PVSYST 7

Near shadings
3D scene

INTRODUCTION

This document is a first step of a series of tutorials that demonstrates the use of PVsyst Version 7 and may be understood as a PVsyst user's manual. This second chapter describes the construction and the use of 3D near shading.

More tutorials on different features of PVsyst are in preparation and will be added in the future. The complete reference manual for PVsyst is the online help that 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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Chapter 2: Basics of 3D Near Shadings Construction

The construction of near shadings is a part of PVsyst that requires some time and exercise to master and make full use of all available options and features. Therefore, we hereby present a complete example as an exercise to explain the main steps and give tips and advice for an easier use of this tool.

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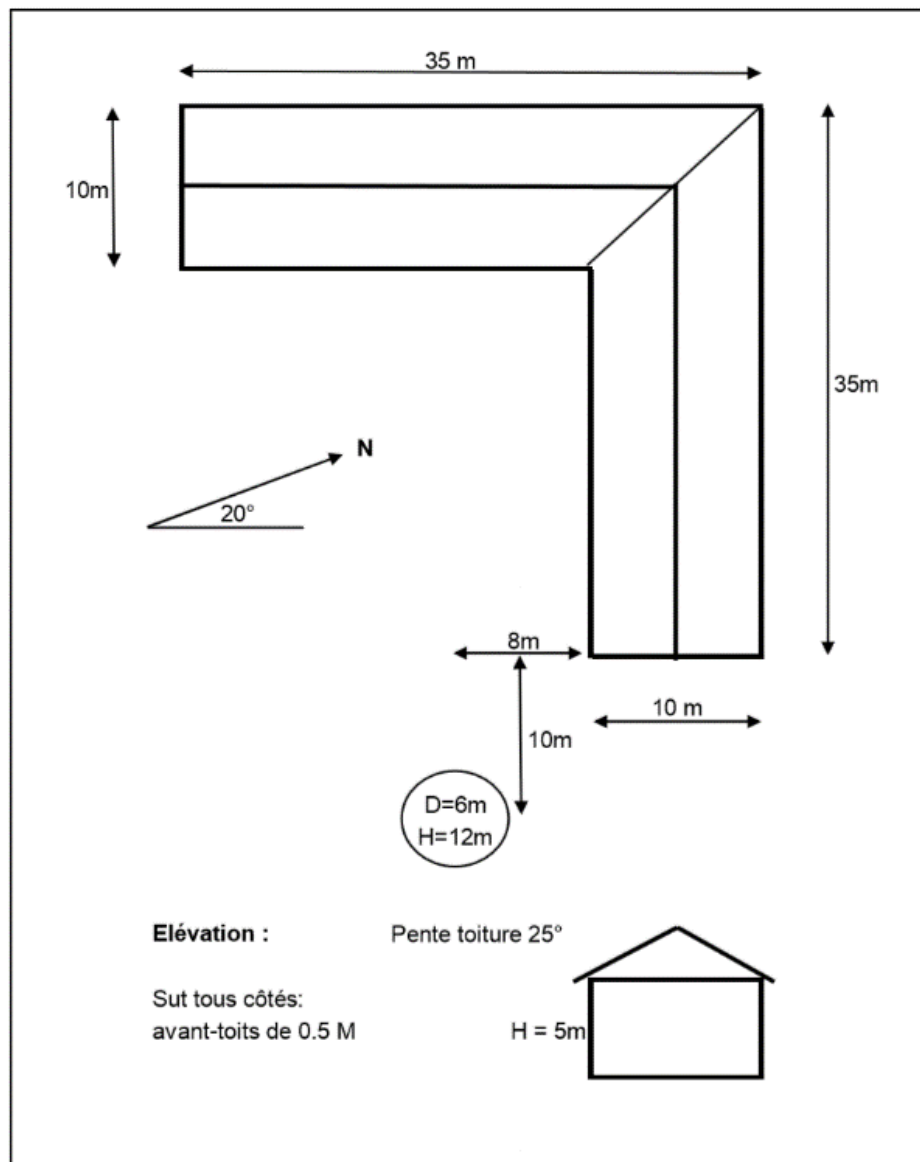

Figure 1: Project sketch.

2.1 Defining the 3D scene

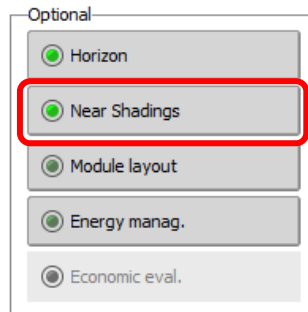In the "Project Design" window, click on the "Near Shadings" button.

Figure 2: Near shadings option.

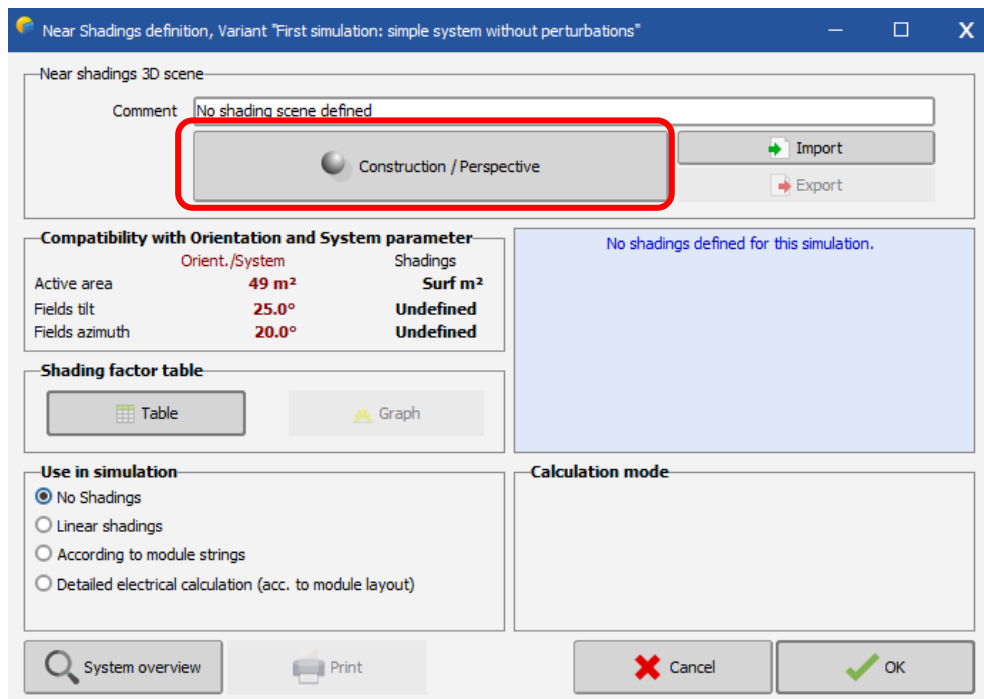The "Near Shadings definition" dialog will open, and here, click on "Construction/Perspective".

