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# PVsystem6

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# INTRODUCTION

This document is a first step of a series of tutorials which explain the use of PVsyst Version 6, and may be understood as a PVsyst user's manual. It contains three different tutorials describing the basic aspects of the simulation:

- Creation of a grid-connected project
- Construction and use of 3D shadings scenes
- Meteorological data in PVsyst

More tutorials are in preparation and will be added in the future. They will explain in more detail the different features of PVsyst. The complete reference manual for PVsyst is the online help, which is accessible from the program through the “Help” entries in the menus, by pressing the F1 key or by clicking on the help icons  inside the windows and dialogs.

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# Part 1: BASIC APPROACH: MY FIRST PROJECT

## 1- First contact with PVsyst

When opening PVsyst you get to the main page:



This gives access to the four main parts of the program:

“Preliminary design” provides a quick evaluation of the potentials and possible constraints of a project in a given situation. This is very useful for the pre-sizing of Stand-alone and Pumping systems. For grid-connected systems, it is just an instrument for architects to get a quick evaluation of the PV potential of a building. The accuracy of this tool is limited and not intended to be used in reports for your customers.

“Project design” is the main part of the software and is used for the complete study of a project. It involves the choice of meteorological data, system design, shading studies, losses determination, and economic evaluation. The simulation is performed over a full year in hourly steps and provides a complete report and many additional results.

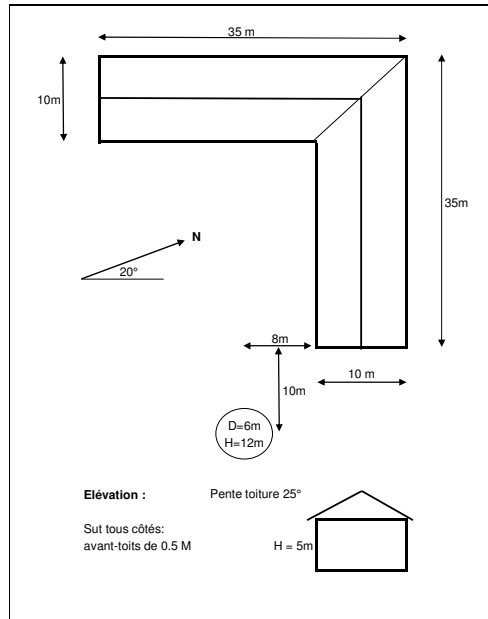
“Databases” includes the climatic data management which consists of monthly and hourly data, synthetic generation of hourly values and importing external data. The databases contain also the definitions of all the components involved in the PV installations like modules, inverters, batteries, etc.

“Tools” provides some additional tools to quickly estimate and visualize the behavior of a solar installation. It also contains a dedicated set of tools that allows measured data of existing solar installations to be imported for a close comparison to the simulation.

## 2- Full study of a sample project

### Project specifications and general procedure

For an introduction to the development of a project design in PVsyst, we will walk through a full project step-by-step. As an example we will consider a farm located in France close to Marseille. The building in question is shown on the following sketch:

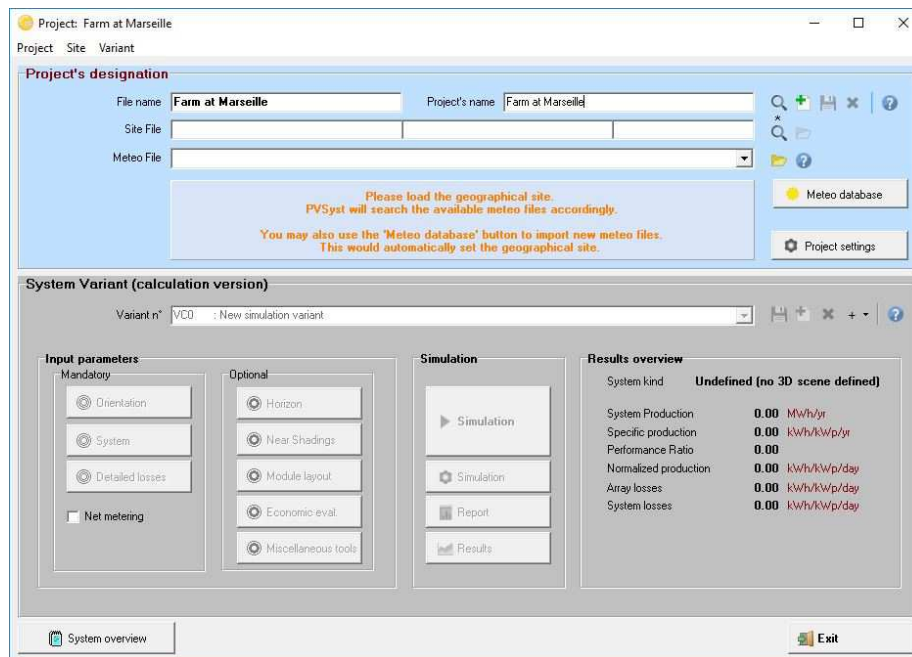


The roof of the farm is facing south and we intend to cover it on an area of about  $5\text{ m} \times 25\text{ m} = 125\text{ m}^2$  with mono-crystalline PV modules.

As explained before, we will not use the “Preliminary Design” for a grid-connected project, but rather start the complete “Project design”.



When you choose "Grid connected" project, you will get the following dashboard for the management of a project:



The dashboard has two parts: the Project basic definitions and the System variant management.

What we call 'Project' in PVsyst, is just the central object for which you will construct different variants (or system configurations, calculation variants) of your system. The Project contains the geographical site of your system, the reference to a file with the meteorological data, and some general parameters like the Albedo definition, some sizing conditions and parameters specific to this project. In the database it will get a filename with the extension \*.PRJ.


Each System Variant contains all the detailed definitions of your system, which will result in a simulation calculation. These definitions include the choice of solar panels and inverters, the number of panels and inverters, geometrical layout and possible shadings, electrical connections, different economic scenarios, etc. In the database, the files with the Variants of a project will have the Project's file name, with extensions VC0, VC1, VCA, etc. You can define up to 36 Variants per project.

### Steps in the development of a project

When developing a project in PVsyst, you are advised to proceed in small steps:

- Create a project by specifying the geographical location and the meteorological data.
- Define a basic system variant, including only the orientation of the PV modules, the required power or available area and the type of PV modules and inverters that you would like to use. PVsyst will propose a basic configuration for this choice and set reasonable default values for all parameters that are required for a first calculation. Then you can simulate this variant and save it. It will be the first rough approximation that will be refined in successive iterations.
- Define successive variants by progressively adding perturbations to this first system, e.g., far shadings, near shadings, specific loss parameters, economic evaluation, etc. You should simulate and save each variant so that you can compare them and understand the impact of all the details you are adding to the simulation.

### Tips - Help

In PVsyst, you can always get to the context Help by pressing F1. Sometimes you will also see little orange question mark buttons . Clicking on them will lead to more detailed information on the topic in the Help section.

When PVsyst displays messages in red, you are advised to carefully read them! They may be either warnings or error messages, or they can be procedures that should be followed to get a correct result.

## Defining the Project

In the project dashboard click on «New project» and define the project's name.

Then click on “Site and Meteo”.



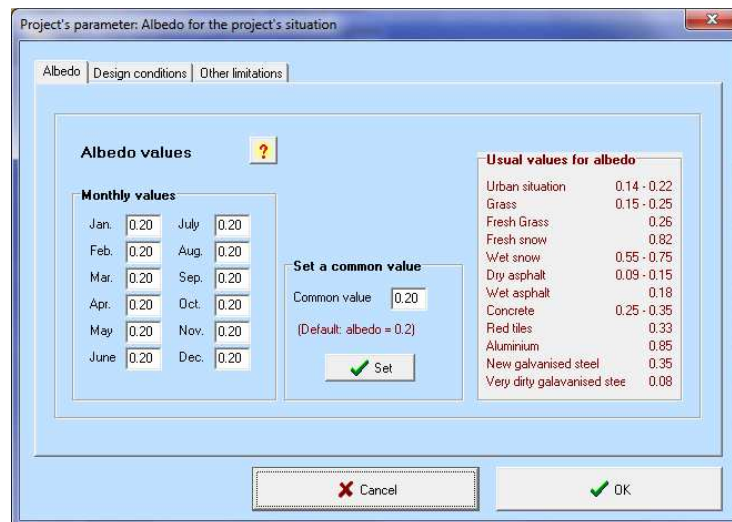
You can either choose a site from the built-in database, which holds around 1,200 sites from Meteonorm, or you can define a new site that can be located anywhere on the globe. Please refer to the tutorial “Meteorological Data management” if you want to create or import a site other than those available in the database.

The project’s site defines the coordinates (Latitude, Longitude, Altitude and Time zone), and contains monthly meteorological data.

The simulation will be based on a Meteo file with hourly data. If a near meteo file exists in the vicinity (less than 20 km), it will be proposed. Otherwise PVsyst will create a synthetic hourly data set based on the monthly meteo values of your site. However, you can always choose another Meteo file in the database. A warning will be issued if it is too far from your site.

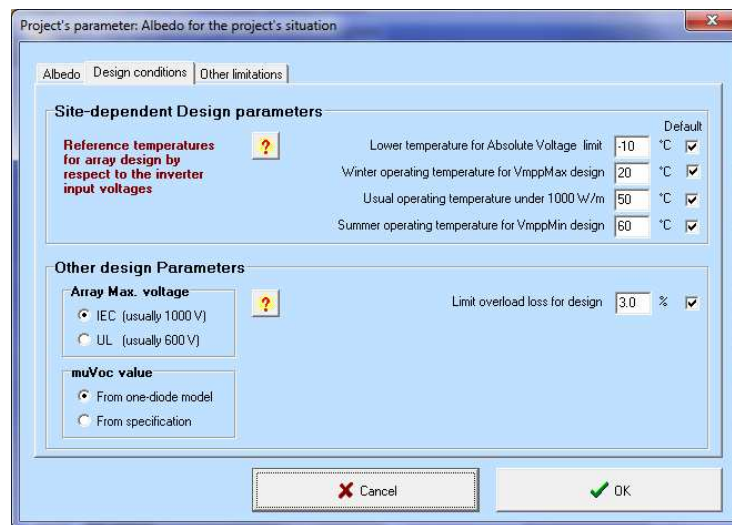
NB: If you begin by choosing a meteo file, you have the opportunity of copying the site associated with this file to the Project's site.

In the project dashboard you can click on the button "Albedo - Settings" which will give you access to the common project parameters, namely the albedo values, the design conditions and design limitations.



Usually you will never modify the albedo factor. The value of 0.2 is a standard adopted by most people. Nevertheless, if for example your site is located in the mountains, you can define in this table a higher albedo factor like 0.8 for the months where there is persistent snow.

The second tab in the project parameters dialog contains the "Design Conditions" page.



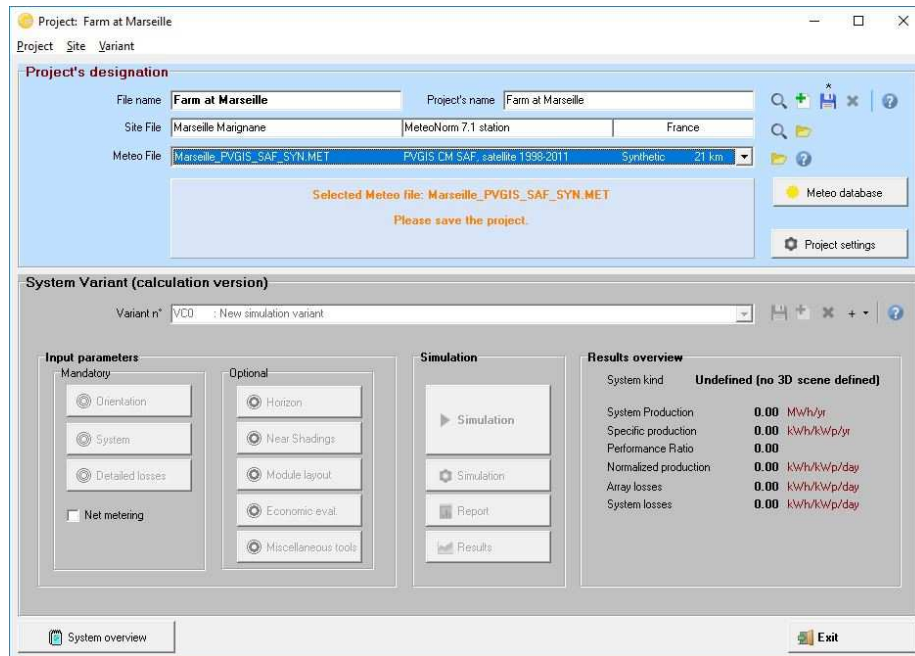
This page defines sizing temperatures, which may be site-dependent. These are only used during the sizing of your system; they are not involved in the simulation.

The "Lower temperature for Absolute Voltage Limit" is an important site-dependent value, as it is related to the safety of your system (it determines the maximum array voltage in any conditions). Ideally, it should be the minimum temperature ever measured during daylight at this location. In Central Europe the common practice is to choose -10°C (lower in mountain climates).



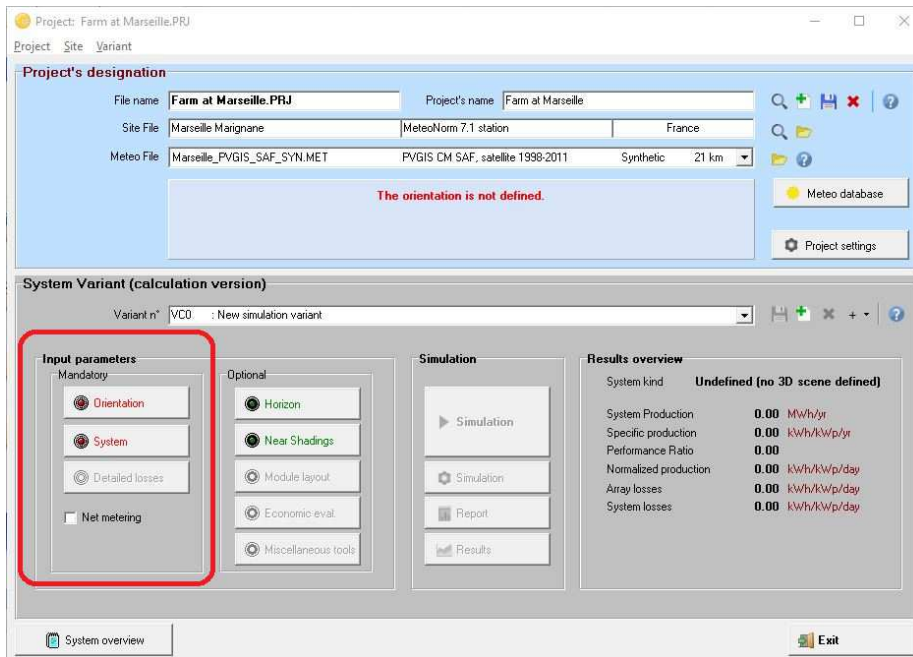
### 3- Saving the Project

When you are finished (i.e. you have gone to the Variant choices), you will be prompted to save the definitions of your project. The dialog that comes up allows you to rename the project. We recommend that you use a simple filename, since it will be used as a label for all the Variants.

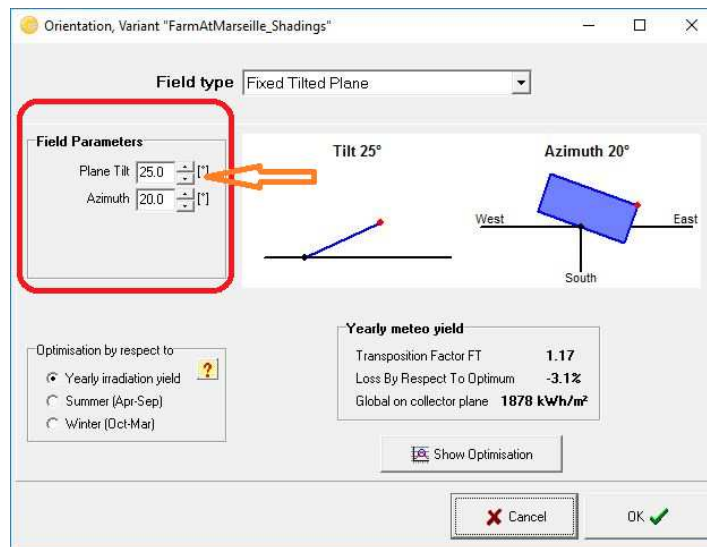


### Creating the first (basic) variant for this project

After having defined the site and the meteorological input of the project, you can proceed to create the first Variant. You will notice, that in the beginning there are 2 buttons marked in red: "Orientation" and "System". The red color means that this variant of the project is not yet ready for the simulation, additional input is required. The basic parameters that have to be defined for any of the variants, and that we have not specified yet, are the orientation of the solar panels, the type and number of PV modules and the type and number of inverters that will be used.



First, click on "Orientation". You will get the orientation dialog where you have to supply values for the type of field for the solar installation and tilt and azimuth angles.



The solar panels in our example will be installed on a fixed tilted plane. From the project's drawing (page 5) we get the Plane Tilt and Azimuth angles (25° and 20° west respectively). The azimuth is defined as the angle between the South direction and the direction where the panels are facing. Angles to the west are counted positive, while angles to the east are counted negative.

After setting the correct values for tilt and azimuth, you click on "OK" and the "Orientation" button will turn green. Next click on "System".

## Presizing Help

From the system description, we remember that we have an available area of around 125 m<sup>2</sup>. It is not mandatory to define a value here, but doing so will simplify our first approach as it will allow PVsyst to propose a suitable configuration.

## Select a PV module

Choose a PV module in the database. Among "All modules", select "Generic" as manufacturer and select the 110 W model. In the bottom right part of the dialog PVsyst will display a hint for choosing the inverter: "Please choose the Inverter model, the total power should be 13.2 kW or more."

Grid system definition, Variant "New simulation variant"

**Global System configuration**

1 Number of kinds of sub-arrays

**Global system summary**

Nb. of modules	1	Nominal PV Power	0.1 kWp
Module area	1 m <sup>2</sup>	Maximum PV Power	0.1 kWdc
Nb. of inverters	1	Nominal AC Power	0.0 kWac

**PV Array**

**Sub-array name and Orientation**

Name: PV Array

Orient.: Fixed Tilted Plane

Tilt: 25°

Azimuth: 20°

**Presizing Help**

No sizing

Enter planned power: 15.3 kWp

... or available area(modules): 125 m<sup>2</sup>

**Select the PV module**

Available Now

Maximum nb. of modules: 139

Generic

110 Wp 23V Single Poly 110 Wp 72 cells Since 2015 Typical

Open

Sizing voltages: Vmpp (60°C): 29.2 V

Voc (-10°C): 48.7 V

Use Optimizer

**Select the inverter**

Available Now

Huawei Technologies

Open

Number of inverters: 1

Operating Voltage: 300-600 V

Global Inverter's power: 0 kWac

Use multi-MPP  Secondary used but maximum voltage: 0 V

**Design the array**

**Number of modules and strings**

Mod. in series: 1  only possibility 1

Nbre strings: 1  only possibility 1

Overload loss: 0.0 %

Prism ratio: 0.00

Show sizing

Nb. modules: 1 Area: 1 m<sup>2</sup>

**Operating conditions**

Plane irradiance: 1000 W/m<sup>2</sup>

Vmpp (60°C): 29 V

Vmpp (20°C): 35 V

Voc (-10°C): 49 V

Max. in data  STC

Impp (STC): 3.2 A

Isc (STC): 3.4 A

Max. operating power at 1000 W/m<sup>2</sup> and 50°C: 0.1 kW

Isc (at STC): 3.4 A

Array nom. Power (STC): 0.1 kWp

Please choose the Inverter model !  
The total power should be 11.4 kW (optimal) or more

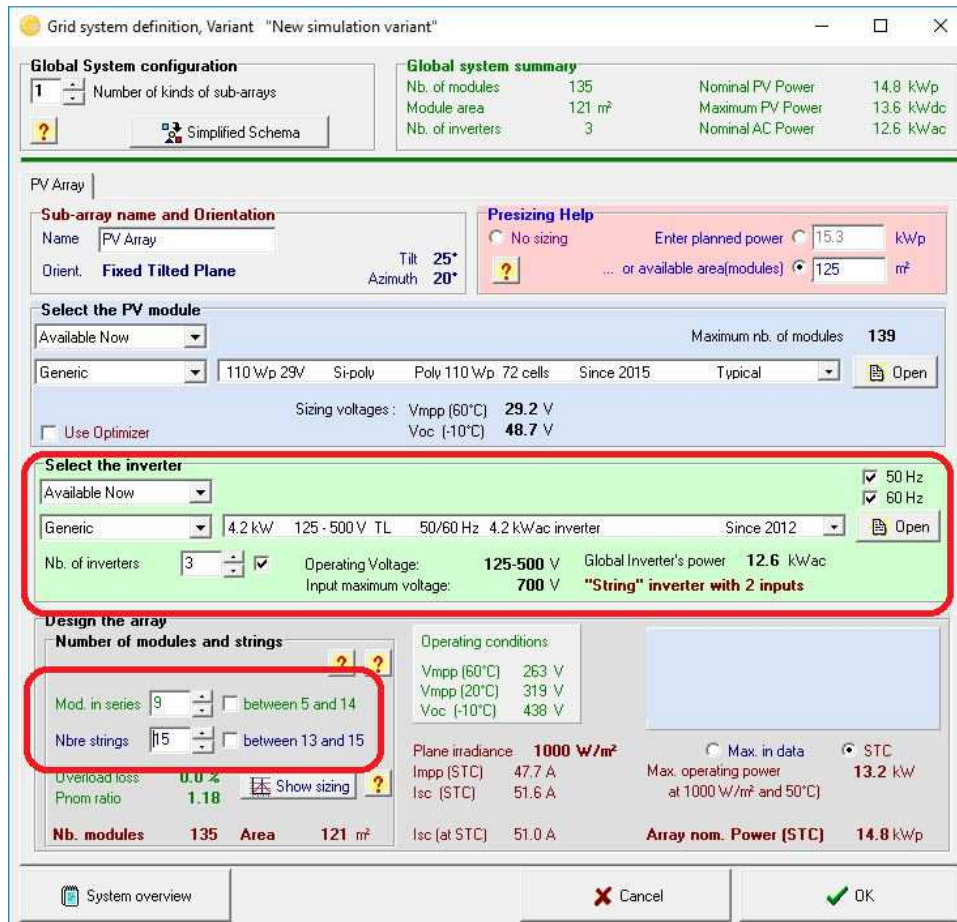
System overview

Cancel

OK

## Select the Inverter

For the installation in our example we could choose either a Triphased inverter of around 13 kW, or 3 Monophased inverters of 4.2 kW to be connected on the 3 phases. We choose the Generic 4.2 kW and PVsyst proposes a complete configuration for the system: 3 inverters, 15 strings of 9 modules in series.



After the module type, the inverter and the design of the array have been defined, the blue panel in the bottom right part of the dialog should be either empty or orange. If you get a red error message, check all choices you made and correct them to the values described above (it may take a few seconds for the message to adapt to the changes you make).

We have now defined all compulsory elements that are needed for a first simulation. We will go through more details of this very important dialog later in this tutorial. For now, you can click on "OK" to validate the choices. You will get a message box with the warning: "The inverter power is slightly undersized". For the time being we will ignore it and just acknowledge with the OK button.

### Message colors in PVsyst

In many of the PVsyst dialogs you will be prompted with messages that are meant to guide you through the different steps of the definition and execution of a simulation. The color of the text gives you a clue on how important the message is:

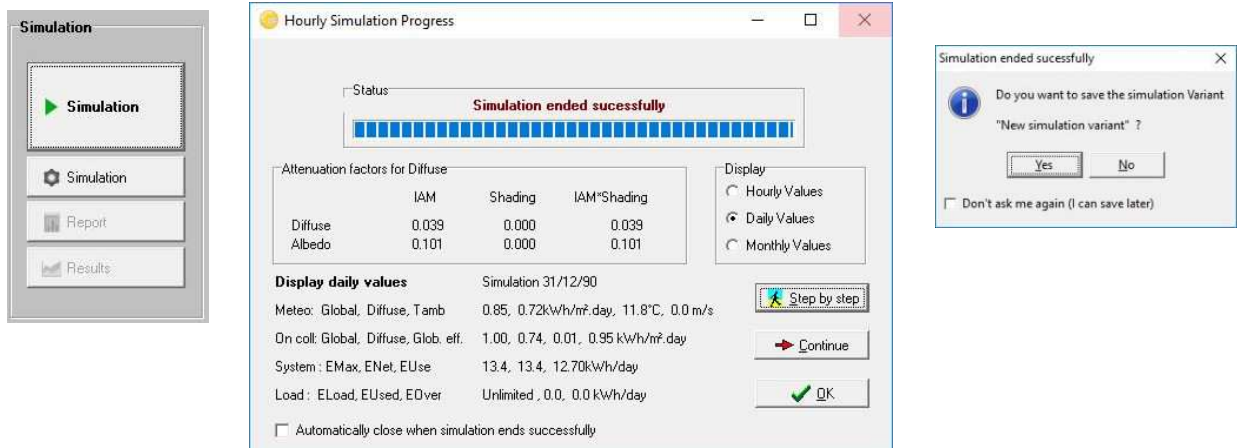
- Messages in black are additional information or instructions on how to proceed.
- Warnings in orange indicate design imperfections, but the system is still acceptable.
- Errors in red mean serious mistakes, which will prevent the execution of the simulation.

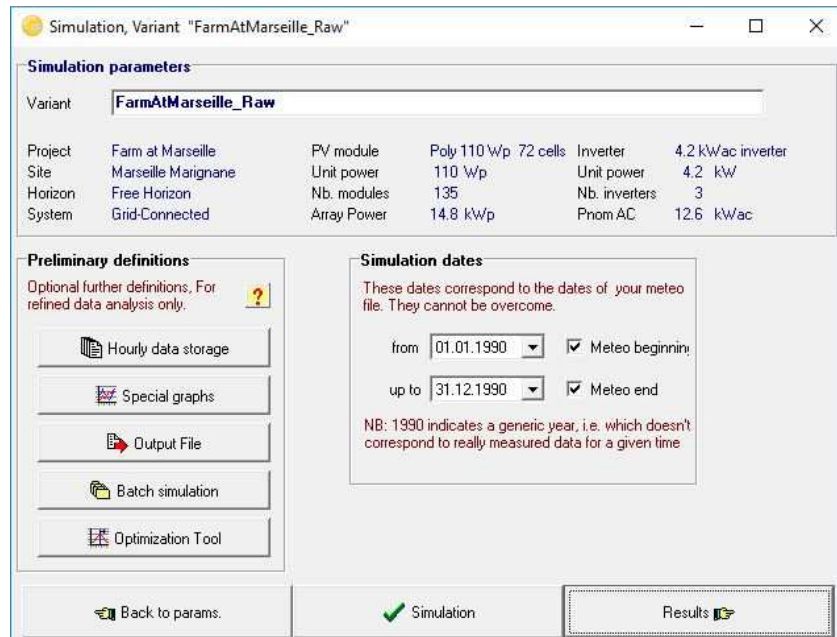
A similar color code is also valid for the buttons on the project's dashboard (in addition a greyed-out button means "has not been defined").

## 4- Executing the first simulation

On the Project's dashboard, all buttons are now green (eventually orange) or Off.

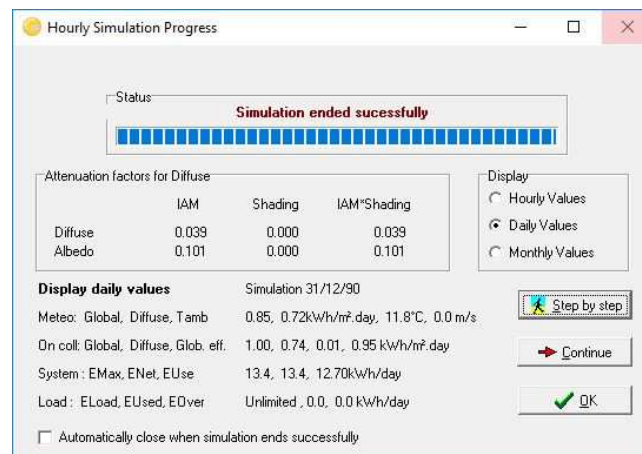
The "Simulation" button is activated, and we can click on it.





The simulation dates are those of the underlying meteo data file. Don't modify them (you cannot perform a simulation outside of the available meteo data).

The preliminary definitions are additional features which may be defined for advanced purposes. We will skip them for now, and click right away on "Simulation".

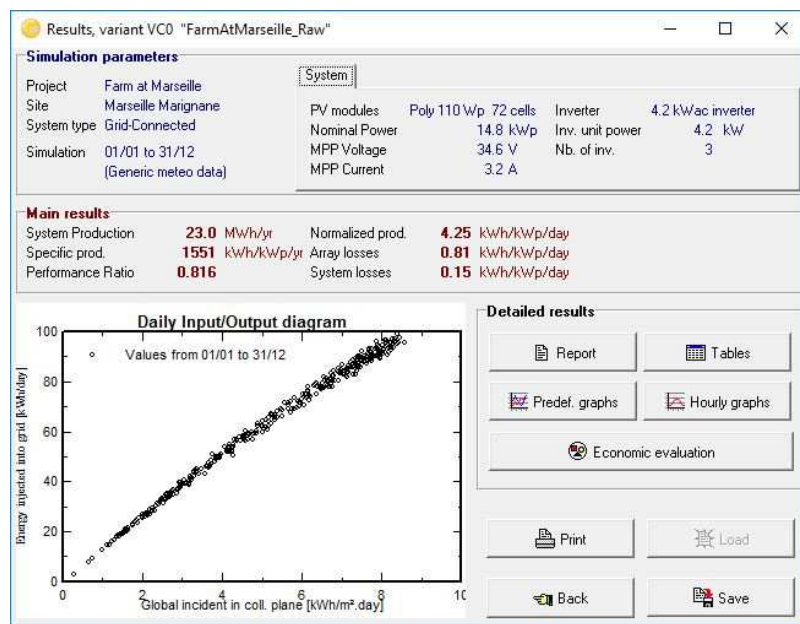


A progress bar will appear, indicating how much of the simulation is still to be performed. Upon completion, the "OK" button will get active. When you click on it, you will get directly to the "Results" dialog.

### Analyzing the results

This dialog shows on the top a small summary of the simulation parameters that you should quickly check to make sure that you made no obvious mistake in the input parameters. Below is a frame with six values that summarize at one glance the main results of the simulation. They only give a very coarse picture of the results and are there to quickly spot obvious mistakes or to get a first impression of a change or a comparison between variants of the project.

In the bottom left part of the dialog you will see the "Input/Output" diagram, which gives you already more detailed information about the general behavior of the system. It displays for every day that was simulated, the energy that was injected to the grid as a function of the global incident irradiation in the collector plane. For a well dimensioned grid-connected system, this should be roughly a straight line that slightly saturates for large irradiation values. This slight curvature is a temperature effect. If some points (days) deviate at high irradiances, this is an indication of overload conditions. For stand-alone systems, a plateau indicates overload (full battery) operation.



The main information of the simulation results is gathered in the report. The other buttons give access to complementary tables and graphs for a deeper analysis of the simulation results. For now we will ignore them. When you click on  you will get the complete report, which for this first simple variant consists of only three pages (for simulations with more detail you can get up to 9 pages of report). In this report you will find:

**First page:** All the parameters underlying this simulation: Geographic situation and Meteo data used, plane orientation, general information about shadings (horizon and near shadings), components used and array configuration, loss parameters, etc.

**Second page:** A reminder of the main parameters, and the main results of the simulation, with a monthly table and graphs of normalized values.

**Third page:** The PVsyst arrow loss diagram, showing an energetic balance and all losses along the system. This is a powerful indicator of the quality of your system, and will immediately indicate the sizing errors, if they exist.

### Analyzing the report

#### Second page: main results

For our first system: three relevant quantities are now defined:

Produced Energy: The basic result of our simulation.

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).

Performance ratio: An indicator of the quality of the system itself, independently of the incoming irradiance. We will give its definition below.

<b>Main simulation results</b>			
System Production	<b>Produced Energy</b>	<b>21.54 MWh/year</b>	Specific prod. 1451 kWh/kWp/year
	Performance Ratio PR	80.4 %	

The bottom of the second page contains a table with the main variables, given as monthly values and the overall yearly value. The yearly value can be an average like the temperature, or a sum, like the irradiation or energies. The meaning of the different variables is the following:

GlobHor: Global irradiation in the horizontal plane. This is our meteo input value.

T amb: Ambient (dry-bulb) average temperature. This is also our meteo input value.

GlobInc: Global irradiation in the collector plane, after transposition, but without any optical corrections (often named POA for Plane of Array).

GlobEff: "Effective" global irradiation on the collectors, i.e. after optical losses (far and near shadings, IAM, soiling losses).

EArray: Energy produced by the PV array (input of the inverters).

E\_Grid: Energy injected into the grid, after inverter and AC wiring losses.

EffArrR: PV array efficiency EArray related to the irradiance on the Collector's total area.

EffSysR: System efficiency E\_Grid related to the irradiance on the Collector's total area.

**New simulation variant  
Balances and main results**

	GlobHor kWh/m <sup>2</sup>	T Amb °C	GlobInc kWh/m <sup>2</sup>	GlobEff kWh/m <sup>2</sup>	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	53.5	6.29	83.0	80.1	1.104	1.063	10.96	10.56
February	79.2	6.99	112.0	108.4	1.481	1.430	10.90	10.53
March	133.9	11.20	167.4	162.6	2.135	2.062	10.52	10.16
April	153.4	14.37	165.6	160.3	2.077	2.005	10.34	9.98
May	199.4	19.14	198.7	192.5	2.424	2.339	10.06	9.70
June	217.8	23.44	210.9	204.4	2.496	2.408	9.76	9.42
July	220.9	24.90	217.1	210.3	2.556	2.467	9.71	9.37
August	188.2	24.67	200.9	194.9	2.366	2.284	9.71	9.38
September	138.9	19.74	161.5	156.6	1.977	1.909	10.09	9.74
October	93.0	16.05	125.0	120.9	1.573	1.518	10.38	10.01
November	58.3	9.96	87.1	84.2	1.139	1.099	10.78	10.39
December	46.1	6.50	74.2	71.5	0.993	0.957	11.03	10.62
Year	1582.5	15.32	1803.3	1746.7	22.323	21.540	10.21	9.85

The monthly graphs on the second page of the report are given in units called «Normalized Performance Index». These variables have been specified by the "Joint Research Center" JRC (Ispra) for a standardized report of PV system performance, and they are now defined in the international IEC61836 norm. The PVsyst online help contains a full explanation of these values (you can directly access this section of the online help by pressing F1 when you are on this page of the report). In these units the values are expressed in [kW/kWp/day] and contain the following information:

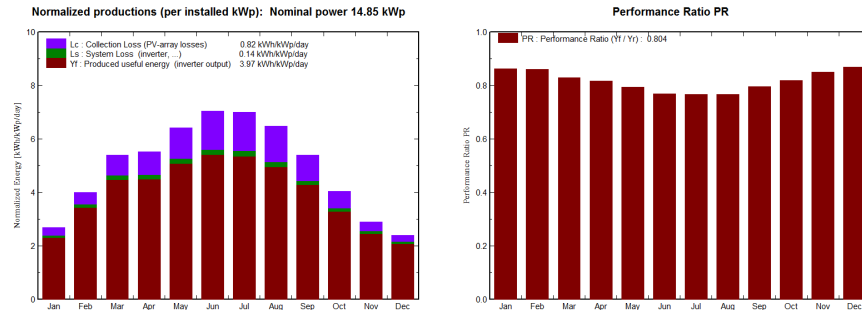
Yr Reference Yield Energy production if the system were always running at "nominal" efficiency, as defined by the array Pnom (nameplate value) at STC.

This is numerically equivalent to the GlobInc value expressed in [kWh/m<sup>2</sup>/day].

Ya Array yield Energy production of the array



$Y_f$  = Final System yield Energy to the grid  
 $L_c$  =  $Y_r - Y_a$  Array capture losses  
 $L_s$  =  $Y_a - Y_f$  System losses  
 $PR$  =  $Y_f / Y_r$  Performance Ratio =  $E_{Grid} / (GlobInc P_{nom}(nameplate))$

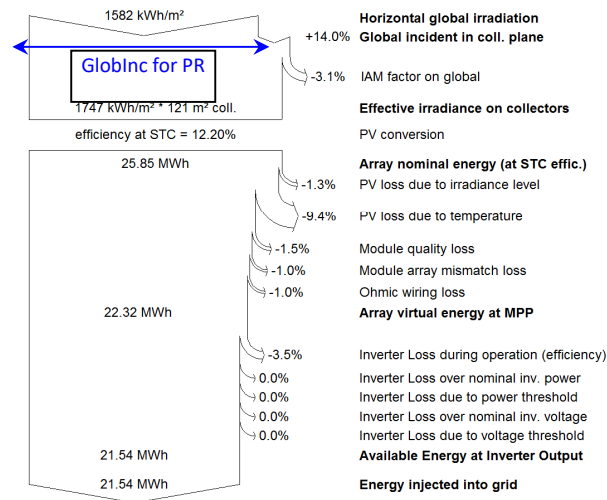



### Third page: arrow loss diagram

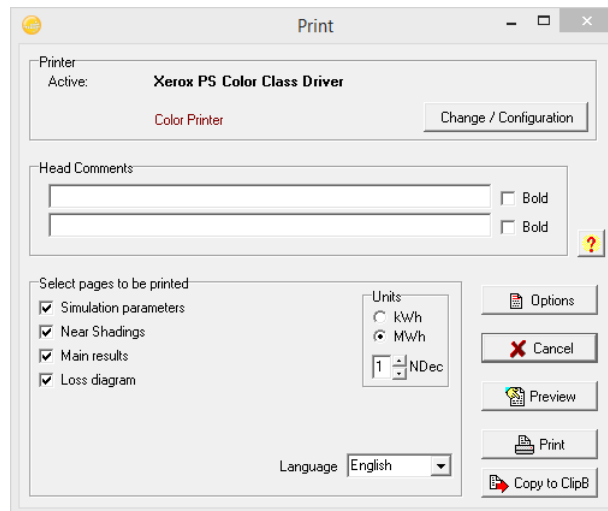
This is the PVsyst way of reporting the system's behavior, with all detailed losses. This diagram is very useful for the analysis of the design choices, and should be used when comparing systems or variants of the same project.

GlobHor	Horizontal irradiation (meteo value): starting point.
GlobInc	After transposition (reference for the calculation of PR, which includes the optical losses).
IAM	The optical losses. When adding further details to a variant, there will be additional arrows for far and near shadings, soiling, etc.
GlobEff · Coll. Area	Energy on the collectors.
EArrNom	Array nominal energy at STC (= GlobEff Effic. nom).
Array losses	Collection losses (irradiance, temperature, mismatch, module quality, wiring, etc.).
EArrMPP	Array available energy at MPP.
Inverter losses	Efficiency and eventual overload loss (all others are usually null).
EOutInv	Available energy at the output of the inverter.
AC losses	Eventual wiring, transformer losses between inverter and injection point, unavailability.
EGrid	Energy injected into the grid.

