UNIVERSIDAD DE VALLADOLID

International Semester in Industrial Engineering

Academic Year 2022/2023

The Environment and Renewable Energy

SELF CONSUMPTION PVSyst PROJECT REPORT

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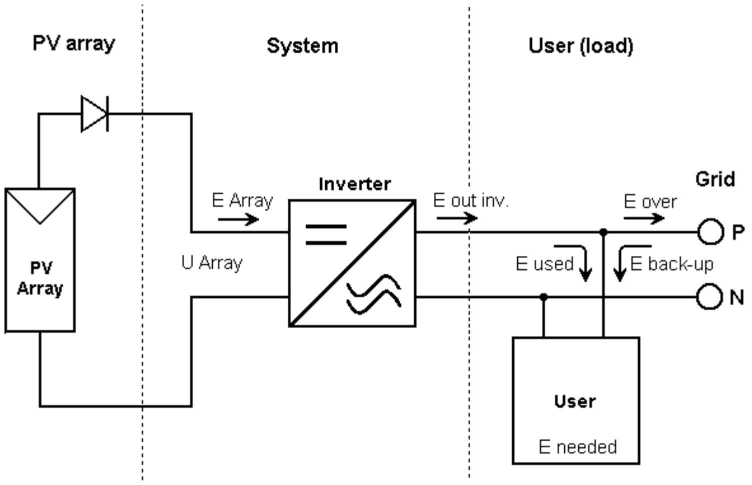
ABSTRACT

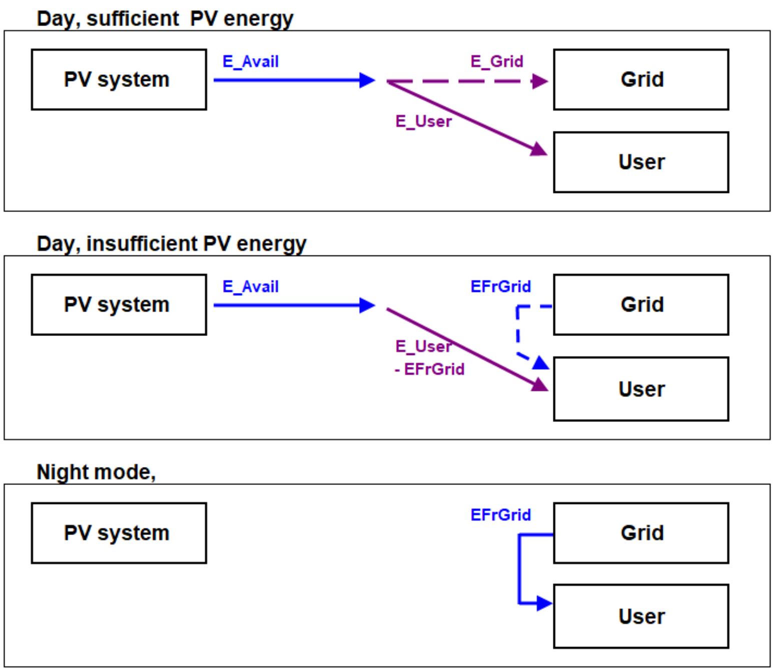
The main objective of this exercise is to design two grid connected photovoltaic systems using the PVSyst software. The first located in IndUva Building, Valladolid and the second located in our own country Bari, Italy.

The two projects will have a planned power of 55kWp and the orientation of the PV modules will be the best for the different location. To compare the performances of the two installation PV panel model and inverter model was already given. In addition will be taken in account losses to obtain more realistic results.

Instead of the last assignment about grid connected system, where the energy needed from the user was zero now it has a weight into the calculation, as shown as follows:



The previous image will be the configuration used in these two projects. In this case user's needs could be satisfied by the grid, PV panel or both of them. Following an example taken from PVSyst documentation:



The user's needs are managed as daily profile, with a seasonal modulation. All of us will be treated as AC loads. The following table shows the daily profile in spring in hourly values. In summer the daily profile is 80% of the spring profile, 120% in autumn and 150% in winter.

HOURLY VALUES							
Hour	Power (kW)		Hour	Power (kW)		Hour	Power (kW)
0:00	3.68		8:00	4.56		16:00	18.64
1:00	4.66		9:00	6.26		17:00	18.42
2:00	2.68		10:00	3.54		18:00	6.24
3:00	2.16		11:00	2.36		19:00	3.70
4:00	3.08		12:00	1.96		20:00	2.78
5:00	2.86		13:00	3.62		21:00	3.26
6:00	3.16		14:00	11.06		22:00	11.88
7:00	2.72		15:00	1.00		23:00	7.00

This report is divided, as follows, in five parts:

1. **Inputs of first report**
2. **Procedure of first report**
3. **Inputs of second report**
4. **Procedure of second report**
5. **Outputs**

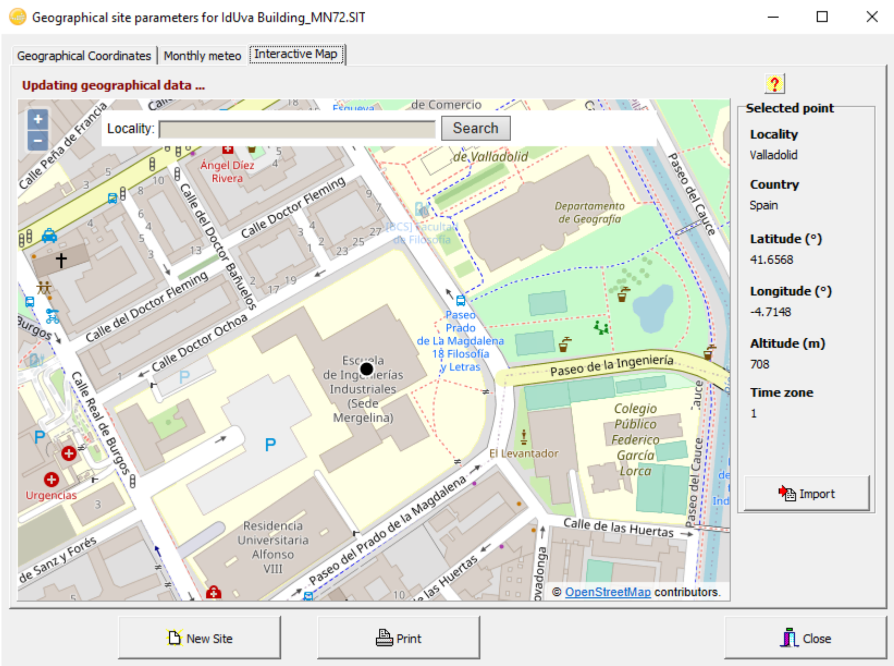
Every part shown will explored in the following report.

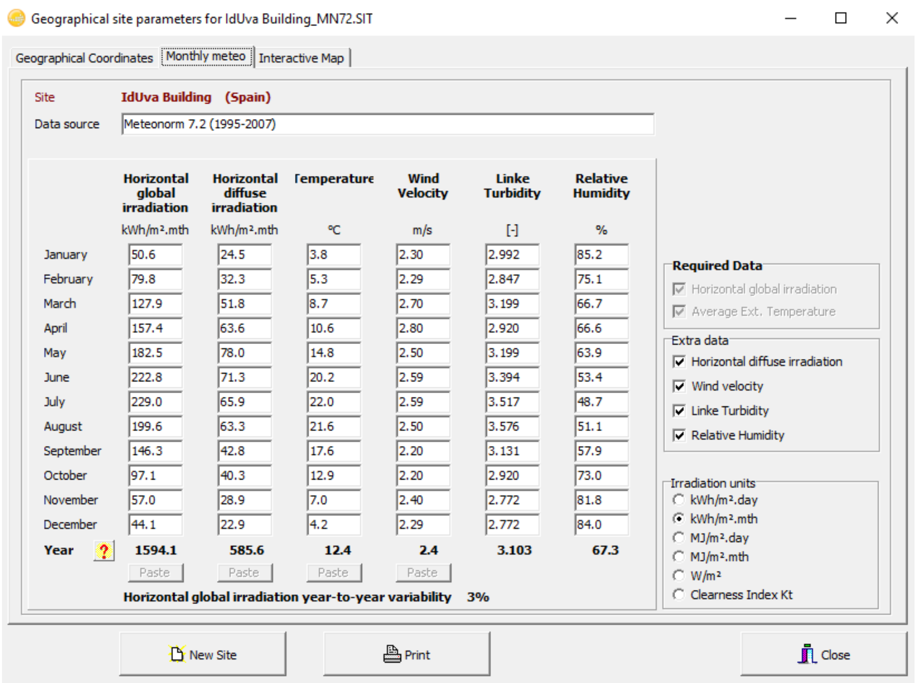
INPUTS OF THE FIRST REPORT

1. Location: the location was set in IndUva Building, the university of Valladolid, and the meteorological values are already provided by the map of PVSyst.
2. PV system components: as an overview the system will include PV modules and inverter taken from database.
3. User’s needs: a planned power of 55kWp and daily profile of consumption with a seasonal modulation.

