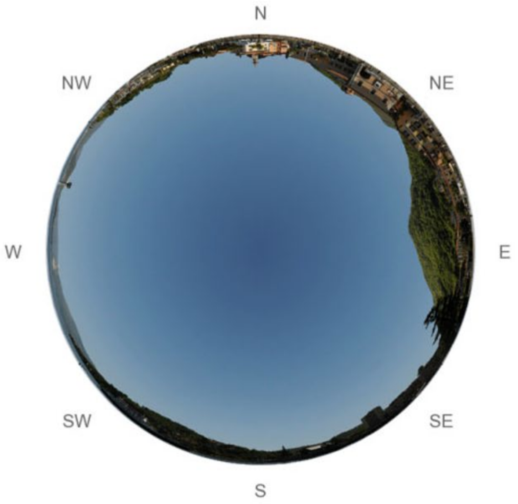
☑ Calculated horizon

Calculated horizon

The solar radiation and PV output will change if there are local hills or mountains that block the light of the sun during some periods of the day. PVGIS can calculate the effect of this using data about ground elevation with a resolution of 3 arc-seconds (around 90m). This calculation does not take into account shadows from very nearby objects such as houses or trees. In this case you can upload your own horizon information.

It is normally a good idea to use the horizon shadowing option.





EXAMPLE

-Installation in the city of Elche (general location by default)

-Roof installation.

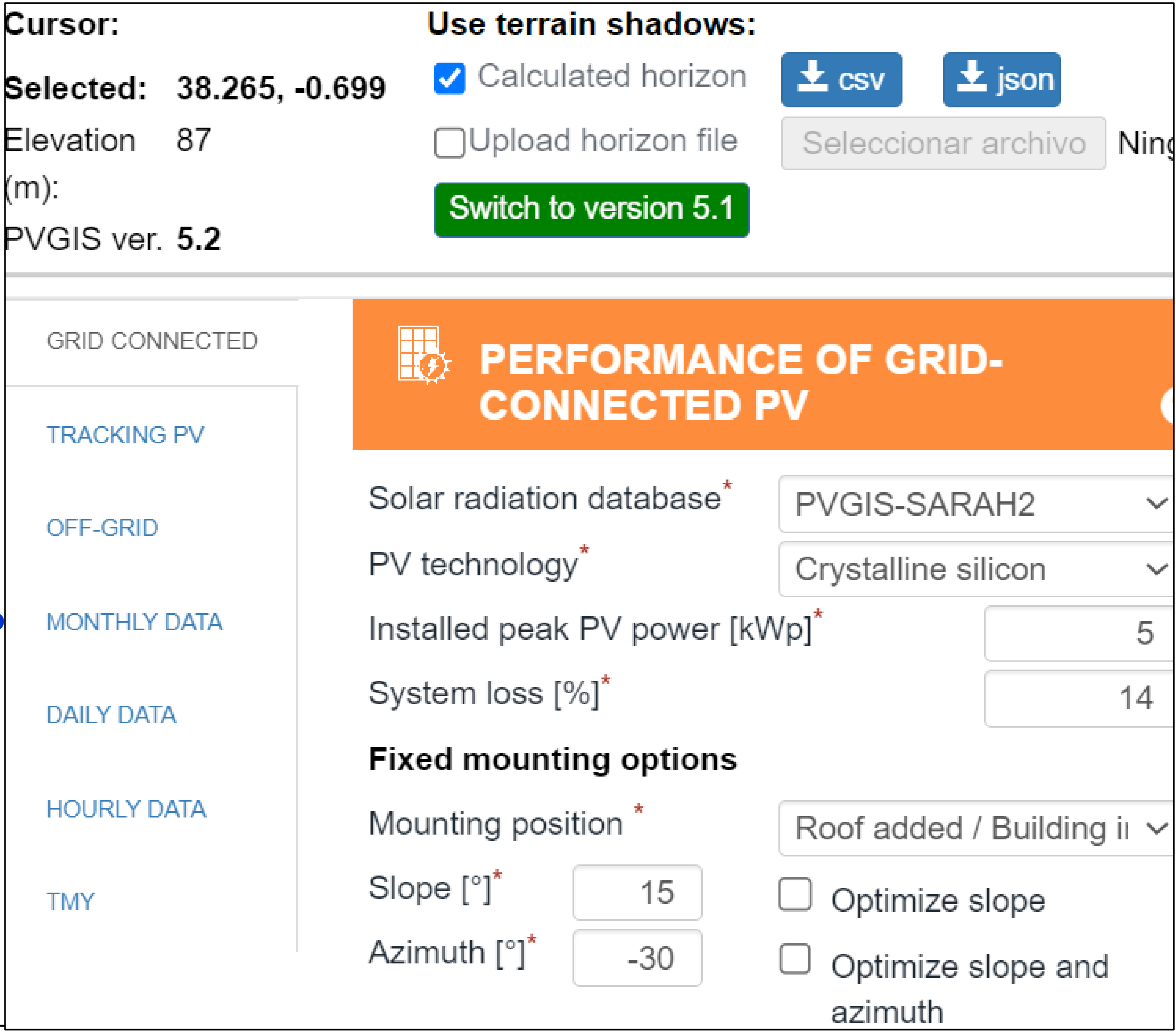
-System losses considered: 14% (by default)

-Orientation (azimuth) angle: -30º (southeast)

-Inclination (slope) angle: 15º

-Power: 5 kWp

-Consider terrain shadows?: Yes



RESULTS

In this example, there is greater production in the summer months not only due to the greater number of HSPs, but also due to the small inclination angle of the modules (15º in this case).