### Loss diagram over the whole year



The report can be sent to a printer or copied to the clipboard. These options are accessible through the Print button . When pressing it you will get the "Print" dialog:



Here you can select which parts of the report should be printed or copied and define comments that will show up in the header of the report. With the "Options" button you can customize even more details for the header comments and the clipboard copy resolution.

### *Saving your simulation*

Take the habit to "Save" your different variants for further comparisons. Be careful to define a significant title in order to easily identify your variant in the future. This title will be mentioned on the report (it can also be defined in an earlier step, for example at the time of the simulation).

The first variant will be saved in the file "Marseille\_Tutorial.VC0". Later Variants will get the file endings VC1, VC2, etc. If you want to create a new Variant, make sure that you use "Save As" to avoid overwriting your previous variants. For opening previous simulations of the project, you can click the button "Load" which is situated just above the "Save" button

## 5- Adding further details to your project

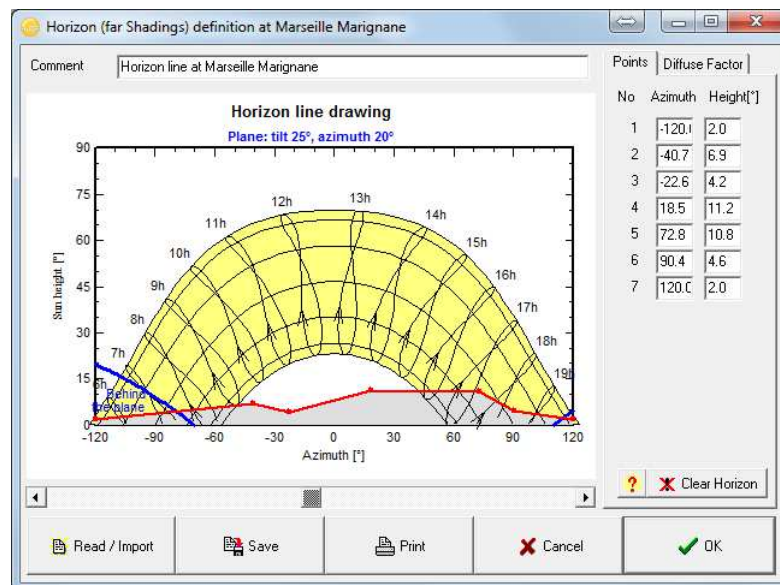
After this first "standard" simulation, you can progressively add the specific details to your project. You are advised to perform and save a new simulation at each step in order to check its effect and pertinence - especially by analyzing the "Loss diagram".

### Far shadings, Horizon profile

The horizon profile is only suited for shading objects that are located sufficiently far from your PV system, so that the shadings may be considered global on your array. This is the case when the distance to the shading object is more than about 10 times the PV system size. The Horizon Profile is a curve that is defined by a set of (Height, Azimuth) points.

The Far Shadings operate in an ON/OFF mode: i.e. at a given time, the sun is or is not present on the field. When the sun is behind the horizon the beam component becomes null. The effect on the diffuse component will be explained below.

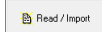
Clicking the "Horizon" button will open a graph of the sun paths at your location.

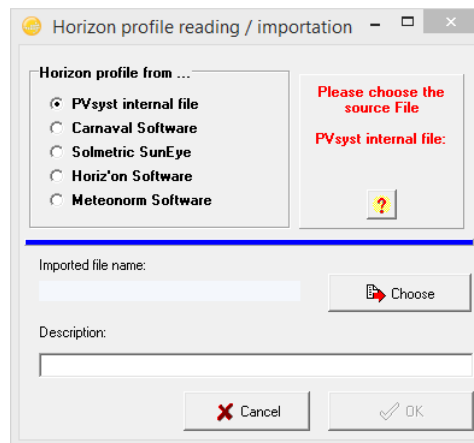


You can either define the horizon line manually. For this the values (Height, Azimuth set of points) have been recorded on-site using a compass and a clinometer (measuring the height angles), a land surveyor or some specific instrument, photographs, etc. But you can also import a horizon line that has been generated with the "SunEye" device or some dedicated software as explained below.

### Defining a horizon line by hand:

You can move any of the red points, by dragging it with the mouse, or define accurately its values in the edit boxes on the right. For creating a new point right-click anywhere. For deleting a point right-click on the point. You can save this horizon as a file for further use in other PVsyst projects.

When you click on the "Read / Import" button  you will get the "Horizon profile reading / importation" dialog. You can either read a horizon line that you have previously saved in PVsyst, or you can import a predefined format from sources external to PVsyst.



### Importing Horizon from Solmetric "SunEye" instrument

The "SunEye" records the horizon line using a fisheye camera, and provides the result in several files. You should choose the file called "ObstructionElevation.csv". Do not use the "Sky0x\_PVsyst.hor" file! This is an obsolete format, which was created by Solmetrics for the old versions 4.xx of PVsyst.

NB: If near objects are present on the pictures taken by the "SunEye", you should remove them from the data by editing the horizon line after importing it.

### Importing Horizon from the "Carnaval" software

"Carnaval" is a georeferenced free software (including altimetry data), which is able to create a horizon line starting from geographical coordinates - Latitude and Longitude – of a site. It works only for locations in France and its neighboring countries.

NB: You should not use the 'near objects' option in this software when creating the far shadings for PVsyst. Carnaval produces a file named "YourProject.masque.txt". You will have to rename this file, removing the ".masque" characters, as PVsyst does not accept file names with 2 dots in them.

### Importing Horizon from the «Horiz'ON" software

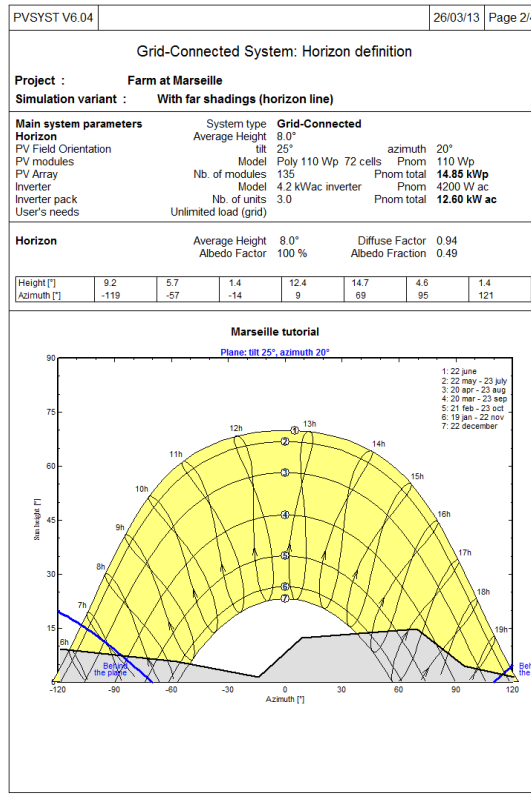
The "Camera Master" tool is a special support for photo cameras, which allows to take a series of pictures in precise horizontal rotation steps (every 20° in azimuth). The software "Horiz'ON" gathers these photographs in a single panorama picture, on which you can draw the horizon line by using the mouse. The software will produce a file format of the horizon line that is directly readable in PVsyst.

NB: When you want to create a horizon line starting from a geographical location (like in Carnaval or Meteonorm), the exact coordinates of your PV system have to be carefully defined. You may determine them using GoogleEarth or with a GPS instrument. Keep in mind that a degree in latitude corresponds to 111 km, a minute to 1850 m and a second to 31 m. For the longitude this is also valid for locations on the equator. As you move away from the equator these values will decrease.

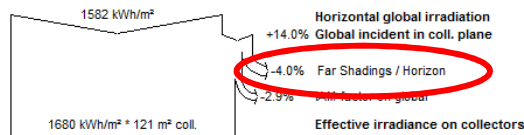
### Using the horizon in the simulation

After defining a horizon line, the button in the project dashboard will turn from greyed-out to green. If we now perform again a simulation the shading of the horizon will be taken into account. The report will

now have an additional page. On the second page of the report you will find the horizon definition and the sun graph that includes the far shading effect:

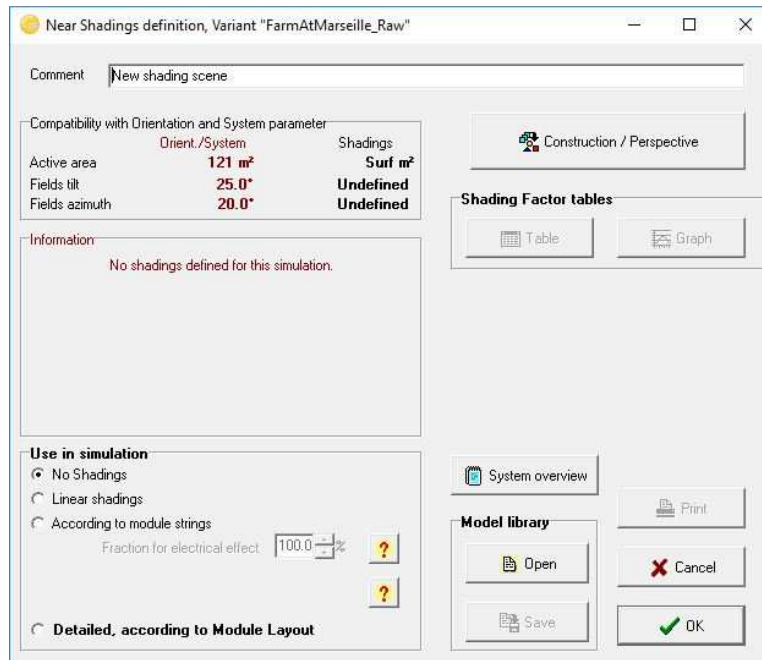


Also the loss diagram on the last page of the report will now include the effect of the far shadings:

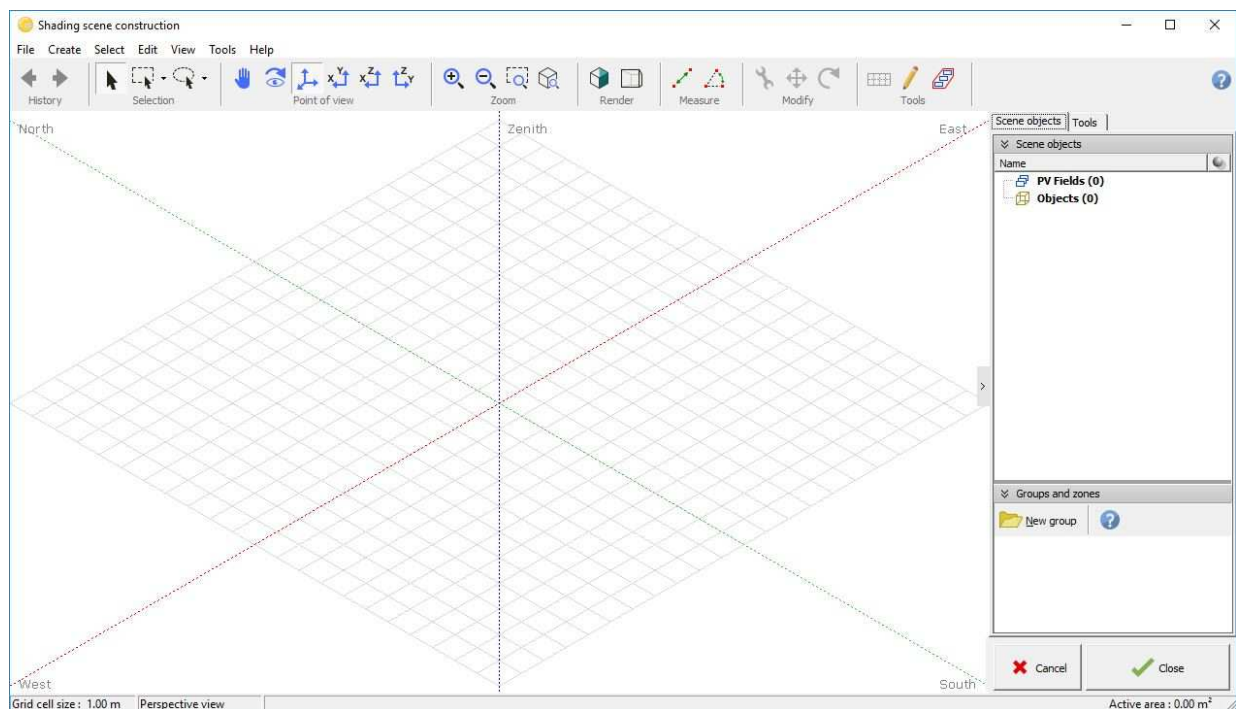


### Near shadings, 3D construction

The construction of the near shadings is described in the dedicated tutorial “3D Near Shadings Construction”. The near shadings treatment (shading of near objects) requires a full 3D representation of your PV system. This is managed from the following central dialog:



The construction of the 3D scene is performed in a 3D editor, which opens when you click on the button "Construction/Perspective"



If you have near shadings, you should construct your PV installation and its surroundings as a 3D scene (see the dedicated tutorial). The instruments described in the far shadings section (including SunEye) are not useful for this construction. The starting point should be the architect's drawings or anything equivalent, and they should include topological information to get the height of the objects right.

After constructing the 3D representation of the installation, you should perform the simulation in the "linear shadings" mode which takes into account only the irradiance deficit. This will give you a lower

bound for the estimation of the shadings effect. Then you repeat the simulation once more in "according to module strings" mode, which also considers electrical effects resulting from the fact that the modules are arranged in groups (strings). The modules in each of these strings are assumed to be connected in series. This will provide an upper bound for the estimation of the shading losses. For the final report that will be submitted to your customer, you choose an intermediate value for the electrical effect, taking the by-pass diode recovery into account. For this you have to choose an intermediate fraction for the electrical effect, which will depend on your system geometry. There is no well-established value that would generally cover all possible situations. A rough estimate would be 60 to 80% (Higher for regular shading patterns like sheds).

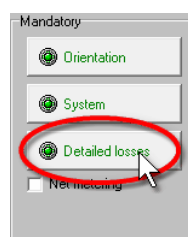
NB: The near shading loss does not cumulate with the far shadings. When the sun is behind the horizon, the beam component is null, and therefore there is no near shading contribution.

### Final layout of the system

In PVsyst there is no direct link between the definition of the system (PV panels and inverters), and the definition of your 3D scene. But when you do modifications in either one of these parts, the program will check if they remain compatible, and issue warning or error messages if it detects any incoherence. Namely it will require that the plane orientations are identical in the two parts, and that you have defined a sufficiently large sensitive area in the 3D scene for installing the PV modules defined in the system. PVsyst will perform this test only on the total areas, it will not check the real physical (geometrical) compatibility. You need to check the arrangement of your modules on the sensitive area in the 3D scene and if you do not find a possible arrangement, you have to modify the system definitions (number of modules in series and parallel) or the 3D scene in order to make these two parts match. The "Module layout" section will help you in finding a consistent arrangement. This part of PVsyst will be described in a different tutorial. For the present example we only need to make sure that the PV sensitive area in the 3D scene is at least as large as the total PV module area from the system definitions. This will allow to perform the simulation.

### Detailed losses

Finally there are several parameters which are fixed by PVsyst as reasonable default values for your early simulations, but that you should modify according to the specificities of your system. These parameters are accessed with the button "Detailed losses" in the project dashboard.

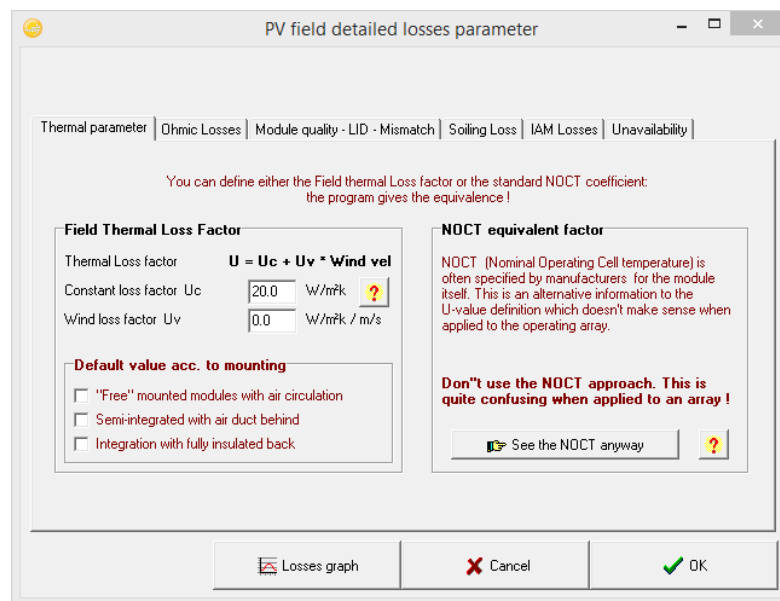


The Dialog "PV field detailed losses parameter" will pop up. It contains the following six tabs:

- Thermal Parameters
- Ohmic Losses
- Module Quality – LID – Mismatch
- Soiling Loss
- IAM Losses
- Unavailability

In the following we will go through all of them and give a brief explanation of the different parameters and options.

### Thermal parameters



The thermal behavior of the array is computed at each simulation step, by a thermal balance. This establishes the instantaneous operating temperature, to be used by the PV modules modelling.

The thermal balance involves the "Heat loss factor"  $U = U_c + U_v \cdot \text{WindSpeed}$  [W/m<sup>2</sup>·K]. In practice we advise not to use the wind dependency, as the wind speed is usually not well defined in the meteo data, and the parameter  $U_v$  is not well known. Therefore we put  $U_v = 0$  and include an average wind effect in the constant term.

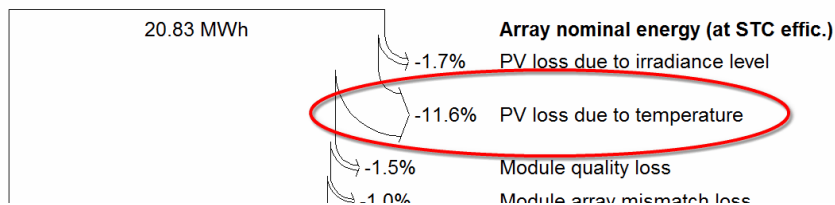
According to our own measurements on several systems, PVsyst proposes:

- $U_c = 29 \text{ W/m}^2\text{K}$  for complete free air circulation around the collectors ("nude" collectors).
- $U_c = 20 \text{ W/m}^2\text{K}$  for semi-integrated modules with an air duct on the back.
- $U_c = 15 \text{ W/m}^2\text{K}$  for integration (back insulated), as only one surface participates to the convection/radiation cooling.
- There are no well-established values for intermediate situations with back air circulation. Our measurement on quasi-horizontal modules on a steel roof, 8 cm spacing and not joint collectors, gave  $18 \text{ W/m}^2\text{K}$ ;



NB: up to PVSyst version 5.1, the default value was 29 W/m<sup>2</sup> (free standing). From version 6 onwards the default is set to 20 W/m<sup>2</sup> since nowadays more and more installations are being built in an integrated way.

The thermal loss effect will show up on the array loss diagram in the final report.



The 'Standard NOCT factor' (Nominal Operating Cell Temperature) is the temperature that the module reaches in equilibrium for very specific surrounding and operation conditions. It can often be found together with the module specifications supplied by the manufacturers. It has no real relevance for the simulation, because the conditions for which it is specified are far away from a realistic module operation. PVSyst only mentions it for completeness and for comparison with the manufacturer's specifications.

### Wiring Losses

The wiring ohmic resistance induces losses ( $R \cdot I^2$ ) between the power available from the modules and that at the terminals of the array. These losses can be characterized by just one parameter R defined for the global array.

Thermal parameter | Ohmic Losses | Module quality - LID - Mismatch | Soiling Loss | IAM Losses | Unavailability

**DC circuit: ohmic losses for the array**

Global wiring resistance: 117.1 mOhm  Calculated

or in loss fraction at STC: 1.5 %  Default

Voltage Drop across series diode: 0.0 V  Default

**AC circuit: inverter to injection point**

Significant length, to be accounted for

Length Inverter to injection: 0.0 m

Loss fraction at STC: 0.00 %

Voltage drop at STC: 0.0 V (0.0%)

**External transformer**

External transformer present (default)

Iron loss (constant value): 0.00 % 0 W

Resistive/Inductive losses: 0.00 % at STC

(quadratic,  $R \cdot I^2$ ,  $R = 0.0$  mOhm)

Night disconnect

The program proposes a default global wiring loss fraction of 1.5% with respect to the STC running conditions. But you have a specific tool for establishing and optimizing the ohmic losses (press "Detailed Calculation" button). This tool asks for the average length of wires for the string loops, and between the intermediate junction boxes and the inverter, and helps the determination of the wire sections.

NB: remember that the wiring loss behaves as the square of the current. Therefore operating at half power (500 W/m<sup>2</sup>) will lead to only a quarter of the relative loss. The effective loss during a given period will be given as a simulation result and shown on the loss diagram. It is usually of the order of 50-60% of the above specified relative loss when operation at MPP.

It is also possible to include losses between the output of the inverter and the injection point (energy counter). You have just to define the distance and the loss will also appear in the loss diagram.

In addition there is the option to include the losses due to an external transformer. If you select this option, you will get two radio buttons in the “AC circuit” frame, where you select if the AC losses to be accounted for are between the inverter and the transformer, or between the transformer and the injection point.

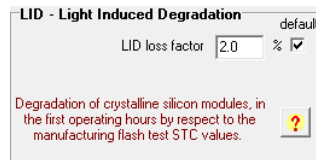
### Module quality loss

The aim of this parameter is to reflect the confidence that you put in the matching of your real module set performance, with respect to the manufacturer's specification. The default PVsyst value is half the lower tolerance of the modules.

The value that is specified in this field might not be exactly the same as the one shown in the "Array loss diagram". The reason for this is, that this parameter is defined with respect to the Standard Test Conditions (STC) while value in the diagram is given with respect to the previous energy.

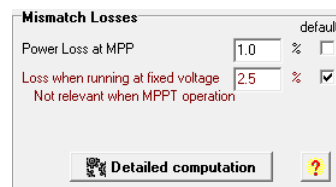
## LID – Light Induced Degradation

The light induced degradation happens in the first few hours of module operation. Typical values are around 2%, but you can define a different value in this field.

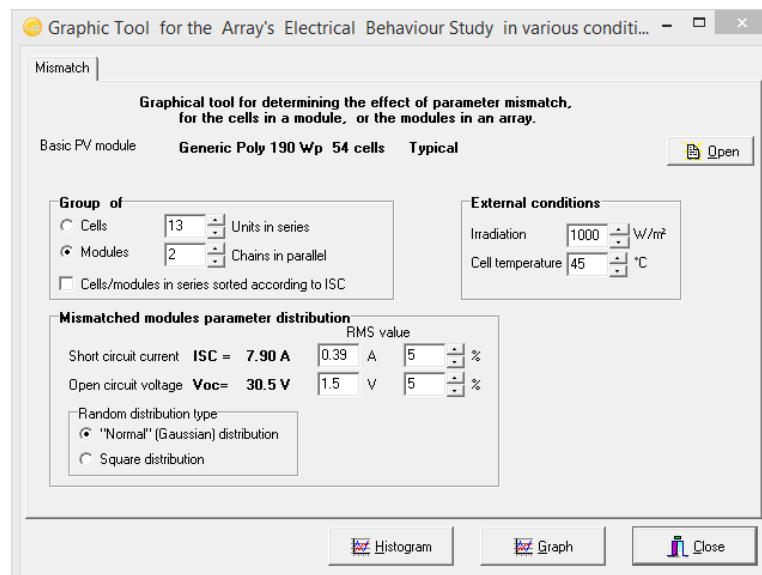


## Mismatch loss

Losses due to "mismatch" are related to the fact that the modules in an array do not have exactly the same I/V characteristics. In a string of PV modules, the worst module drives the string's current.



The button "Detailed computation" helps to understand this phenomenon, and gives indications on the loss parameter to be set for the simulation, according to your estimation of the inhomogeneity of the set of modules.

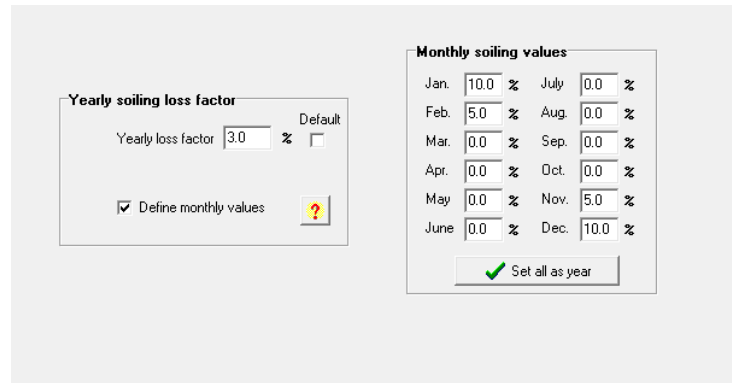


This parameter acts as a constant loss during the simulation. It is lower for thin film modules. It can become almost zero if the modules are well sorted according to their real performance (flash-test results provided by the manufacturer).

NB: There is probably a correlation between these last two parameters. The Module quality loss is rather related to the average of the module's distribution, while the mismatch refers to its width.

### Soiling loss

According to our experience, the soiling effect is almost negligible in middle-climate residential situations.

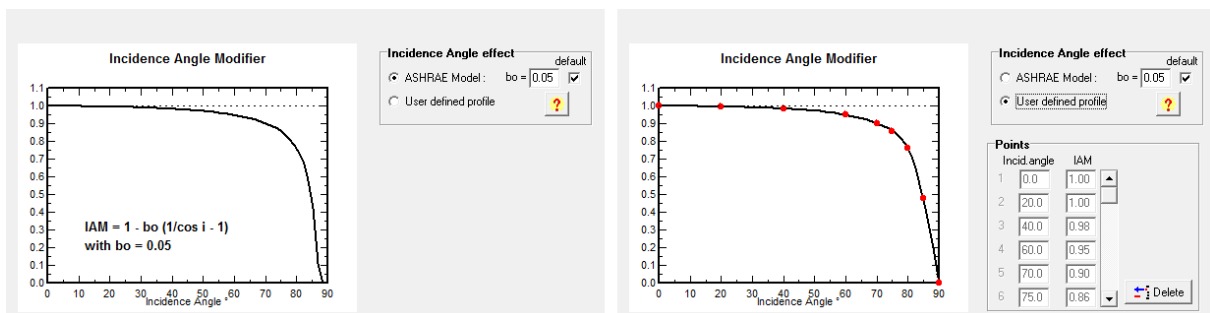


It may become significant in some industrial environments (for example near railway lines), or in desert climates. The soiling loss can be defined individually for each month to take into account periodical cleaning or rainy periods.

This parameter may also be used for describing the effect of snow covering the panels (for example put 50% in winter months with 15 days of snow coverage).

### IAM loss

The incidence loss (reflections due to the Fresnel's laws) is sufficiently well defined by a parameterization proposed by "Ashrae" (US standards office). You will in principle never have to modify this parameter. Nevertheless, you have also the possibility to define a custom curve described by a set of points. PVsyst will make an interpolation to generate values for all possible angles.



NB: Assuming an isotropic diffuse irradiance, the IAM factor on the diffuse part is computed by an integral over all space directions, which include important low-incidence contributions.

### Unavailability of the System

It is sometimes useful to foresee system failures or maintenance stops in the production expectations. You can define system unavailability as a fraction of time, or a number of days. As this is usually

unpredictable, you have the opportunity of defining specific periods of unavailability of the system, and also to create these periods in a random way. The effective energy loss is of course depending on the season and the weather during the unavailability periods. Therefore the unavailability loss has only a statistical meaning

**Unavailability of the system** default

Unavailability time fraction:  %

Unavailability duration:  days/yr

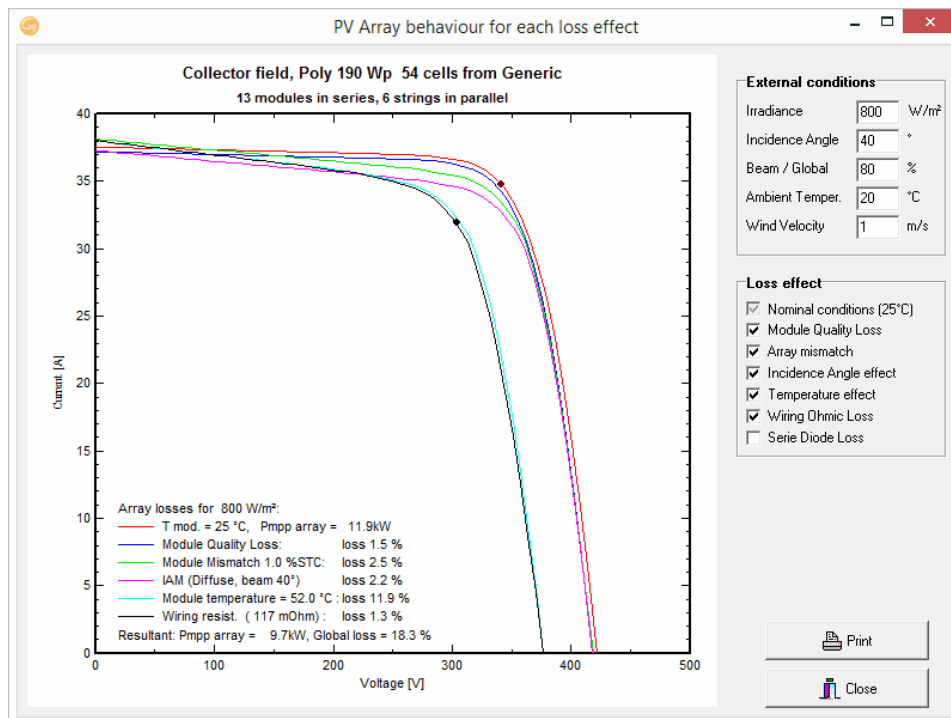
Number of periods:

**Unavailability periods**

Beginning Date / Hour	duration
30.01.2004 21:00	58 hour
09.06.2004 02:00	58 hour
07.07.2004 14:00	58 hour

### Losses graph

To visualize the impact that the losses have on the I/V-behavior of the array, you click on “Losses Graph” to get to the window “PV Array behavior for each loss effect”. In the top right field you can define the running conditions of the array. From the field below you select the kind of loss you want to display. The red curve gives the nominal conditions, which represent the upper limit of the system performance. For each selected loss you will get a curve in a different color.

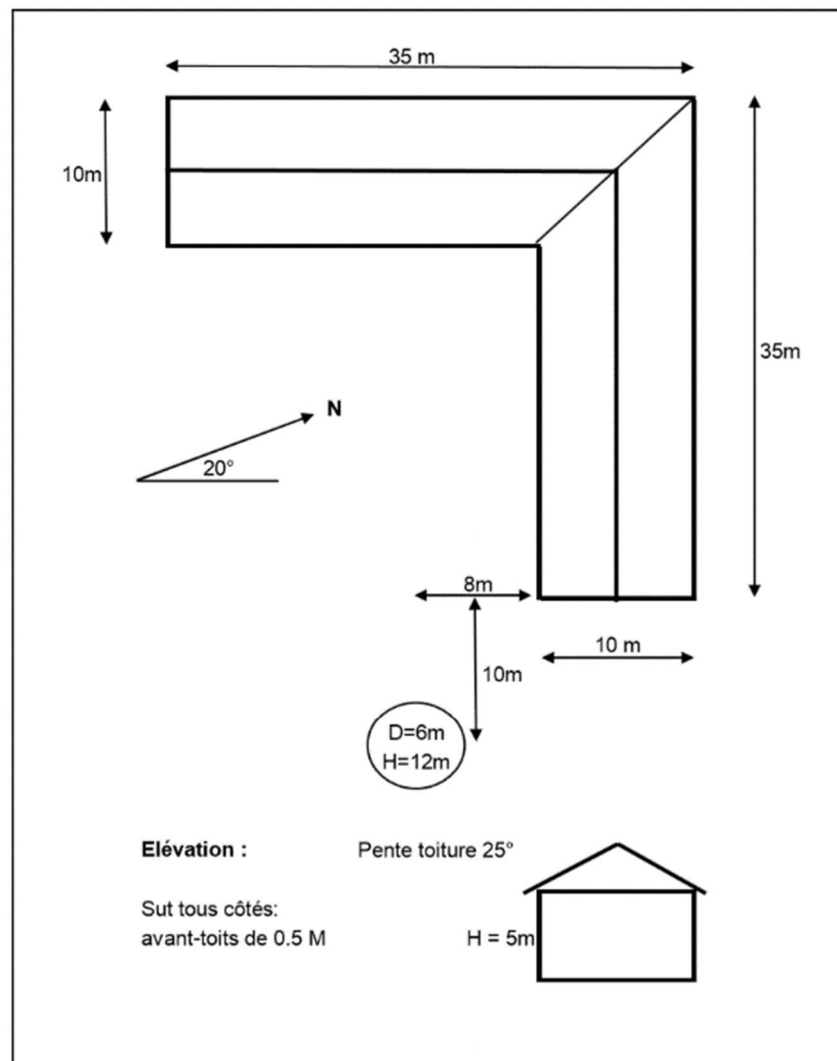


## Part 2: 3D Near Shadings Construction

The construction of the near shadings are a part of PVsyst that requires some time and exercise to be fully mastered and take advantage of all available options and features. Therefore we present here a complete example as an exercise to explain the main steps, and give tips and advices for an easier use of this tool.

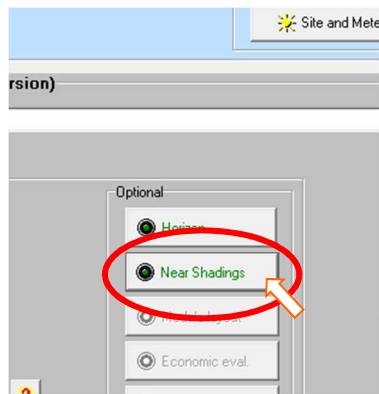
Presently it is not possible to import 3D shading scenes into PVsyst from other software packages like Autocad or SketchUp. The reason for this is, that the basic data structure in PVsyst is very different from standard CAD programs, and it is not straightforward to convert these formats in a fully automatic way. Work is ongoing to provide an import filter for the SketchUp format.

For the present example, we will create the farm that is used in the "DEMO Geneva" project that is distributed with every PVsyst installation. The starting point for the tutorial will be the following sketch:

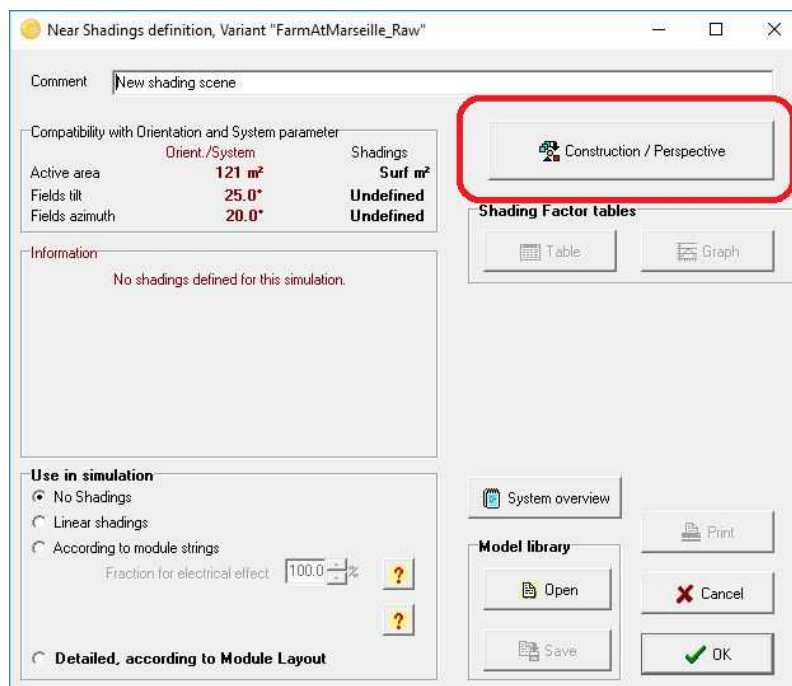


## 1- Defining the 3D scene:

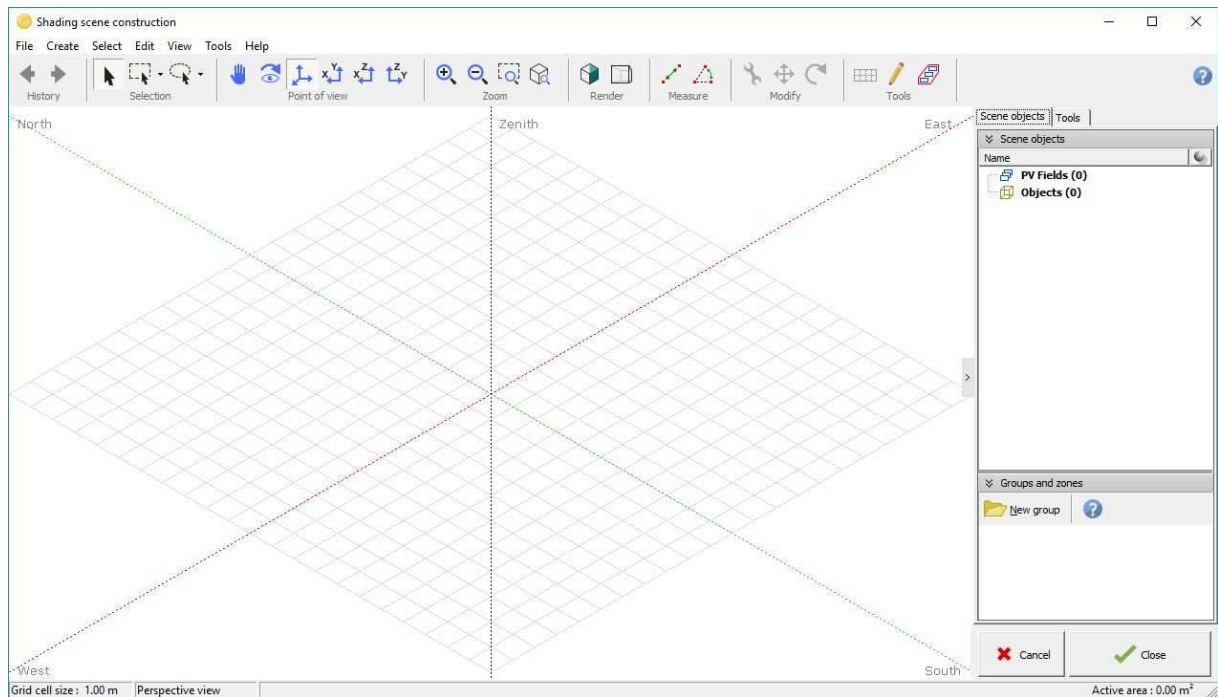
In the "Project Design" window click on the button "Near Shadings"



The "Near Shadings definition" dialog will open, and here you click on "Construction/Perspective".