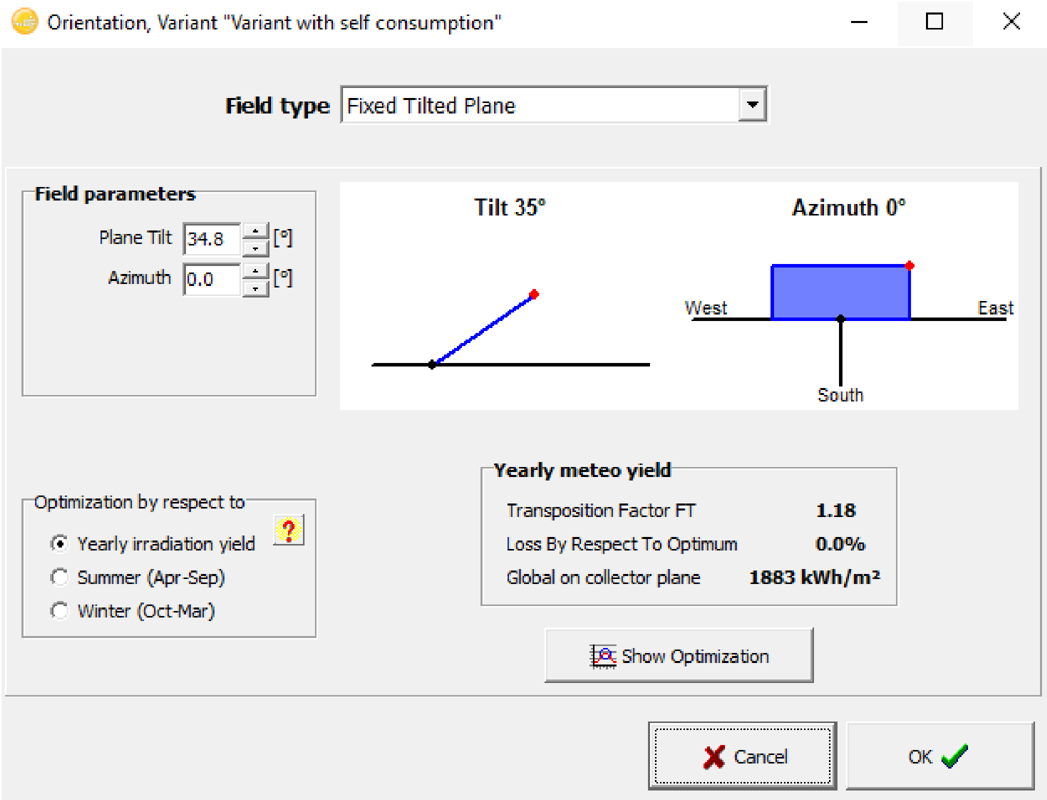
PROCEDURE OF THE FIRST REPORT

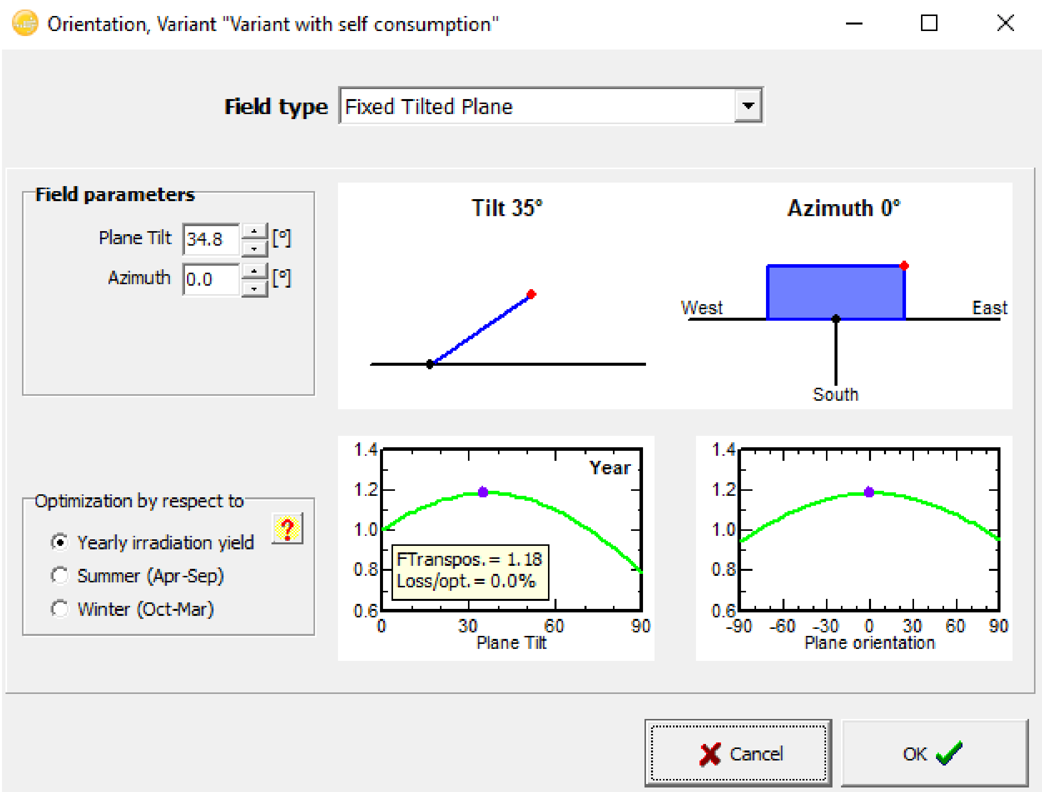
1. *Set the project’s destination (Name, Geographical location and weather file)*: in this case the building location was not already present into the database. So, it was added during the simulation as new site;



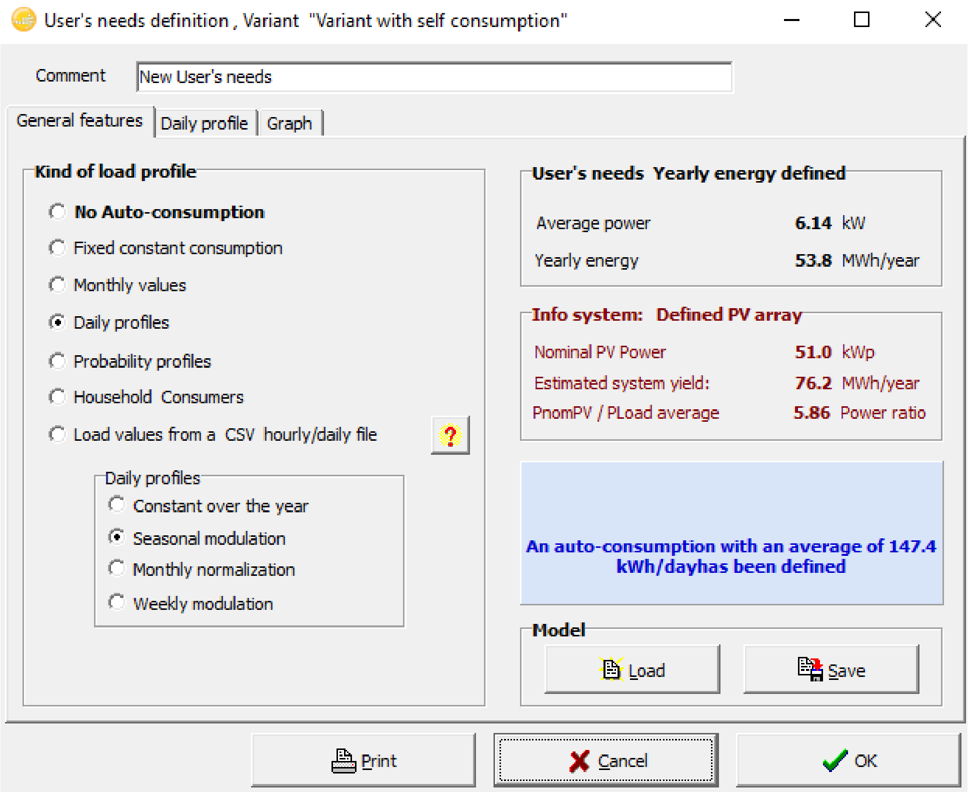


2. *Set the orientation of the PV module*: as specified before the tilt and azimuth angle will be taken as the optimal, as optimization method was chosen the one that take an average between winter and summer needs (called: *yearly irradiation yield*) this because a grid connected system aims to produce all the possible energy and feed the electrical grid and not perfectly satisfy a building demand;