Figure 3: Near shadings dialog.

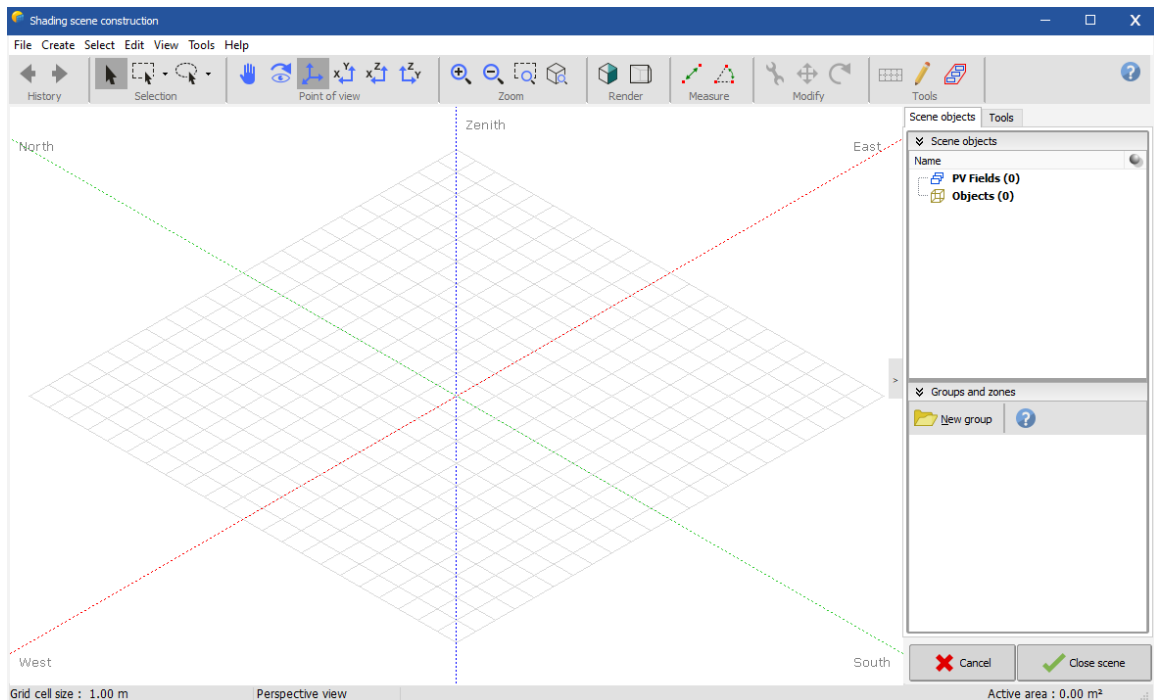You are then directed to the main 3D window to construct the "scene".

Figure 4: 3D scene editor.

2.1.1 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.

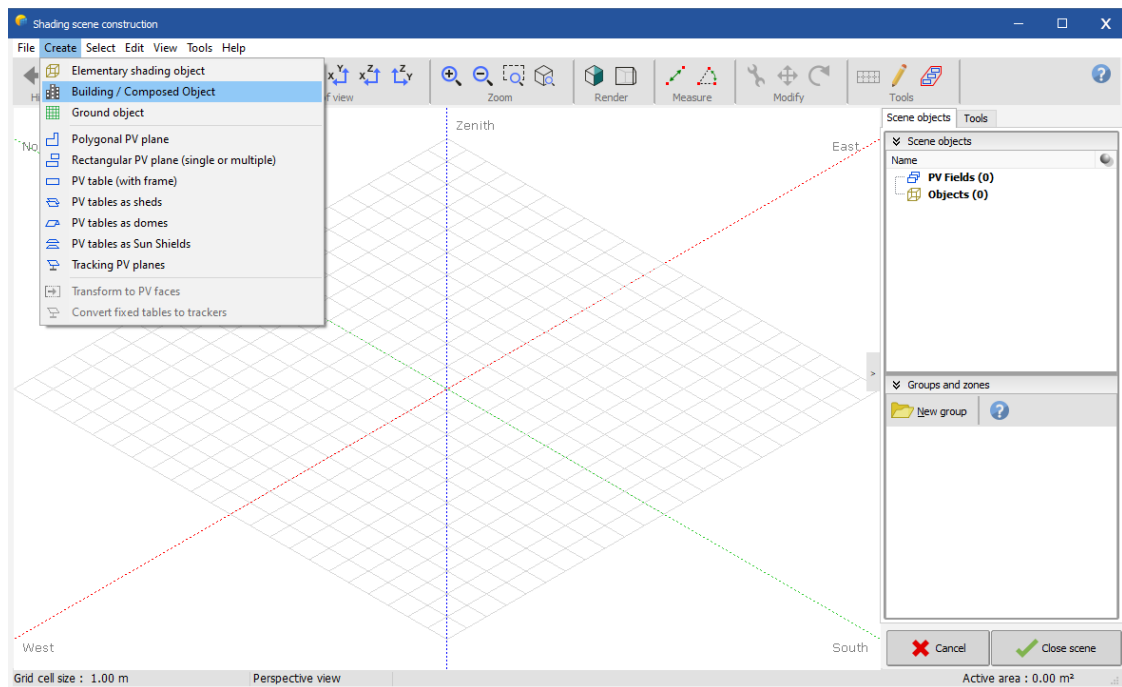From the menu, choose "Create" - "Building / Composed object".