PERFORMANCE OF GRID-CONNECTED PV: RESULTS

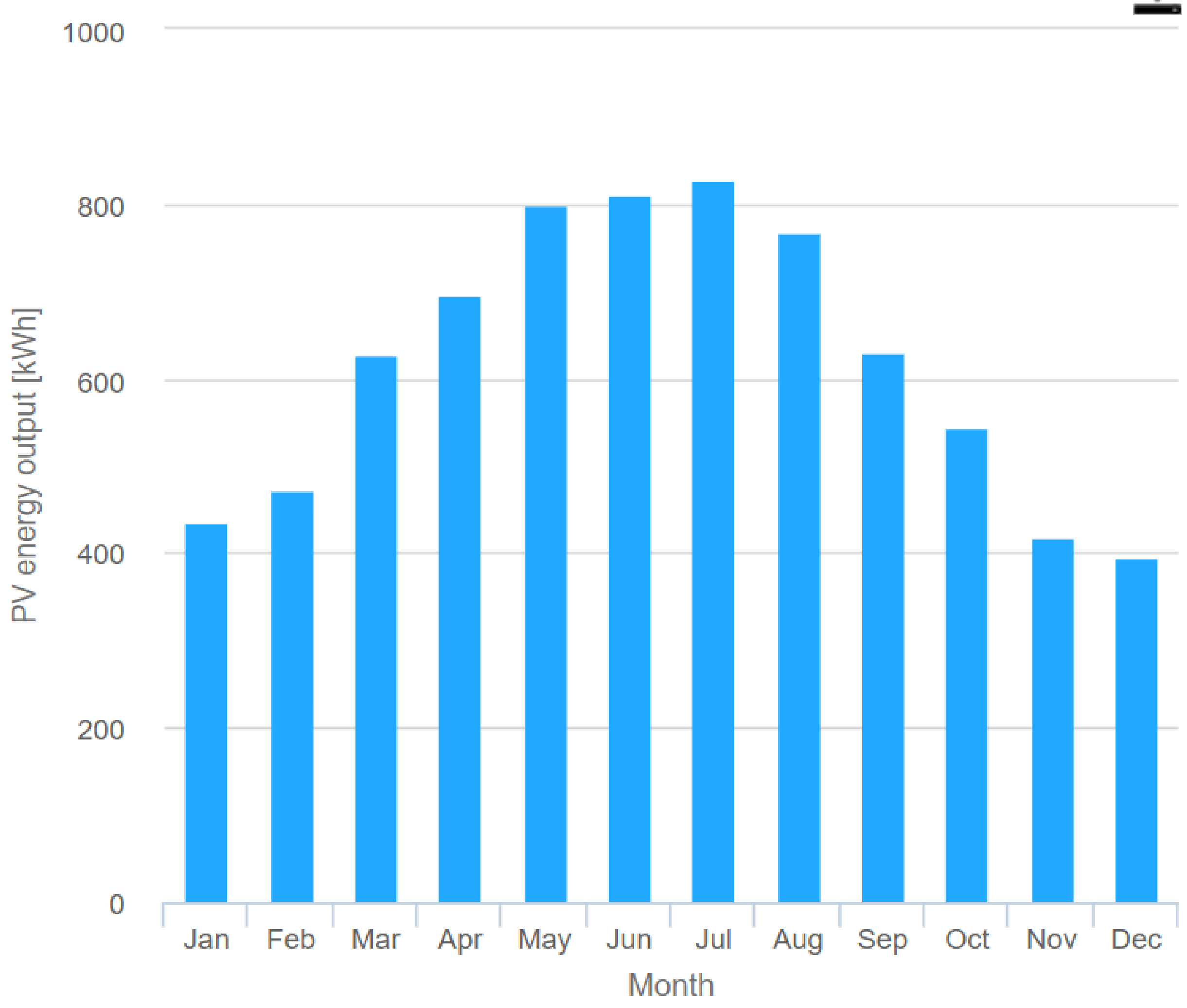
PV output

Summary

Provided inputs:	
Location [Lat/Lon]:	38.265,-0.699
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed [kWp]:	5
System loss [%]:	14

Simulation outputs:	
Slope angle [°]:	15
Azimuth angle [°]:	-30
Yearly PV energy production [kWh]:	7425.82
Yearly in-plane irradiation [kWh/m^2]:	2031.96
Year-to-year variability [kWh]:	167.81
Changes in output due to:	
Angle of incidence [%]:	-2.86
Spectral effects [%]:	0.46
Temperature and low irradiance [%]:	-12.9
Total loss [%]:	-26.91

Monthly energy output from fix-angle PV system



THANK YOU FOR YOUR ATTENTION

Sergio Valero Verdú | svalero@umh.es