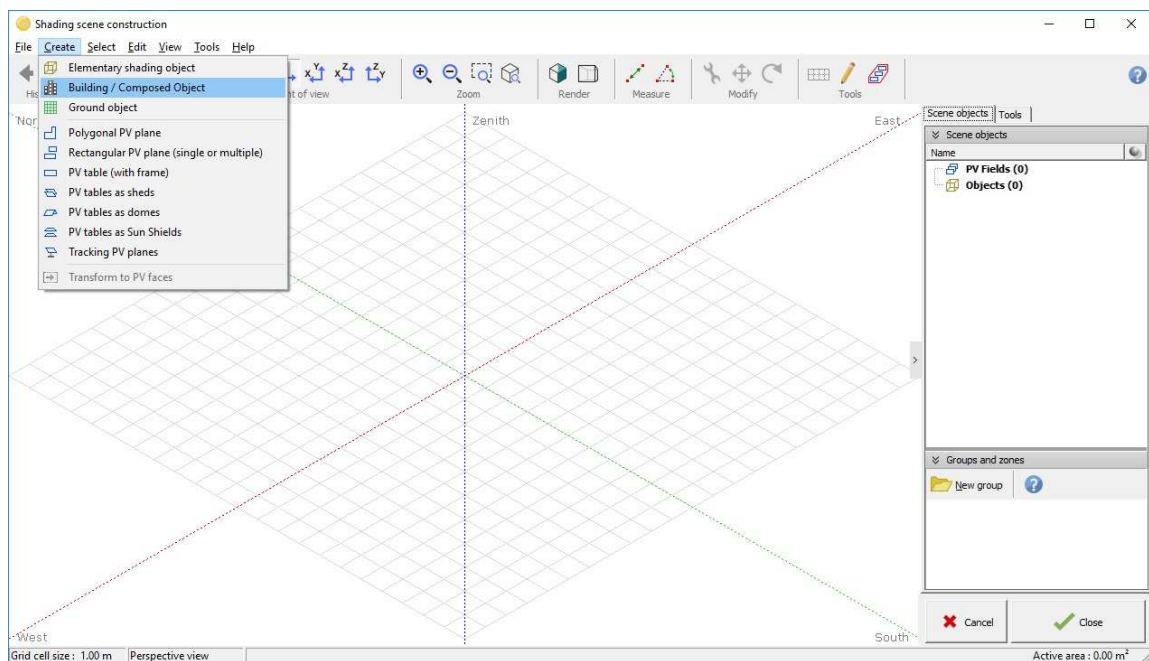
You obtain the main 3D window where you will construct the "scene".



### Constructing a building.

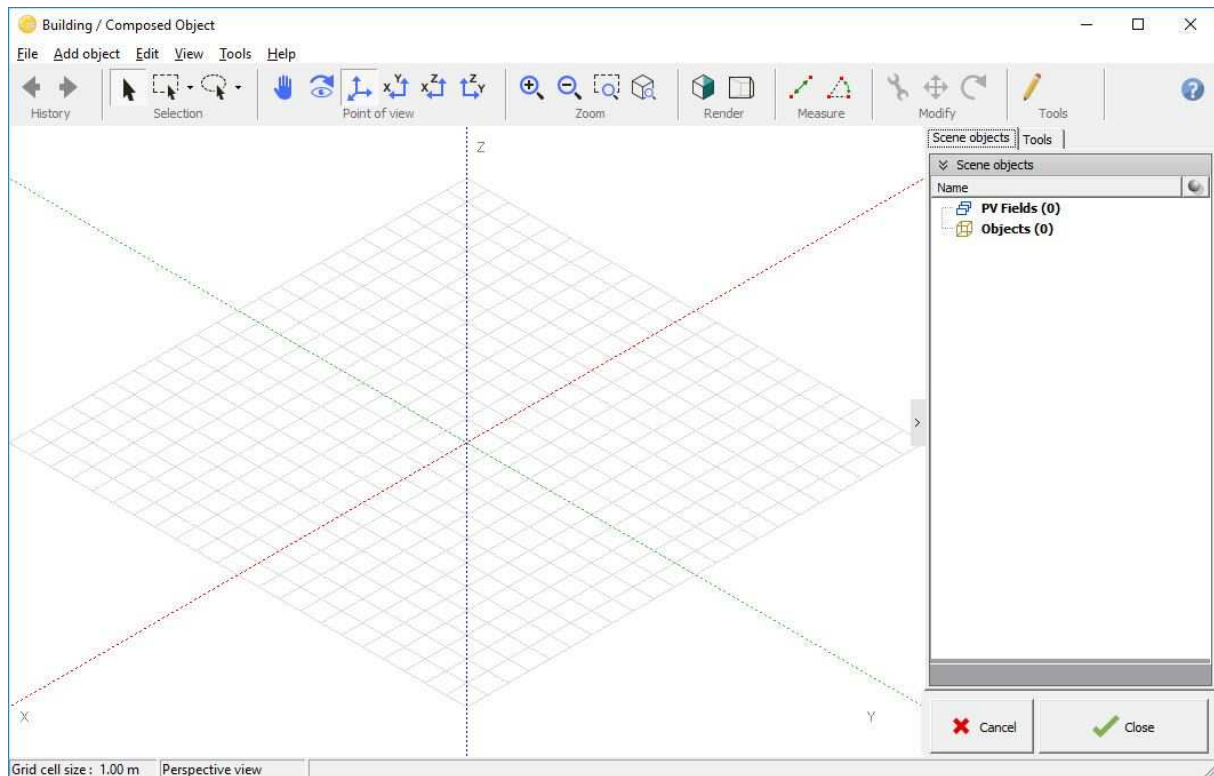
The building in our example will be an assembly of elementary objects that will be grouped afterwards and used as one single object in the main 3D scene.

From the menu, choose "Create" - "Building / Composed object"



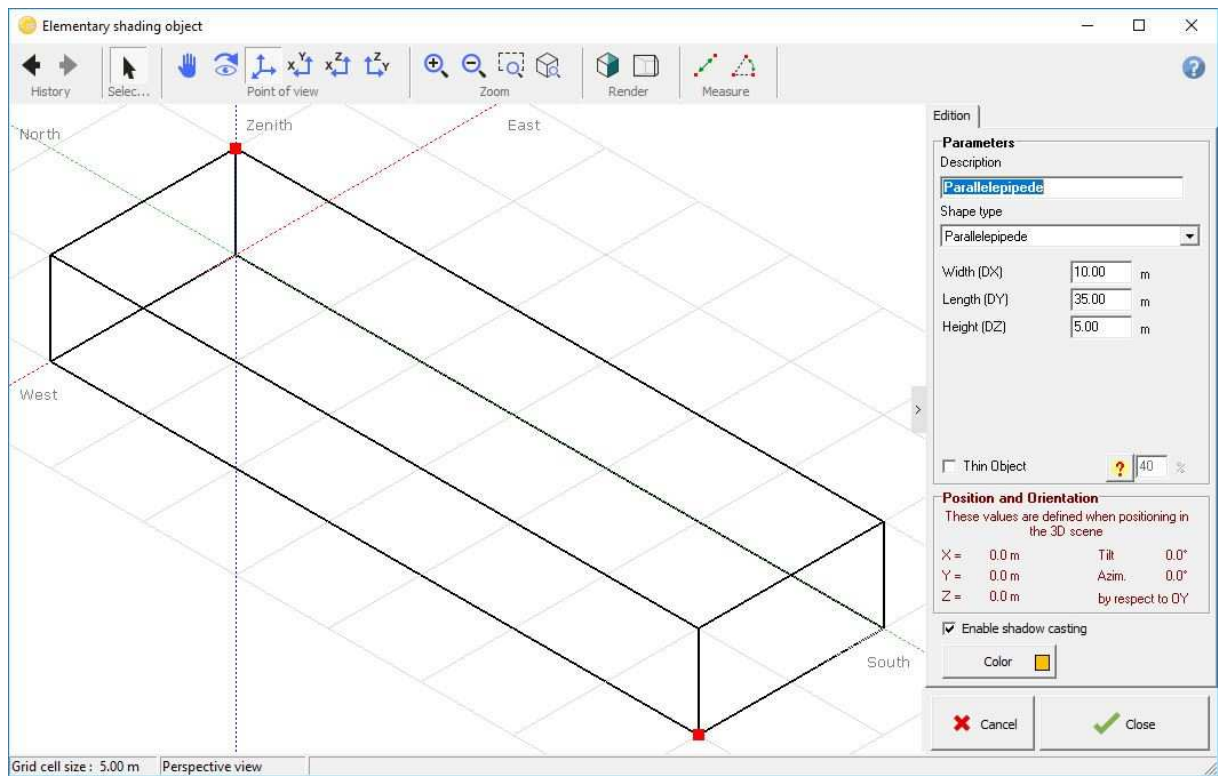


This will open a secondary 3D window in the reference coordinate system of the new building object.

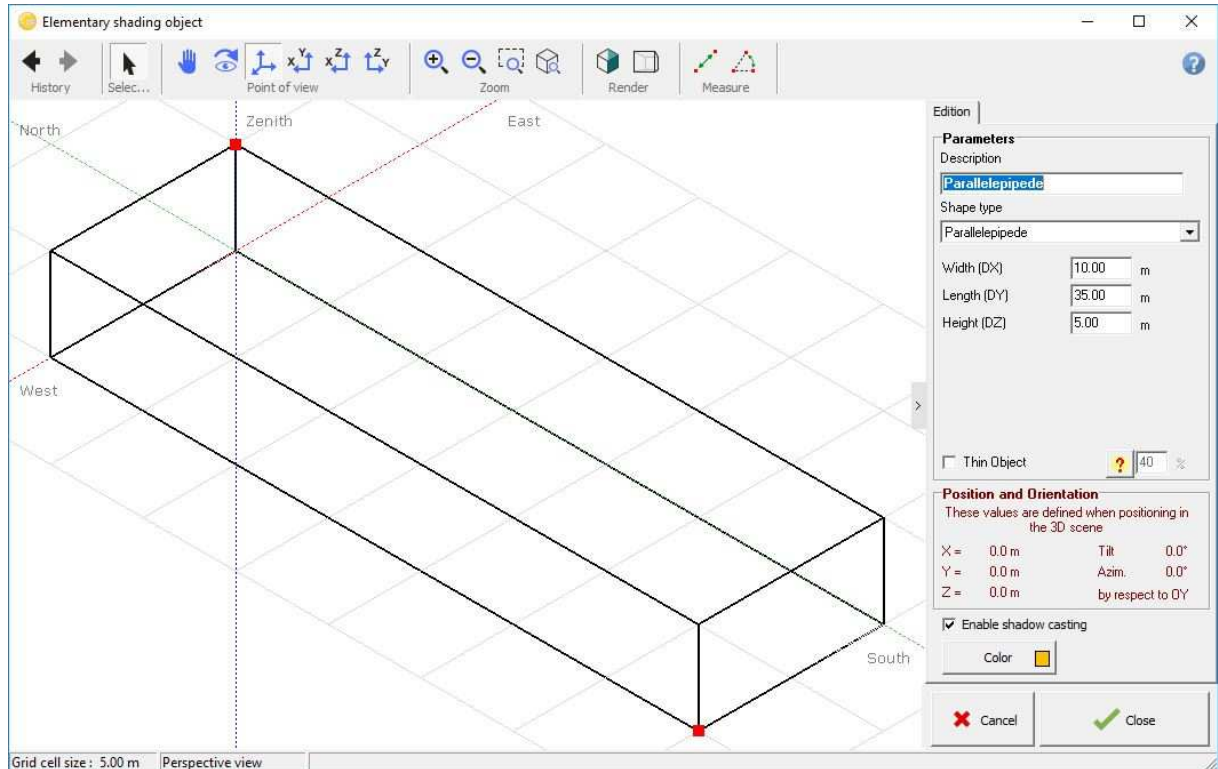


- From the menu, choose "Add Object". It will open a new window where you can choose the type of your object and its properties.

Here choose "Parallelepiped" and define the sizes (Width = 10m, Length = 35m, Height = 5m).

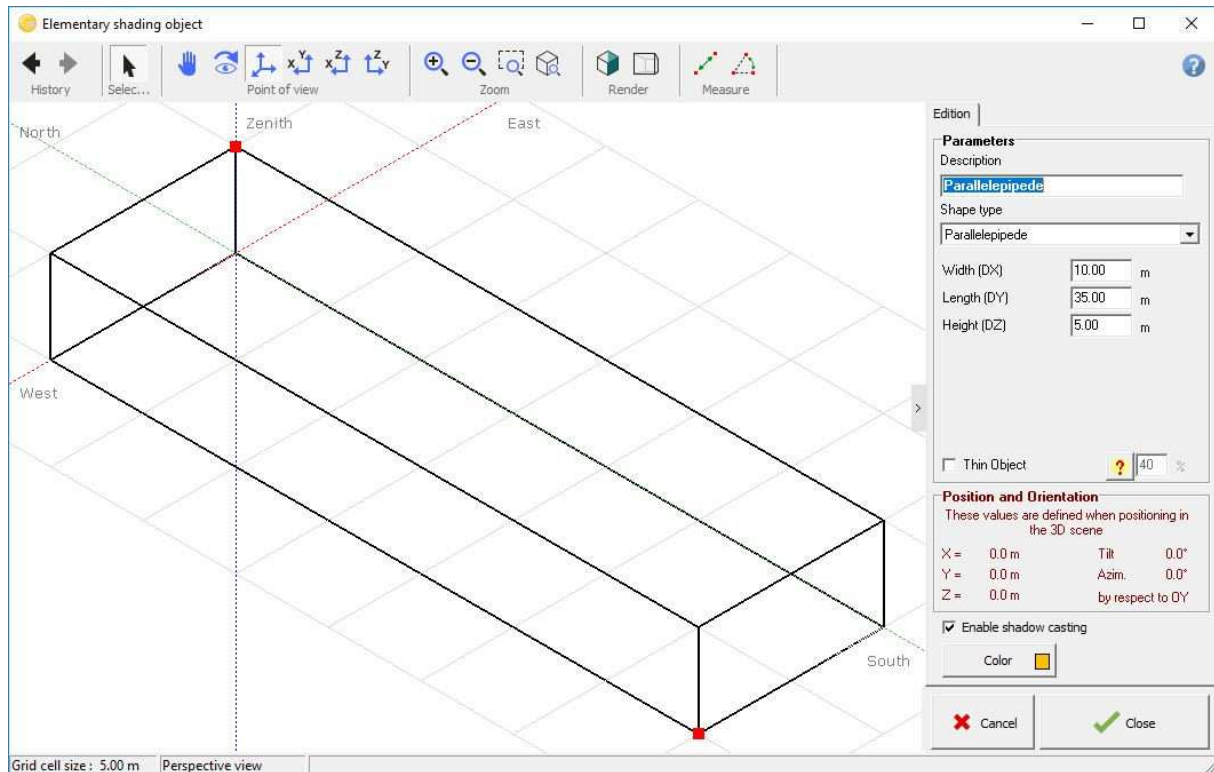


- Click "Close", this will place the parallelepiped in the coordinate system of the buildings' object



From the menu, choose again "Add Object".


Now choose "Parallelepiped" and define the sizes of the second wing of the farm (Width = 10m, Length = 25m, Height = 5m).  
Click "Close", this will place the parallelepiped in the coordinate system of the buildings' object, again positioned at the origin.

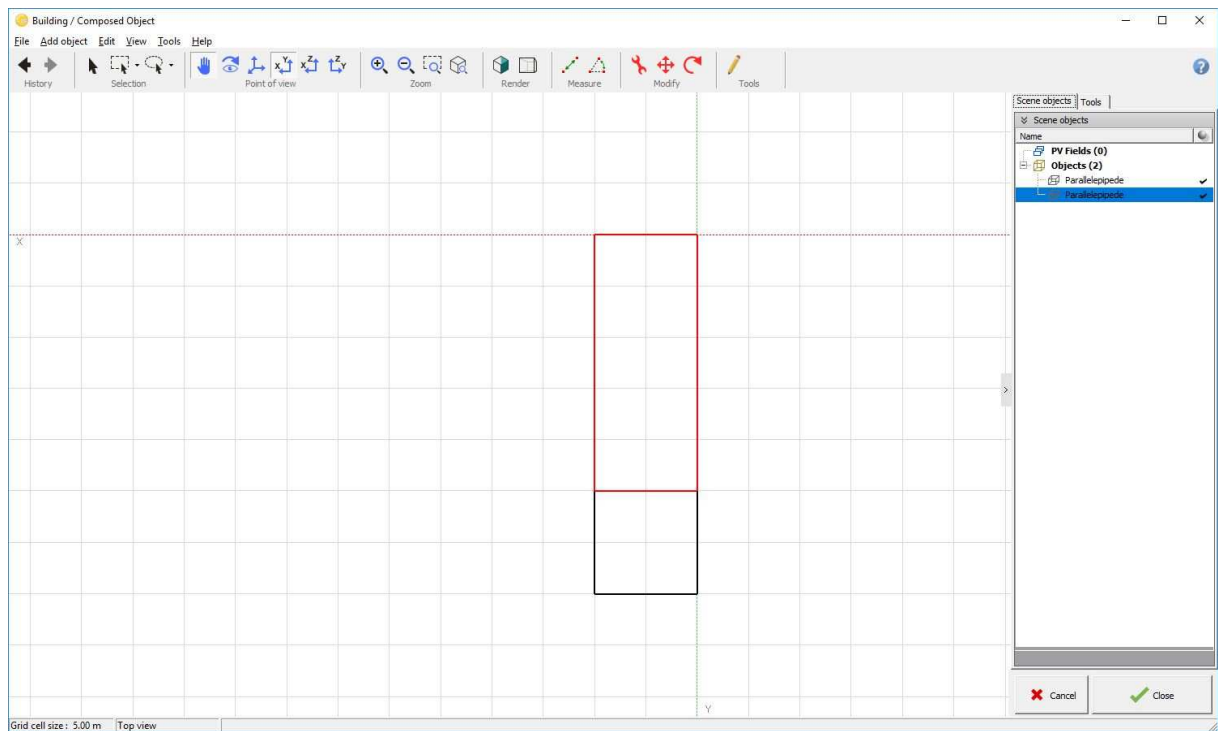




### *Positioning in the 3D scene*

You have now to position this second wing inside the buildings' object.

Please note that for selecting an object, you have to click on its borders (remember: the objects don't "know" their interior!). The selected object becomes carmine red.

Click the "Top View" button  (the five buttons top left are for the positioning of the observer).

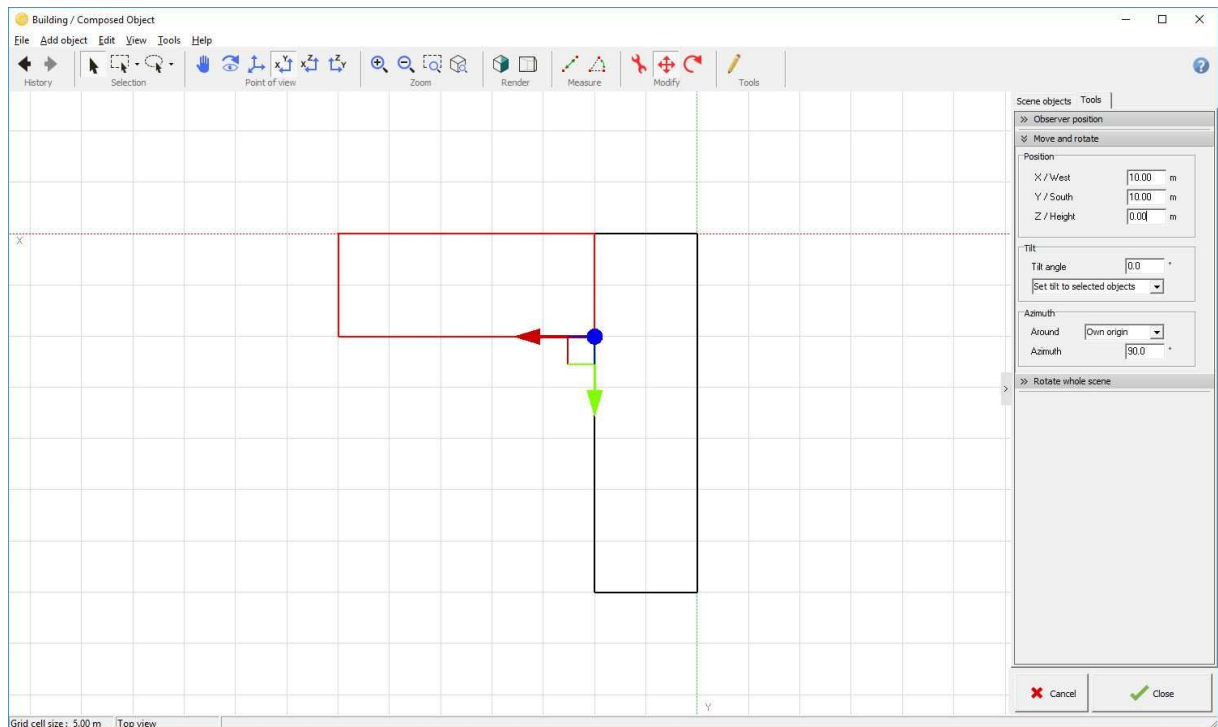


You can zoom in or out with the two "Zoom" buttons  .

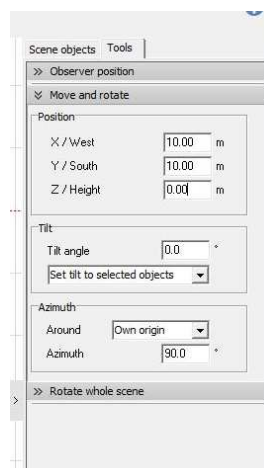
You can also re-center the scene, by clicking anywhere on the scene - but not on an object - and drag the scene's plane.

Click on the positioning tool button  to toggle the "Object positioning" panel.

Now, you can click and drag the red point and displace the selected object with the mouse, and the violet point for rotating it. Move and rotate the object coarsely to its place as second wing, perpendicular to the first parallelepiped.

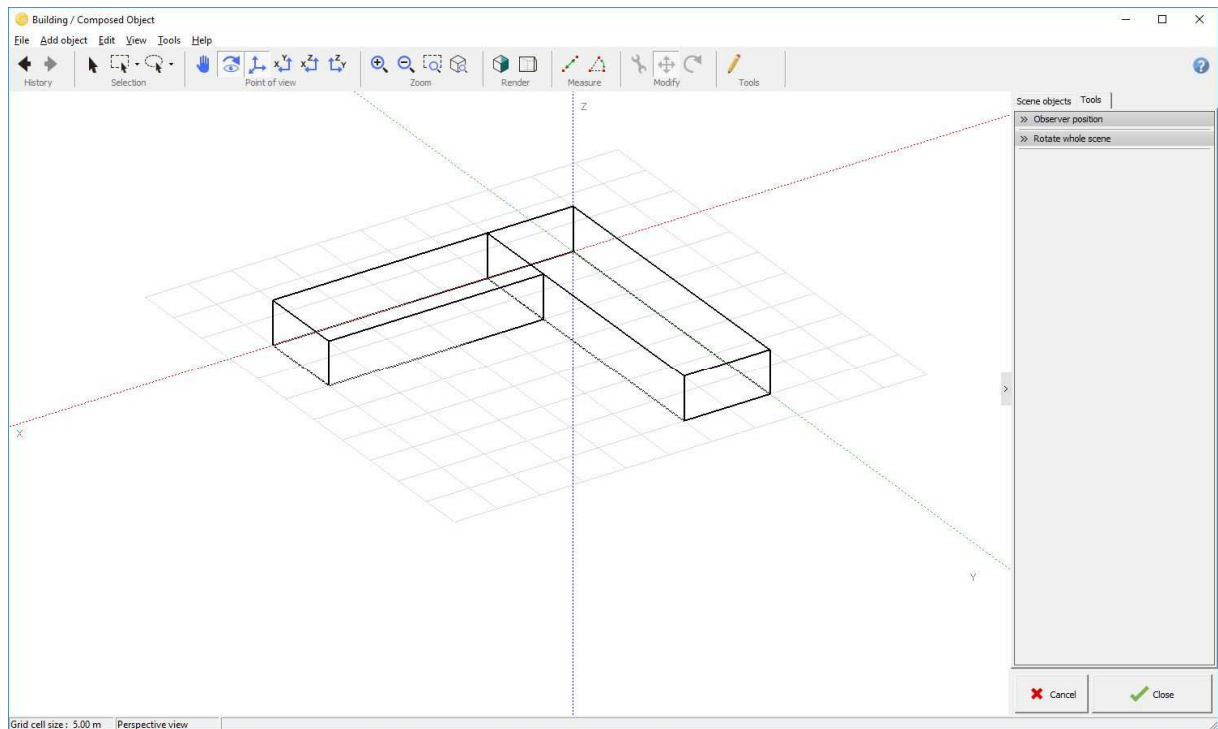


The mouse will not allow you to get precise positioning. But after the object has been placed coarsely, the “Object Positioning” dialog will display the approximate displacement and rotation, and now you can finely adjust the exact values according to the drawing. In our case you will put X = 10.00m, Y = 10.00m, and don't forget Azimuth = 90.0°



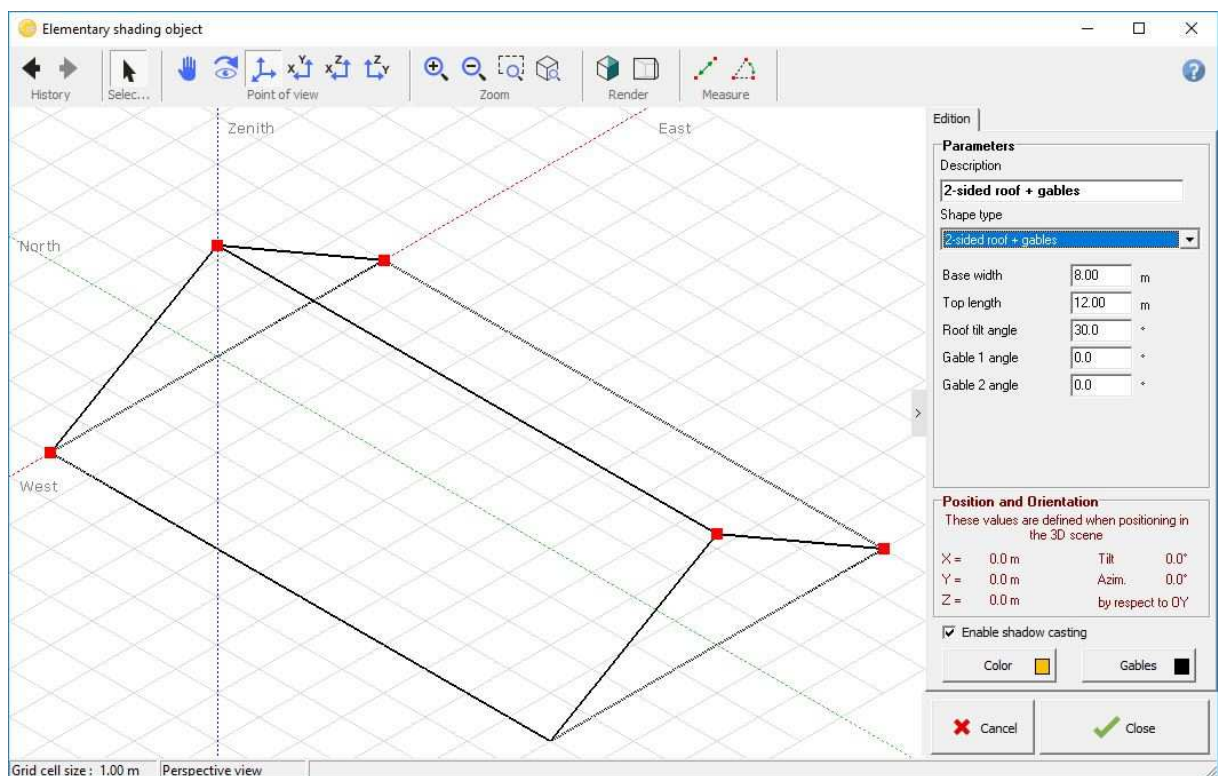
NB: Avoid the interpenetration of objects. This often creates problems for the calculation of the shades.

If you click on the 'Standard Perspective' button  or press F2, the building should now look like this:

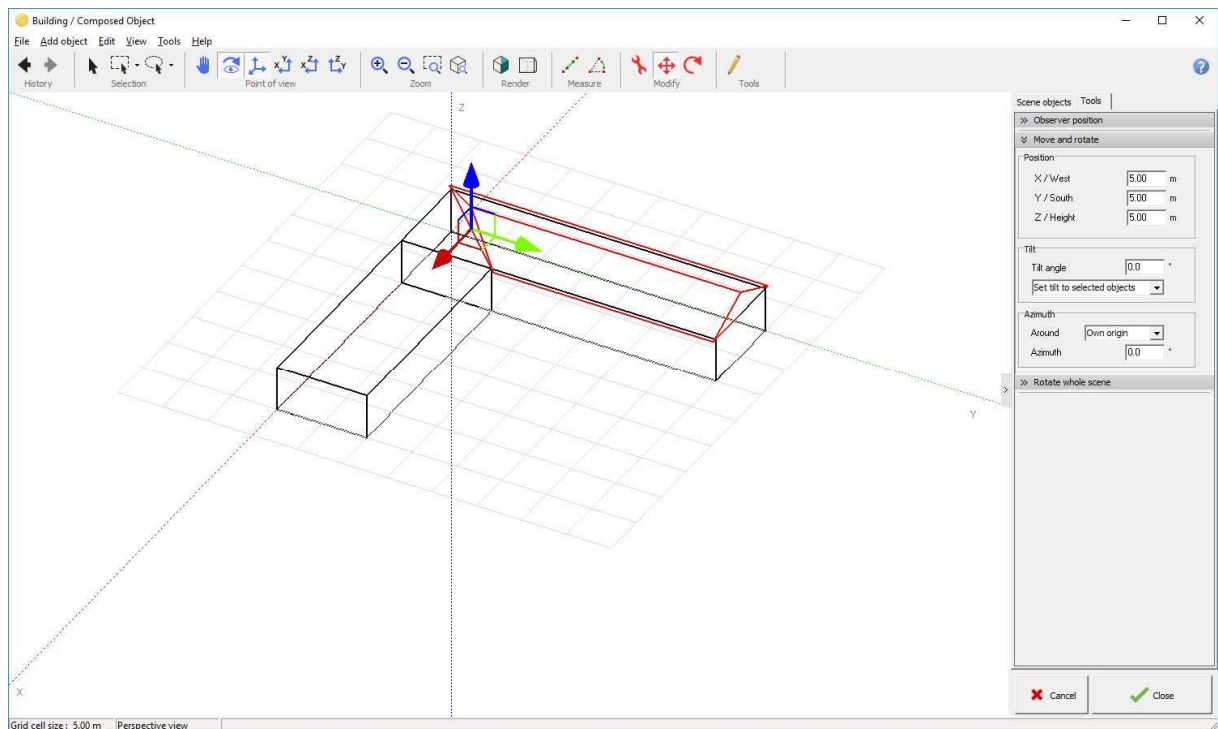


### Adding the roof.

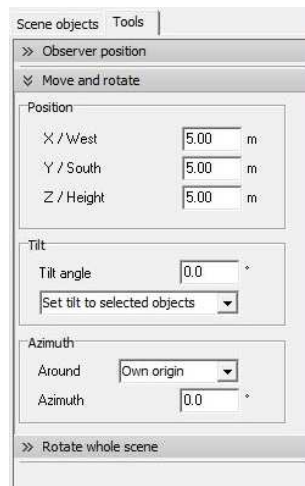
- Click on the menu "Add Object" and choose "Two-sided roof + Gables" in the new window.



- Define the sizes: "Base width" = 11m, "Top length" = 30.5 m (for eaves), "Roof tilt" = 25°, and "Gable 1 angle" = -45° and click "Close"



- This will put the roof in the buildings' scene. First position it with the mouse and then supply the exact values as before (X = 5m, Y = 5m, and Z = 5m, building height).

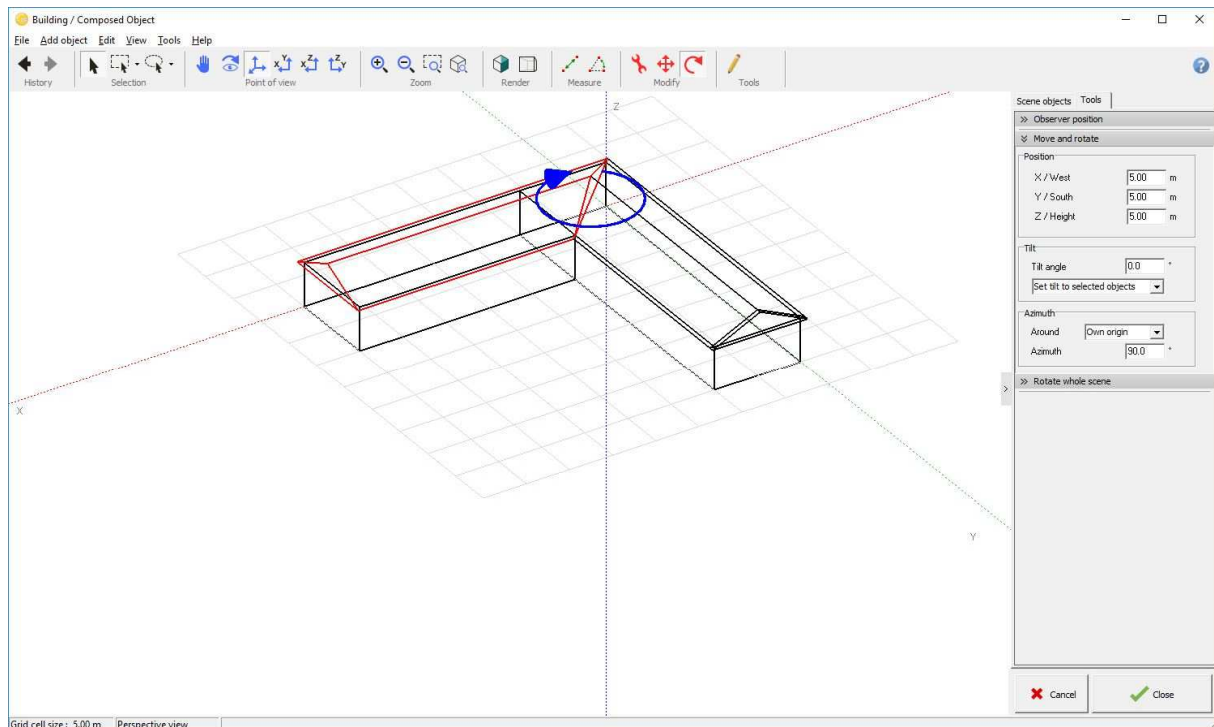


- For the second wing of the roof you could proceed in the same way. You can also reuse the roof you just created: "Edit" / "Copy", and "Edit" / "Paste". You will obtain a second instance of the selected object.

- Position this object using again first the mouse and then entering the exact values in the "Object Positioning" dialog (make sure that the new azimuth is exactly 90°).

Now the 45° cut gable is still not correct. For modifying the selected object, you can:

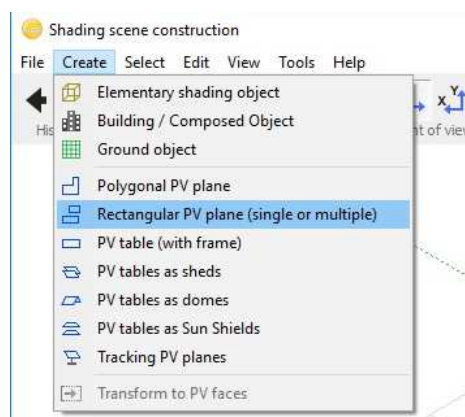
- Either choose "Elementary Object" / "Modify",
- Or, more easily, double-click the object on its border.
- Change -45° to +45° and click Close.



### Adding the PV plane

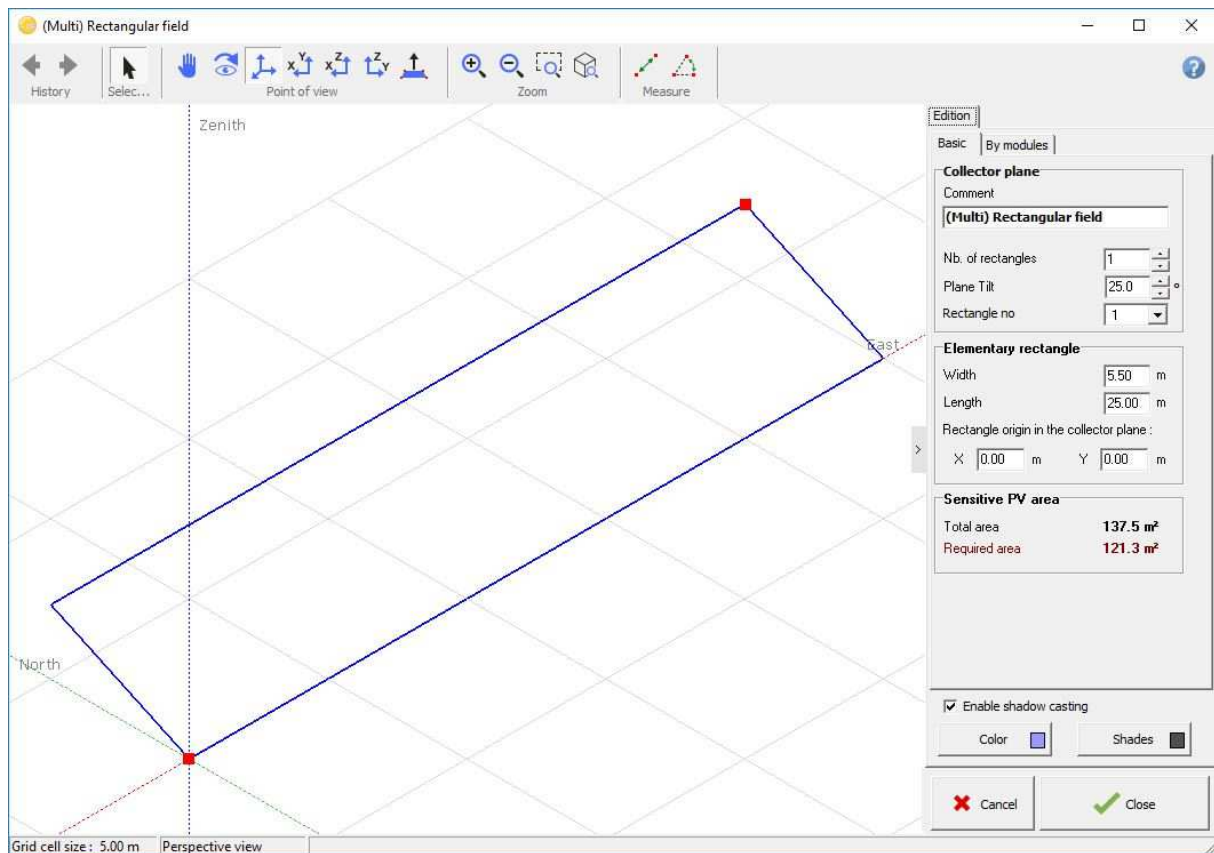
PV planes cannot be integrated in building objects, as the PV planes elements (sensitive areas) are treated differently by the program. They have to be positioned on the buildings within the main 3D scene.