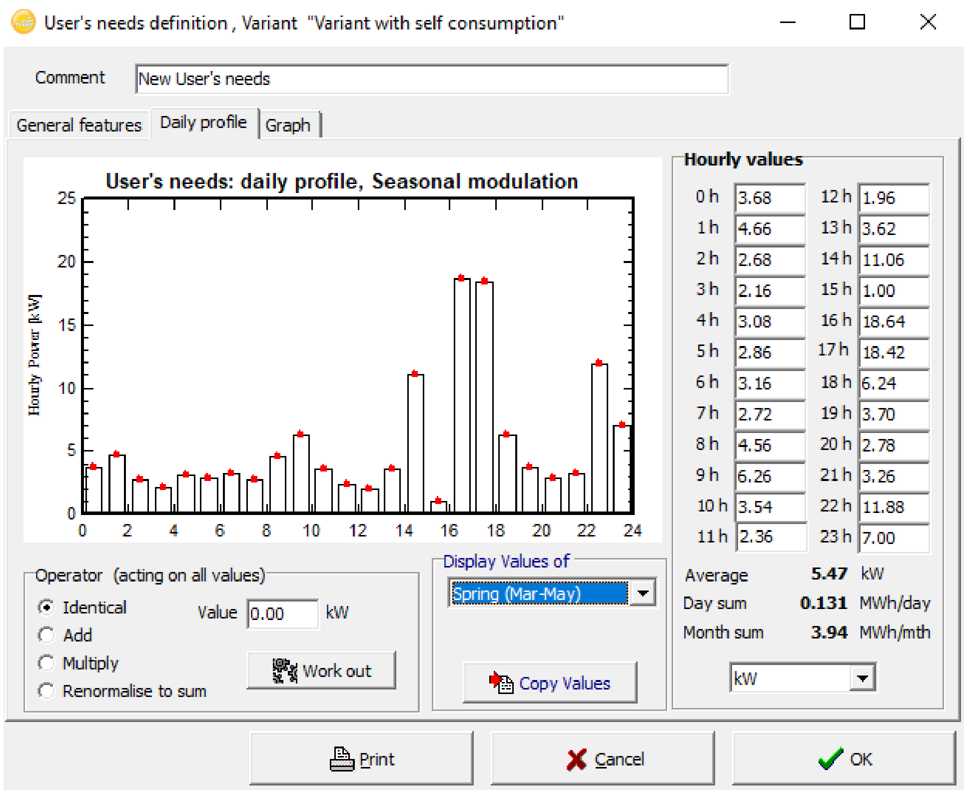




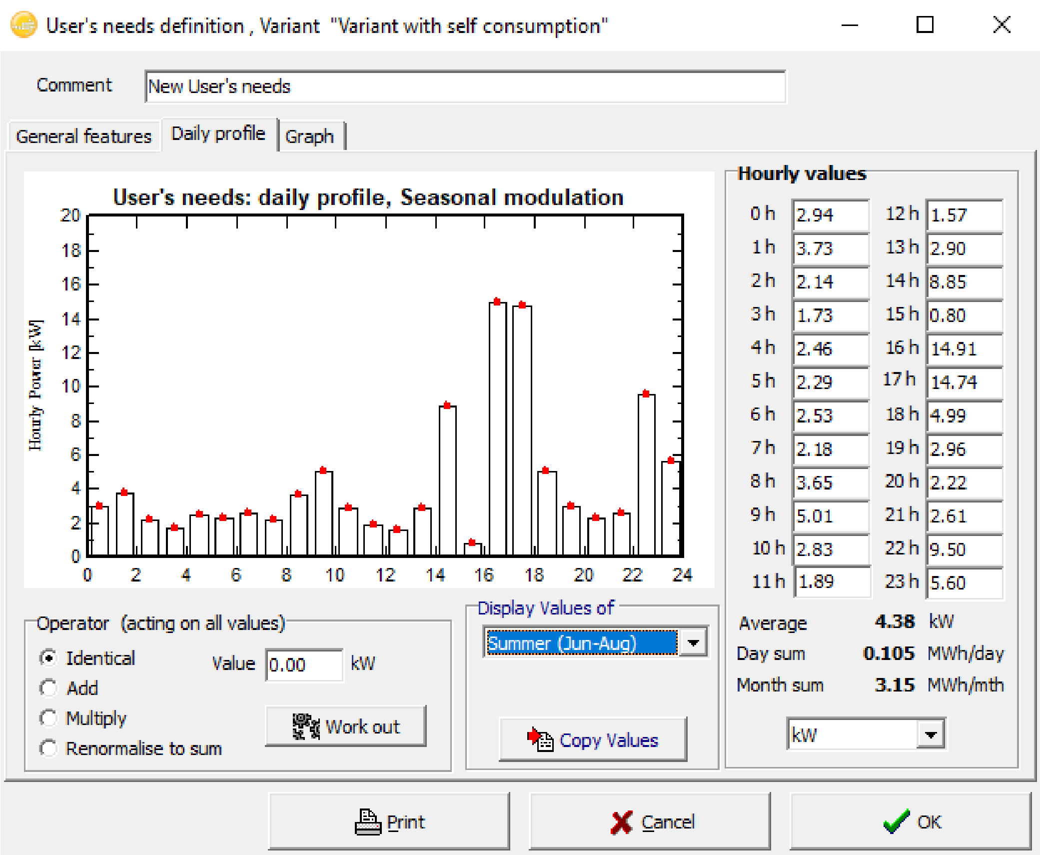
3. *Set the user's need*: the user's needs are managed as daily profile, with a seasonal modulation. All of us will be treated as AC loads.



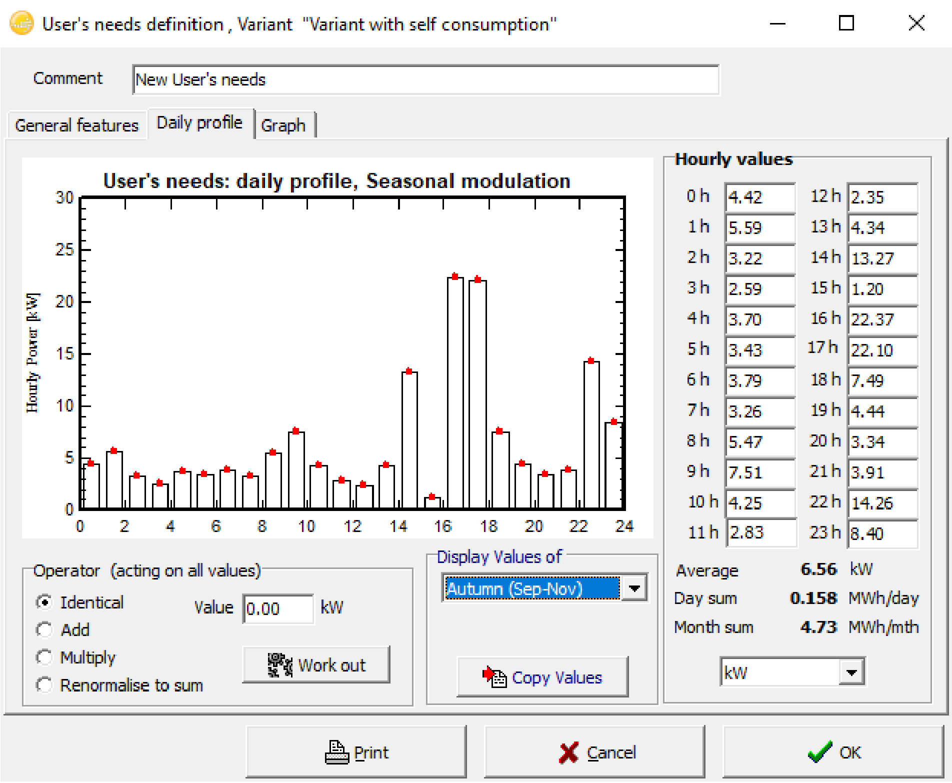
So, starting with the consumption of spring, there will be defined the others copying and multiplying them by a certain factor:



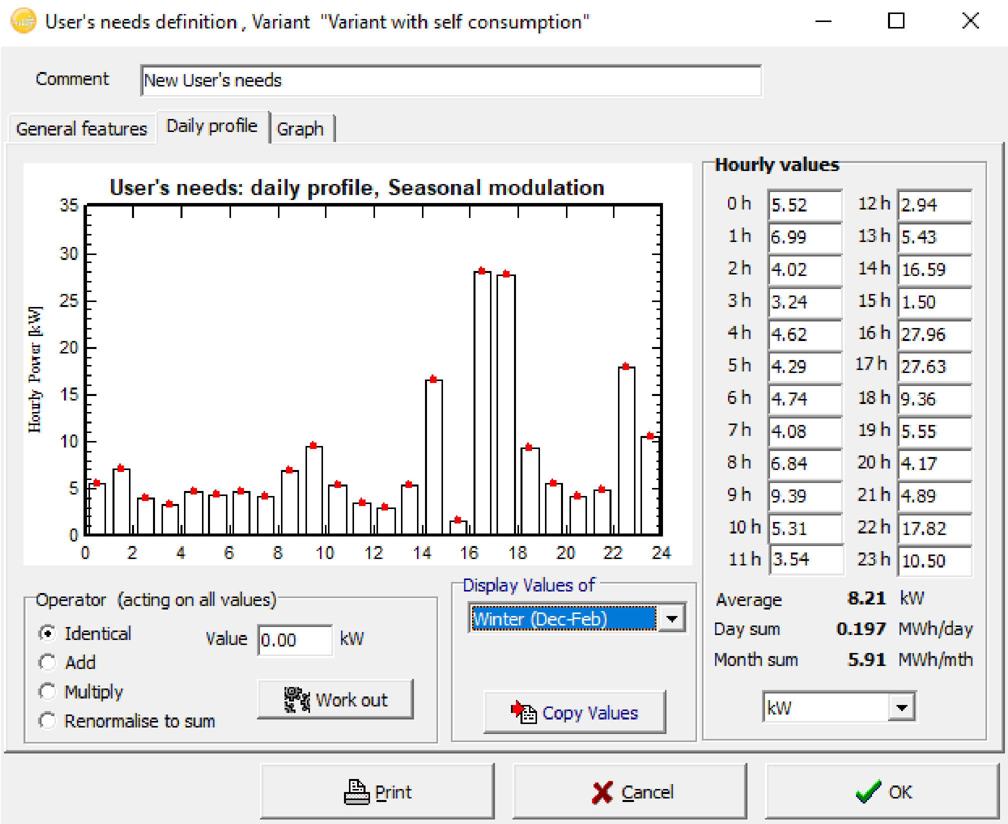
Summer needs are defined as 0.8 times spring needs.



Autumn needs will be 1.2 times of spring needs.

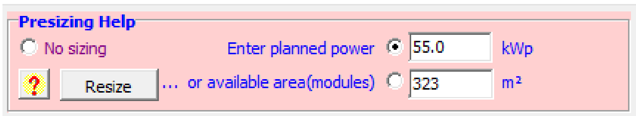


Winter needs will be 1.5 times of spring needs.



As can be noticed the graphs along every seasons have the same shape but different scale of values.

Also in this case a the PV system has a planned power of 55kWp.