Figure 5: Creating a building.

This will open a secondary 3D window in the reference coordinate system of the new building object.
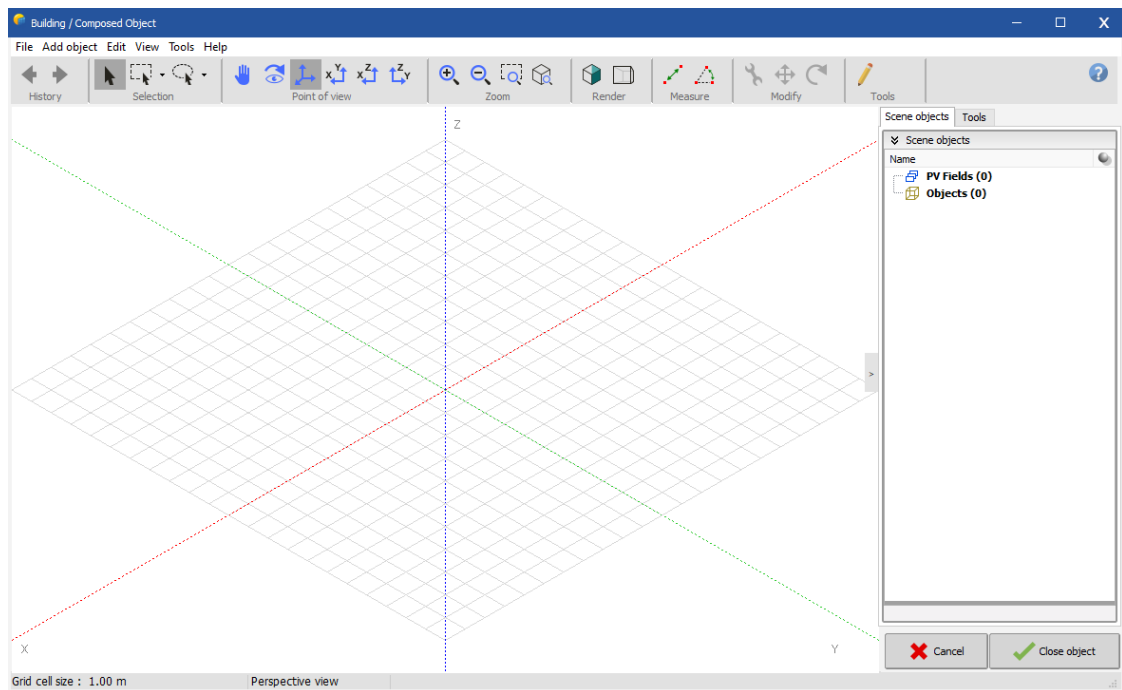
Figure 6: Secondary 3D editor in the reference coordinate system.

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

For this example, choose "Parallelepiped" and define the sizes (Width = 10m, Length = 35m, Height = 5m), see (Figure 7).

Figure 7: Parallelepiped and its dimension.

Click "Close". The parallelepiped will be placed in the coordinate system of the buildings' object

From the menu, choose "Add Object" once again.

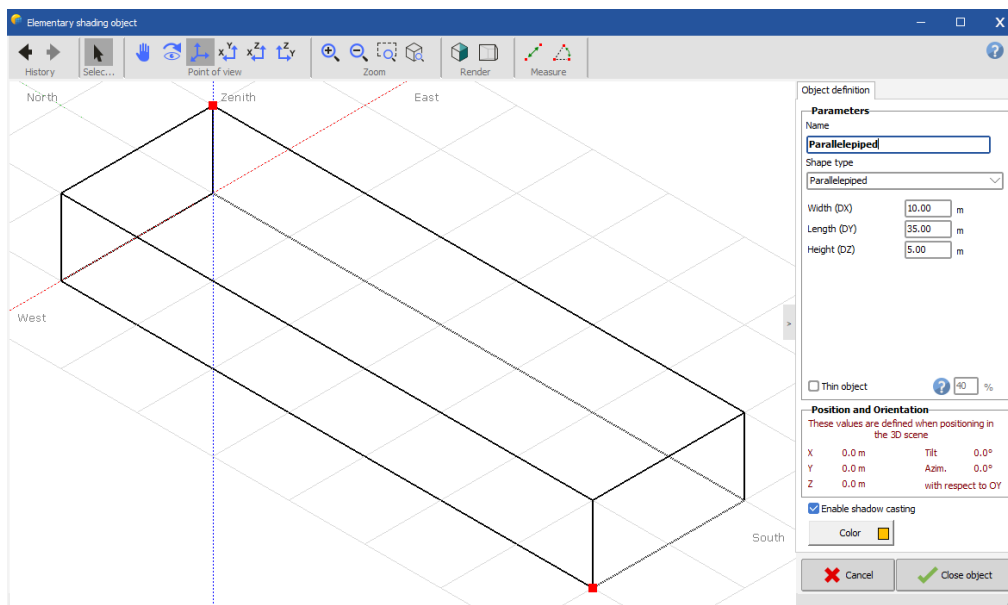Then, choose "Parallelepiped" and define the sizes of the second wing of the farm (Width = 10m, Length = 25m, Height = 5m), see (Figure 8).