- In the main 3D scene, choose: "Object" / "New..." / "Rectangular PV plane".



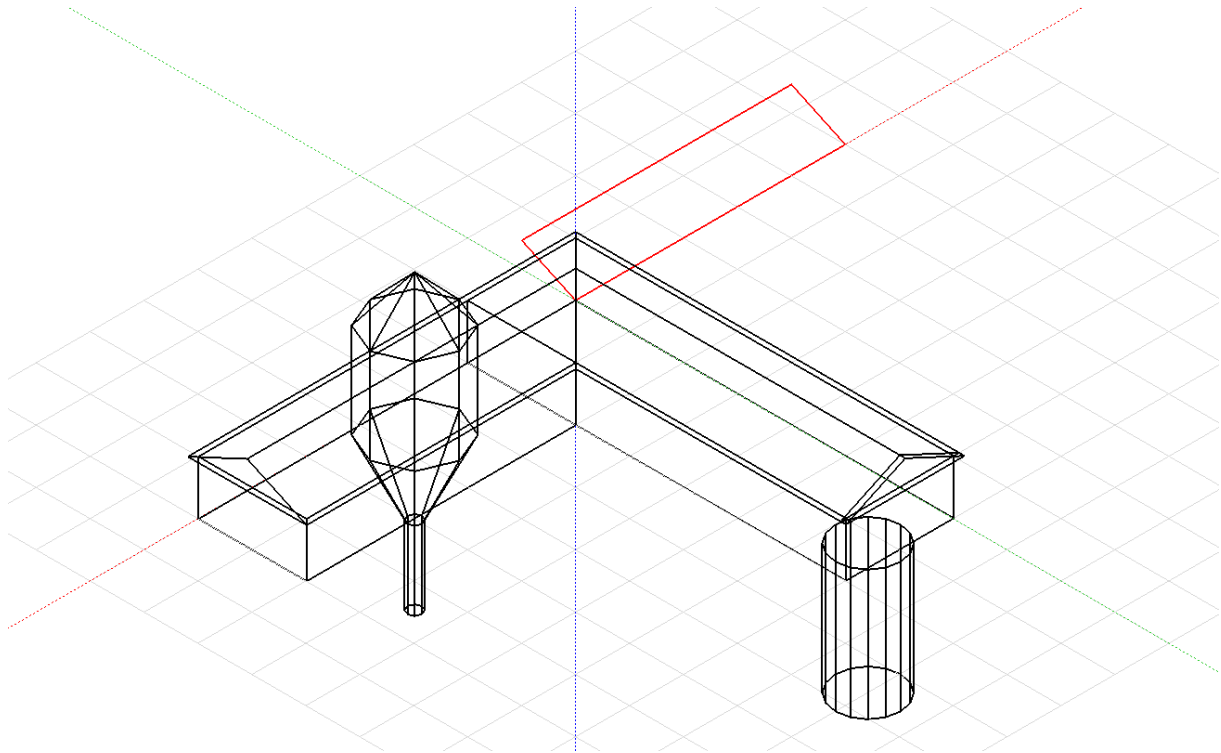



- You have to define the sizes: "Nb of rectangles" = 1 (you could define several non-interpenetrating rectangles in the same plane), "Tilt" = 25°, «Width" = 5.5 m, «Length" = 25 m.





NB: At this stage, there is no relation with the real size of the PV modules in your system definition. The program will just check at the end of the 3D construction that the PV sensitive area in the scene is larger than the area of the PV modules defined in "System". No check is made to verify that the panels can be arranged such that they fit into the sensitive area in the 3D scene. The detailed arrangement of the modules has to be defined in the "Module Layout" part of the project. Please refer to the online help for instructions.

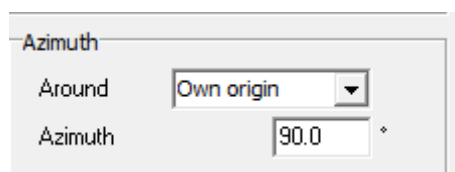
- Click "OK". The plane will be aligned to the origin of the 3D scene.




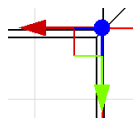
- For positioning it, again click "Top view" , position it globally with the mouse. Now you don't have rigorous references and you don't need to adjust the values, but be careful not to interpenetrate the other roof! Check the azimuth value (should be exactly 90°).

Use Rotate and move buttons to position the PV Plane 

First rotate the plane and have it parallel to the roof axis using the rotate button  or the azimuth

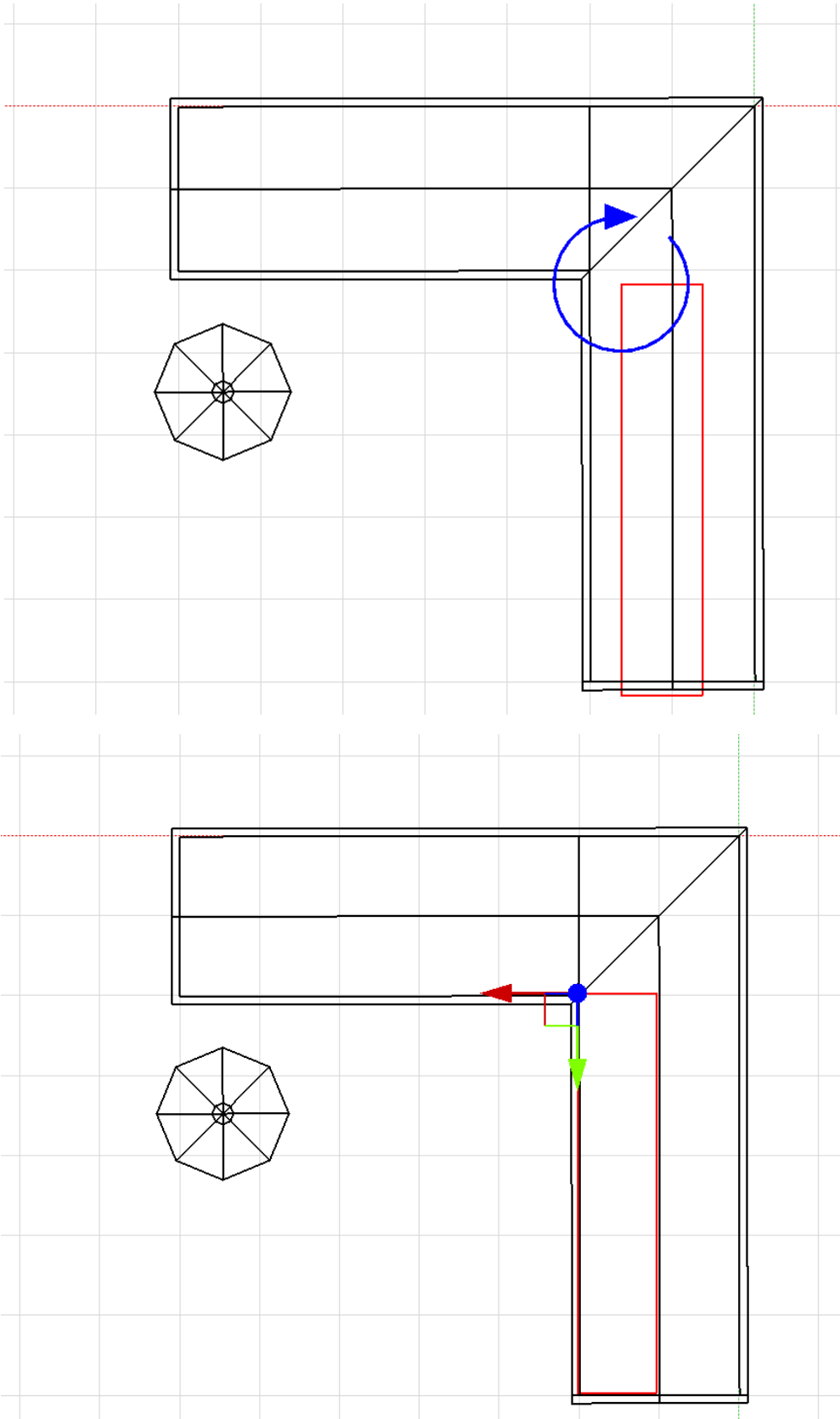



Then click the move button  and slide by dragging the green and red arrows to position correctly.




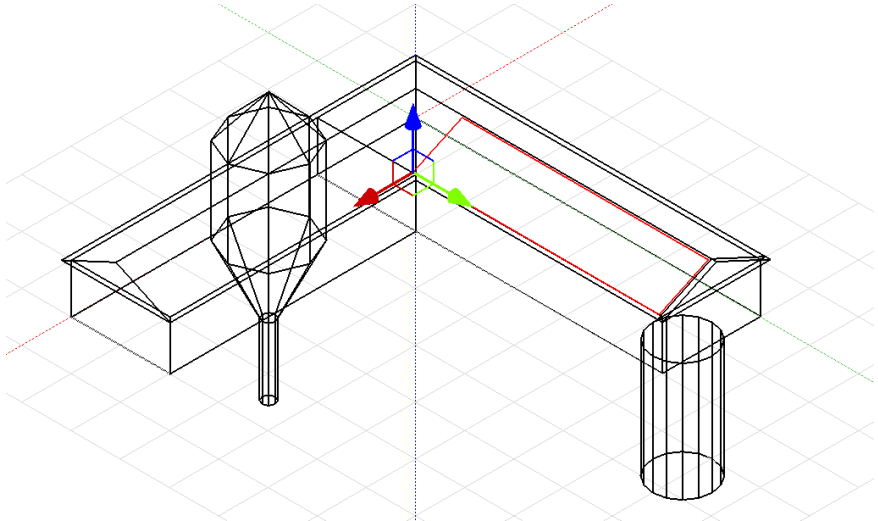
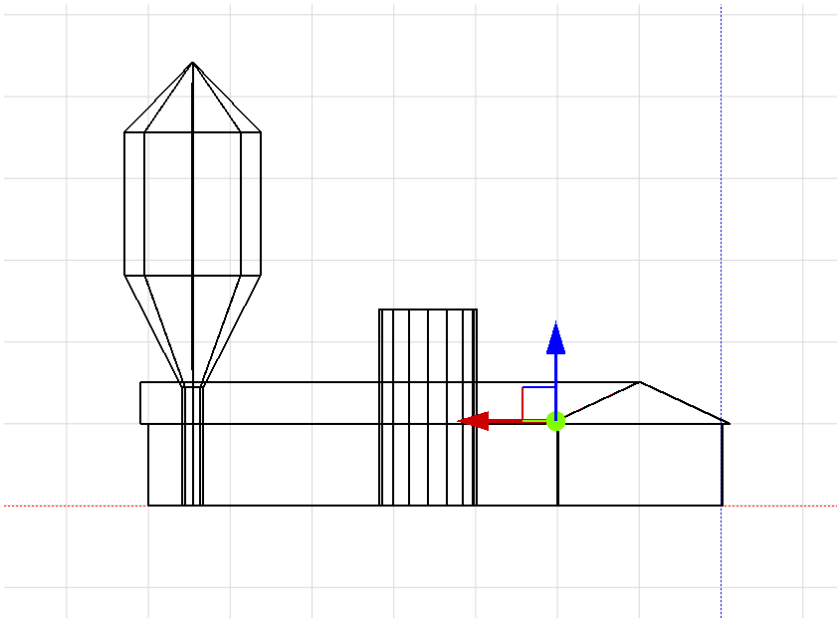
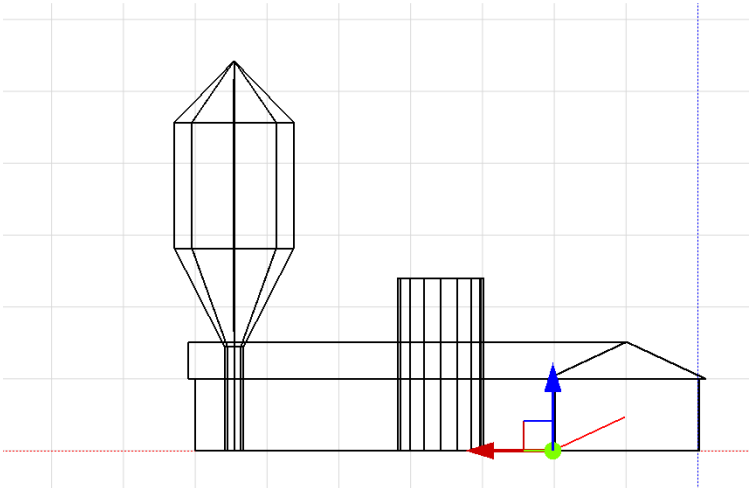
When hovering the different arrows, they will change to yellow color and indicate along which axis you'll be moving





- Vertical positioning: now your field is on the ground. Click the observer's "Front View"  button, and position your plane on the roof by dragging the red arrow with the mouse along Z Axis (vertically blue arrow below). Always remember to let some spacing between any active area and other objects (minimum 2 cm). If you put the plane below the roof, it will be permanently shaded!

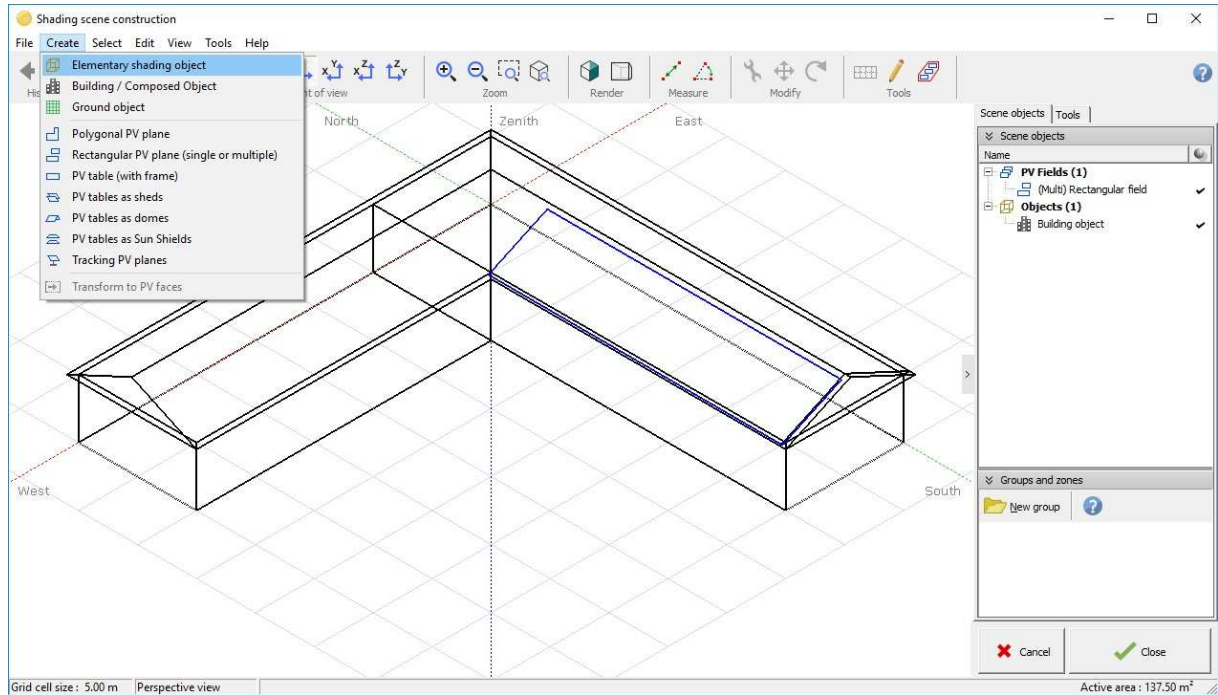
- You can then check the position using the 3D button 





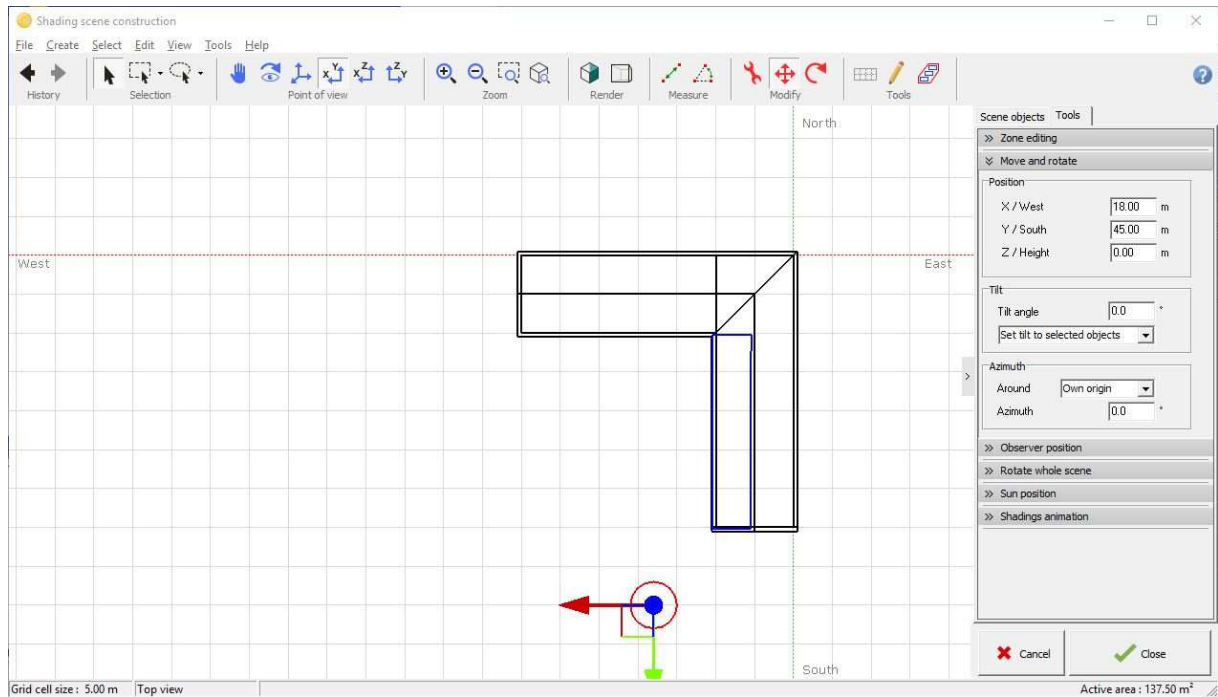
## Adding more shading objects

In our example we will now add a silo and a tree to the scene. These are “Elementary shading objects” that will be positioned directly inside the main 3D scene.

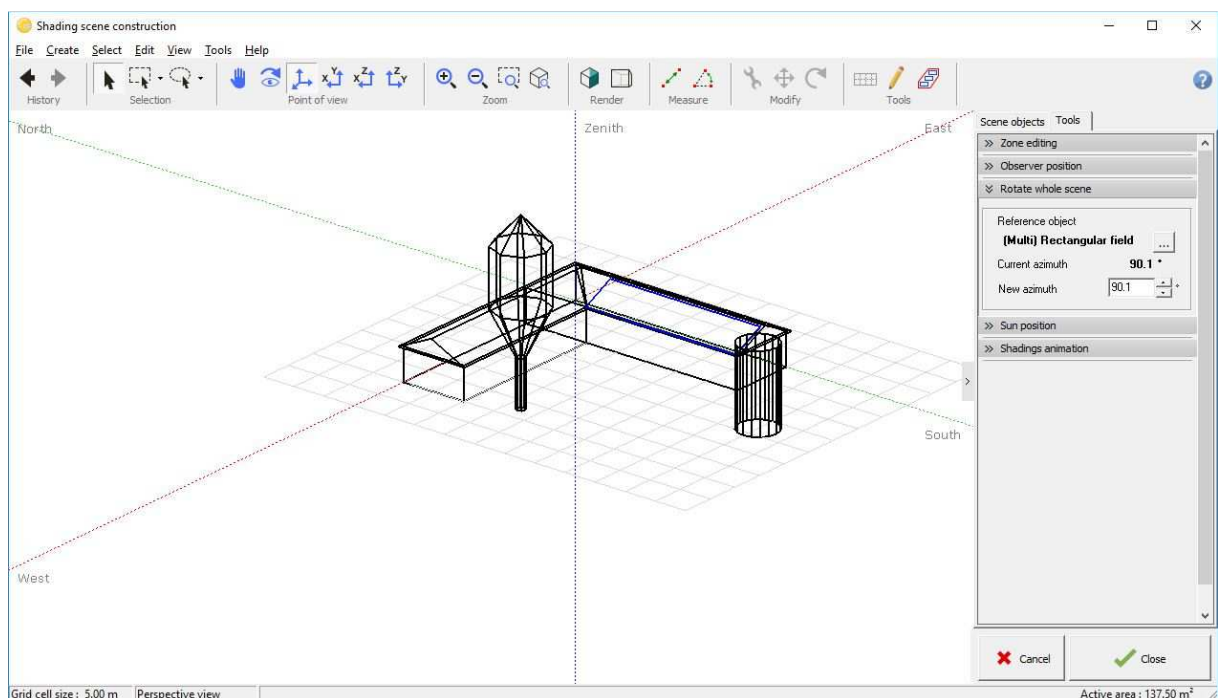
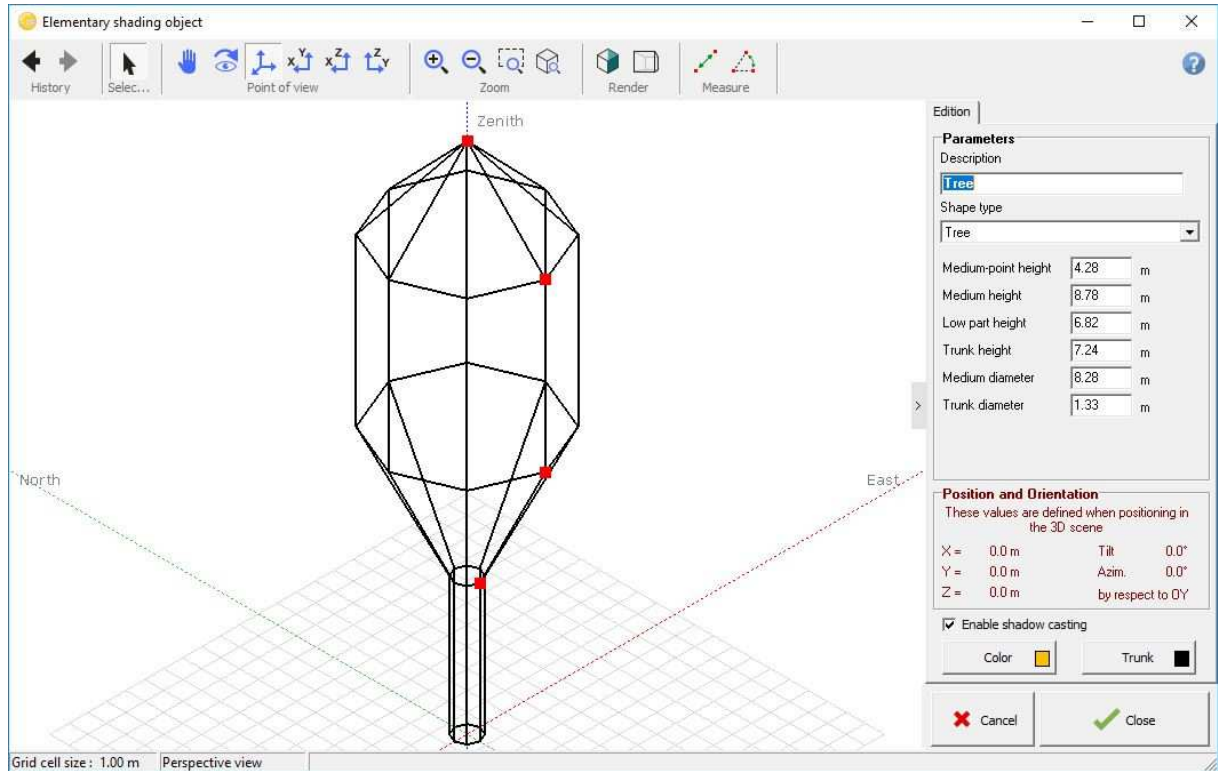
- In the main scene select "Object" / "New..." / "Elementary shading object" / "Portion of cylinder". According to the drawing, define Radius = 3m, Aperture angle = 360°, Nb of segments = 16, Height = 12m. Click "OK".




- In the main scene, be sure that the "Positioning" tool  is activated, click "Top view"  and position the silo with the mouse (if you don't know the order of magnitude or signs), and then with values (X = 18m, Y = 45 m).



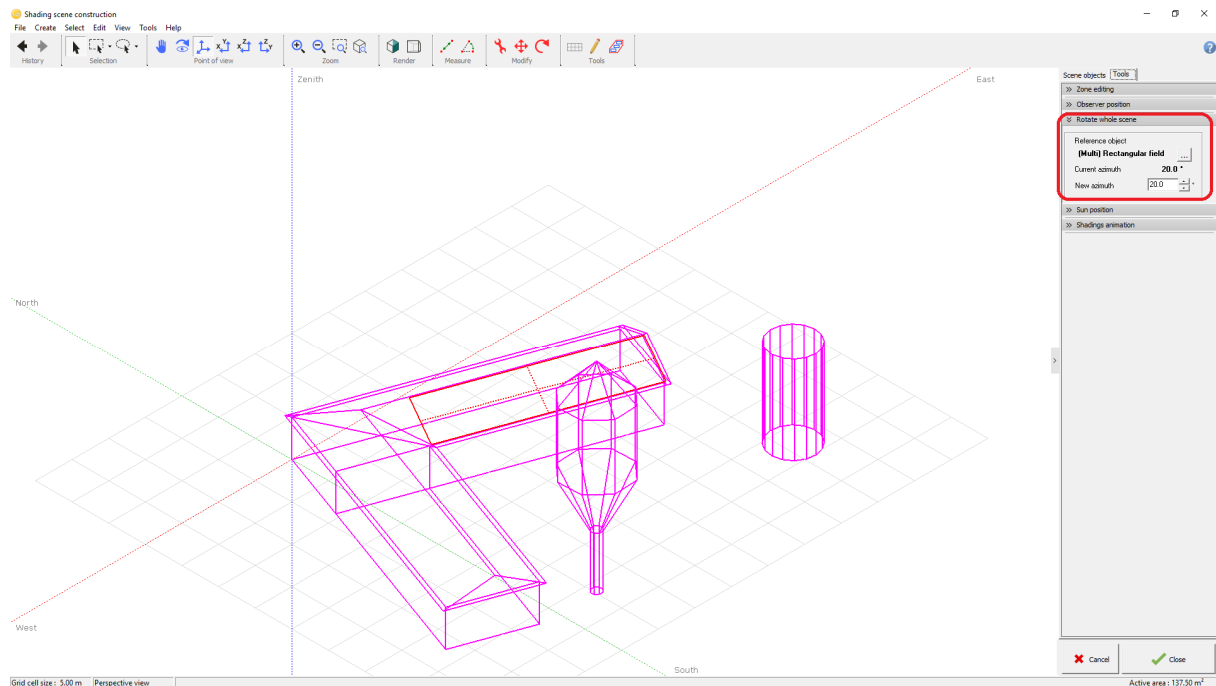
- You can now add a tree in the courtyard by selecting "Object" / "New..." / "Elementary shading object" / "Tree". To define shape and size of the tree, select "Front view" from the toolbar, and then click on the red points with the mouse and drag them to adjust shape and size of the tree. When you are done, position the tree to your like in the courtyard (always remember for your future projects, that a tree does not have a definitive size, the shading may vary as the tree grows or is pruned!).



## Positioning with respect to the cardinal direction

Usually you construct a scene first in the reference coordinate system that is used in the drawings, and that has been chosen by the architect. After that, the button "Rotate whole scene"  will allow you to perform the final rotation of the global scene to fit the real orientation of the installation with respect to the cardinal direction.

- Select the reference object for the orientation (normally the PV plane).
- In the "Rotate Whole Scene" dialog, define the new azimuth (here +20°, west). This will rotate the whole scene by 20° towards west.

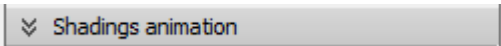


If later on you need to re-position or add a new object in the scene, it might be easiest to rotate back to the original coordinate system. To do this, select an object which is aligned with the coordinate system in which you would like to work and put a value of 0° or 90° into the "Rotate whole scene" dialog. Perform the modifications and then apply the reverse rotation.

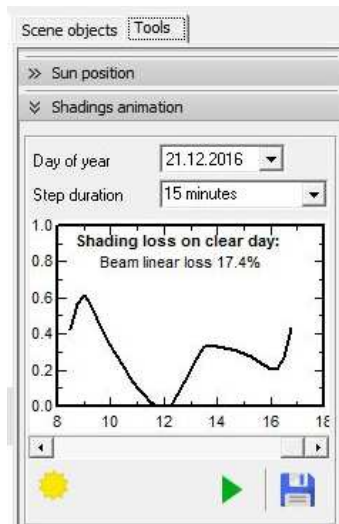
## Shading test and animation

Now that the 3D scene holds all the potential obstacles and the sensitive panel area, we are ready for a first shading analysis.

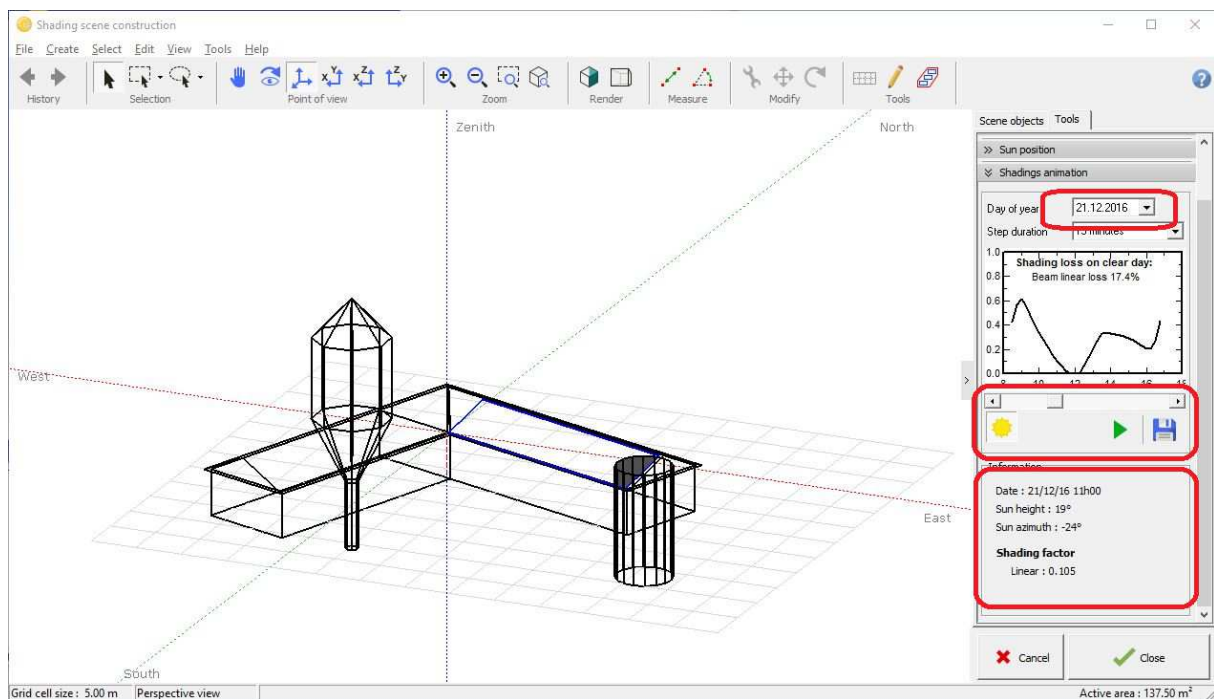
- Click Tools on the left pane and choose Shadings animation sub panel.

 The "Shadow animation" tool will expand and here you click on "Play/Record animation". The shadows will be shown for the whole selected day. After execution you have a scrollbar for reviewing one or the other situation.

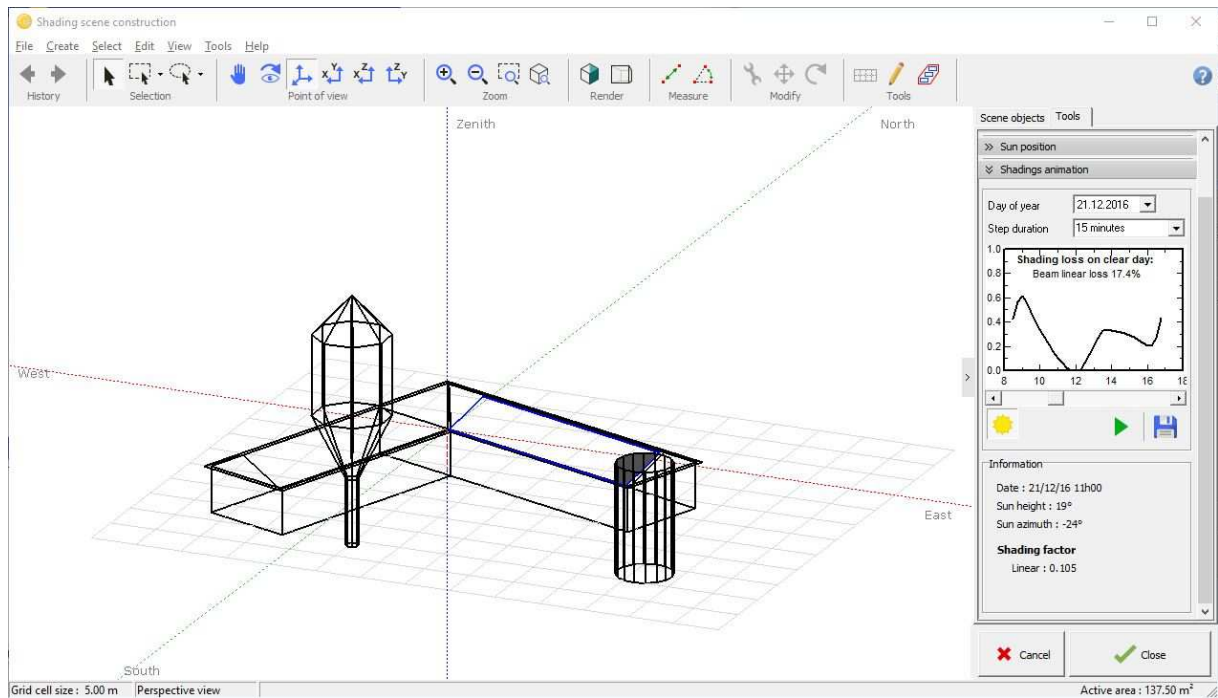




For each time step, the date/hour, sun position and shading factor are displayed on the bottom of the 3D window. You can try this for different dates in the year, the two extreme situations being June 21st and December 21st.



If there is some shade that you don't understand well, you can click the button "View from the sun direction" ☀️ from the toolbar on top. The animation will now be shown from the sun's perspective. In this way you will immediately understand which object casts which shadow.

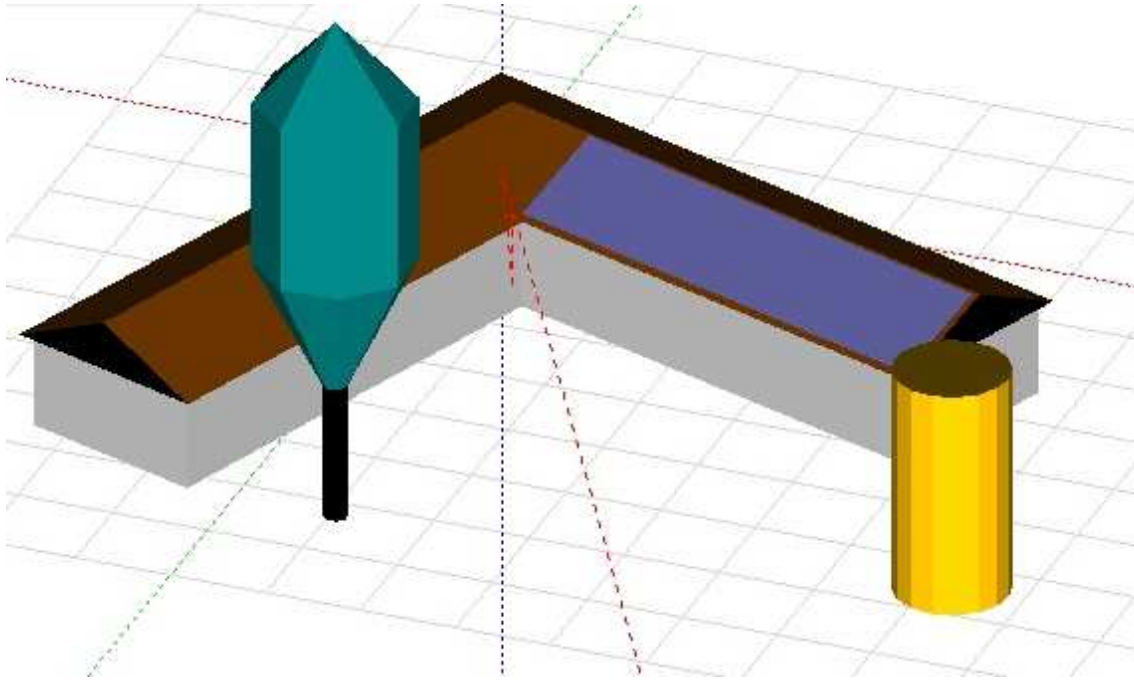


## More Options

### Colors


You can personalize the view of your scene by defining colors.

- Click the button "Realistic / technical view" on the "render" toolbar 🏠.
- The color of each element can be defined in its definition dialog.
- For example for the building: Double-click the building, this will open the building construction.
- Double-click the roof, this will open the definition dialog for the roof.
- In this dialog you can define the color of the roof, and the color of the gables independently of each other.