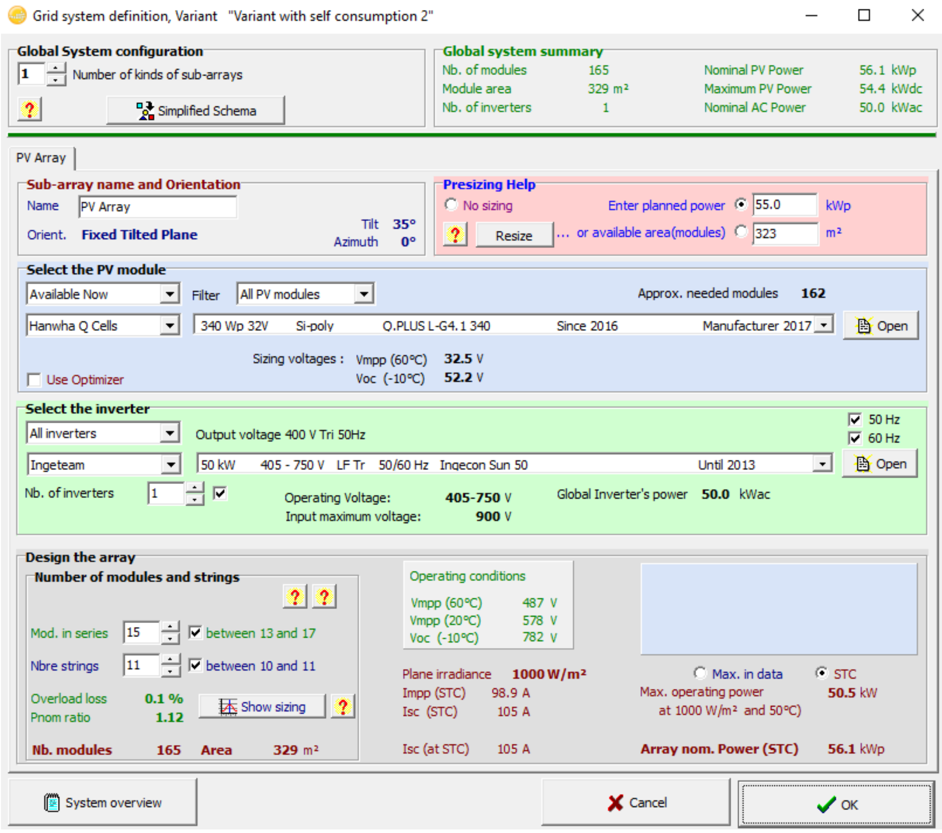


Set the system in terms of: array and pre-sizing of inverter, define system components and define losses;

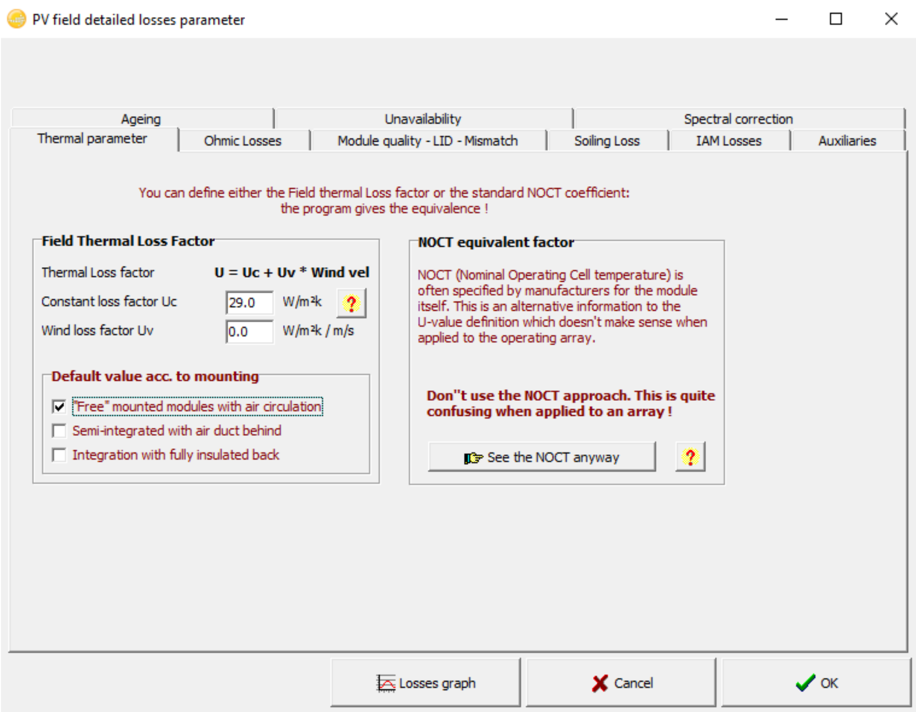
4. *Array and inverter pre-sizing*: typically, there is an oversizing of the PV panels' total power respect to inverter power about 10-20% because inverter allows overload. In the first time the inverter was selected as an intersection of its operative voltage with the voltage of an array of PV panels in serial connection (Vmppp 20 Celsius degree).
After this, the minimum voltage of a single array dependent on the higher temperature of the location (Vmpp 60 Celsius degree) and it has to be higher respect the minimum voltage of the inverter
The maximum voltage of a single array dependent on the minimum temperature of the location (Voc -10 Celsius degree) and it has to be lower than input maximum voltage of the inverter;
5. *Define system component*:

Chosen inverter	It was given, this to have a low number of degrees of freedom in the problem
Chosen PV	It was given, this to have a low number of degrees of freedom in the problem

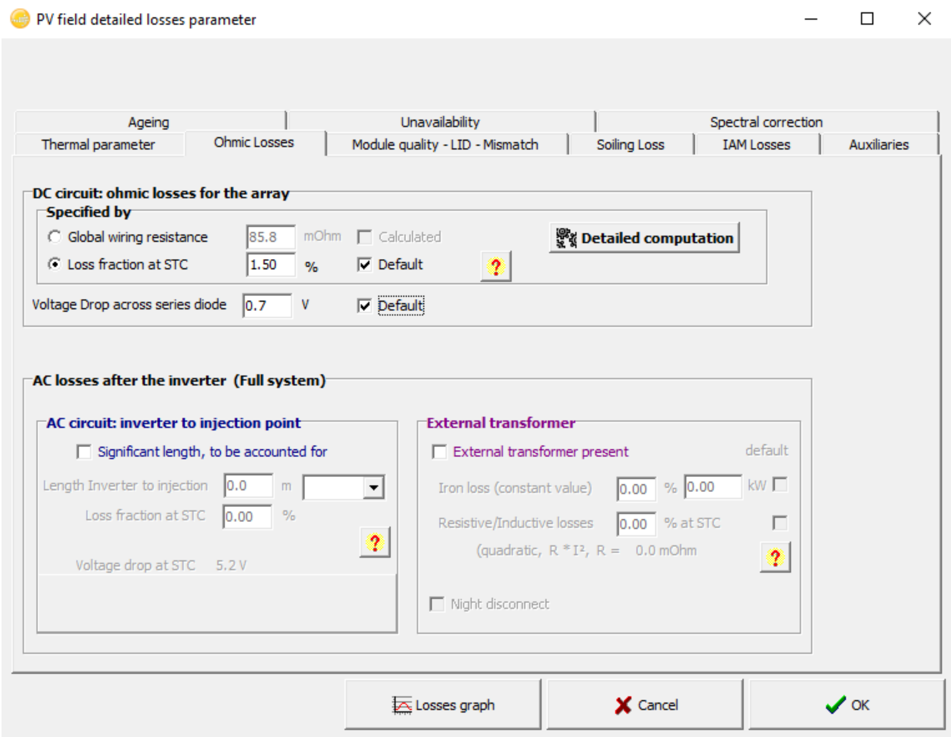
So, as follows:



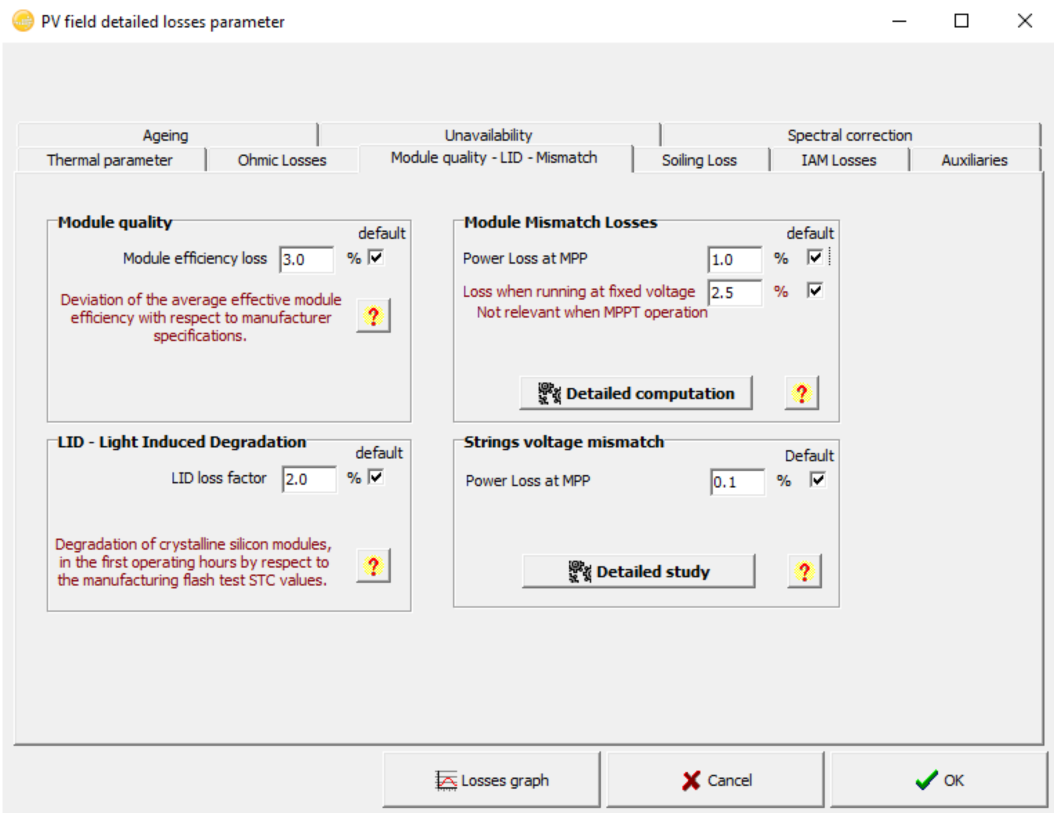
6. *Define losses*: will be taken in account losses to obtain more realistic results, such as the following. They will be explained losses that were added on standard losses during simulation classroom:



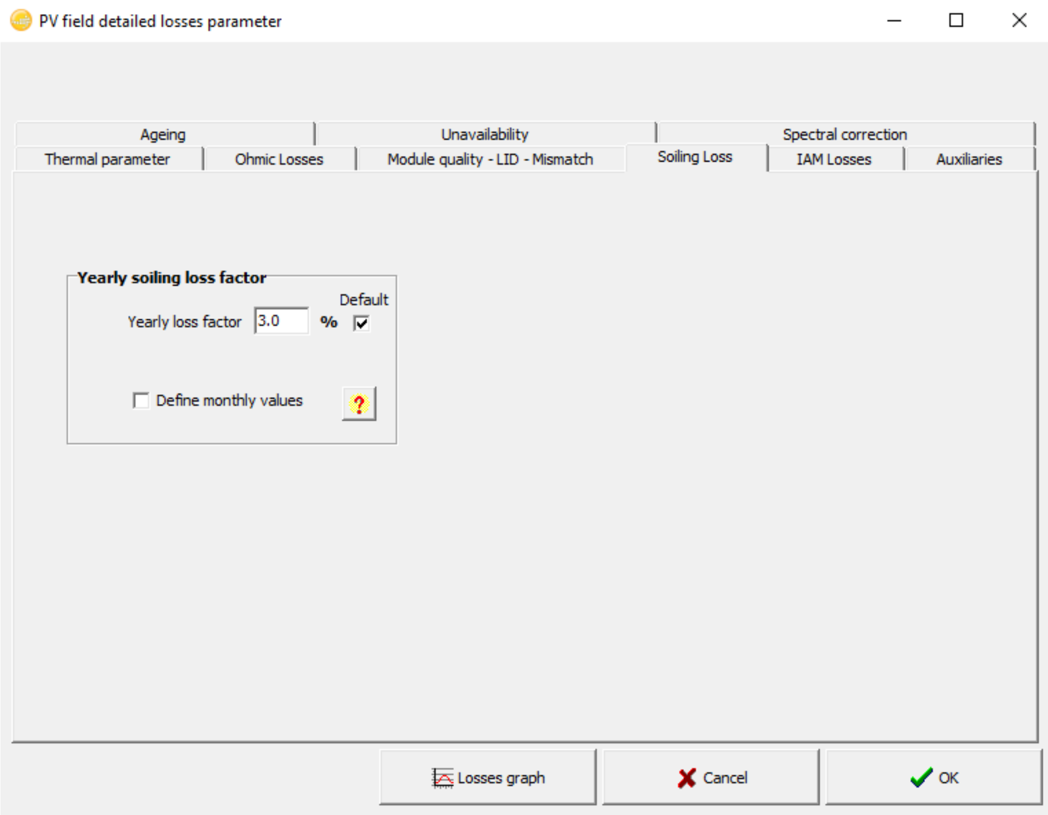
Thermal parameter: to take in account the type of the installation. A “free mounted” installation means that there is enough space under the PV panel to allow air flow and the best dissipation of heat than others mounting system.



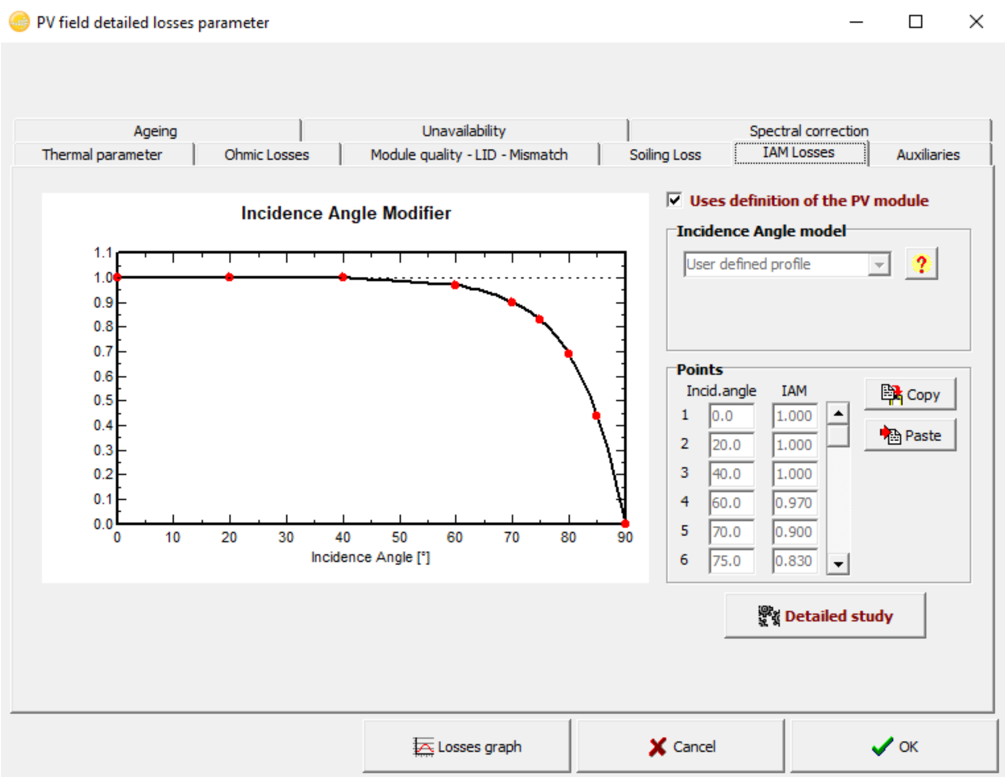
Voltage drops across series diode: Each diode causes a voltage drop of almost 0.7 Volt. Diodes are typically used to transport electricity from one string to another.



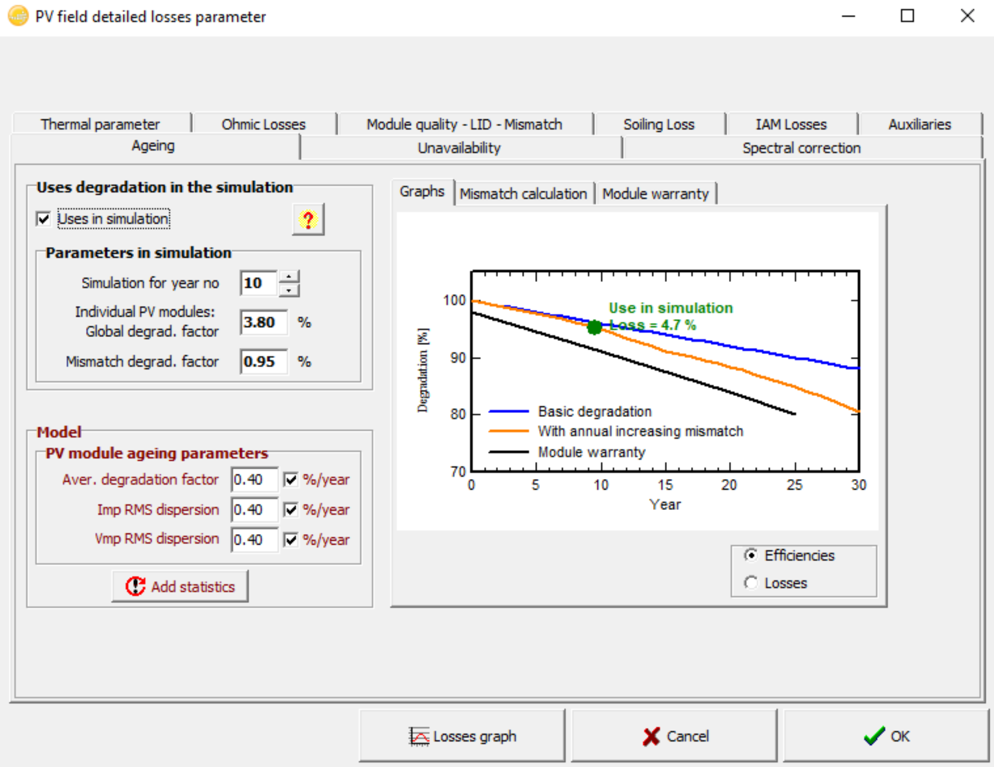
Light Induced Degradation: as is already shown from the software, take in account the degradation of crystalline silicon modules in the first operating hours by respect to manufacturing test in standard test condition.