Click "Close". This will place the parallelepiped in the coordinate system of the buildings' object, again positioned at the origin.
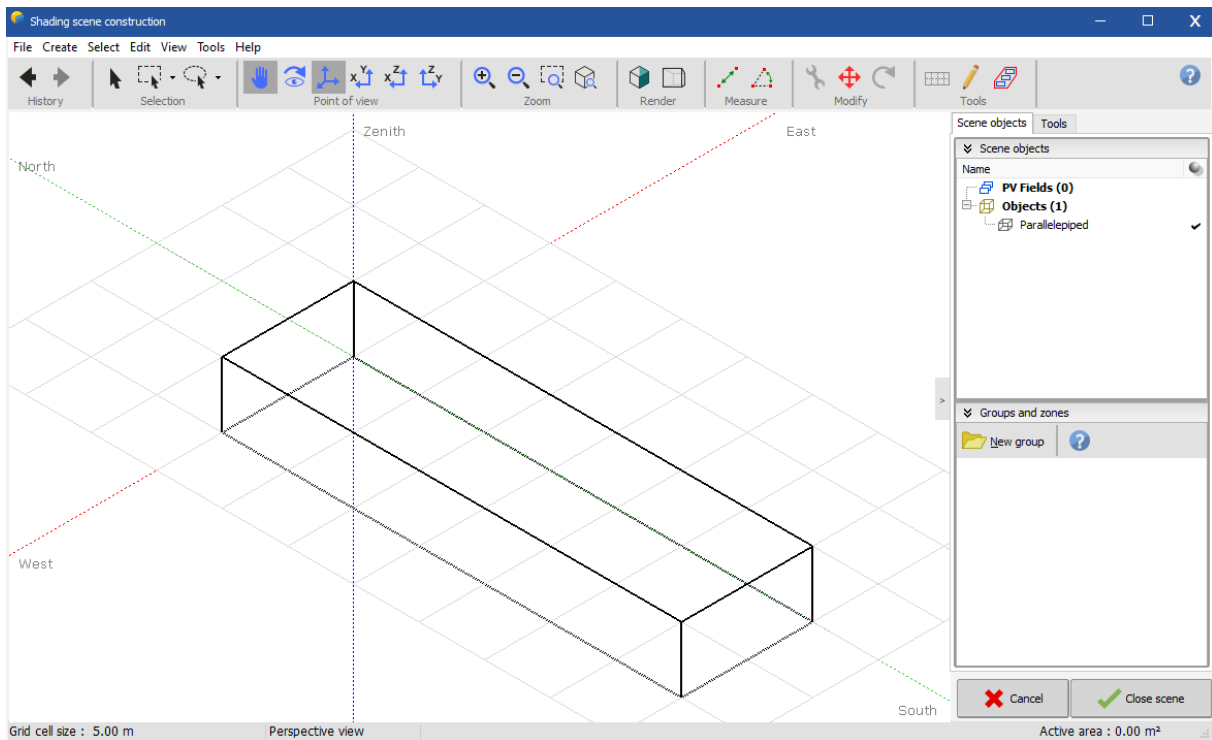

Figure 8: Second parallelepiped for the second wing of the farm.

2.1.2 Positioning in the 3D scene

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

Please note that to select 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).
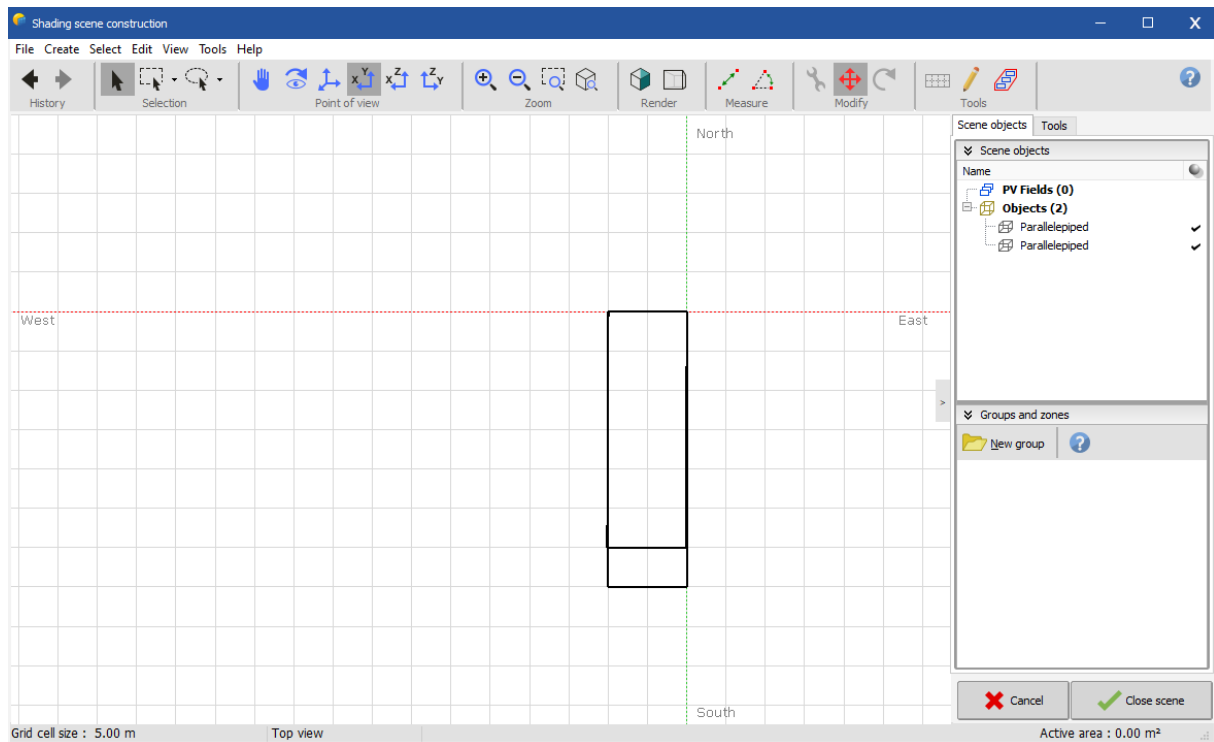
Figure 9: Top view referential.