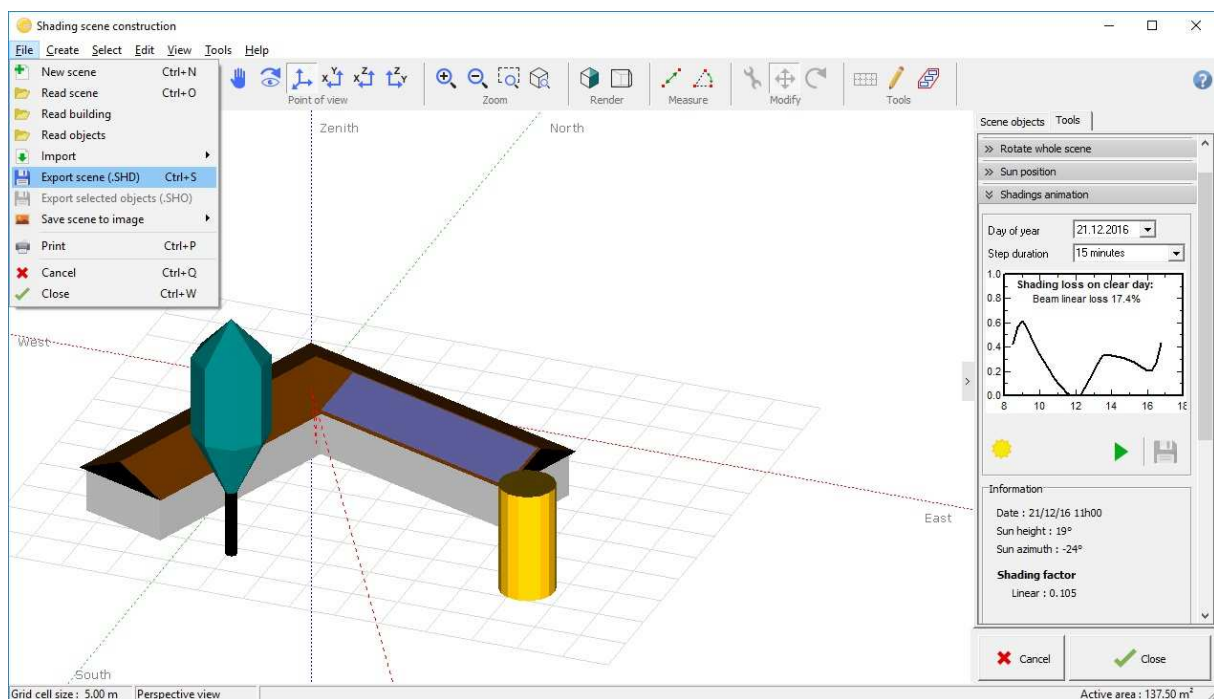


- Please note that the colors are defined "at bright sun". You should choose them rather light.
- If you define your own colors, store them as "personalized color" in order that you can reuse them for other similar objects.

### Saving the scene

If you do some bad manipulation, you can undo it with the "Undo" button  from the top toolbar.

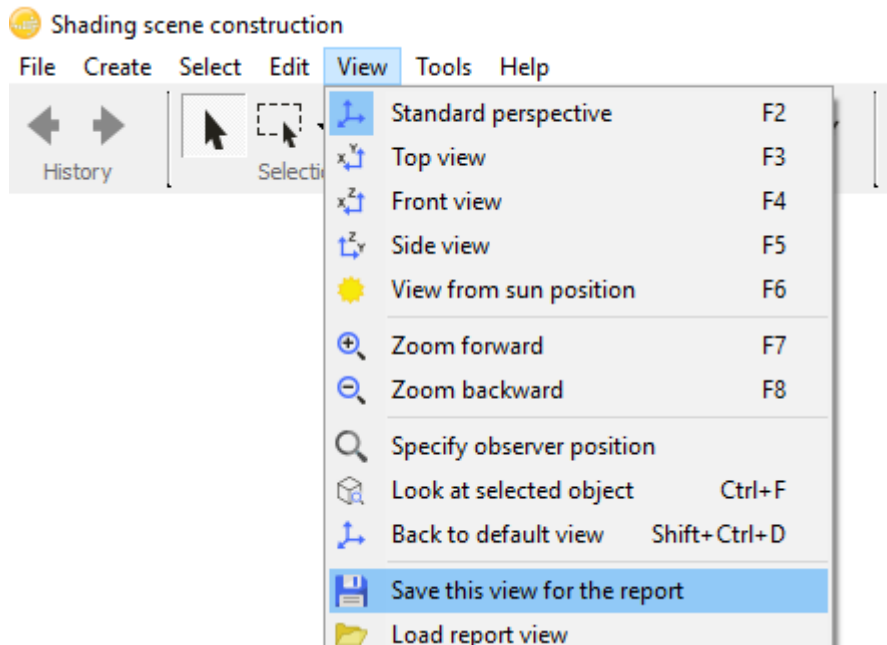
You are advised to periodically save your shading scene using "File" / "Export scene" as a \*.shd file. This will allow you to roll back in case you made an unwanted modification and avoid losing your work in case of a crash (Alas there still remain some bugs in PVsyst).



Please note: your final scene (used in the simulation) will be stored along with your "MyProject.VCi" file. It does not need an \*.SHD file.

### *Display in report*

This scene will appear on the final report. If you want to have a specific view of the scene in the report, you can request it by "View" / "Save this view for the report".

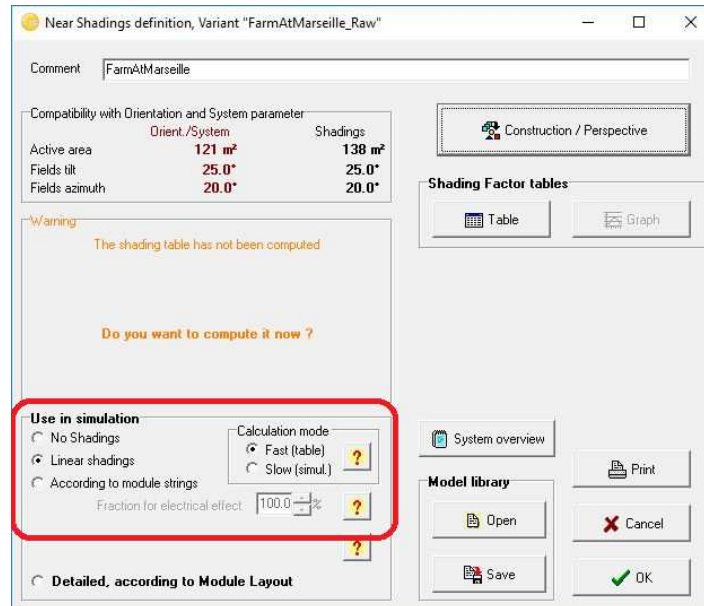


## 2- Use the 3D scene in the simulation

### Linear Shadings

Your shading scene is now ready for the simulation.

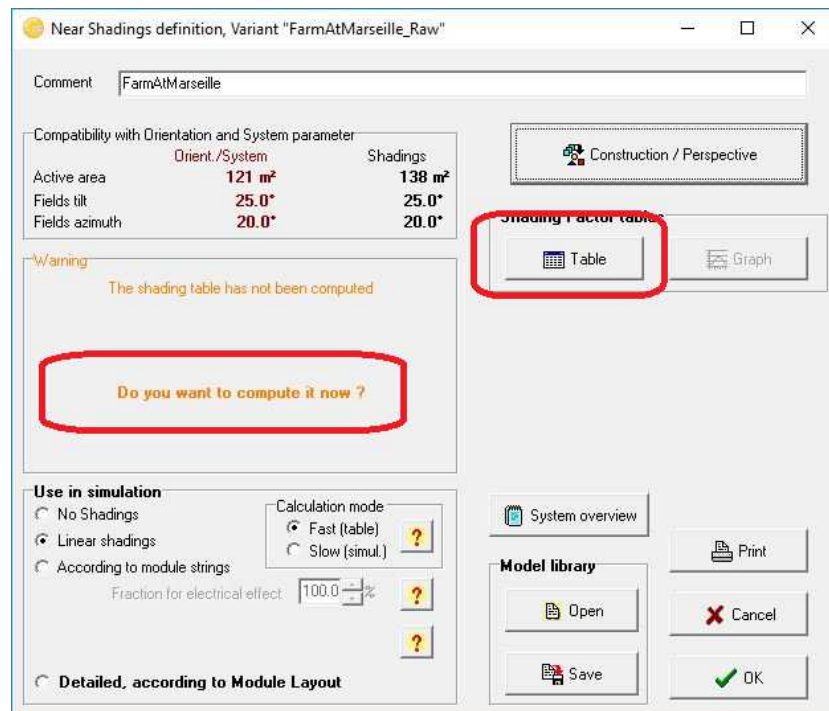
- Choose "File" / "Close". You return in the near shadings dialog.
- Choose "Linear shadings" in the box "Use in simulation".



Now the program checks the compatibility of your 3D scene with the other definitions of your system.

- The plane orientation should match the one defined in the "Orientation" part. If it does not, there is a button to correct the "Orientation" parameters according to the 3D construction.
- The sensitive area should be large enough to position the PV modules defined in the system definitions. This is a rough test, which checks only the total area and does not take into account the individual sizes and geometrical positions of the modules. A warning will be issued if the total area of the panels exceeds the total sensitive area of the 3D scene. If the total area of the panels is much smaller than the sensitive area defined in the 3D scene, there will also be a warning. The threshold for this warning is much higher (factor of 1.5) to allow spacing between the PV panels. The thresholds for both warnings are defined in the "Hidden Parameters" and can be modified if necessary.

- When everything is correct, the program will ask you to compute the Table of the shading factors. Click on the "Table" button.



Project: Farm at Marseille.PRJ, FarmAtMarseille

Status: Table computed with success [Recompute]

Plane orientation: Fixed Tilted Plane Tilt = 25°, Azimut = 20°

Shading factor table (linear), for the beam component

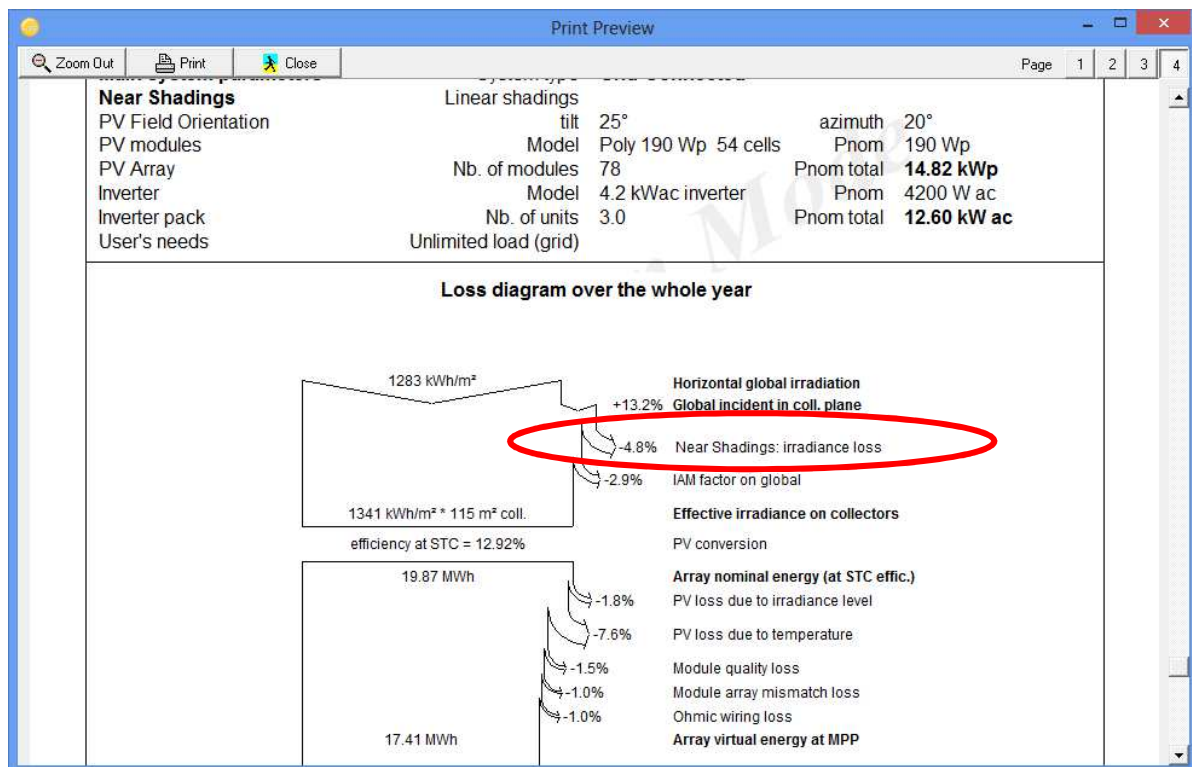
Azimuth	-180°	-160°	-140°	-120°	-100°	-80°	-60°	-40°	-20°	0°	20°	40°	60°	80°	100°	120°	140°	160°	180°	
Height																				
90°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.092	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.003	0.095	0.330	0.324	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.146	0.064	0.096	0.328	0.331	0.096	0.001	0.005	0.005	0.001	0.000	0.000	0.000
10°	Behind	Behind	Behind	0.000	0.000	0.000	0.040	0.452	0.107	0.033	0.195	0.210	0.061	0.075	0.101	0.101	0.002	0.000	Behind	Behind
2°	Behind	Behind	Behind	Behind	Behind	0.000	0.040	0.464	0.107	0.000	0.065	0.232	0.507	0.715	0.751	0.197	Behind	Behind	Behind	Behind

Shading factor for diffuse: 0.046 and for albedo: 0.218

The table is a calculation of the shading factor (shaded fraction of the sensitive area, 0 = no shadings, 1 = fully shaded), for all positions on the sky hemisphere "seen" by the PV plane. It allows the calculation of the shading factor for the diffuse and albedo (which are integrals of this shading factor over a spherical segment). For each hourly value, the simulation process will interpolate this table - according to the sun position - to evaluate the current shading factor of the beam component.

This also allows the construction of the iso-shadings graph, which gives a synthetic view of the times of the day and seasons where the shadings are particularly problematic. The 1% line for example, shows all the sun positions (or time in the year) for which the shading loss is 1%, i.e. the limit of shadings.

Clicking "OK" will incorporate the shading effects in the next simulation. In the final loss diagram on the report, there will be a specific loss for the "Near shadings". This loss reflects the fact that a fraction of the sensitive area will be shaded at certain times of the day and year.




### Electrical effect: partition in module strings

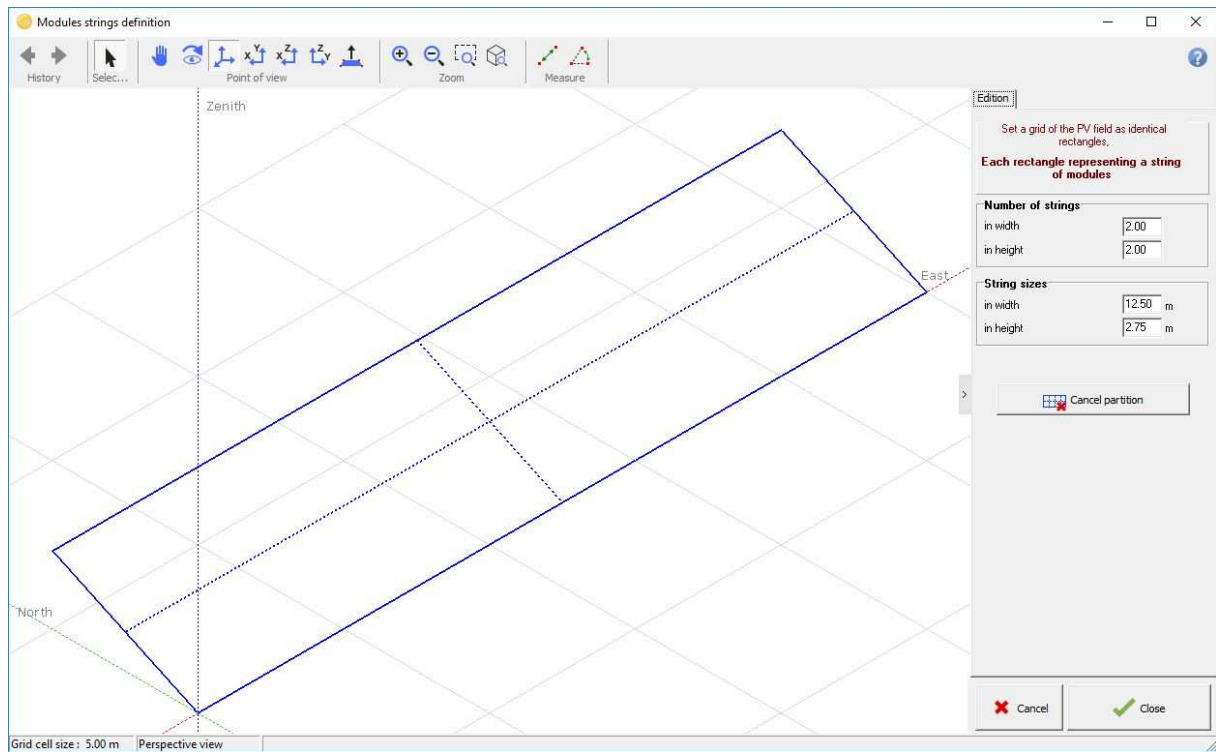
When a PV cell is shaded, the current in the whole string is affected (in principle the current of the string is the current in the weakest cell). There is no possible accurate calculation for this complex phenomenon in PVsystem. We will just assume that when a string is hit by a shade, the whole string is considered "inactive" concerning the beam component. This is an upper limit on the shading effect: the truth should lie between the low limit - which we call the "Linear shading" - representing the irradiance deficit, and this upper limit (see partition in module strings), representing the electrical effect.

### More realistic simulation "According to module strings":

- Go back to the Near Shadings definition, button "Construction/Perspective"

- Click the button "Partition in module chains"  on the left.

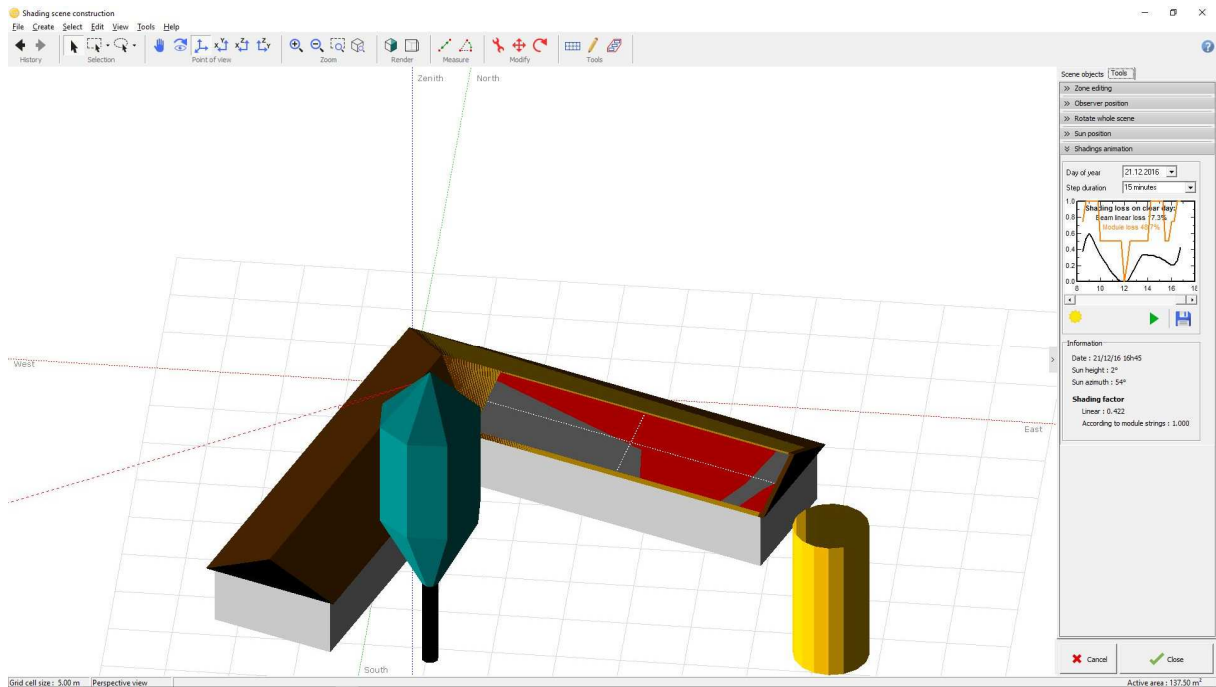
- Here you can split the field into several equivalent rectangles, each representing the area of a complete string (not a module!). If there are several subfields, you should do this for every subfield rectangle.



The fact that one has to use rectangles for the strings limits the possibilities to shape complex arrangements of panels within a string, perhaps you will not be able to represent the exact arrangement of the modules. Since the impact on the simulation is not very high, a rough estimation should be sufficient to give good results. If you want to get a feeling of the impact that the non-perfect arrangement of panels into strings has on the simulation, you should perform the simulation with different configurations and examine the variation of the results.

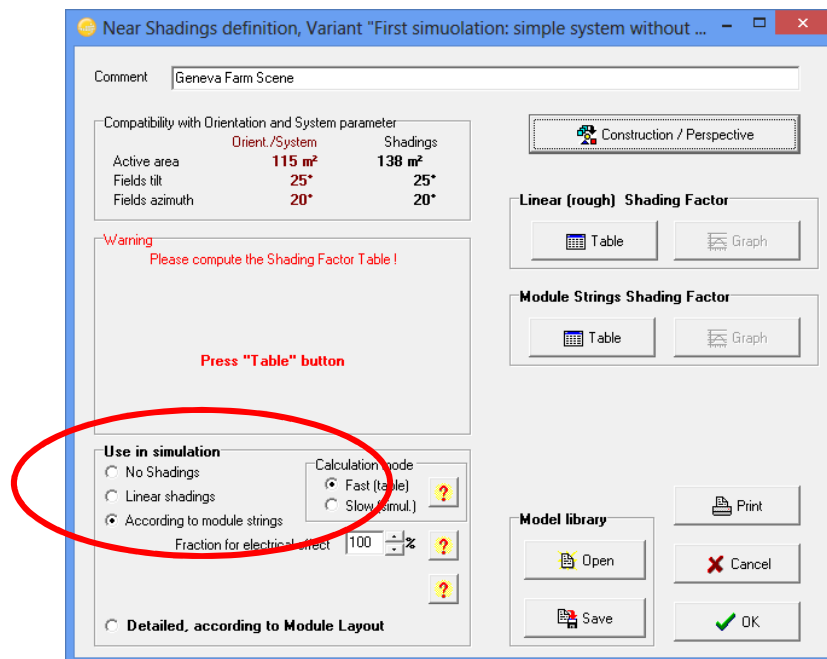


When performing the shading animation, the partially shaded rectangles will now appear in yellow. The improved shading factor is the sum of the grey and yellow areas, with respect to the field area.

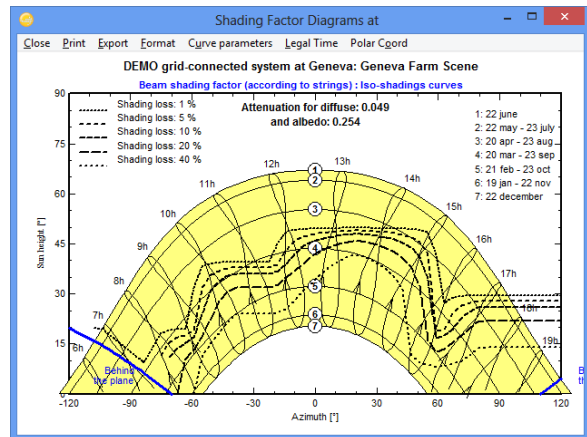
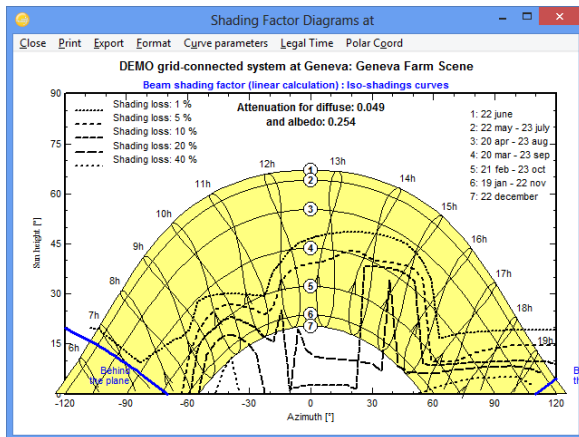


### Use in the simulation

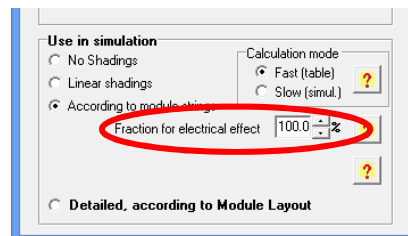
Like before, go the "Near shadings" dialog and choose "According to module strings" in the options field "Use in simulation".



You will be asked once more to compute the shading factor tables, after which you can open the iso-shading graph to compare the results of the improved shadings with the "Linear shadings" case.



"Fraction for Electrical effect": this is the way how the yellow parts will be treated in the simulation. A 100 % value will withdraw the total electrical production of these areas in the simulation. This is the upper limit of the shading effect. Perform a simulation with this value.



For the simulation that you will present to you end-customer, you can fix a different value to get closer to reality. For the present time there is no means to get a good estimation of this factor (a reasonable guess would be around 60-80%, accounting for a partial recovery due to the by-pass diodes).

### Combining the near shadings with the horizon (far) shading

In a first step of the simulation, the program will evaluate the beam component according to the horizon line, resulting in full or zero beam depending if the sun is above the horizon or not. After this, the near shadings factor is applied to the beam component.

Therefore when the sun is below the horizon line, there will be no near shading loss as the beam is null. In other words, potential near shadings for sun positions already affected by the horizon will not produce any additional losses.

# Part 3: Meteorological Data Management

## 1- Introduction

This tutorial will guide you through the different options for the management and organization of meteorological data in PVsyst, and explain the importing of data from external sources.

The meteorological data (short: 'meteo' data) are the starting point of the evaluation of a project. Special care should be taken when importing and generating these data, since they represent the main source of uncertainty for the simulation. We recommend to use only data from reliable sources and to always perform some basic crosschecks on them, as will be explained in this tutorial. This will make sure that no serious mistake was made which could compromise the quality of the results.

Self-measured data should only be used, if the measurements were performed with the proper equipment that has been installed, carefully calibrated and the results analyzed by qualified experts.

### Data organization

#### Input Data

The first input that PVsyst needs is the geographical location of the project to be simulated. This will determine the sun path over the year, and allow to interpolate meteorological data for places where no direct measurements were taken.

The meteorological data that is used as input for the simulation consists of the following quantities:

- Horizontal global irradiation (required)
- Average External Temperature (required)
- Horizontal diffuse irradiation (optional)
- Wind velocity (optional)

The first two, horizontal global irradiation and average external temperature, have to be supplied as external input to the simulation. There is no good way to estimate them just from the geographical location. The other two quantities can either also be supplied as external measured data or, in case there are no good measurements available, they are estimated by PVsyst with the help of established models.

#### Synthetic generation of hourly data

The simulation of PVsyst is done in hourly steps over a whole year. Usually the meteorological data is not available with this time resolution. The most common case is that data will come in monthly values. It is therefore necessary to generate artificially the hourly values, starting from the monthly ones. PVsyst uses special algorithms to generate the hourly values for the meteorological data.

#### \*.SIT and \*.MET files

PVsyst stores the geographical location together with the monthly meteo data in one file for each site. These files have the extension '.SIT'. You can have more than one file for each site, if you have monthly data from different sources or from different years that you would like to compare. The hourly data is stored in files with the extension '.MET' and here too you can have more than one file per site to compare different years or different data sources. Remember though that each \*.MET file is attached to only one single \*.SIT file.

## Data Sources

The built-in meteorological data source of PVsyst is the program METEONORM. This program delivers monthly meteorological data for almost every spot on the globe and PVsyst will use this source by default if no other is explicitly specified. Alternatively it is also possible to choose satellite data from the NASA-SSE project as data source. Furthermore, PVsyst gives an easy access to several public sources directly available from the Web like SolarGIS or Satelligence among others. Self-measured data and data from other providers like national meteorological offices may also be imported from text files using a tool that can be adapted to different data formats.

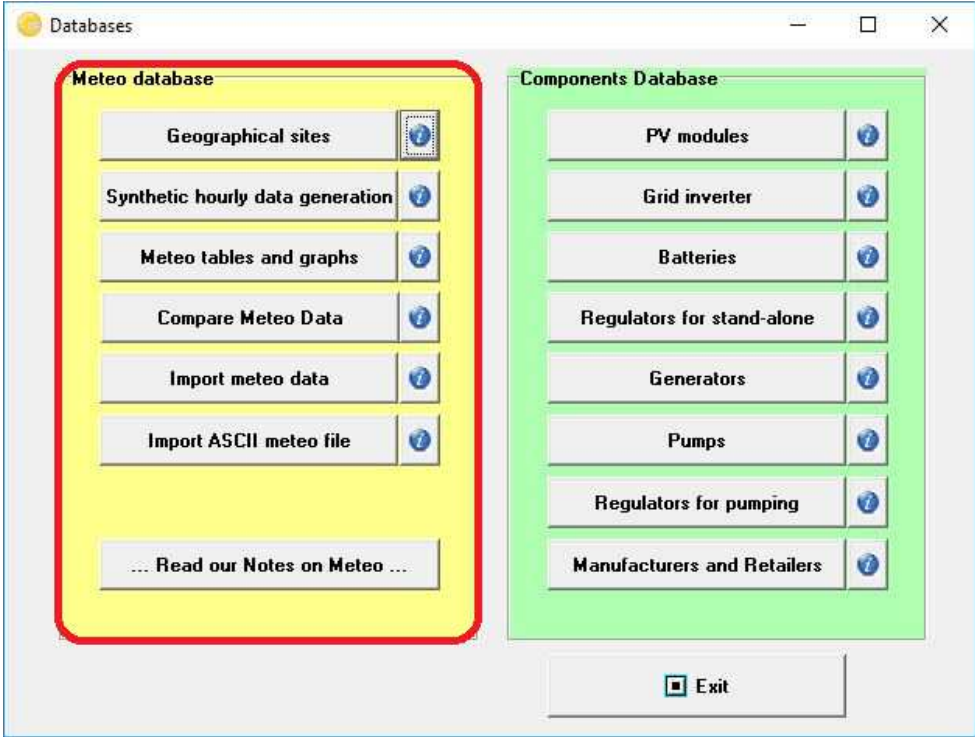
### Opening the meteorological data management options

All manipulations and visualizations of the meteo data are accessed through the option "Databases" in the Main Window:



After clicking on this Button, the Database Window will pop up on the screen. The left side contains the options related to meteorological data. It contains the options:

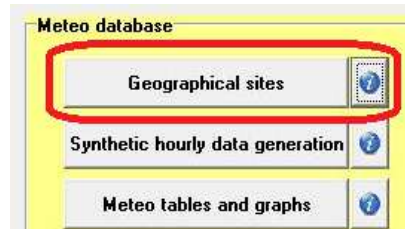
Geographical sites:	Monthly data management
Synthetic hourly data generation:	Generate hourly values from the monthly data
Meteo tables and graphs:	Visualization and crosschecks of the hourly data
Import meteo data:	Import meteo data from predefined sources
Import ASCII meteo file:	Import meteo data from an ASCII file with custom format



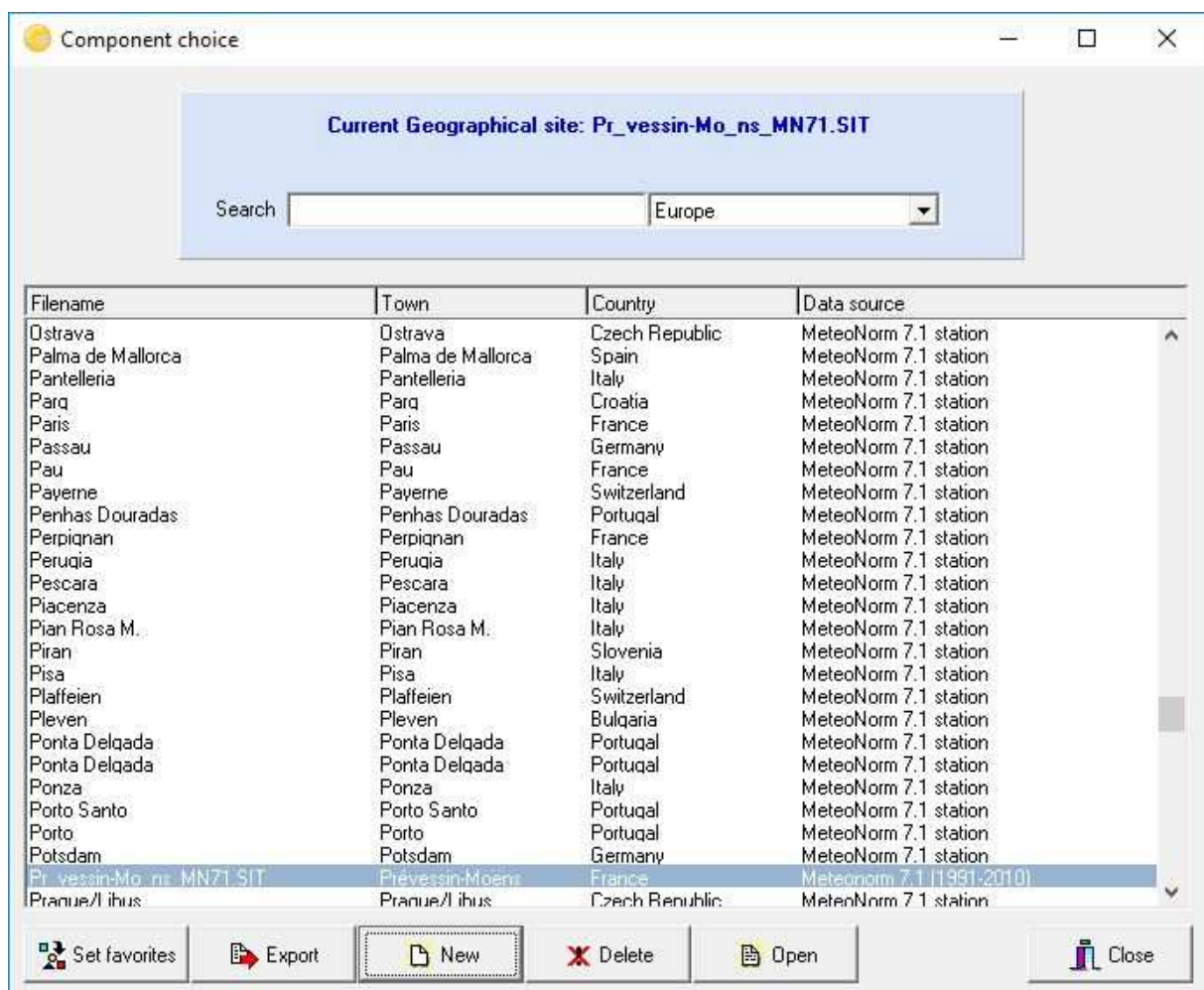
## 2- Geographical sites

The main database is given as objects including the geographical coordinates and associated monthly meteo data. These objects are stored as files with the name \*.SIT, situated in the users directory \PVsyst6\_Data\Sites\.

Click on "Geographical sites":



You will get a dialog for the choice of the geographical site, where you can choose the country or region of interest and a given station. The first column is the name of the site, the second one the country in which the site is located and the third one describes the source of the monthly meteorological data.

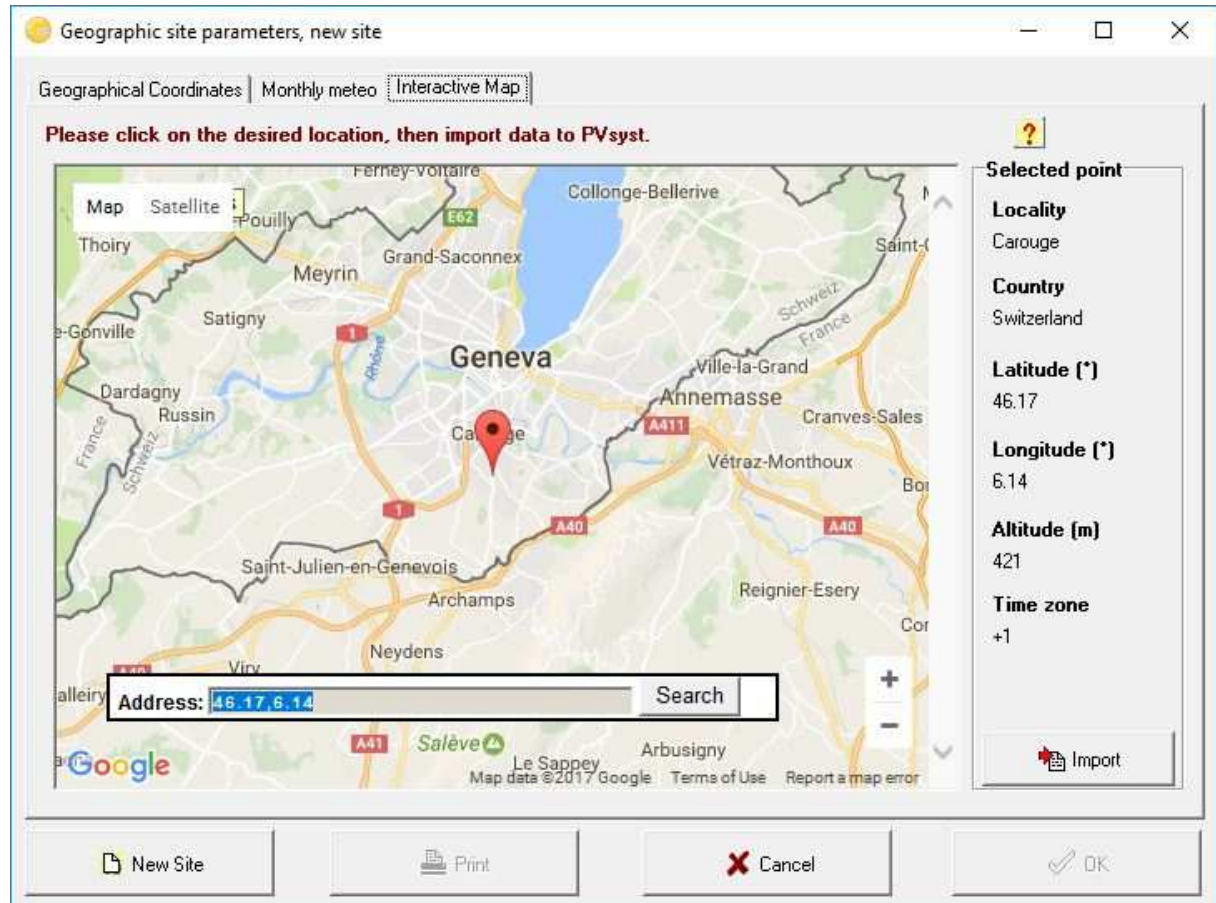


To create a new site for a project click on 'New'. You will get a window with the geographical site parameters that contains three tabs:

Geographical Coordinates

Monthly meteo

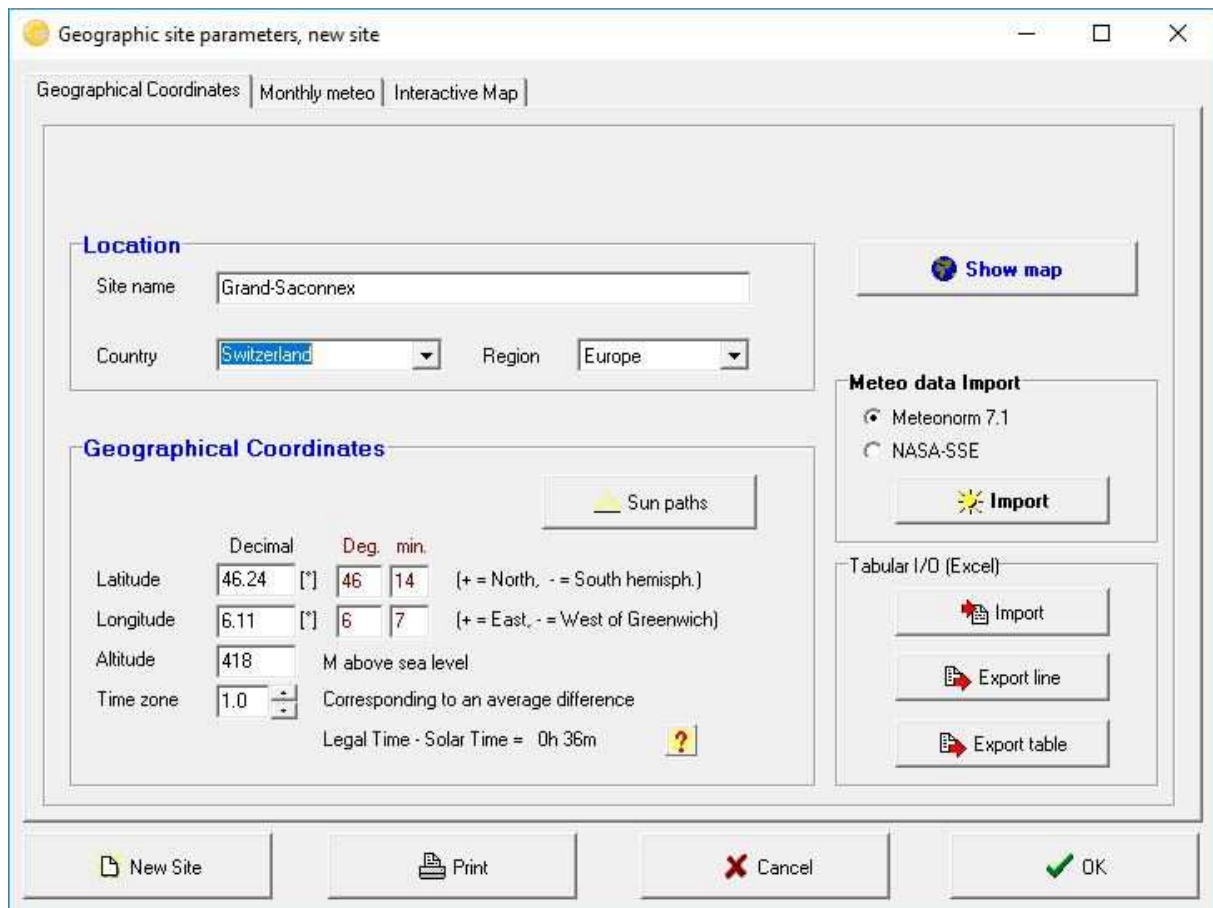
Interactive Map



The tab "Interactive Map" allows you to select interactively the location of your site using Google maps. You can click on the map to choose the site location. You can zoom into and out of the map, and you can use the search field to find the name of a place. When the red mark is at the desired place, click on "Import" to transfer the location to the "Geographical Coordinates" tab.