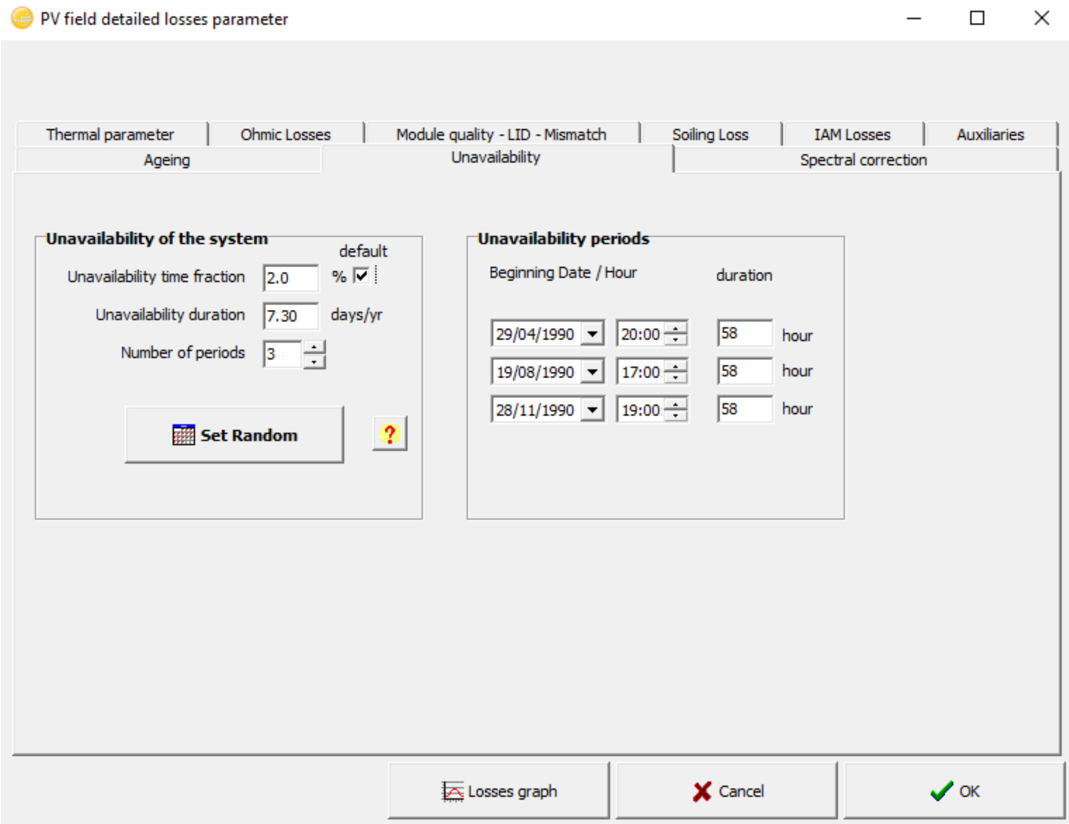
Yearly soiling loss factor: to take in account accumulation of dirt and its effect on the system performance of the PV panel.



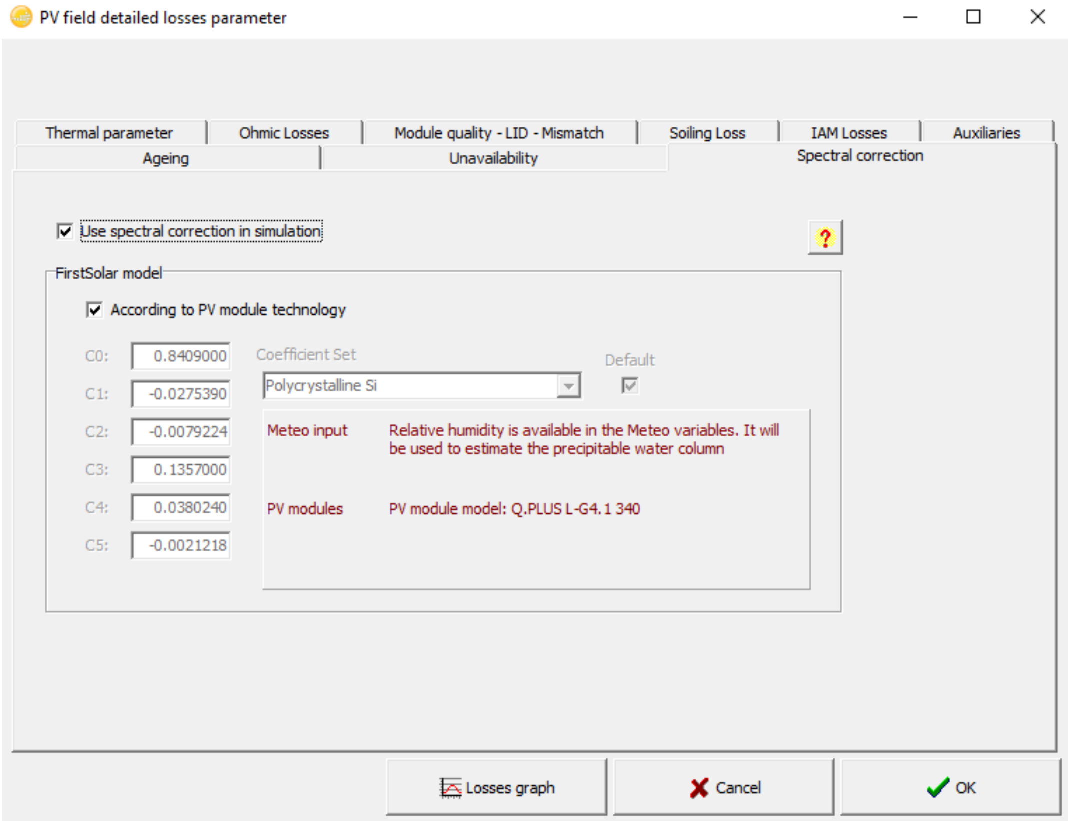
Incidence Angle Modifier: to take in account the incidence effect corresponds to the decrease of the irradiance really reaching the PV cells' surface, with respect to irradiance under normal incidence. This decrease is mainly due to reflections on the glass cover, which increases with the incidence angle.



Ageing: to take in account the lost of the performance of the PV panel as time goes by. The simulation will be performed after 10 years of usage of the panel.



Unavailability of the system: to take in account the time while panels will be turned off for maintenance operations.



Spectral correction: to take in account changes in the solar spectrum due to scattering and absorption in the atmosphere that changes its characteristics.

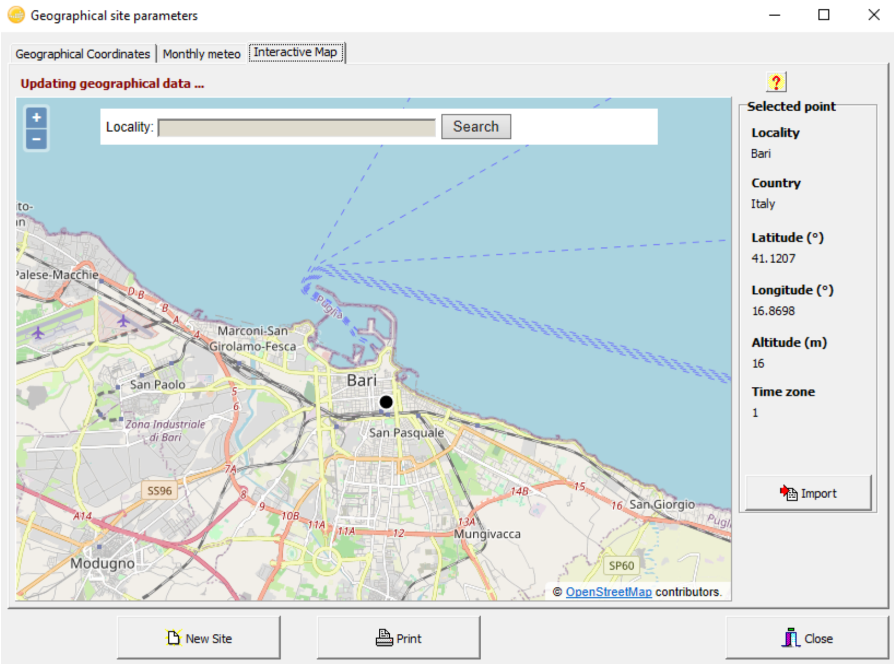
Shadow losses are not taking into the account.

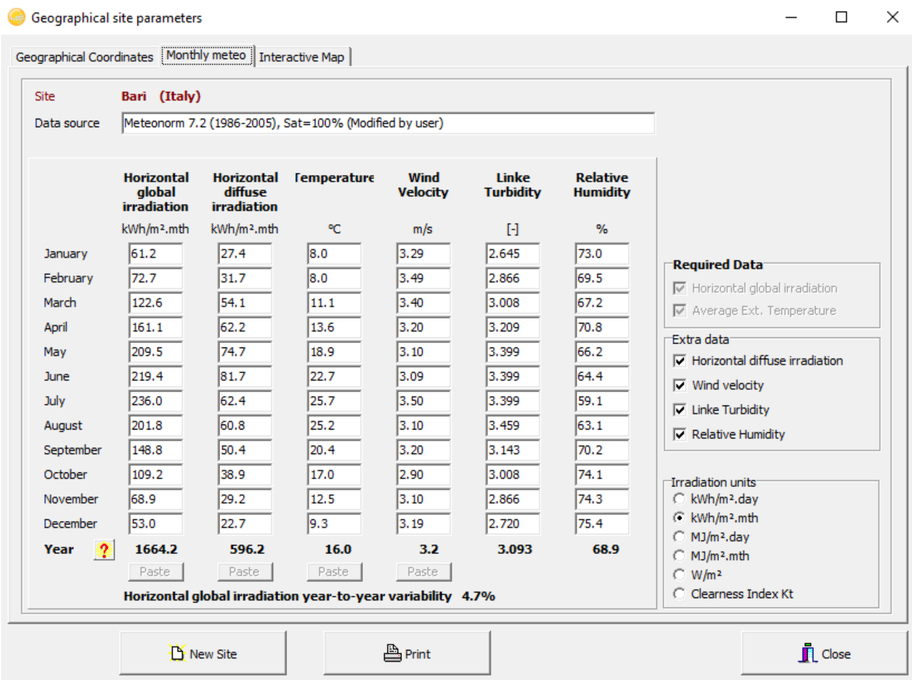
INPUTS OF THE SECOND REPORT

1. Location: the location was set in Bary, the bigger country in the South of the Italy, and the meteorological values are already provided by the map of PVSyst.
2. PV system components: as an overview the system will include PV modules and inverter taken from database.
3. User's needs: a planned power of 55kWp and daily profile of consumption with a seasonal modulation.