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 move the selected object with the mouse, and the violet point to rotate it. Move and rotate the object roughly to its place as second wing, perpendicular to the first parallelepiped.
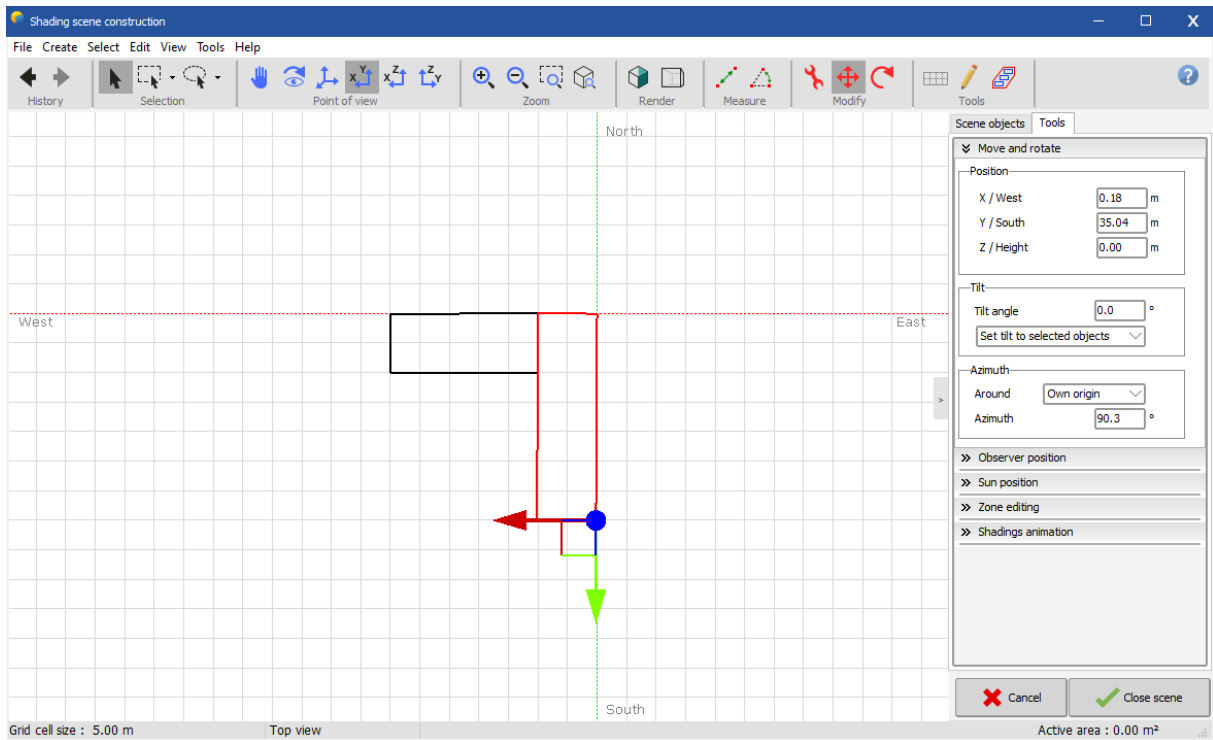
Figure 11: Moving and rotating the object with the cursor.

The mouse will not allow you to get precise positioning. But after placing the object roughly, the "Object Positioning" dialog will display the approximate displacement and rotation, and now you can adjust the exact values according to the drawing. In our case, you will put X = 10.00m, Y = 10.00m, and do not forget Azimuth = 90.0°.
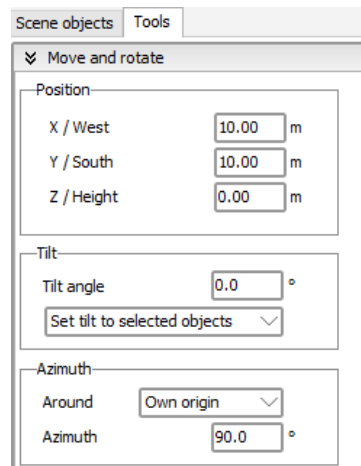
Figure 10: Object positioning dialog.

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 Figure 12.
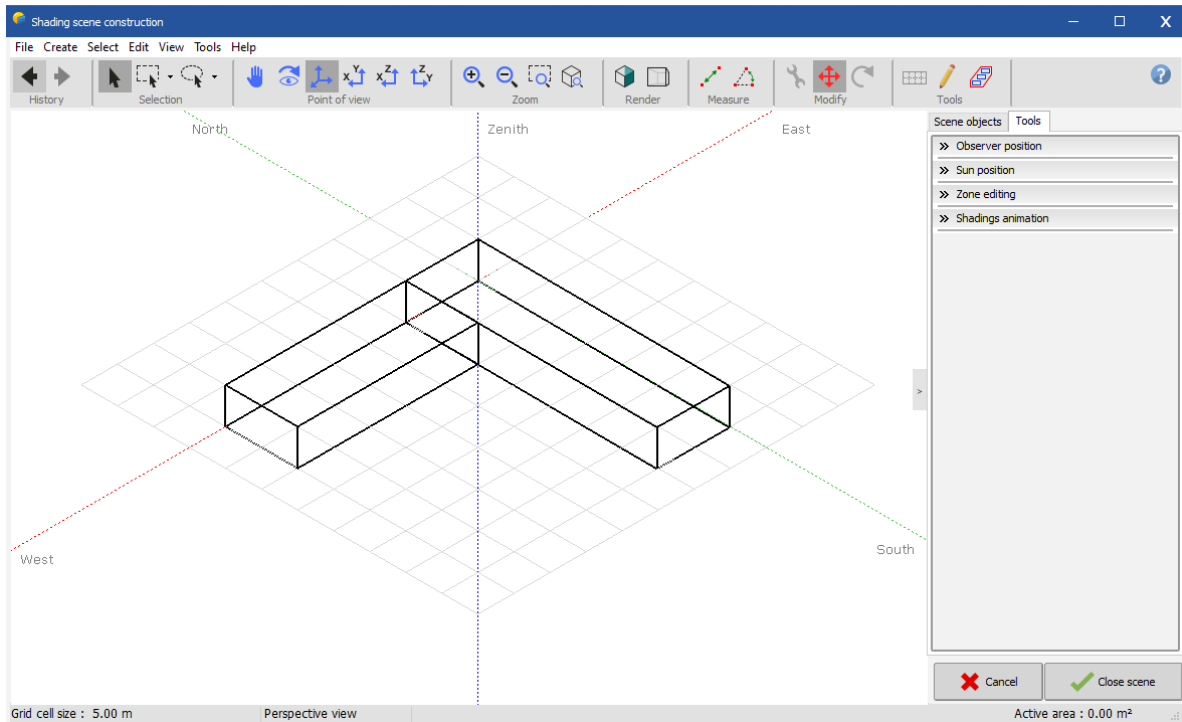

Figure 12: Standard perspective of the object.