In the tab "Geographic coordinates" you define:

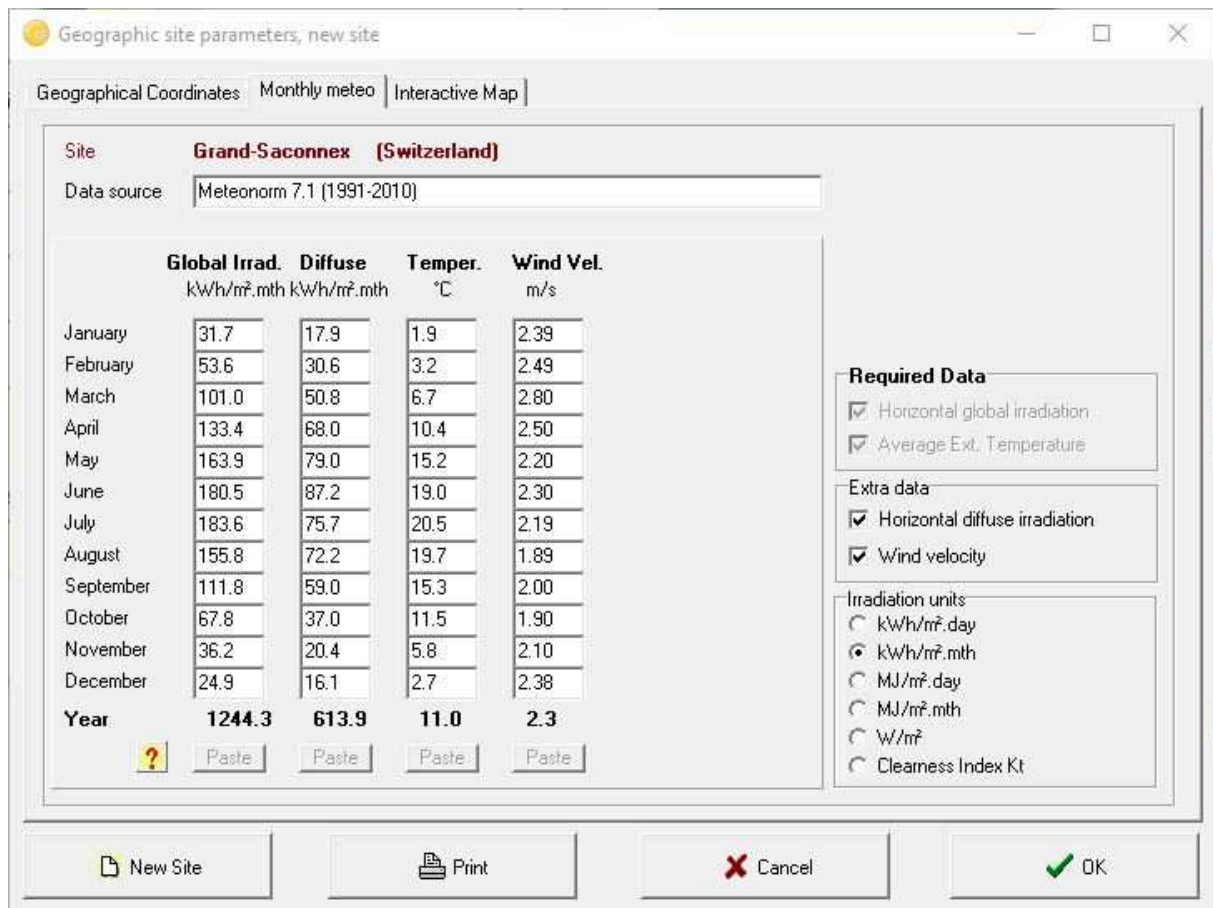
- |                           |   |
|---------------------------|---|
| Site name:                | Choose a name for the site of your project  |
| Country and Region:       | Normally you do not need to change this   |
| Geographical Coordinates: | The Latitude, Longitude, Altitude (which uniquely define the (x,y,z) coordinates of a given point of the earth), and the time zone. Ex: for central Europe, the winter time corresponds to GMT+1, while the summer time is GMT+2. You can obtain accurate Latitude/Longitude coordinates from your GPS or Google Earth. |



In this dialog you can also:

- see the sun paths corresponding to your site,
- import/export the site data with "copy/paste" (for example into or from a spreadsheet like EXCEL),
- print a complete form with the data of this site.
- If you define a new site (by its geographical coordinates), PVsyst will import by default the data from METEONORM, which is considered to be the most reliable source for monthly meteorological data. Alternatively you can also obtain a set of monthly values from the Nasa-SSE data, which are available for any point on the earth, in steps of  $1^\circ \times 1^\circ$  (latitude  $\times$  longitude).





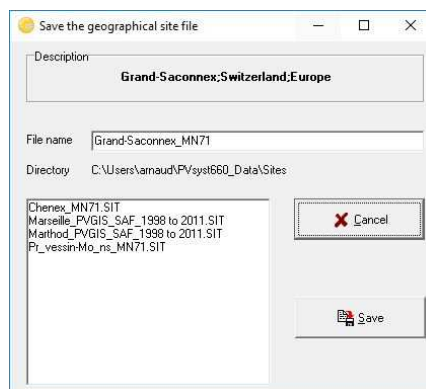
Once monthly data has been imported, the tab "Monthly meteo" will display the monthly values. Values for Global irradiance and Temperature are mandatory input for the simulation. Global diffuse and wind velocity are optional. They will be evaluated by models if and when necessary.

**Data source:** Describe the source of the monthly meteo data, PVsyst will fill this field when you import the data from a predefined source.

**Irradiation units:** You can choose the units in which the global and diffuse irradiation values are displayed. This is useful to import or compare to data sources that use units different from the PVsyst default.

**Data fields:** You can edit these values by hand. If data are given as lines or columns in a spreadsheet, you can "paste" entire columns at a time.

After defining or modifying a site, the program will ask whether you want to keep your modifications, and if so it will modify or create a new site in the database (i.e. a new file in the \Sites\ directory).



### Managing Favorites

The sites will normally have a white background in the selection list. Green entries are sites that have been defined as favorites by the user. New sites that are created by the user are put into favorites by default. They can be removed from the list of favorites by clicking on 'Set Favorites', selecting the site from the list and clicking on 'Close Favorites'. In the same way you can add more sites to the list of favorites.

### PVsyst's built-in database

The built-in meteorological database of PVsyst is based on the METEONORM database, which defines about 1'100 "Stations" for which measured irradiances values are available. The Meteonorm data are usually 1961-1990 average values (the new Meteonorm V6.0 includes also some 1983-1993 averages, but they do not differ very much from the previous ones).

In Meteonorm, data of all other sites are interpolated between the three nearest stations. For most of the European countries, all the measured stations available in Meteonorm are inside the PVsyst built-in database. But for many other regions of the world, the measured "Stations" are very scarce, and Meteonorm has to use Satellite data to complete this information.

Besides the built-in database, PVsyst also offers tools for easily importing meteo data from many other sources. This will be described in the chapter "Importing data from predefined sources". If you need to import data from a source or format that is unknown to PVsyst, you can import it as an ASCII file as explained in the Chapter "Importing Meteo Data from an ASCII file".

### The year 1990

In PVsyst, we have adopted the convention to label all data which don't correspond to really measured data at a given time as 1990. This is the case, namely, of all synthetic hourly data, or TMY/DRY data files.

You will notice that recent data are really scarce in the "public" published data. This can be explained by the fact that analyzing and assessing real measured data sets for sizing purpose is a very complex job, and the results of these research groups are only available after a long period of analysis and validation.

### 3- Synthetic hourly data generation

The simulation process in PVsyst operates on hourly values. If no measured hourly data is available, we have to construct a set of hourly meteo data from the monthly values. The hourly data will be stored in \*.MET files, which reside in the \Data\Meteo\ directory.

For the irradiance, the synthetic generation of hourly values from monthly averages is performed by using stochastic models that have been developed by the Collares-Pereira team in the 1980's. This model first generates a sequence of daily values, and then a sequence of 24 hourly values per day, using Markov transition matrices. These matrices have been established such as to produce an hourly sequence, with distributions and statistical properties analogous to real hourly meteo data measured on more than 30 sites all around the world.

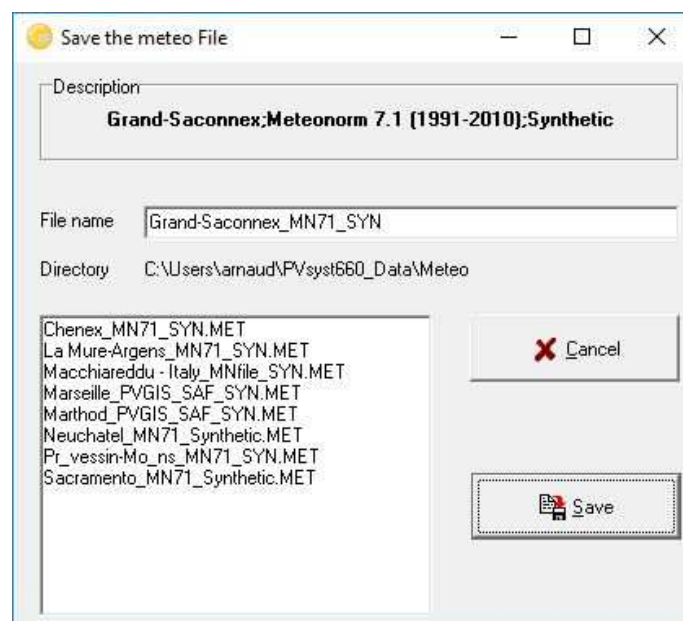
For the temperatures there is no model predicting the temperature evolution as function of the daily irradiation, as the temperatures are mostly governed by atmospheric circulations. Therefore the sequence of daily temperatures is mostly random, with constraints on the transition from one day to the other. Nevertheless within a day, the temperature profile is well correlated to the irradiance. This results in a sinusoidal-like shape over 24 h, with an amplitude proportional to the daily irradiation and a phase shift of around 3 hours with respect to the highest solar angle (the warmest hours are at around 3:00 solar time).

Please note that the generation of the hourly values is a fully random process, two successive generations performed with the same monthly data will result in different hourly values. When performing simulations of grid-connected systems, this may produce variations of 0.5 to 1% in the yearly result.

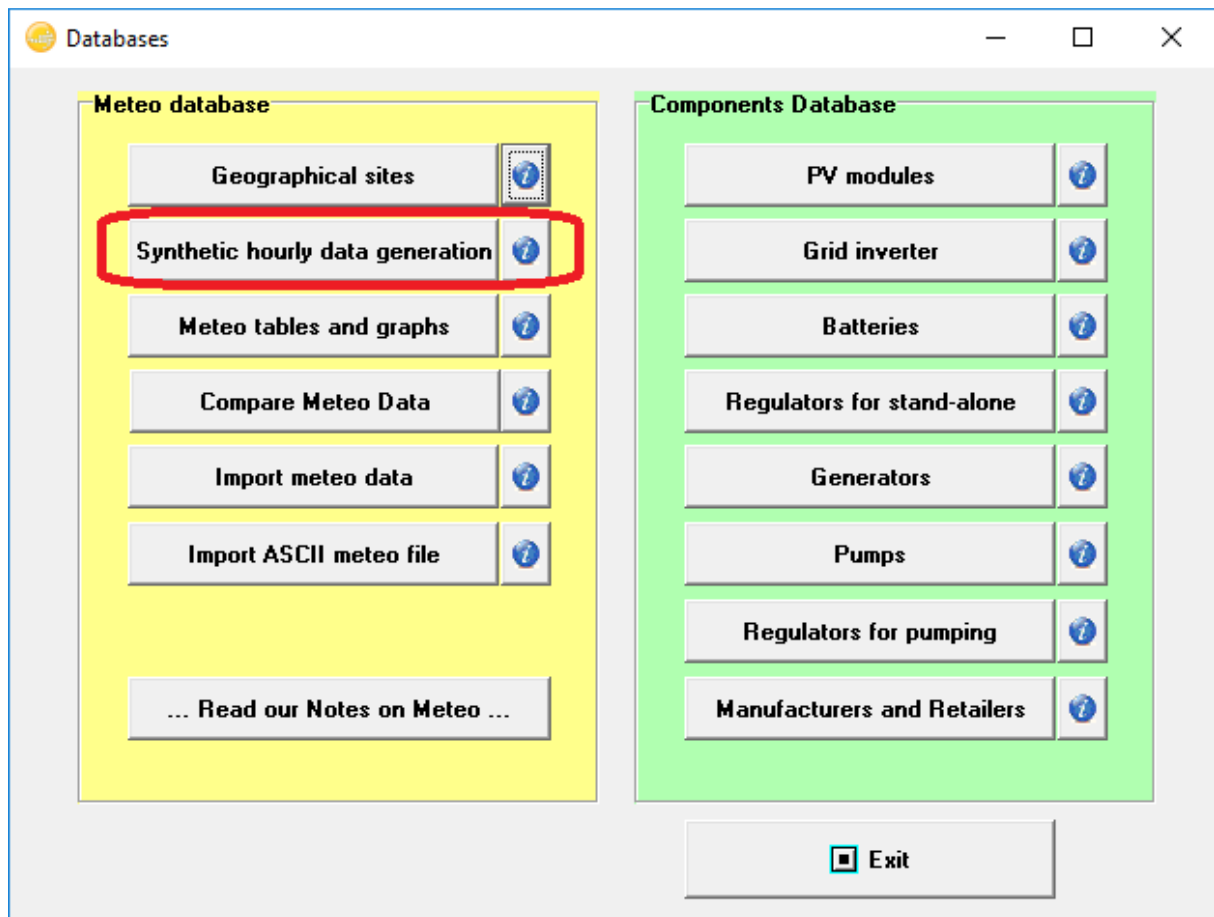
The synthetic hourly data from the monthly values is automatically generated, just press the save button when it appears.

The dialog “Generation of Synthetic Hourly Meteo Values” will pop up.

You can then save the meteo file.



You can regenerate using different parameters using the corresponding button:



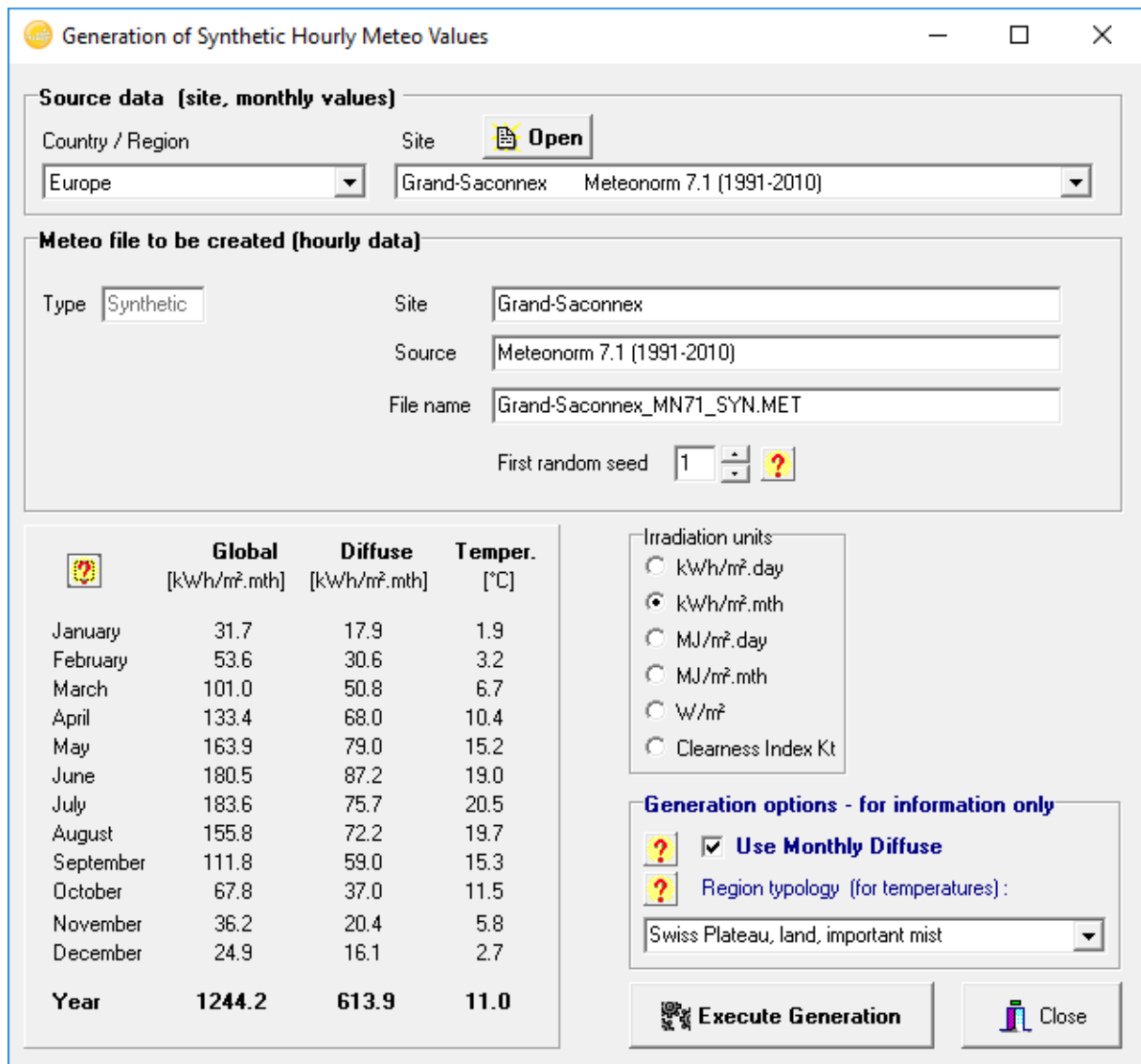
First choose a site holding monthly meteo data. Now you can specify:

**Site name:** This is the site name that will be used in the .MET file. You can have it different from the one used in the .SIT file if you want to generate more than one .MET file for the same site. This site name will be visible if you select a meteo file for your project.

**Source:** The source of the data. This is automatically filled in and normally you do not need to change this. This information will also be visible when you select a meteo file for your project.

**File name:** Select a unique name for a new file or overwrite an existing one.

Press the «Execute Generation" button, the successful generation of the data is acknowledged by a message:



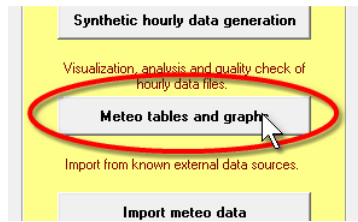
There are some options that you will in principle never modify:

"Use monthly diffuse": The diffuse part is evaluated using the Liu-Jordan hourly correlation. At the end of each month, the diffuse values are renormalized in order to match the specified monthly diffuse.

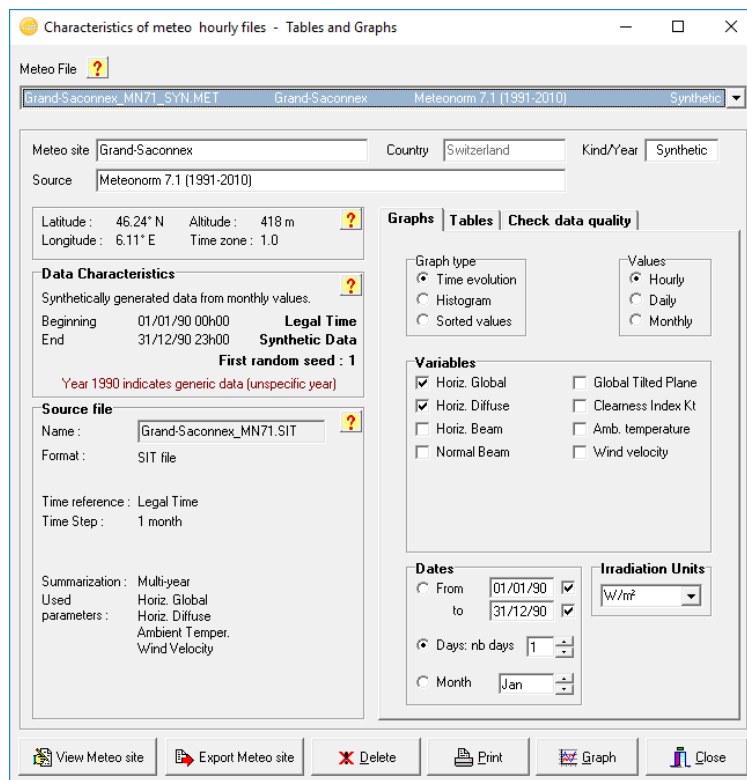
Region topology: The temperature model that is used by PVsyst was established using Swiss data, with a detailed analysis of climate type dependence. It is possible to choose one of the topology types that are defined for this model, but the differences between all these options are very small (slight coupling differences between irradiance and amplitude, or inertial shifts). If you are unsure which option to use, select the PVsyst default "Swiss Plateau, land, important mist".

#### 4- Visualization of the hourly values

In PVsyst, the hourly values files \*.MET are binary files, which cannot be edited in a text editor. For visualizing their contents, you have to use the button «Meteo Tables and Graphs" in the "Tools" group.



The “Meteo Tables and Graphs” dialog will appear on the screen. After choosing a meteo file, information on the site and the type of data is displayed on the left side of the dialog. On the right side it is possible to select if you would like to have a graphical output (“Graphs”) or a table (“Tables”). Both options allow you to look at hourly, daily or monthly values. The third tab “Check data quality” allows you to perform some deeper analysis on the data quality. This step is very important, especially if you imported data with custom format.



## Graphical output

When the tab “Graphs” is selected you can first select the Graph type:

- Time evolution: Plots the data values against time.
- Histogram: Plots a distribution of the values.
- Sorted values: Displays all values in decreasing order.

The variables that you can plot are:

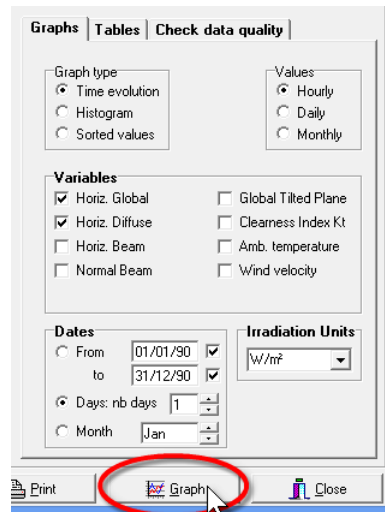
- Horizontal global irradiance
- Horizontal diffuse irradiance
- Horizontal beam irradiance
- Normal beam irradiance

Clearness Index Kt  
Ambient temperature  
Wind velocity

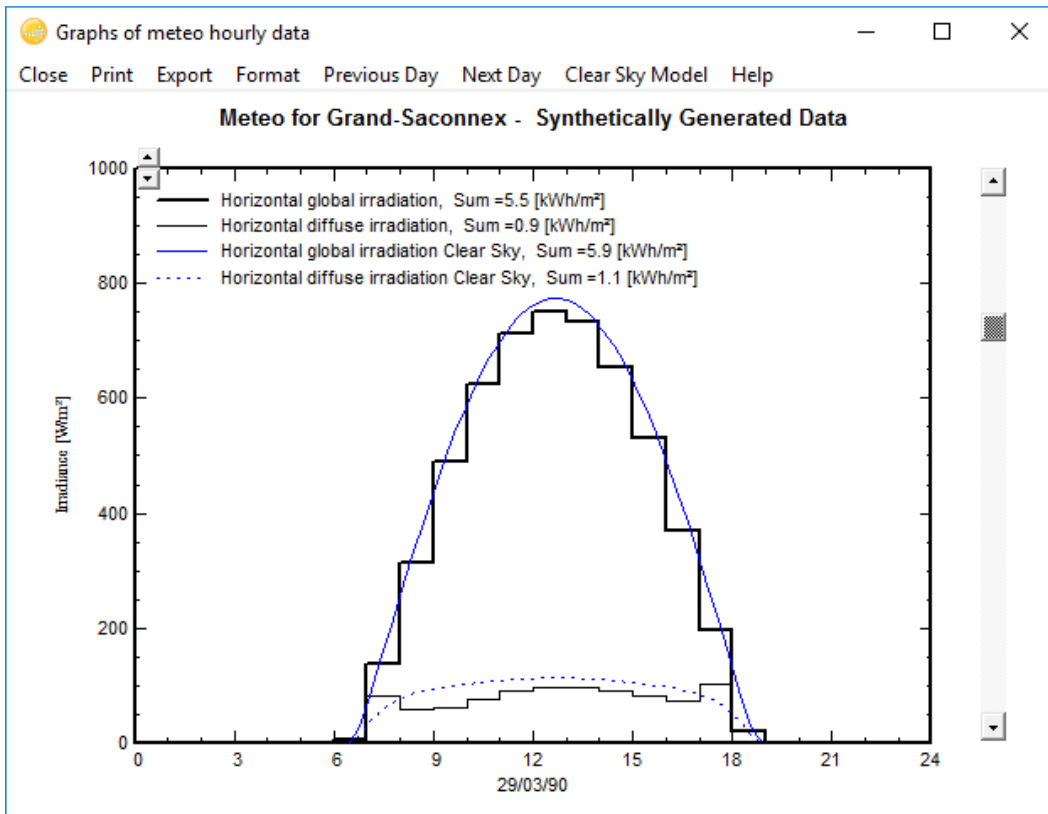
Note that since some of these options exclude each other you will not be able to select all the variables at the same time.

### Graphs of hourly values

In the "Graph" tab, choose "Time evolution", "Hourly", "Global" and "Diffuse" (default selection), and click the button "Graph".

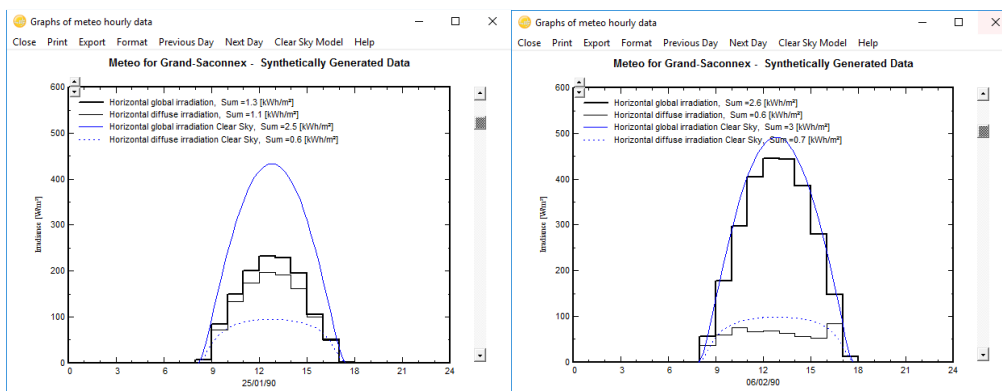


This will open a graph with the hourly meteo values, and you can walk through your entire data using the Scrollbar on the right. The plot includes a blue line, which represents the Clear day model, superimposed on your data. It is very important that the data is not shifted on the time axis with respect to the blue line. This will always be the case for the synthetic data or the data imported from known sources using the "Import meteo data" PVsyst tool.



But this may be different for personal data that is imported with the "Import ASCII meteo files" tool. If the data are not matching the Clear day model (i.e. are shifted toward morning or evening), this indicates that the time stamps of the data don't match the PVsyst standard, and all the models using solar geometry will not work properly.

When walking through the year, you will see that clear conditions, where the horizontal global irradiation matches well the clear sky model, correspond to a low diffuse component. When the sun becomes hazy and the horizontal global irradiation is well below the blue line of the clear sky model, the diffuse part increases. The difference between the global and the diffuse corresponds to the beam component.



### Graphs of daily values

To get a plot with daily values, select "Daily" in the "Values" selection.



Graph type

- Time evolution
- Histogram
- Sorted values

Values

- Hourly
- Daily
- Monthly

Variables

- Horiz. Global
- Horiz. Diffuse
- Horiz. Beam
- Normal Beam
- Global Tilted Plane
- Clearness Index Kt
- Amb. temperature
- Wind velocity

Dates

From: 01/01/90

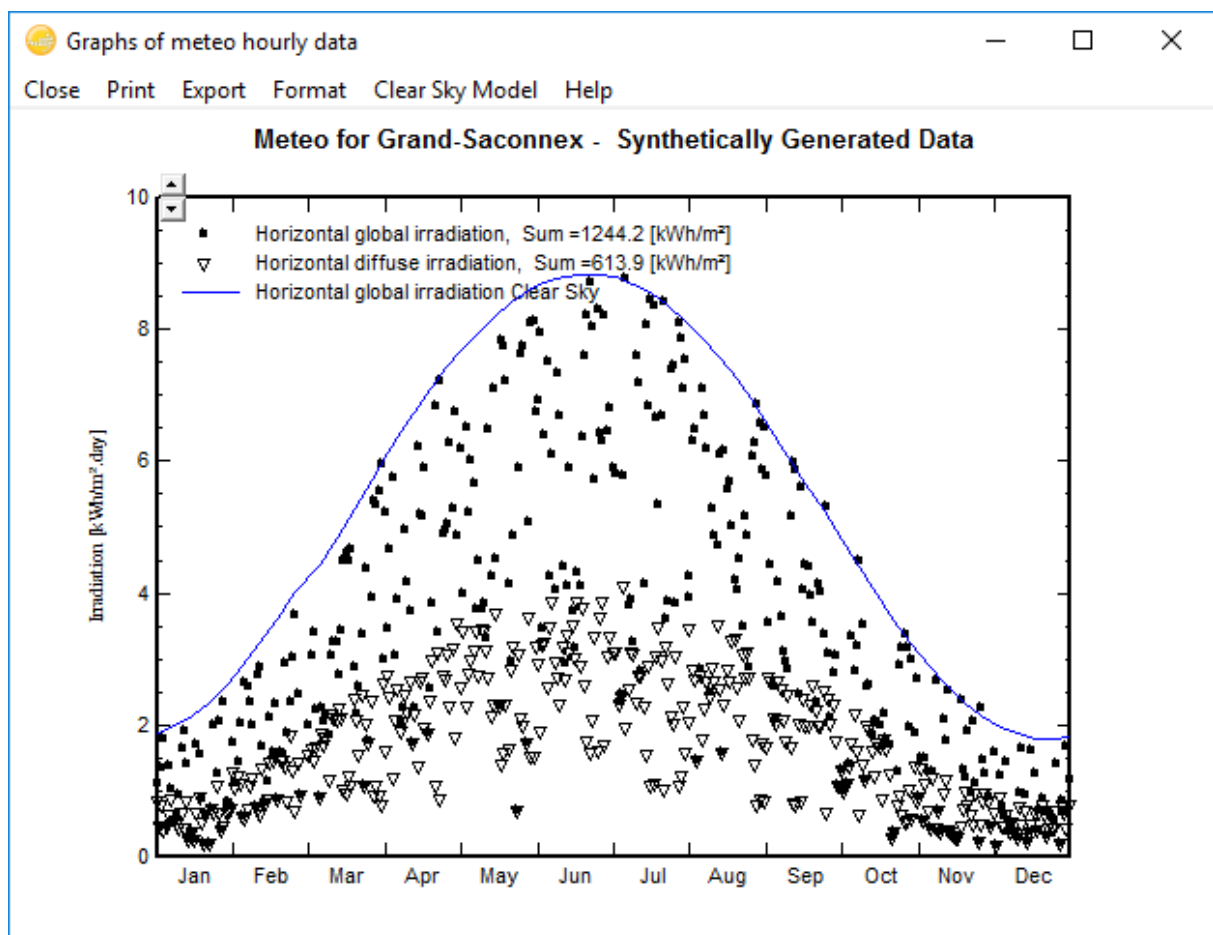
to: 31/12/90

Month

Irradiation Units

kWh/m<sup>2</sup>.day

You will get a scatter plot of the irradiation values against the day of the year. Each point represents the irradiance for a single day in [kWh/m<sup>2</sup>/day]. The blue envelope curve describes the Clear sky model. This plot gives a quick crosscheck of the quality of the data. The Clear sky model is an upper limit for the measured irradiance, and none of the points should exceed this curve significantly (more than 3-5%). If larger discrepancies are seen, this indicates that the data are not good.



## Tables

You can also show your data as tables. You can choose up to 8 values to be put into the table at the same time, including the irradiance on a tilted plane (transposition model) or the normal beam component (for concentration).

As for each data table in PVsyst, you have the possibility to:

**Print the table:** You will get the Print dialog, where you can add comments to the header of the table and specify the time range for which you want to print the values.

**Export / Copy as text:** This will "copy" the full table to the clipboard, from where so you can "Paste" it directly into an external spreadsheet like MS Excel. Remember that in MS EXCEL, the imported data will usually be gathered in one single column. To expand the data to cells you have to use the standard EXCEL options for importing data: menu «Data" / "Convert...", and here you should choose «Delimited" / "Semicolon" separator.

**NB:** The data will be copied with a decimal point. If you are using decimal commas (international preferences in Windows), you will perhaps have to change all points to commas.

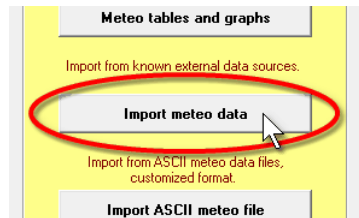
**Export / Copy as image:** Will copy a bitmap image of the table to the clipboard, from where you can paste it into a report.

**Export / Copy to file:** Will create a CSV file which you can open in any spreadsheet program.

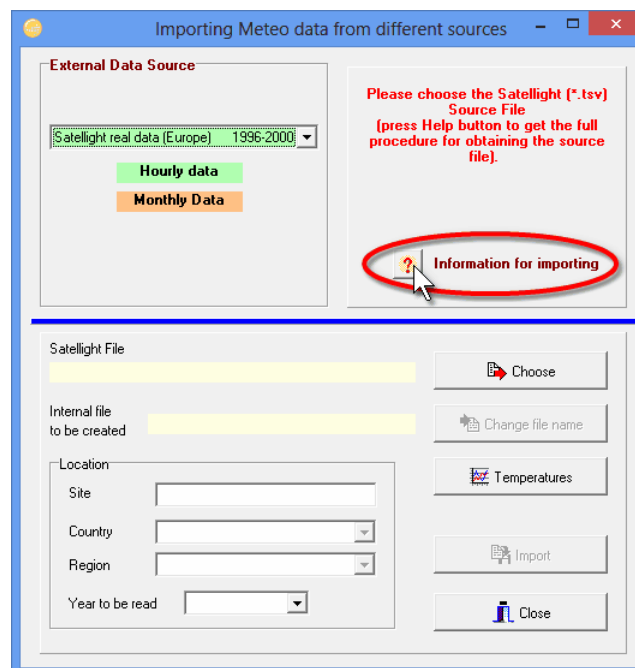
**NB:** Due to contractual constraints of the METEONORM provider, the hourly tables of METEONORM data cannot be exported.

## 5- Importing Meteo data from predefined sources

In PVsyst it is also possible to import meteorological data from external sources. There is a set of predefined data sources for which importing has been semi-automatized. To access this option, click the "Import meteo data" button in the Database window.



The "Import Meteo Data" dialog will pop up, which gives access to the easy-to-use tools for importing meteo data from predefined sources. If you press F1 you will obtain a detailed description of the available data sources. After choosing a source, clicking on "Information for importing" button will open the online help window with a detailed procedure for importing the data. Please follow it carefully and pay attention to the messages written in red at the top of the screen during your progress.



The data from the different sources are not always completely comparable. The online Help of PVsyst includes a comparison of such data for 12 sites from the north to the south of Europe.

The following two sections contain complete examples on how to import meteorological data from the PVGIS project, which covers Europe and Africa and from TMY3 files which cover the United States of America.