PROCEDURE OF THE SECOND REPORT

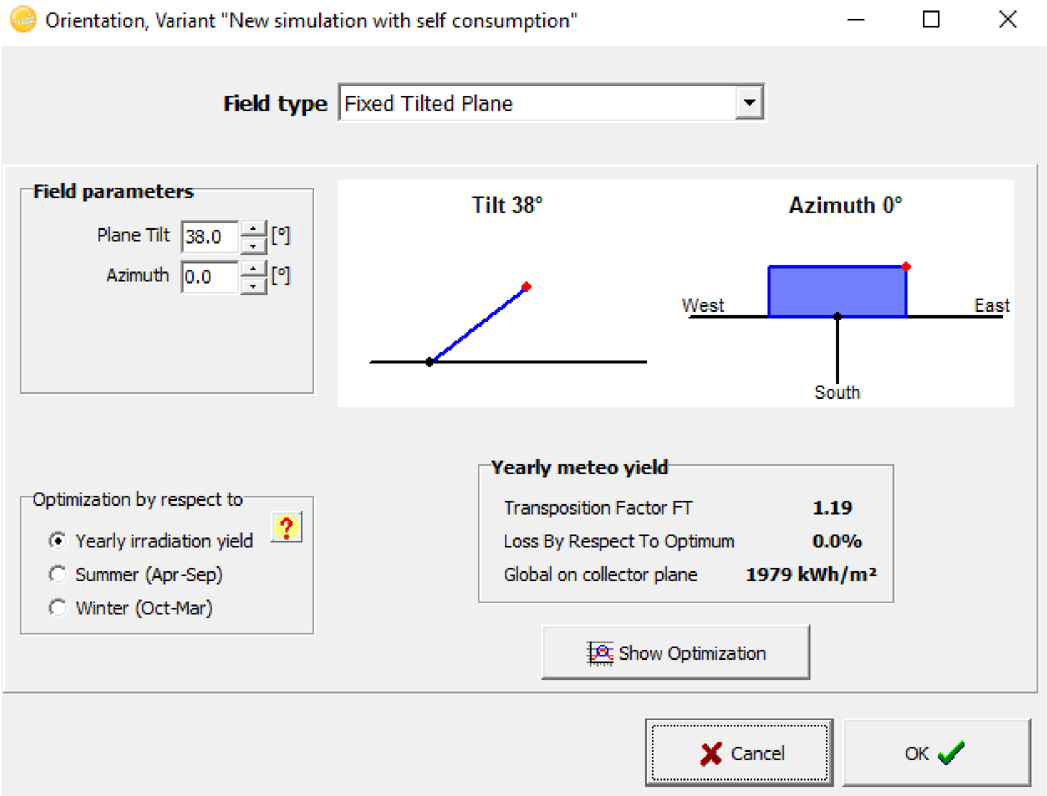
1. *Set the project's destination (Name, Geographical location and weather file)*: in this case country was not already present into the database. So, it was added during the simulation as new site;

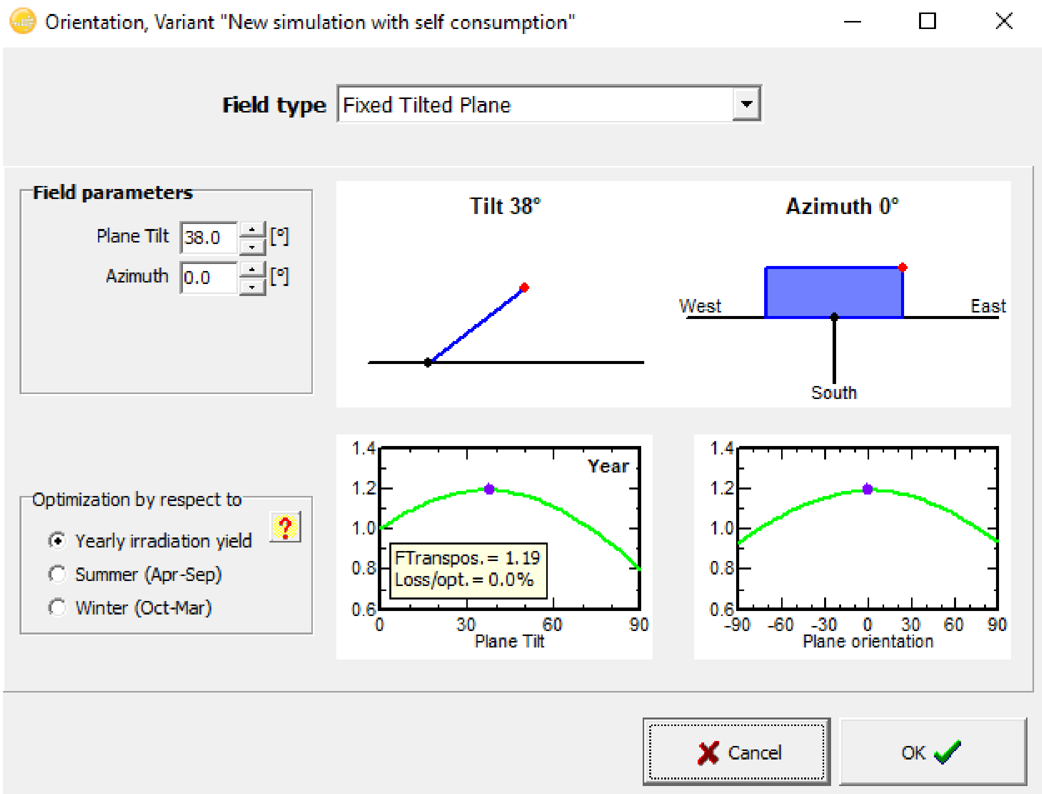




	Horizontal global irradiation kWh/m².mth	Horizontal diffuse irradiation kWh/m².mth	Temperature °C	Wind Velocity m/s	Linke Turbidity [-]	Relative Humidity %
January	61.2	27.4	8.0	3.29	2.645	73.0
February	72.7	31.7	8.0	3.49	2.866	69.5
March	122.6	54.1	11.1	3.40	3.008	67.2
April	161.1	62.2	13.6	3.20	3.209	70.8
May	209.5	74.7	18.9	3.10	3.399	66.2
June	219.4	81.7	22.7	3.09	3.399	64.4
July	236.0	62.4	25.7	3.50	3.399	59.1
August	201.8	60.8	25.2	3.10	3.459	63.1
September	148.8	50.4	20.4	3.20	3.143	70.2
October	109.2	38.9	17.0	2.90	3.008	74.1
November	68.9	29.2	12.5	3.10	2.866	74.3
December	53.0	22.7	9.3	3.19	2.720	75.4
Year	1664.2	596.2	16.0	3.2	3.093	68.9

2. *Set the orientation of the PV module*: as specified before the tilt and azimuth angle will be taken as the optimal, as optimization method was chosen the one that take an average between winter and summer needs (called: *yearly irradiation yield*) this because a grid connected system aims to produce all the possible energy and feed the electrical grid and not perfectly satisfy a building demand;





3. Set the user's need: in this case a planned power of 55kWp and the daily consumption are added like the previous case with, of course, a seasonal modulation.

Set the system in terms of: array and pre-sizing of inverter, define system components and define losses;

4. *Array and inverter pre-sizing*: typically, there is an oversizing of the PV panels' total power respect to inverter power about 10-20% because inverter allows overload. In the first time the inverter was selected as an intersection of its operative voltage with the voltage of an array of PV panels in serial connection (Vmppp 20 Celsius degree).
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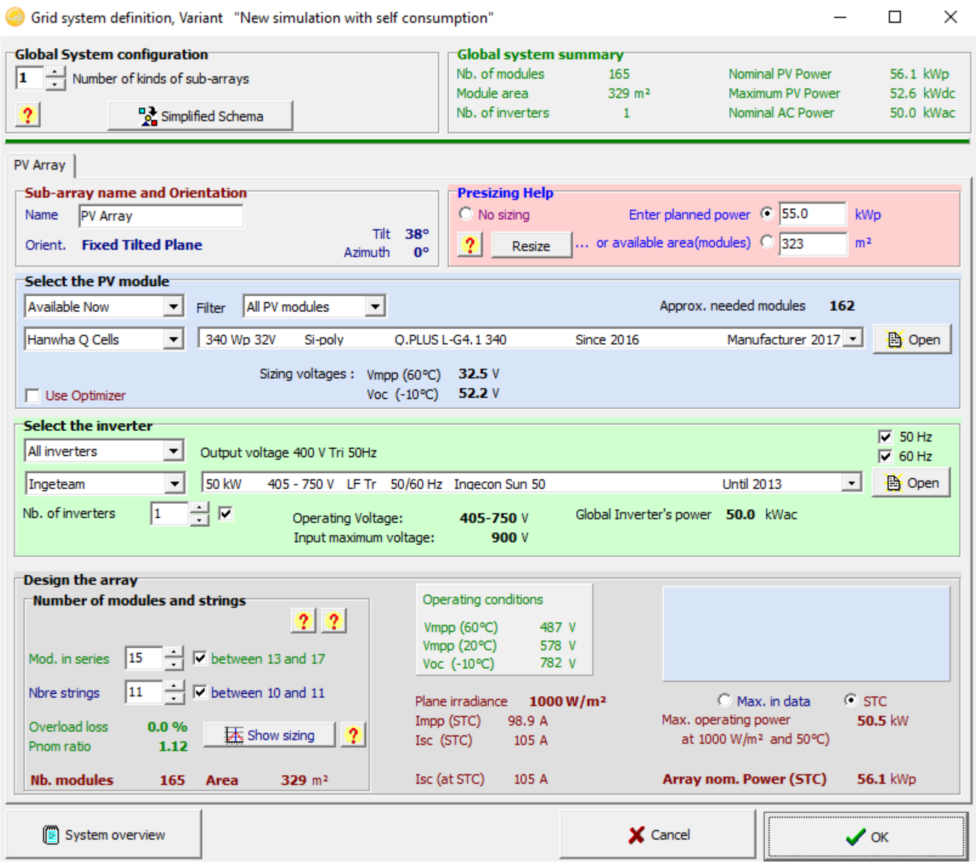


6. Define losses: will be taken in account losses to obtain more realistic results, such as: *Thermal parameter, Voltage drops across series diode, Light Induced Degradation, Yearly soiling loss factor, Yearly soiling loss factor, Incidence Angle Modifier, Ageing, Unavailability of the system* and *Spectral correction*. They will be the same as the losses of the first project.