2.1.3 Adding the roof

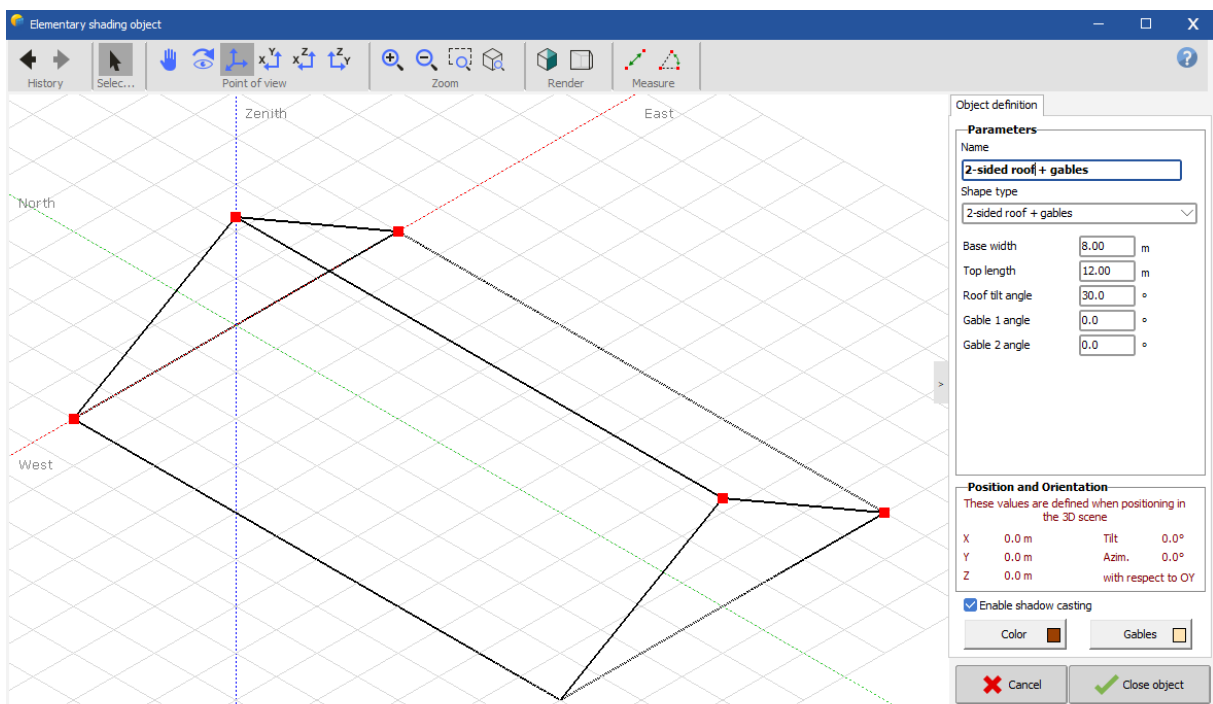Click on the menu "Add Object" and choose "Two-sided roof + Gables" in the new window.

Figure 13: Two-sided roof + gables.

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).
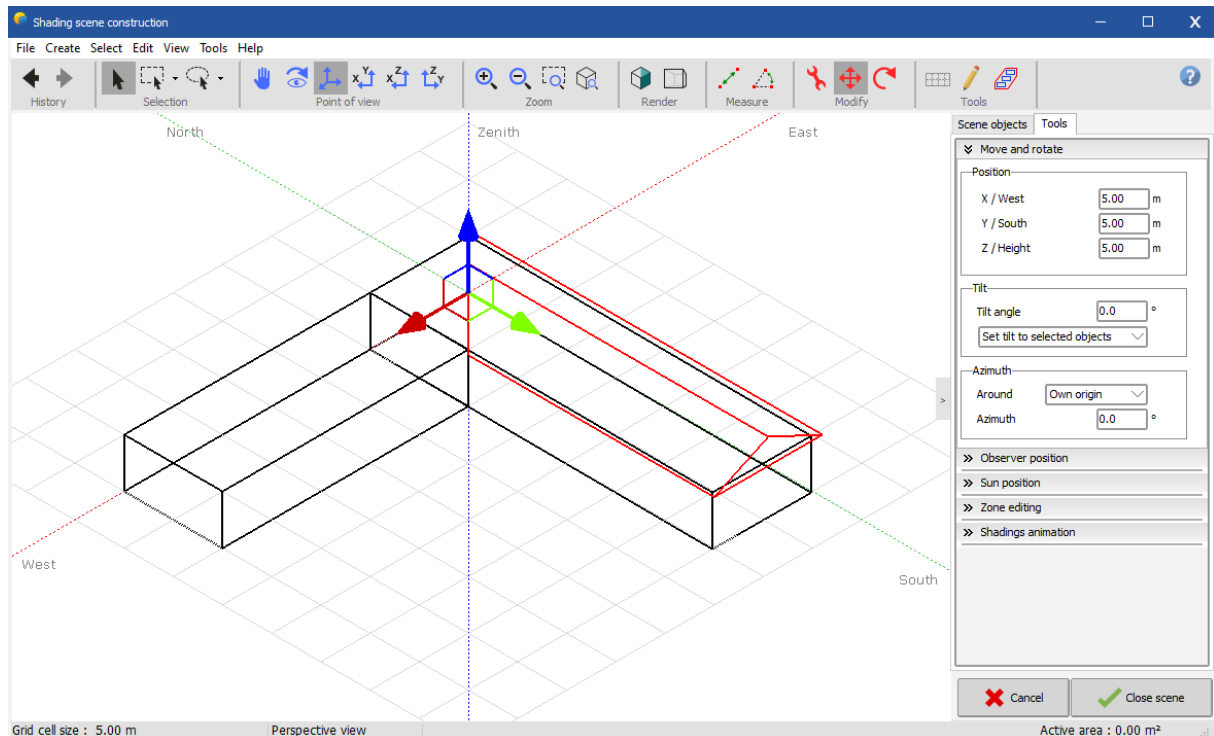
Figure 14: Positioning the roof.

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. To modify 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.