## Importing PVGIS Data

PVGIS (Photovoltaic Geographical Information System) is a research, demonstration and policy-support instrument for solar energy resource, part of the SOLAREC action at the JRC Renewable Energies unit of the European Communities (Ispra). You will find a complete description of this project at <http://re.jrc.ec.europa.eu/pvgis/info/faq.htm#data>. The GIS database covers Europe, the Mediterranean basin, Africa and South-West Asia

The data is based on calculations from satellite images performed by CM-SAF (Geostationary Meteosat and Polar EUMetSat). The database represents a total of 12 years of data. From the first generation of Meteosat satellites (Meteosat 5-7), known as MFG, there are data from 1998 to 2005 and from the second-generation Meteosat satellites (known as MSG) there are data from June 2006 to May 2010. The spatial resolution is 1.5 arc-minutes (about 3km right below the satellite at 0° N, 0° W). The coverage extends from 0° N (equator) to 58° N and from 15° W to 35° E. These data are more representative for the climate of the last years, and show often higher irradiances than the "Classic" PVGIS.

See [http://re.jrc.ec.europa.eu/pvgis/apps4/databasehelp\\_en.html](http://re.jrc.ec.europa.eu/pvgis/apps4/databasehelp_en.html) for further details.

### Importing PVGIS data

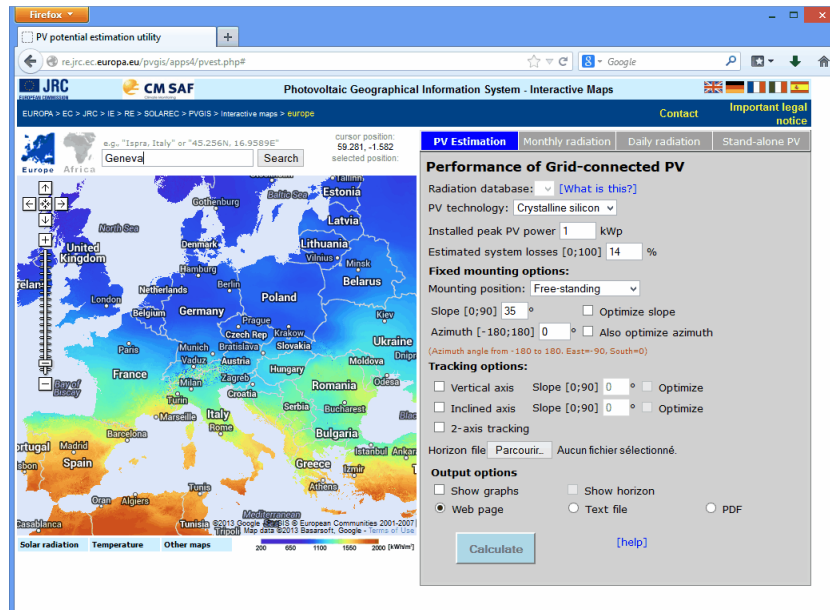
The procedure to import PVGIS data consists in generating a set of meteo data with the PVGIS web interface, copying it into the Windows clipboard and then importing it from the clipboard into PVsyst. We will walk through each of the steps in detail.

### Generate a set of monthly data

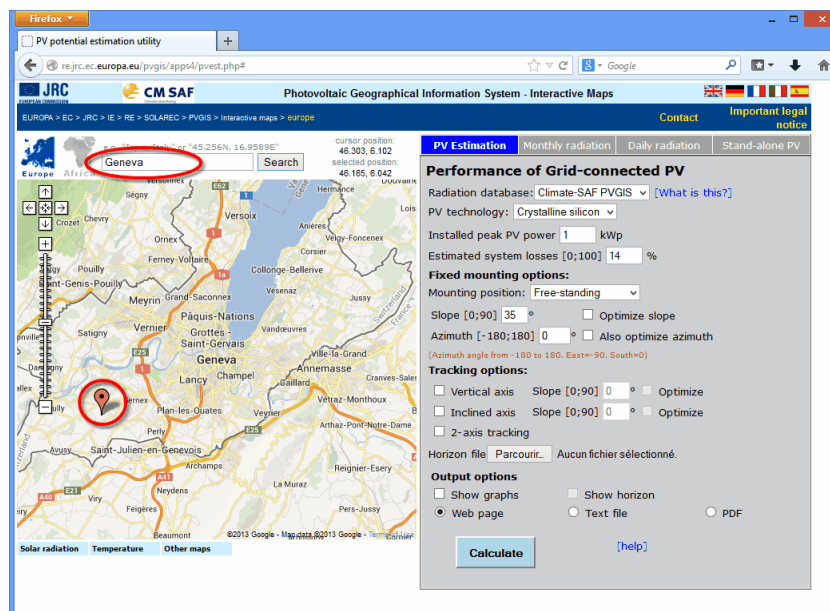
Open the web site <http://re.jrc.ec.europa.eu/pvgis/>. In the frame "Interactive access to solar resource and photovoltaic potential", click on the "Europe" or "Africa" icon.



You will get to a page which is divided into two areas. The left part contains a map for choosing a site location, while the right part is a tool with four tabs, to estimate the potential of PV installations at the chosen site and for generating meteorological data for that same location.

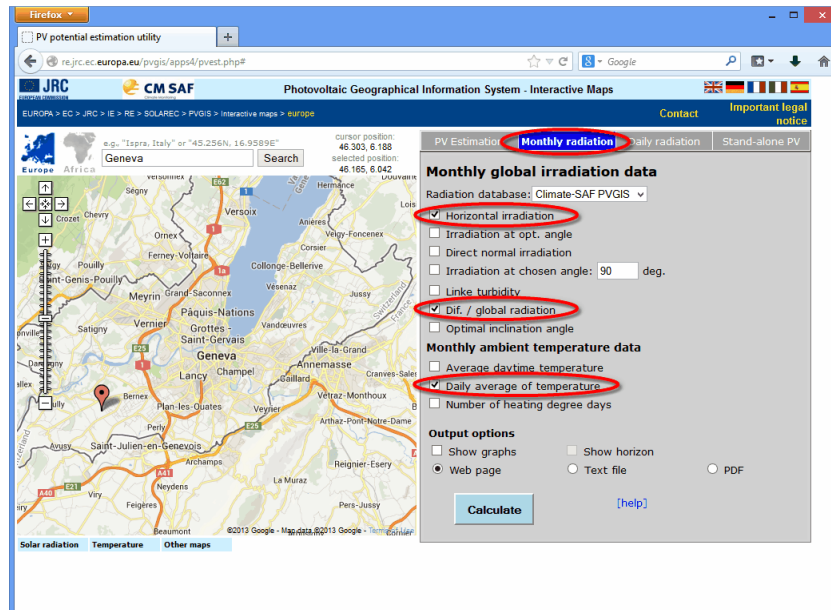


The map on the left is a GoogleMap tool with which you can choose a geographical location. Typing the name of a city or another location into the search field and clicking on 'Search' will put the map at a scale suitable for navigating and easily finding the exact location of your project. Clicking with the mouse on the map will place the red marker at that position. The coordinates will be displayed on top of the map next to the search field. Once you are satisfied with the location you can proceed to generate the meteorological data.



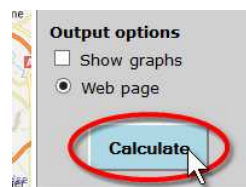
On the right dialog, select the "Monthly Radiation" tab. You will get a dialog from which you can select the variables to be considered in the output. Check the following variables to be imported:

- Horizontal irradiation
- Dif. / global radiation
- Daily average temperature (not available for Africa, will be imported from other sources)



PVsyst does not make use the "Average Daytime Temperature", as the synthetic generation model for the daily profile includes the Day/Night effect, and expects a 24h average as input.

Then you choose "Web Page" output option, and click on "Calculate".



You will get a new window containing the monthly values for the variables that were selected. The last line in the table shows the yearly sums of the variables.

Mozilla Firefox

re.jrc.ec.europa.eu/pvgis/apps4/MRcalc.php

### Monthly Solar Irradiation

PVGIS Estimates of long-term monthly averages

Location: 46°54' North, 6°23'2" East, Elevation: 463 m a.s.l.

Solar radiation database used: PVGIS-CMSAF

Optimal inclination angle is: 36 degrees  
Annual irradiation deficit due to shadowing (horizontal): 0.0 %

Month	$H_h$	D/G	$T_{24h}$
Jan	1140	0.64	1.9
Feb	2070	0.51	3.4
Mar	3490	0.44	7.0
Apr	4940	0.41	10.0
May	5640	0.43	14.9
Jun	6430	0.40	18.6
Jul	6330	0.38	20.3
Aug	5270	0.39	19.8
Sep	4160	0.39	13.8
Oct	2470	0.49	12.2
Nov	1370	0.59	3.7
Dec	986	0.69	2.6
Year	3700	0.43	11.0

$H_h$ : Irradiation on horizontal plane (Wh/m<sup>2</sup>/day)  
D/G: Ratio of diffuse to global irradiation (-)  
 $T_{24h}$ : 24 hour average of temperature (°C)

PVGIS © European Communities, 2001-2012

NB: If the window with the data doesn't appear after clicking on "Calculate", the cause could be that your web navigator is blocking the advertising windows. In MS Internet Explorer, you can manage this in the "Options" of the main menu.

Copy the PVGIS data to the clipboard

Select all text starting from "PVGIS Estimates ..." up to the end of the table. Do not select the legend of the table. Now Copy the selection to the clipboard by right-clicking on it with the mouse and selecting 'Copy' from the pop-up menu or by using the keyboard shortcut 'Ctrl-C'.

Monthly Solar Irradiation

PVGIS Estimates of long-term monthly averages:

Location: 46°54' North, 6°23' East. Elevation: 463 m a.s.l.

Solar radiation database used: PVGIS-CMSA1

Optimal inclination angle is: 36 degree

Annual irradiation deficit due to shadowing (horizontal): 0.0 %

Month	$H_h$	D/G	$T_m$
Jan	1140	0.64	1.9
Feb	2070	0.51	8.4
Mar	3490	0.44	7.0
Apr	4940	0.41	10.0
May	5640	0.43	11.9
Jun	6420	0.40	13.6
Jul	6320	0.38	20.8
Aug	5270	0.39	19.8
Sep	4160	0.39	15.8
Oct	2470	0.49	12.2
Nov	1370	0.59	5.7
Dec	980	0.69	2.6
Year	3700	0.43	11.0

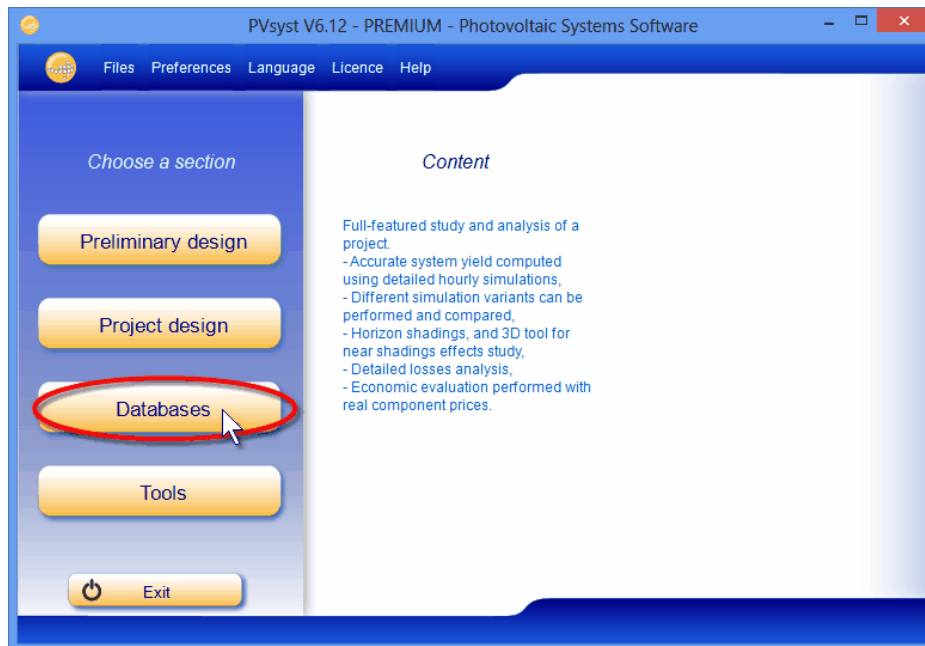
$H_h$ : Irradiation on horizontal plane (Wh/m<sup>2</sup>/day)  
D/G: Ratio of diffuse to global irradiation (-)  
 $T_m$ : 24 hour average of temperature (°C)

PVGIS © European Communities, 2001-2012

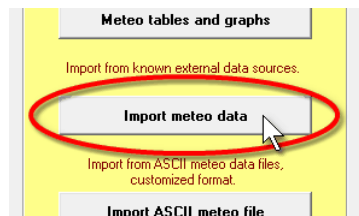


## Importing the clipboard containing PVGIS data into PVsyst

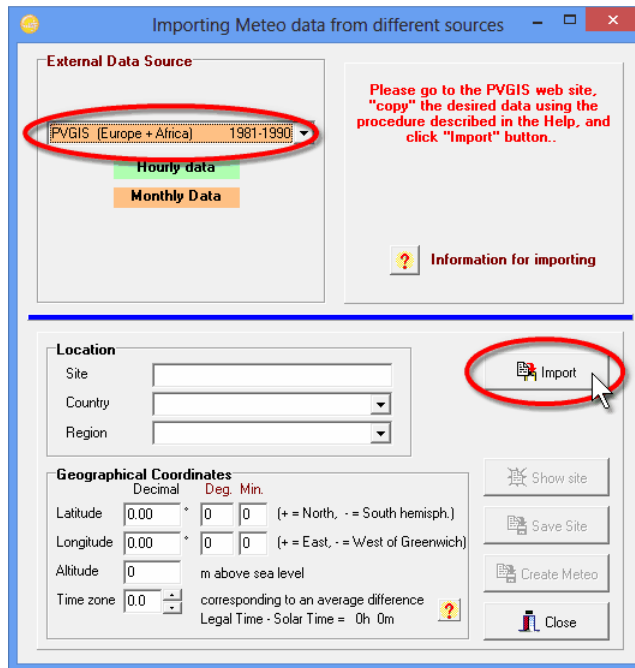
In the PVsyst main window, choose "Databases".



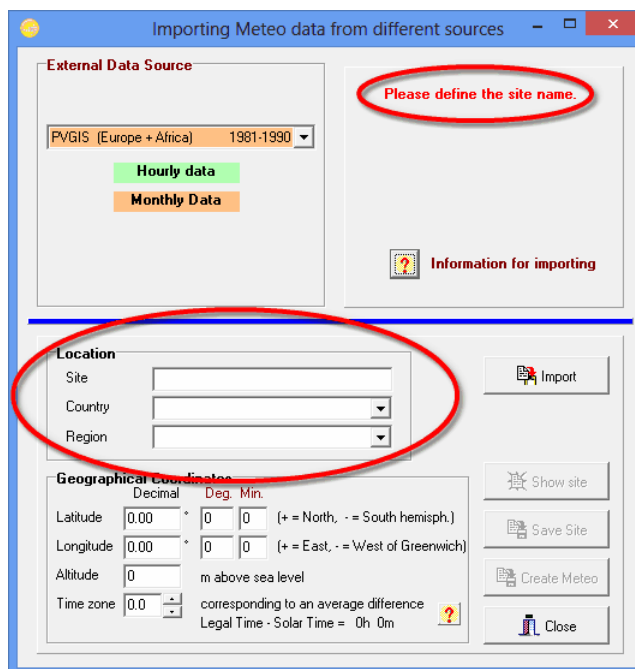
The Databases Window will open, where you click on "Import meteo data".



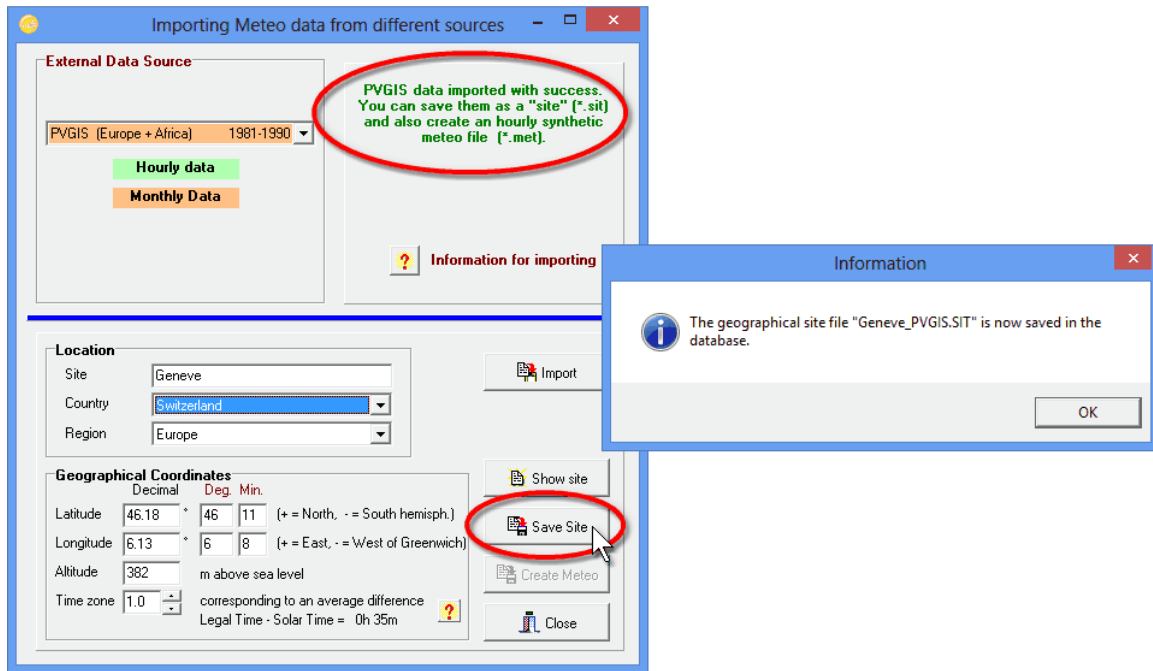
The "Import Meteo data" dialog will pop up. In the top left field you can select one of the predefined data sources. For this example you have to choose "PVGIS". In the top right field there are instructions in red that inform you on the next step to be taken. Since we have already copied the PVGIS table to the clipboard (see previous section), we can proceed to click on the "Import" button.



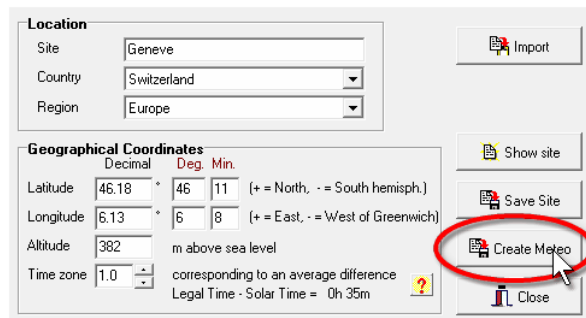
In the bottom field you should see now the geographical coordinates, altitude and time zone of the selected location. The message on the top right will ask you to provide a name for the site and to specify the country where it is located.



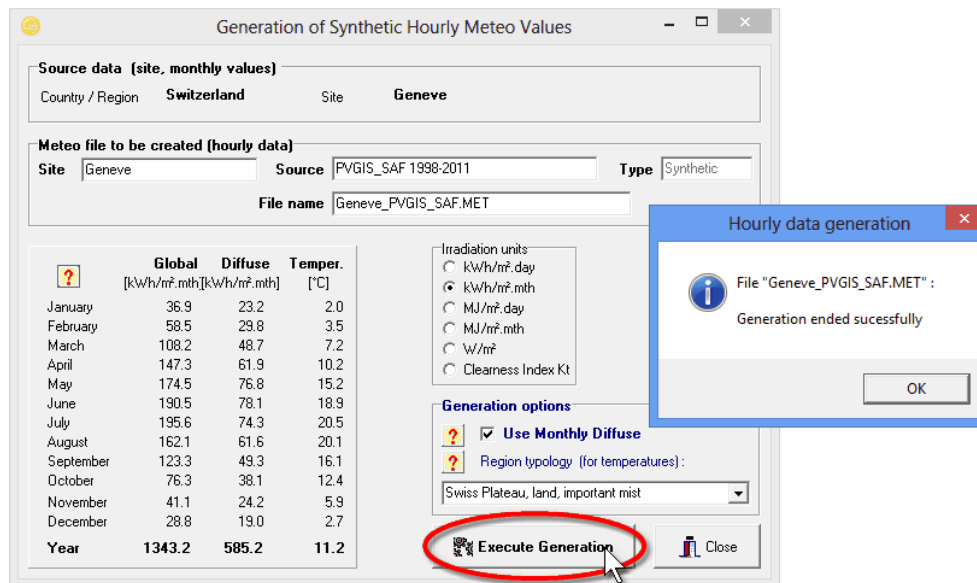
Once the site and country are specified, you will get a message, now in green, that the data has been imported successfully, and that you can proceed to save the data in a local PVsyst file. Click on "Save Site" and you will get an acknowledgement if the data has been saved successfully.



When the site file has been saved, the button “Create Meteo” will become active and you can click on it to generate the hourly data out of the monthly values that have been imported.



The dialog “Generation of Synthetic Hourly Meteo Values” will pop up. Click on “Execute Generation” and PVGIS will create the .MET file with the hourly values. A message window will acknowledge the successful generation of the file with the hourly values.



## Importing TMY3 files

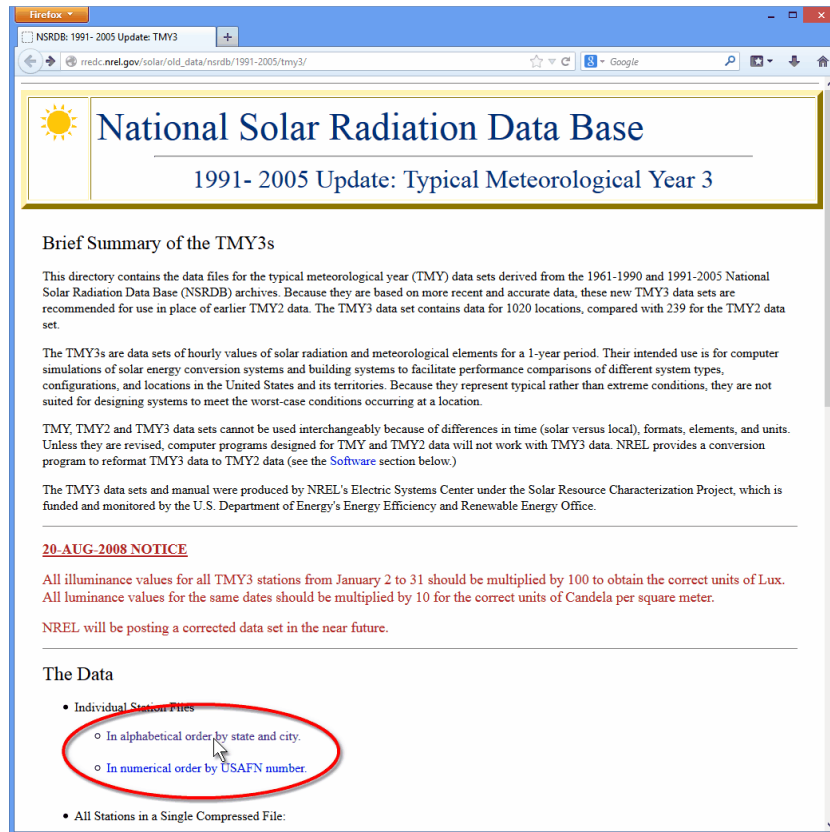
Data files of Typical Meteorological Year (TMY) are available on the web for 1020 stations in the USA, at the address [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2005/tmy3/](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/). They can also be obtained as a single zip file or on a CD-ROM. These data sets are derived from the National Solar Radiation Database (NSRDB) and produced by the National Renewable Energy Laboratory's (NREL). A complete User's manual is available on the web site.

Formerly available as TMY2 (239 stations, 1961-1990 data), since 2008 this database has been extended to TMY3 (1020 stations, 1991-2005 data). These new TMY3 are based on more recent and accurate data.

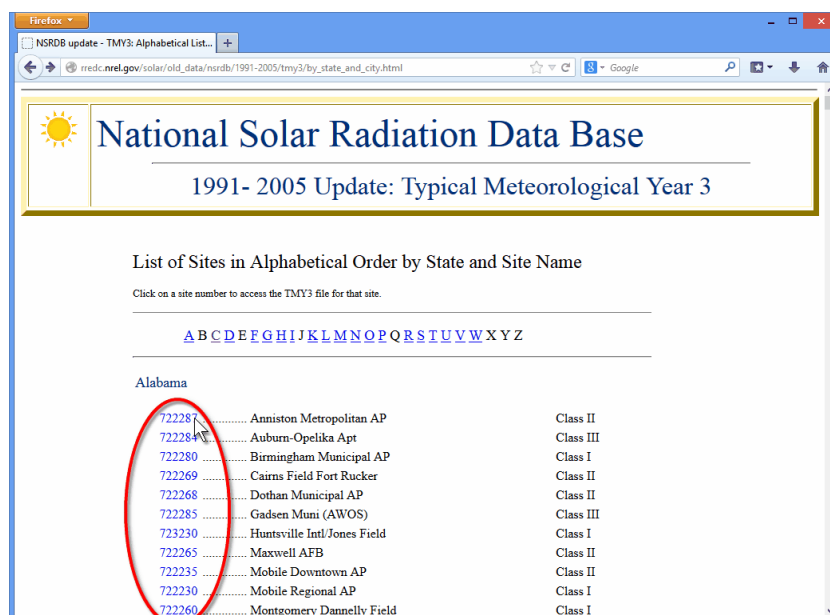
TMY files are data sets of hourly values of solar radiation and meteorological information. They are juxtapositions of months or periods of real data, chosen in the multi-year data set in such a way that they represent a typical 1-year period. Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst-case conditions occurring at a given location.

## Download TMY3 data

NREL TMY3 data can be directly and very easily imported into PVSYS. First you need to download the data files from the TMY website. You can either get a single file for a specific site or download an archive with all available data that you need to decompress to get access to the individual files. In this example we will download a single file and import the data to PVsyst. First open the link [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2005/tmy3/](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/) in a web browser. You will get to the start page of the TMY3 data. In the section "The Data", follow the link "In alphabetical order by state and city" (Alternatively you can choose to get a list in numerical order by USAFN number).



You will get a list of all available stations in the TMY database. Find the site you would like to import and save the .CSV file to which the link with USAFN code in the left column points. You can save the file in any directory of your choice. The individual TMY files have a size around 1.8 MB and the filename is the USAFN code for the site. When saving you can change the filename to something more human readable. If your web browser downloads and saves automatically files of type .CSV, make sure that you know in which directory the files will be saved so that later on you will find it. If your browser will automatically open files of type .CSV, make sure that the corresponding application allows to save a local copy.

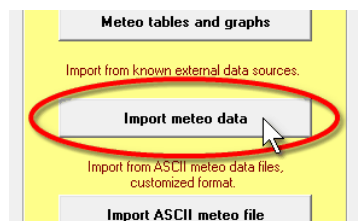


## Import the data

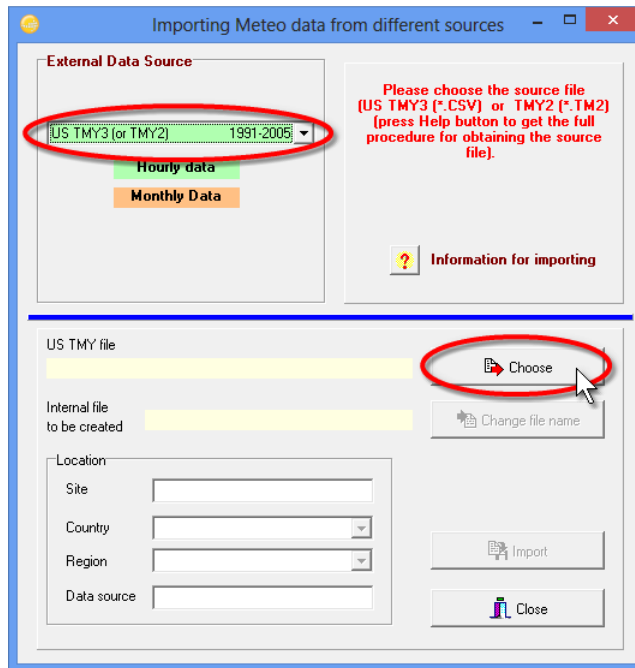
Once the file has been successfully saved you can leave the browser and in the PVsyst main window, choose "Databases".



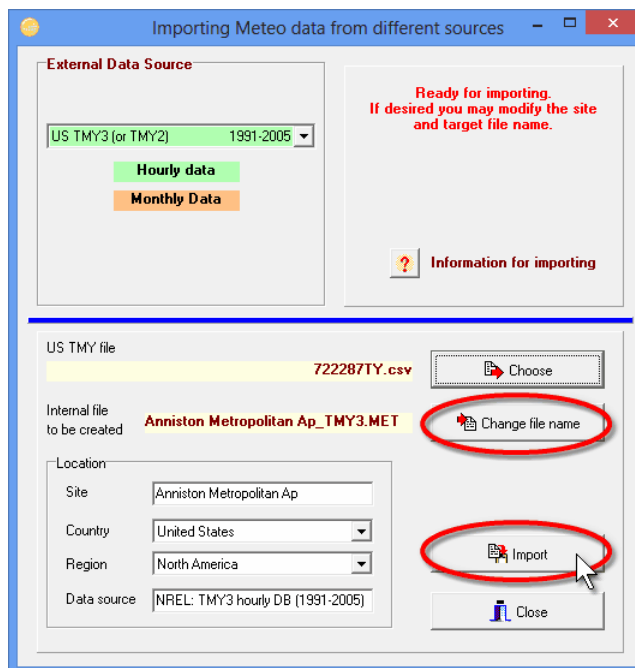
The Databases Window will open, where you click on "Import meteo data".



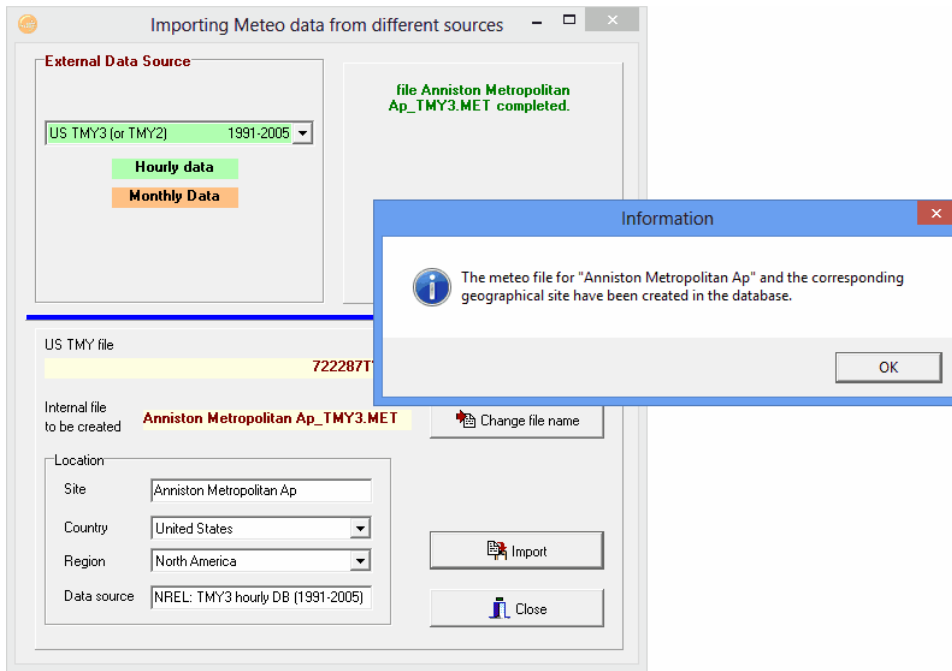
The "Import Meteo data" dialog will pop up. In the top left field you can select one of the predefined data sources. For this example you have to choose "US TMY3 (or TMY2)". In the top right field there are instructions in red that inform you on the next step to be taken. Click on the "Choose" button and find the TMY3 file that was downloaded in the previous step.



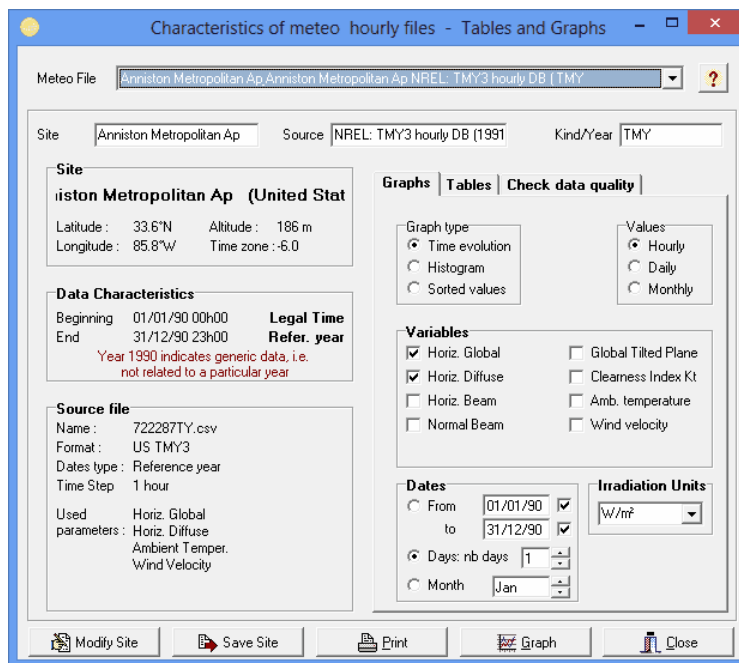
When you have chosen the file, the message on the top right will inform you that everything is ready for importing the data. Under the .CSV-filename that you have selected, the dialog displays the name of the file it will create for the imported data. You can change this filename to something shorter or more talking if you wish. Then click on the “Import” button.



If the data was imported successfully PVsyst will acknowledge it with a short information.



If you click on “OK”, the dialog “Characteristics of meteo hourly files” will pop up. In this dialog you have the possibility to visualize the imported data and to perform some advanced crosschecks to make sure that the data is consistent.





**TMY3 format**

The TMY3 format is also used for the distribution of other kinds of data (i.e. not "Typical Meteorological Years" but real data for given years). This is namely the format used as input for the SAM (Solar Advisor Model). PVsyst has been updated for reading such annual data, including the treatment of leap years. As an example, data for 9 stations in India, (generated by NREL from the SUNY satellite data), are now available for several years (2004-2008) at the NREL web site under the following link:

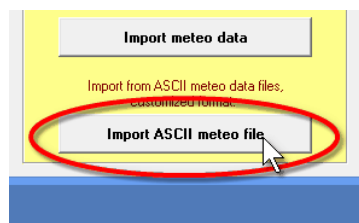
[http://www.nrel.gov/international/ra\\_india.html](http://www.nrel.gov/international/ra_india.html)

## 6- Importing Meteo Data from an ASCII file

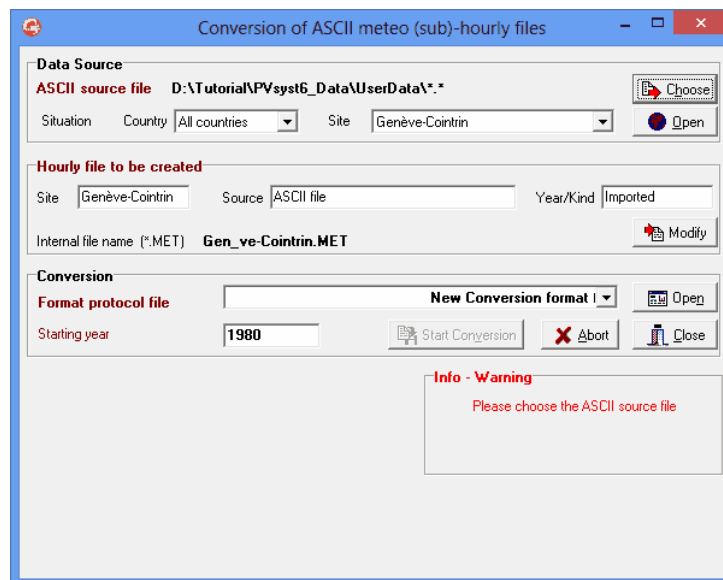
If none of the predefined data sources contains satisfactory data for your project, or if you have access to a better data source, you can import this data to PVsyst from ASCII files.

Please note, that measuring and analyzing meteorological data is a complex and difficult task. It is very easy to get biased or wrong results due to wrong calibration of instruments or inadequate analysis tools. If you want to use self-measured data, please make sure that it has been measured with adapted equipment and analyzed by an expert with the necessary skills. Always perform basic crosschecks on the data as explained in this tutorial. The meteorological data is at the origin of the main uncertainties of the simulation. Poorly measured or processed data can lead to significant deviations of the final results.

To import meteorological data from an ASCII file, click on “Import ASCII meteo file” in the Database window:



The “Conversion of ASCII meteo files” dialog will pop up.



Follow carefully each step of the conversion dialog.

- Choose your ASCII source file, which can reside anywhere on your disk.
- Choose a name for the site and specify the data source and type.
- Give a significant name to the internal file to be created. This will identify the file in the meteo or measured data list boxes. Please carefully choose this title since you won't be able to change it after conversion.

- Choose the target internal PVSYST file, which will be in the \Meteo\ directory (meteo .MET files).
- Choose or define the Format Protocol interpreter.
- In some cases (depending on the Format protocol), the program will still ask for the beginning date or the year.

This list is not exhaustive, for detailed instructions please refer to the online help of PVsyst. When you are ready, press the "Start Conversion" button.

During execution, a control executing window displays the contents of the source-file's line currently being processed, as well as the actually converted meteo values, which will be transcribed on the internal destination-file. You have the opportunity of examining the process step by step in order to ensure that the values are correct. The ASCII interpretation has been made as reliable as possible, regarding to all unexpected events which may arise on measured data files of any kind. For example, if the conversion encounters an extra comment or unreadable line, it will ask the operator to skip it. It also performs some global checks (limits, consistency) on each value. After conversion, you are advised to check your file with the "Graphs and Tables" tool (either for meteo or for measured data files), and carefully check the time shift of your data.

### Detailed example of importing an ASCII file

For this example we will use the file "DEMO\_Import\_Geneva\_POA.csv" which can be found in the PVsyst workspace under "UserData". If you want to follow the example, make sure that you have this file available in some directory that is accessible on your computer. The file contains meteorological data for the year 2006 in hourly steps for Geneva in Switzerland. There are several quantities stored in this file, among which there is the ambient temperature and the Global irradiance measured on a plane with a tilt of 30°. These two are the values we will use in the present example.