OUTPUTS

The main important results are, the same of the previous report and some **new**:

1. Produced energy;
2. Specific production: The produced energy divided by the Nominal power of the array (Pnom at STC). This is an indicator of the potential of the system, taking into account irradiance conditions (orientation, site location, meteorological conditions).
3. Performance Ratio: is the ratio of the energy effectively produced (used), with respect to the energy which would be produced if the system was continuously working at its nominal STC efficiency. Unlike the "Specific energy production" indicator, expressed in [kWh/kWp/year], this indicator is not directly dependent on the meteo input or plane orientation. This allows the comparison of the system quality between installation in different locations and orientations;
4. **Solar fraction**: is the division of Energy Solar by Energy Available, that mean the average between the energy produced by PV modules ad used by users without excess and the energy present at the exit of the inverter (so, what PV modules produce taking into account losses until the energy reaches the inverter). If it is equal to 1 all the needs are covered by PV panels.
5. **Balances and main results**: this table shows parameters as follow:

E_Avail	The PV produced energy (output of the inverter, after eventual AC losses)
E_User	The energy needs (consumed by the user)
E_Grid	The excess energy injected into the grid,
EFrGrid	The energy drawn from the grid for the internal consumption (when PV is not sufficient), and during night.
E_Solar	(E_User – EfrGrid) The PV energy internally consumed.
SolFrac	(E_Solar / E_User) Ratio of the user's consumption covered by the solar production
PVFrac	(E_Avail/E_User) Ratio between annual user's consumption and annual solar production.

6. **Loss diagram over the whole year**: that allow us to recognize the most affecting losses on our systems and now, it displays some other information like: the amount of energy taken from the grid to the user, the amount of energy taken from the PV modules to the users and the amount of energy taken from the PV modules to the grids as unused from the users.

IndUva, Valladolid, SPAIN	Bari, ITALY
Produced Energy **81.09 MWh/year** Specific prod. 1446 kWh/kWp/year Performance Ratio PR 77.22 % Solar Fraction SF 42.53 %	**Produced Energy** **85.63 MWh/year** Specific prod. 1526 kWh/kWp/year Performance Ratio PR 77.87 % Solar Fraction SF 33.50 %

IndUva, Valladolid, SPAIN

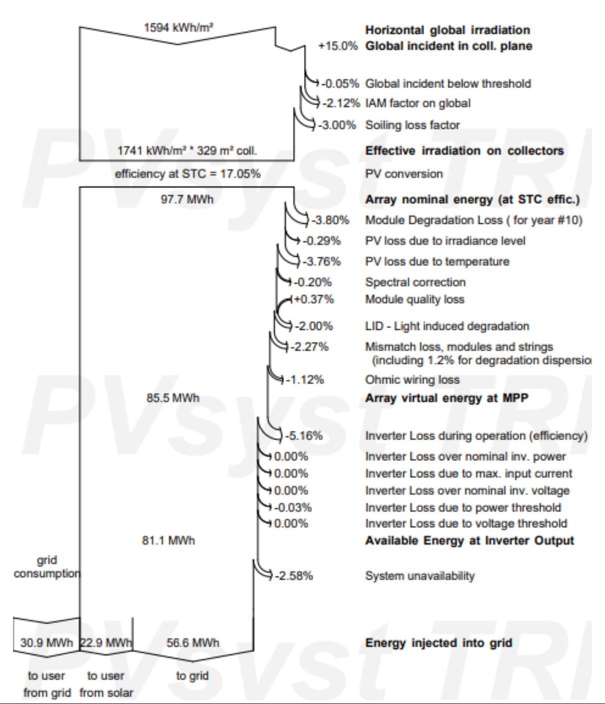
	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
January	50.6	24.46	3.84	84.4	80.6	4.246	6.105	1.564	2.179	4.541
February	79.8	32.35	5.33	121.0	115.6	5.984	5.514	2.048	3.642	3.466
March	127.9	51.81	8.71	163.4	155.3	7.836	4.070	2.131	5.322	1.939
April	157.4	63.57	10.55	170.2	161.3	7.979	3.938	2.121	5.441	1.817
May	182.5	78.05	14.83	176.2	166.5	8.118	4.070	2.241	5.437	1.828
June	222.8	71.33	20.24	206.7	195.3	9.247	3.151	1.971	6.148	1.179
July	229.0	65.91	22.03	218.5	206.8	9.671	3.256	2.017	6.427	1.239
August	199.6	63.26	21.64	210.4	199.6	9.394	3.256	1.969	6.963	1.287
September	146.3	42.84	17.58	179.3	170.5	8.150	4.726	2.281	5.453	2.445
October	97.1	40.28	12.90	139.1	132.6	6.653	4.884	1.919	4.399	2.965
November	57.0	28.90	6.95	89.3	85.2	4.423	4.726	1.299	2.875	3.427
December	44.1	22.92	4.17	75.6	72.2	3.831	6.105	1.320	2.285	4.784
Year	1594.2	585.68	12.44	1834.1	1741.3	85.533	53.799	22.882	56.573	30.917

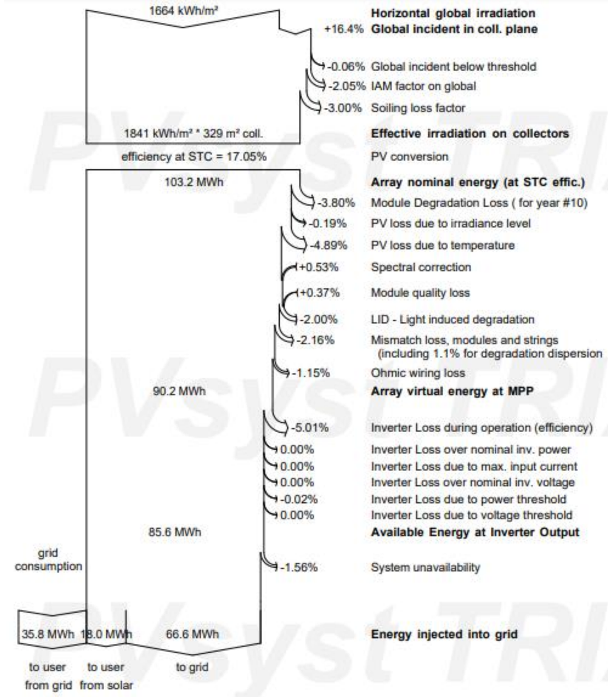
Bari, ITALY

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_User MWh	E_Solar MWh	E_Grid MWh	EFrGrid MWh
January	61.2	27.37	7.99	107.5	102.9	5.361	6.105	1.428	3.567	4.676
February	72.7	31.71	8.02	108.1	103.2	5.287	5.514	1.472	2.862	4.042
March	122.6	54.07	11.07	154.7	147.3	7.399	4.070	1.440	5.587	2.630
April	161.1	62.21	13.62	174.6	165.4	8.167	3.938	1.553	5.978	2.386
May	209.5	74.71	18.93	202.4	191.4	9.244	4.070	1.757	7.016	2.313
June	219.4	81.72	22.68	201.1	190.0	9.060	3.151	1.553	7.050	1.598
July	236.0	62.40	25.68	220.0	208.0	9.722	3.256	1.618	7.610	1.638
August	201.8	60.83	25.17	212.5	201.5	9.456	3.256	1.506	7.481	1.750
September	148.8	50.43	20.43	180.6	171.7	8.276	4.726	1.705	6.165	3.021
October	109.2	38.94	17.04	159.9	152.8	7.556	4.884	1.459	5.732	3.425
November	68.9	29.16	12.48	116.3	111.2	5.678	4.726	1.216	4.181	3.510
December	53.0	22.66	9.28	99.6	95.3	4.951	6.105	1.319	3.378	4.785
Year	1664.3	596.20	16.08	1937.2	1840.6	90.157	53.799	18.025	66.608	35.774

PVFrac = (E_Avail/E_User) yearly =1.51

PVFrac = (E_Avail/E_User) yearly =1.59





Comparing the two locations only by the higher value of specific energy production, Bari is the best location for this type of system because of higher value of horizontal global and horizontal diffuse irradiation.

Taking into the account the performance ratio: Bari is also the best location because of a higher value of performance ratio independently of meteo input or plane orientation.

But, looking for losses, Bari has the higher losses due to the temperature. This is maybe because the colder temperature reached in Valladolid morning allows the PV modules to work better instead higher average temperature in the south of the Italy.

The previous results converge in better working condition for Valladolid instead Bari. In fact, Valladolid has a better value of Solar Fraction than Bari despite in all the other values it has lower performance.

For example, the PVFrac is higher in Bari than Valladolid and is more than 1. It doesn’t mean that Bari’s installation covers all the needs because it is a yearly evaluation and this covering doesn’t happen every time on every day. So, is better to evaluate the Solar Fraction as done before. This value will never be equal to one, without batteries, because of the high needs simulated during the night when PV modules not work.