The building is now ready. Click "Close Object" to return to the shading scene construction.
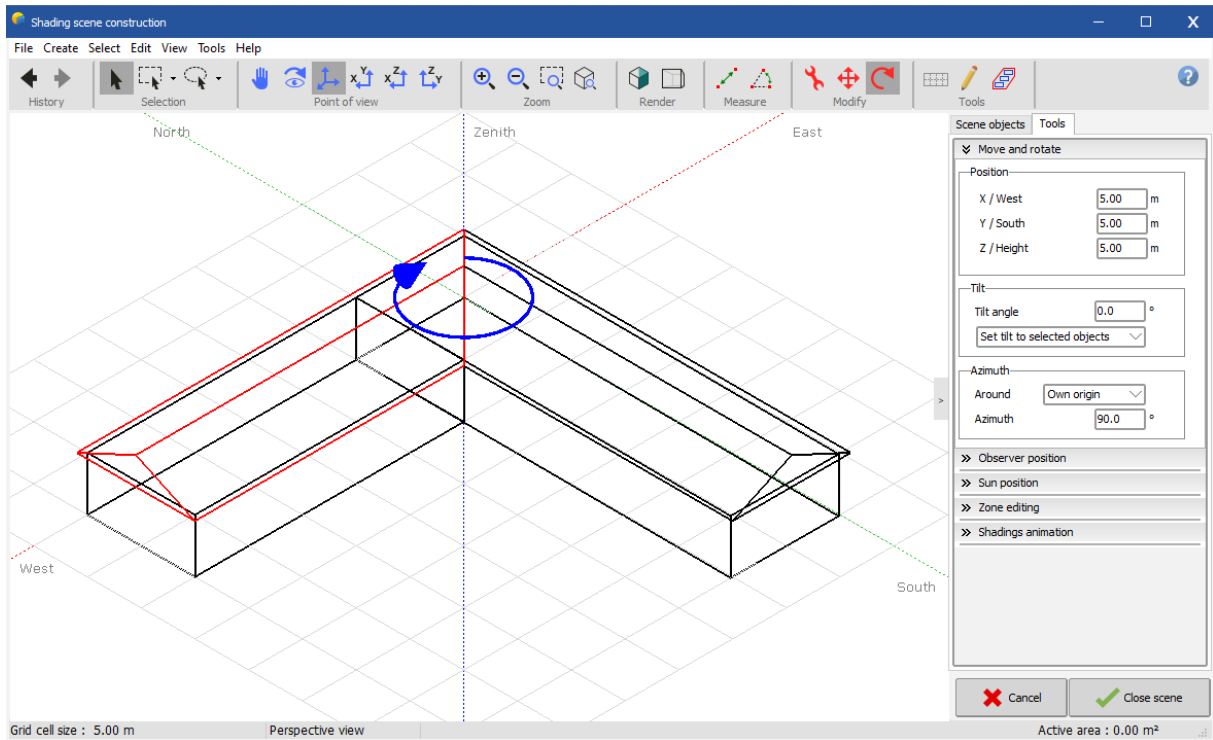
Figure 15: Positioning the second wing of the roof.

2.1.4 Adding the PV planes

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".

Figure 16: Choosing the PV planes.

You have to define the sizes: "Nb of rectangles" = 1 (you could define several non-interpenetrating rectangles in the same plane), "Tilt" = 25°, "Width" = 3.5 m, "Length" = 15.5 m.

13
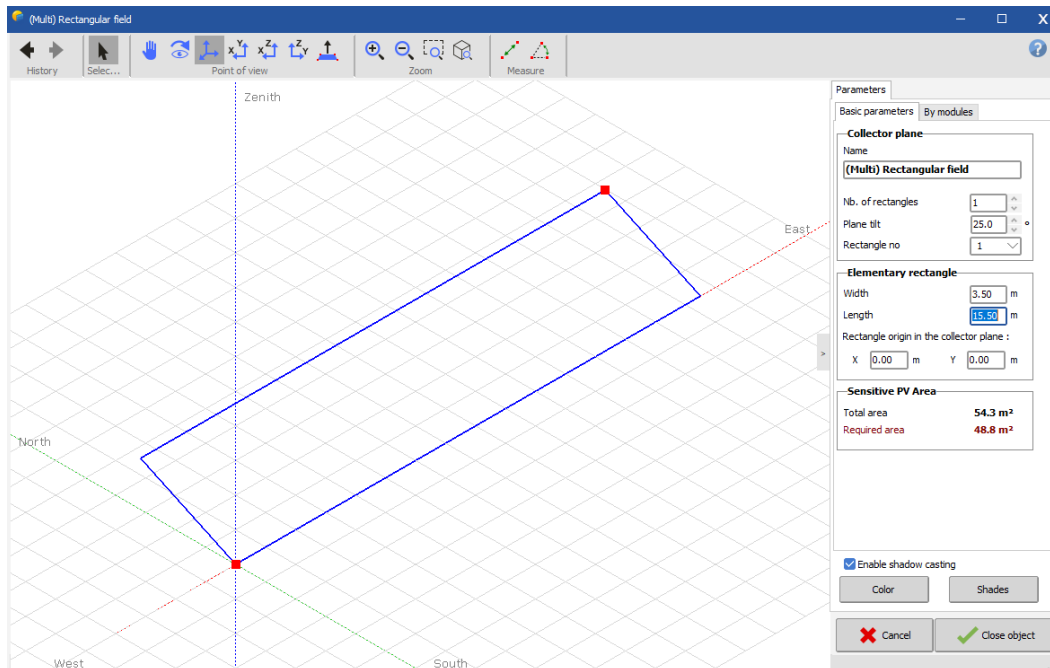
Figure 17: Definition of the size of the PV planes.