After opening "Databases" in the main PVsyst window and selecting "Import ASCII meteo file", you will get the "Conversion of ASCII meteo files" dialog, which is divided into four fields:

Data Source

Hourly file to be created

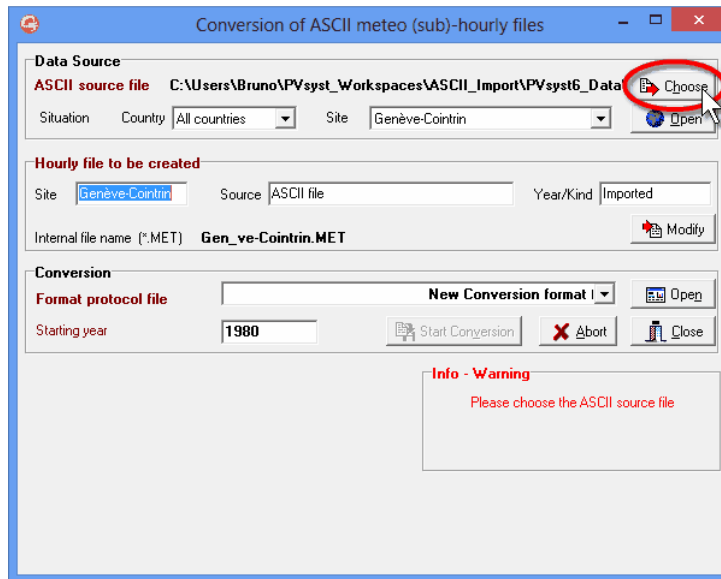
Conversion

Info – Warning

We will go through the first three of them in detail. The "Info – Warning" field will give you information and hints to guide you through the different steps that are required for the successful importing of the data.

### Data Source

When you import meteorological data from an ASCII file, you will take an existing text file with the data, and create a new file in the PVsyst format with hourly meteorological values. This file will be of type \*.MET and it will be associated to the site that you select in "Data Source". You can have several files with hourly values associated to the same site. Make sure that you have already created the site to which you want to attach the \*.MET file that will be created. In the dialog click on "Choose". A file selection dialog will pop up where you can search for the data file. The default filter will display files of type \*.DAT, \*.TXT and \*.CSV.



Once you have selected the file you specify a site for this data. To select the site you first select a country or region to narrow down the choices in the “Site” drop down list.



Next you give a small description of the data that will be attached to the output file. This information will be displayed in PVsyst in dialogs or reports as description of the Meteo file (\*.MET file). You have three fields for which PVsyst proposes default values and that you can complete or change to any text you want. It is recommended to give short descriptions, so that they will fit into the dialog fields.

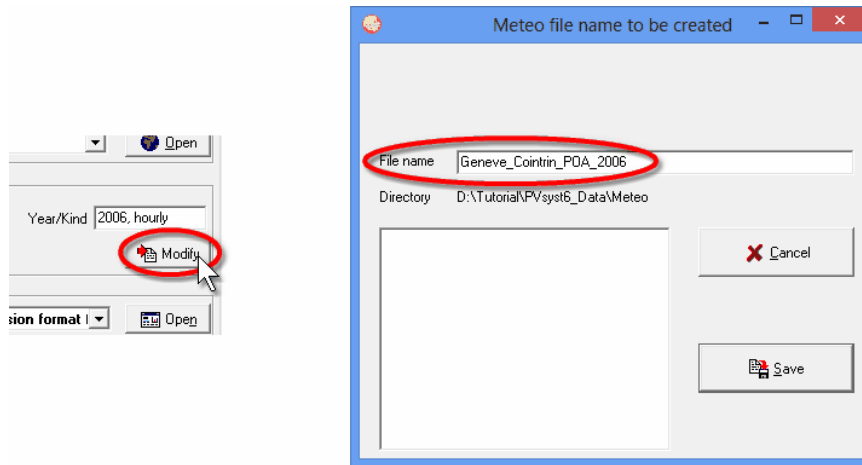


The three fields are:

- Site: The default will be the site name chosen in “Data Source”, but you can change or complete the name in this field.
- Source: Default is “ASCII file”. Here you should put a short label describing from where the data has been retrieved, e.g. the data source filename, or “Measured on site”, or “Provided by Meteo Inc.”, etc.
- Year/kind: Default is “imported”. Give a short label with the year for which this data is valid, and if it is hourly, daily or even sub-hourly data. Try not to exceed the visible width of the field, so you can read this label easily in other PVsyst dialogs.

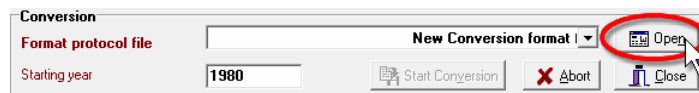
Now you need to specify the output filename. PVsyst proposes a filename generated from the site name in the “Data Source” field. If your source file contains several data sets for the same site, like

for different years or measurements in the horizontal and tilted plane, you are advised to change the output filename to something that will identify which portion of the data is being imported.

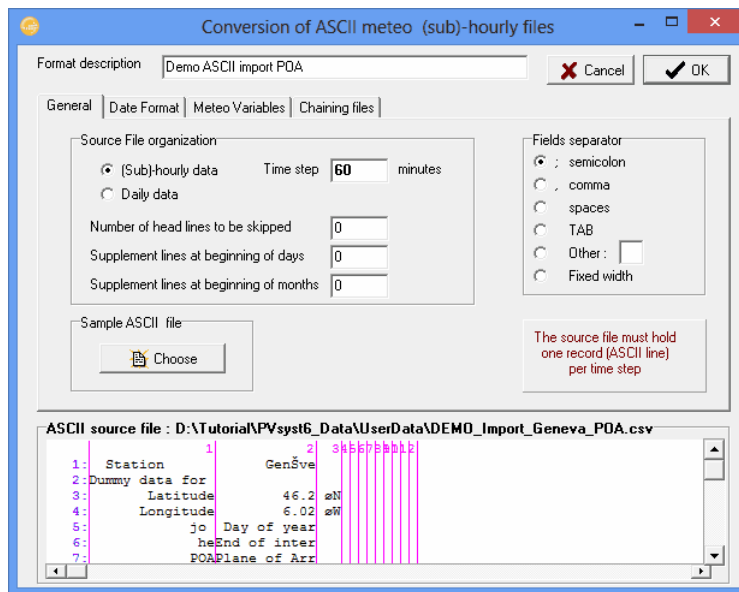


### Define the data format

You need to tell PVsyst what kind of data will be imported from the text file, and where to find the data fields in the file. This information will be stored in an internal PVsyst file of type \*.MEF. You can create as many of these format protocol files as you like. To create a new format, select “New conversion format” from the pull down list in the field “Conversion” and then click on “Open”.



The dialog “Conversion of ASCII meteo (sub)-hourly files” will pop up. It contains a field “Format description” where you can give a short label that will identify this format protocol. The dialog contains four different tabs, “General”, “Date Format”, “Meteo Variables” and “Chaining files”. We will look in detail at the first three tabs. The last tab, “Chaining files”, is needed if your data is distributed among several files and will not be described in this example. The lower part of the dialog gives a visual feedback on how the format protocol that is being defined will apply to the content of the data source file. Here you can quickly check if the different values have been selected properly or if there are problems with the format protocol.

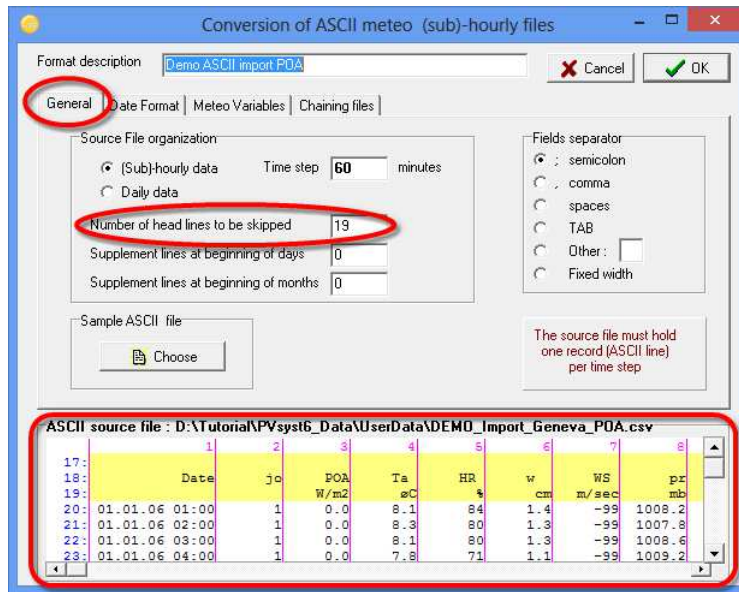


### Requirements for the format of the source file

The interface for importing ASCII data files expects that the data is organized in columns and that it is either daily values or values for fixed time steps expressed in minutes. The columns either need to be separated by an unambiguous character (including TAB or SPACE) or be of fixed width. The file can contain an arbitrary number of header lines before the data and it can have a fixed number of extra lines at the beginning of each month and at the beginning of each day. The number of these extra lines can be different for the start of months or the start of days.

### Tab “General”

For the example file, which contains hourly data, you can leave the default selection “(Sub)-hourly data” with a time step of 60 min. The demo file also uses the default separator, which is a semicolon. In the lower part of the window you can check that the columns containing the data start on line 20 of the file. In the field “Number of head lines to be skipped” you enter therefore 19. In the bottom display the background of the skipped lines will now turn yellow and you can check that the first line with white background is also the first line containing data.

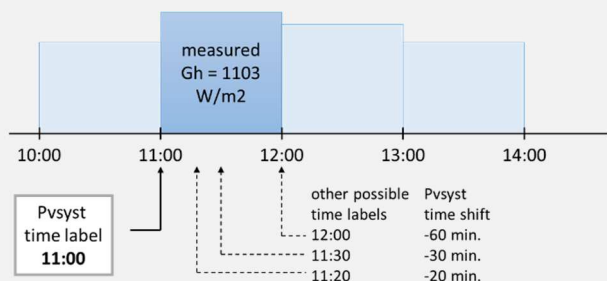


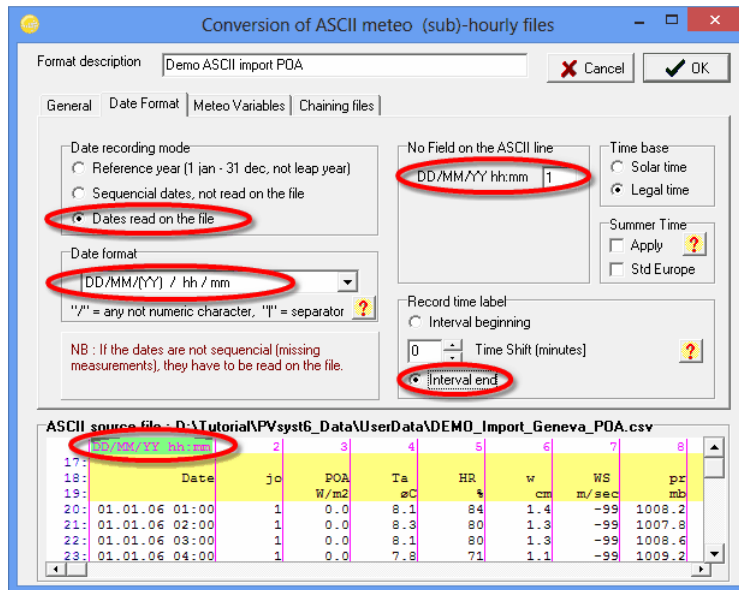
### Tab “Date Format”

In this tab you specify in which column the timestamps can be found, and how they are formatted. For our example you need to select “Dates read on the file” and choose the adequate format from the drop down list “Date format”. In this case it is “DD/MM/(YY) / hh / mm”, which means that the date is ordered as Day/Month/Year and that date and time are not in separate columns. The slashes are wildcards and represent any non-numeric character except for the column separators. Then, in the field “No Field on the ASCII line” you specify the column where the timestamp can be found, which is “1” in our example. In the bottom part of the dialog you will see a green header for the specified column. Finally you need to specify how the time label is related to the measurements. In our example the time labels correspond to the end of the measurement.

#### Time Labels

In PVsyst any hourly value with a time stamp should be representative for the hour that follows the moment given by the time stamp. Thus, if for example the irradiance is measured and averaged over an hour, and then labelled with a timestamp corresponding to the end or middle of this interval, this will lead to a time shift.

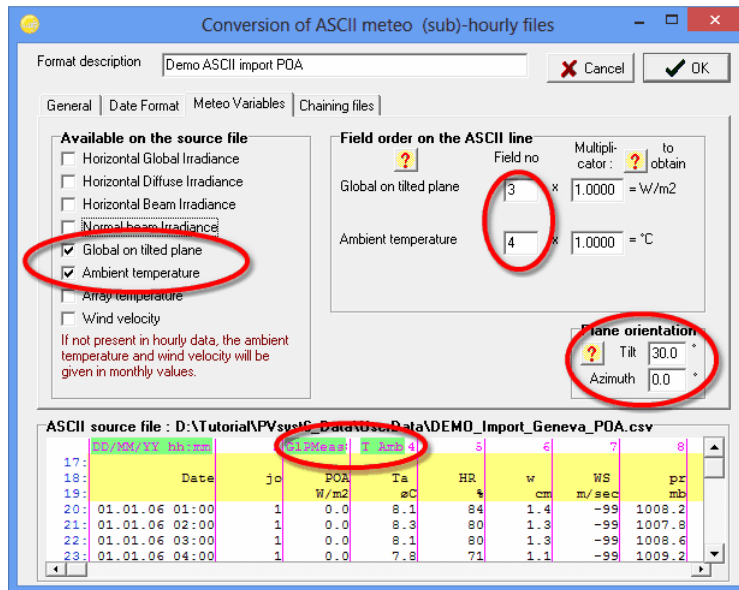




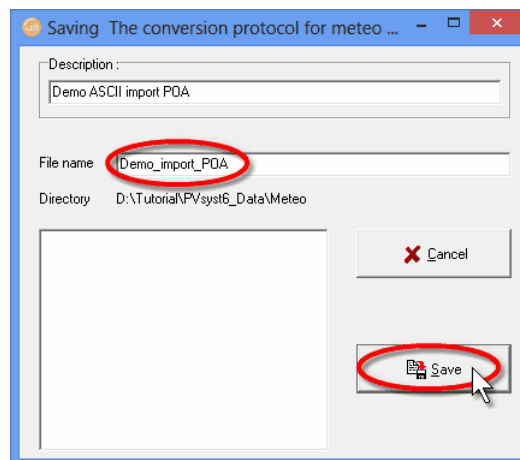
### Tab “Meteo Variables”

In this tab you specify the type of meteorological data and its location. On the left side of the dialog you have a field where you can select several meteorological variables. For the example you need to select “Global on tilted plane” and “Ambient temperature”. For each selected value you will get a line on the right side of the dialog where you should enter the column in which the variable can be found. In our example these are the columns 3 for the Irradiance and 4 for the temperature. The default units for these variables are W/m2 and °C respectively. If the data comes in different units you have the possibility to specify a factor which will be multiplied to the values. In our example file the units correspond to the default values and we can leave 1.000 as factor. Once you have specified a field number for a variable you will see that the corresponding column in the bottom part of the dialog gets a green header with the variable name. This allows to quickly control if the supplied values are correct. Since the measurements are for an inclined plane, you have to specify tilt and azimuth of the plane. In the field “Plane orientation” enter 30° for the tilt and leave the azimuth at zero (south). Note that this field will only be present if a variable for an inclined plane has been selected in the left part of the dialog.

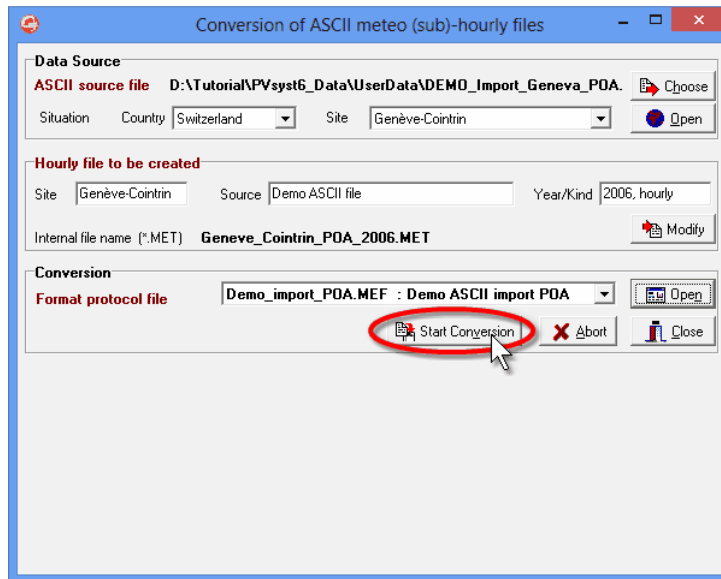




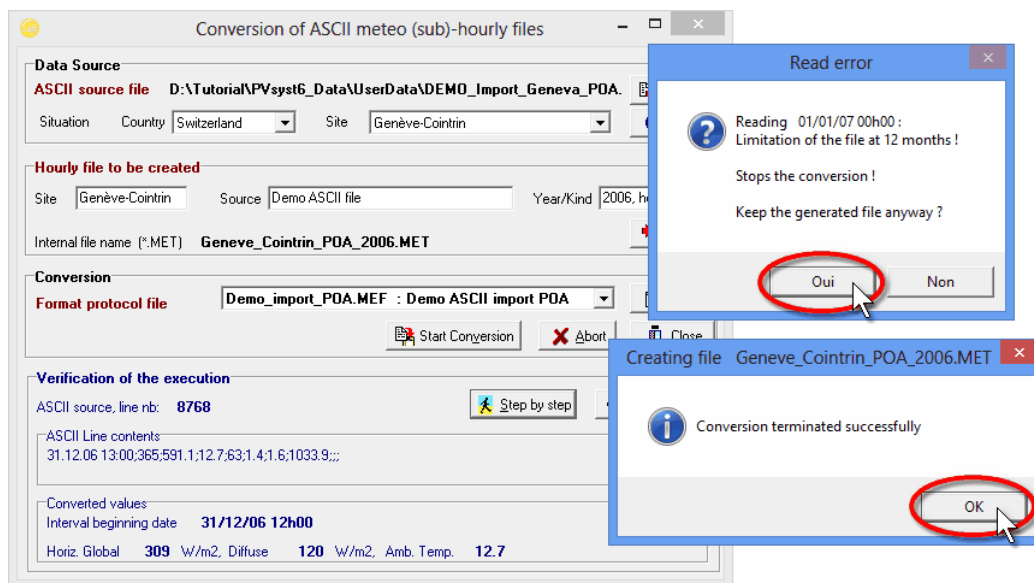
When all the specifications of the format protocol have been entered in the four tabs, click on “OK” and you will be asked to save the newly defined conversion protocol. Give a meaningful description that is not too long to fit in a drop down list. Enter a filename and click on “Save”. If a file with the same name already exists you will be asked to confirm to overwrite it.



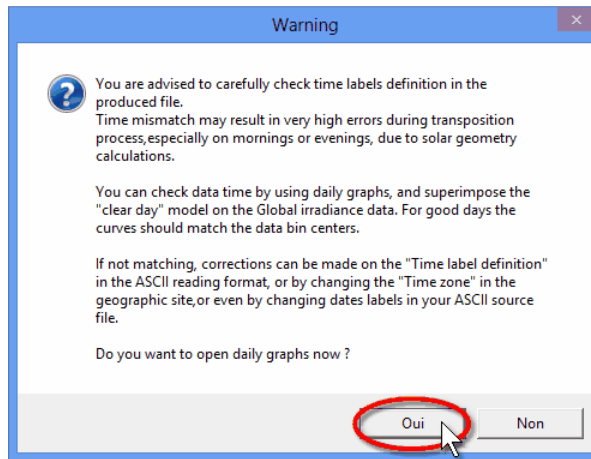
After saving successfully the format protocol you will get back to the dialog «Conversion of ASCII meteo (sub)-hourly files». You can now click on « Start Conversion » to import the data from the ASCII file.



In the example file the timestamp in the last line of data is already the first hour of the following year (2007). You will be prompted with a corresponding warning message that you acknowledge by clicking on “Yes”. When the conversion is finished you will get a prompt where you click on “OK”.

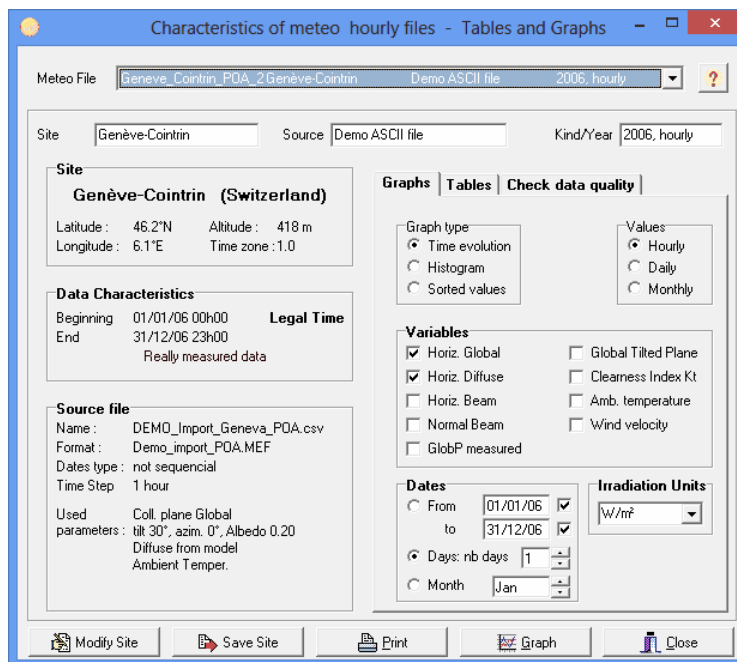


The conversion is now finished and you should carefully check if the result does not contain any obvious error or inconsistency. A prompt asking if you want to open the dialog for visualizing the meteorological data will pop up. Click on “Yes” to open the dialog

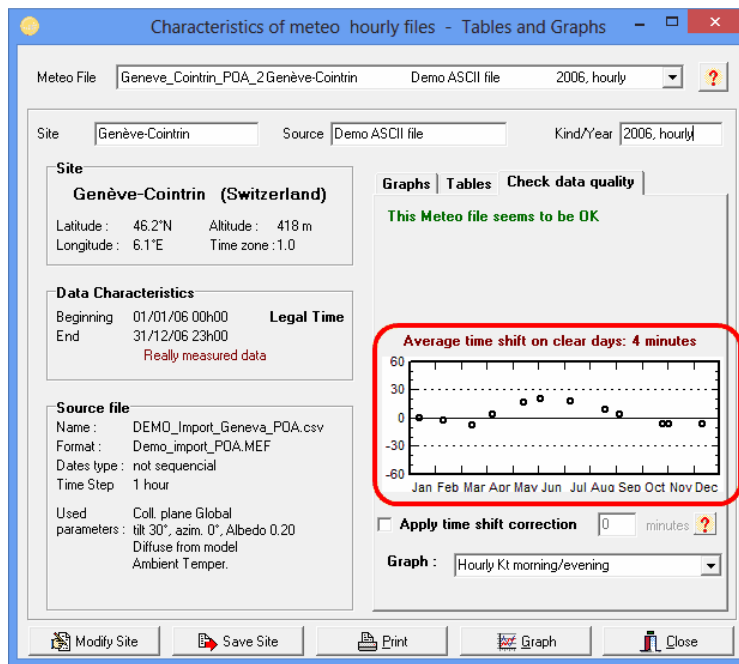


### Check the imported data

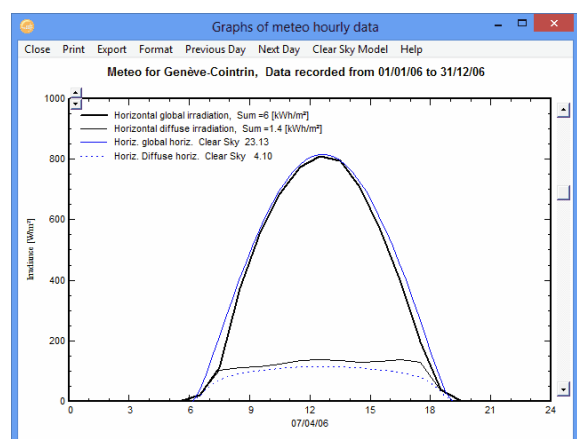
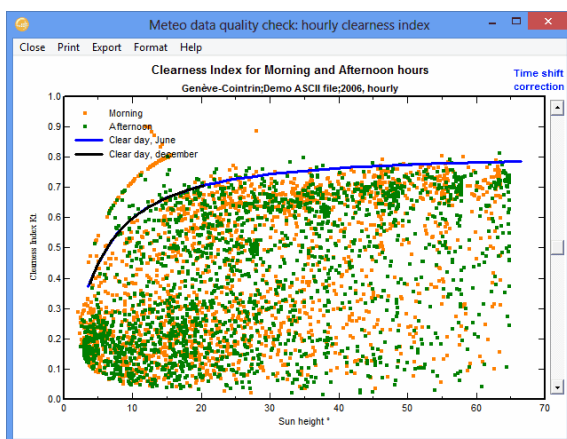
You should always perform some basic checks on the meteorological data that you want to use for a simulation of a PV installation. PVsyst offers a variety of tools to do this in the dialog “Characteristics of meteo hourly files – Tables and Graphs” that will pop up when you select “Yes” in the final prompt after importing an ASCII file as described in the previous paragraph. If the newly created file does not show up in the “Meteo File” drop down list, it could be that the program missed to update the list properly. In this case you need to exit PVsyst, restart it from scratch and access the dialog from the main window by selecting “Databases” and then “Meteo tables and graphs”.



In the upper part of the dialog you will find the three fields “Site”, “Source” and “Kind/Year” that you filled when creating the file. Below on the left side you will find detailed information on the site to which this meteo file has been associated, on the time range covered by the data and on some of the details of the original ASCII file from which the data was imported and that you defined in the conversion protocol. The right side of the dialog contains the options to visualize the meteorological data and is subdivided into three tabs. Select the tab “Check data quality”. The tab contains a small control plot displaying the time shift that PVsyst estimates for the imported data. In the current example it should be close to zero.



There are two more ways to visualize possible time shift contained in the data. The first one is to look at the clearness index for morning and afternoon hours. The orange dots show the clearness index as a function of the sun height in the morning, while the green dots show the same information times after 12:00. Both colors should follow roughly the same distribution. The other possibility is to compare the daily evolution of the measured irradiation (global and diffuse) to the clear sky model. If you select “Monthly best clear days” from the “Graph” pull down menu, you will get a plot like the one shown below on the right side. PVsyst selects for each month of the year the day that fits best to the clear sky model. You can scroll through these 12 plots with the scrollbar on the right. You should see no significant horizontal shift between the measured data in black and the clear sky model in blue.

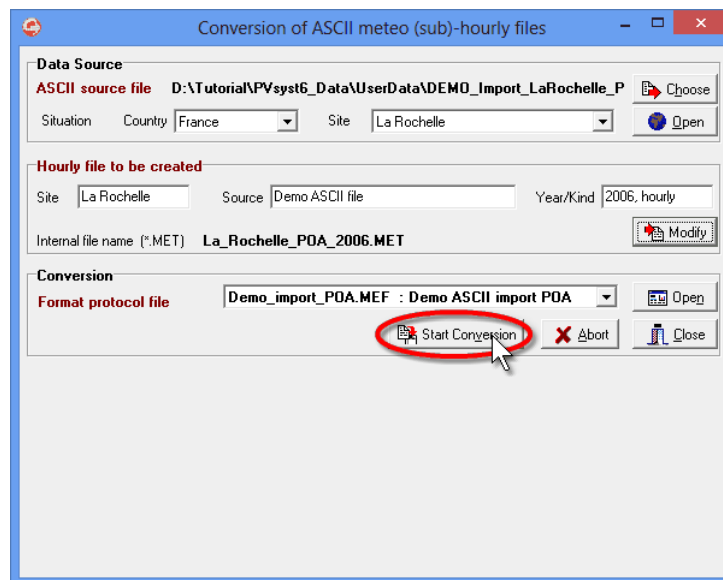


### Example with a time shift

For this example we will use the file “DEMO\_Import\_LaRochelle\_POA.csv” which can be found in the PVsyst workspace under “UserData”. If you want to follow the example, make sure that you have this file available in some directory that is accessible on your computer. The file contains artificial meteorological data for the year 2006 in hourly steps for the city La Rochelle in France.

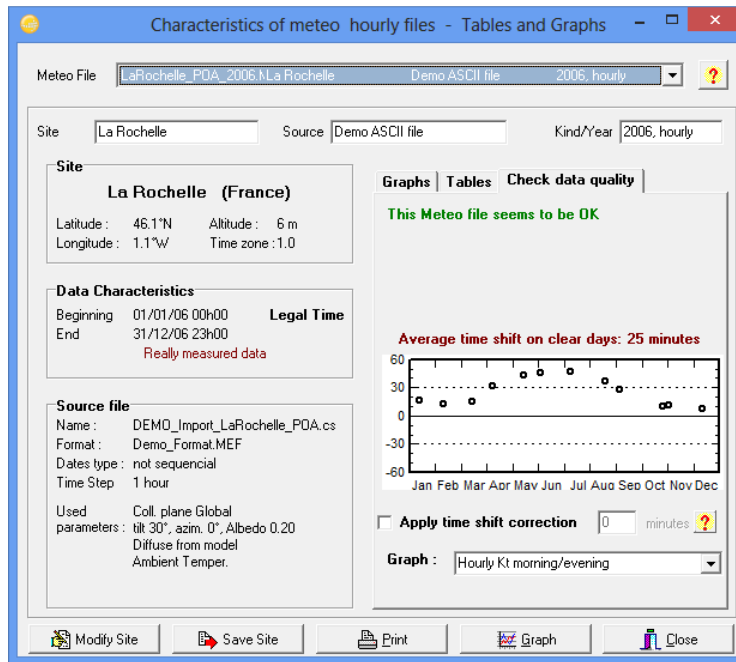
The variables and the format are the same as in the previous example. The timestamps in the file are shifted by 29 min. with respect to the actual measurement time, to provide an example where checks on data quality and subsequent corrections can be exercised. This file does not contain data that can be used in a real project, it is meant only for learning purposes.

First we will import the data in the same way as in the previous example, replacing the site name and location by La Rochelle, France. Since the format of the file is the same, you can reuse the format protocol. When you have filled all the fields, click on “Start Conversion”.

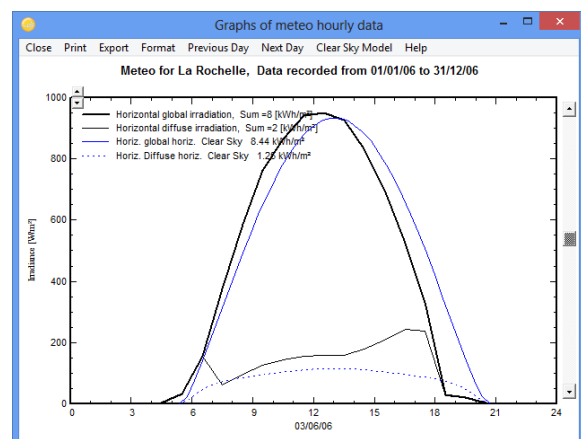
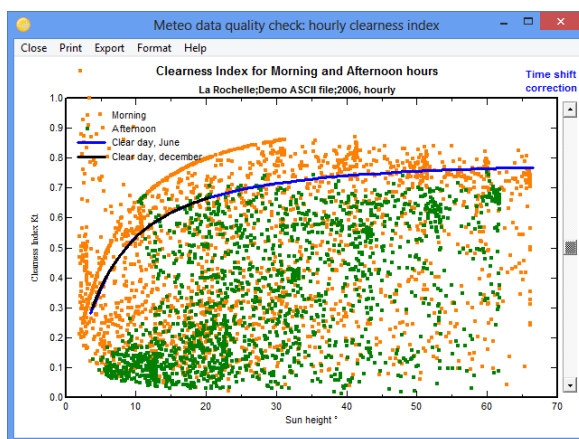


During the conversion you will get the same prompts as in the previous example that you can acknowledge. In the end you should get the window “Characteristics of meteo hourly files – Tables and Graphs” where you can visualize the hourly data. Check in the top field that you are looking at the data from La Rochelle that you just imported. If you do not find a corresponding entry in the pull down list, PVsyst has not updated its information properly. In this case you need to exit PVsyst completely and restart it. From the main window choose “Databases” / “Meteo tables and graphs”. You should now find an entry for La Rochelle in the drop down list at the top of the window.

Select the tab “Check data quality” where you find again the small control plot displaying the time shift that PVsyst estimates for the imported data. In the current example an artificial time shift of 29 min. was introduced in the data. As seen on the plot, PVsyst estimates the shift to be 25 min., which is very close to the real value.



There are two more ways to visualize the time shift contained in the data. The first one is to look at the clearness index for morning and afternoon hours. The orange dots show the clearness index as a function of the sun height in the morning, while the green dots show the same information times after 12:00. Both colors should follow roughly the same distribution, which is clearly not the case in the example, where the morning hours have higher Kt on average. The other possibility is to compare the daily evolution of the measured irradiation (global and diffuse) to the clear sky model. If you select "Monthly best clear days" from the "Graph" pull down menu, you will get a plot like the one shown below on the right side. PVsyst selects for each month of the year the day that fits best to the clear sky model. You can scroll through these 12 plots with the scrollbar on the right. You notice that there is a horizontal shift between the measured data in black and the clear sky model in blue. Also the deformation of the global diffuse curves on the sides is an artefact caused by the time shift in the data.



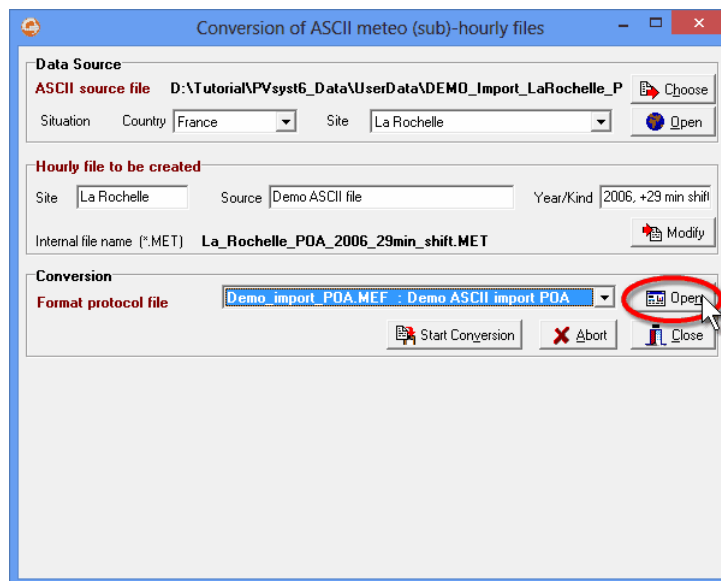
To fix the time shift in the data, two things need to be done: First the data has to be imported again applying the correct time shift. Then PVsyst needs to be told that the data contains a time shift. This is achieved by checking the field "Apply time shift correction" and supplying the corresponding shift value in the field next to it.



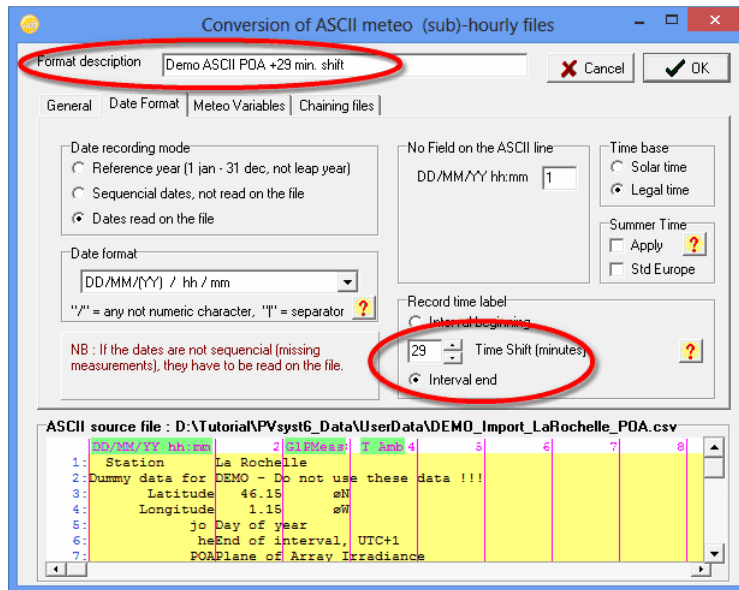
In practice you will only need to worry about the first step, since PVsyst will automatically check the option “Apply time shift correction” and insert the correct shift, when you import the data with a time shift.

Importing the data with a time shift

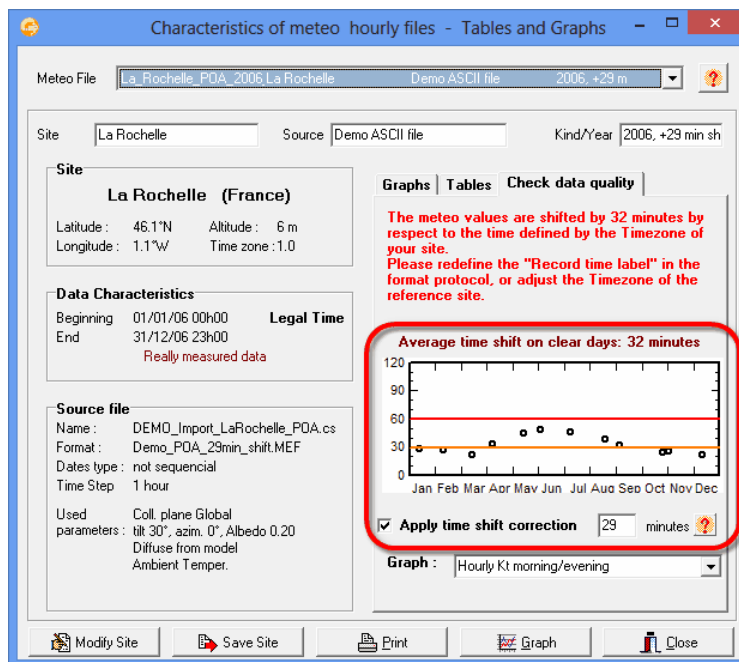
Proceed again like in the previous example, making sure to specify a different output filename and a comment that a time shift will be applied. Choose the same format protocol as in the previous examples and click on “Open”.



The dialog for defining the format protocol will appear on the screen. Choose the tab “Date Format”. In the field “Record time label” specify a time shift of +29 minutes. You might also want to change the comment in “Format description” at the top of the dialog.



When you are done, click on “OK” and save the new format protocol under a separate filename. Now you can start the conversion again and acknowledge the warnings and prompts until you get to the window with the control plots. You will notice, that in the small control plot the twelve points now scatter around the orange line which marks the time shift that is being applied.



When you now look at the plot of the clearness index Kt for morning and afternoon, you notice that the two distributions do not differ much anymore. Also the curves of the global and diffuse irradiation on the horizontal plane are not shifted anymore with respect to the clear sky model.