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 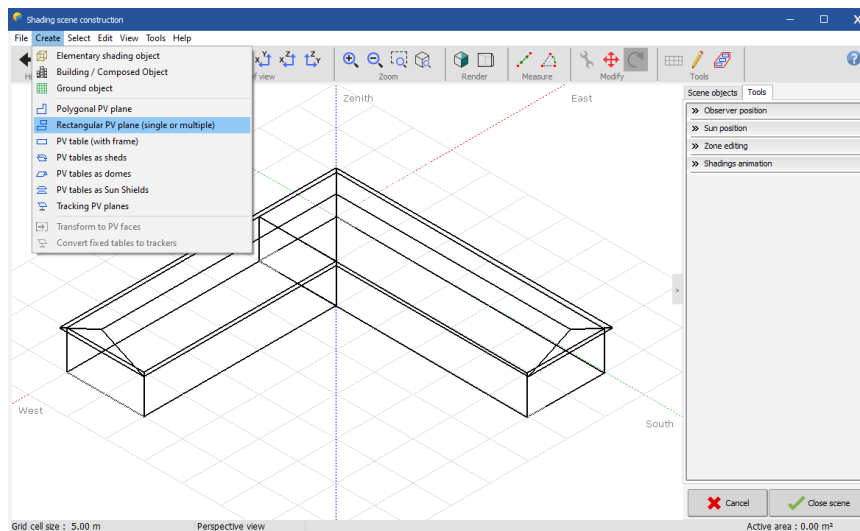the PV modules defined in "System". No check is made to verify that the panels can be arranged such that they fit into the sensitive area in the 3D scene. The detailed arrangement of the modules has to be defined in the "Module Layout" part of the project. Please refer to the online help for instructions.

Click "Close Object". The plane will be aligned to the origin of the 3D scene.

Figure 18: PV plane aligned with the origin of the 3D scene.

To position it, click "Top view" ⬚ again, position it globally with the mouse. At this point, you do not have rigorous references and you do not need to adjust the values but be careful not to interpenetrate the other roof! Check the azimuth value (should be exactly 90°).
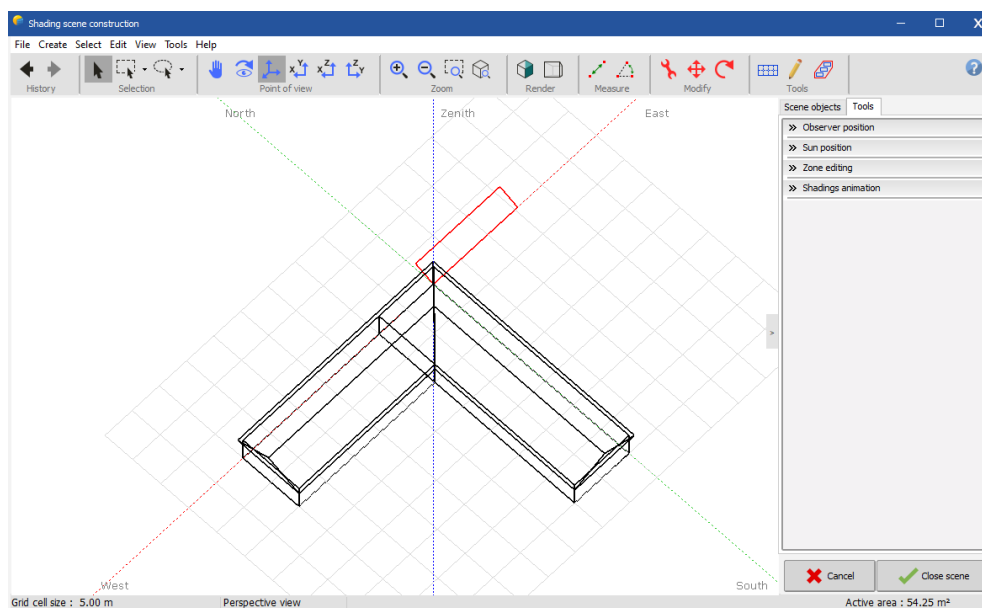
Use Rotate and move buttons to position the PV Plane ⊕ ↻ .

First, rotate the plane and have it parallel to the roof axis using the rotate button ↻ or the azimuth.
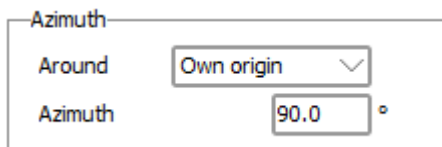
Figure 19: Defining the azimuth.

Then, click the move button ⊕ and slide by dragging the green and red arrows to position correctly.
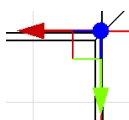
Figure 20: Cursor to position the PV planes.

When hovering the different arrows, they will change to yellow color and indicate along which axis you will be moving.
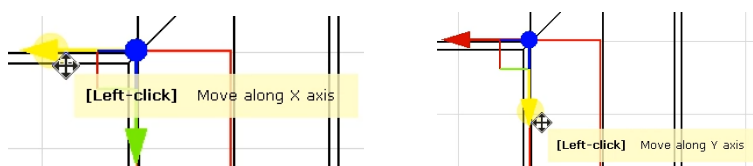
Figure 22: Indications when hovering the different arrows.
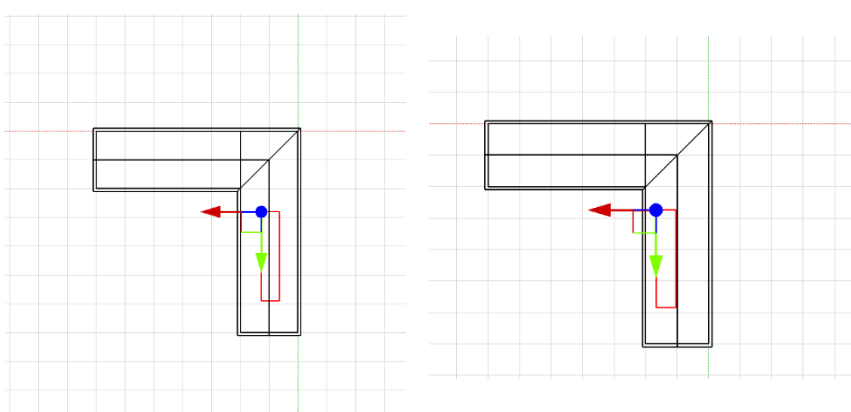
Figure 21: Vertical and horizontal positioning of the PV planes.

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 along the Z Axis (vertically blue arrow below). Always remember to leave some spacing between any active area and other objects. If you put the plane below the roof, it will be permanently shaded!

You can then check the position using the 3D button.
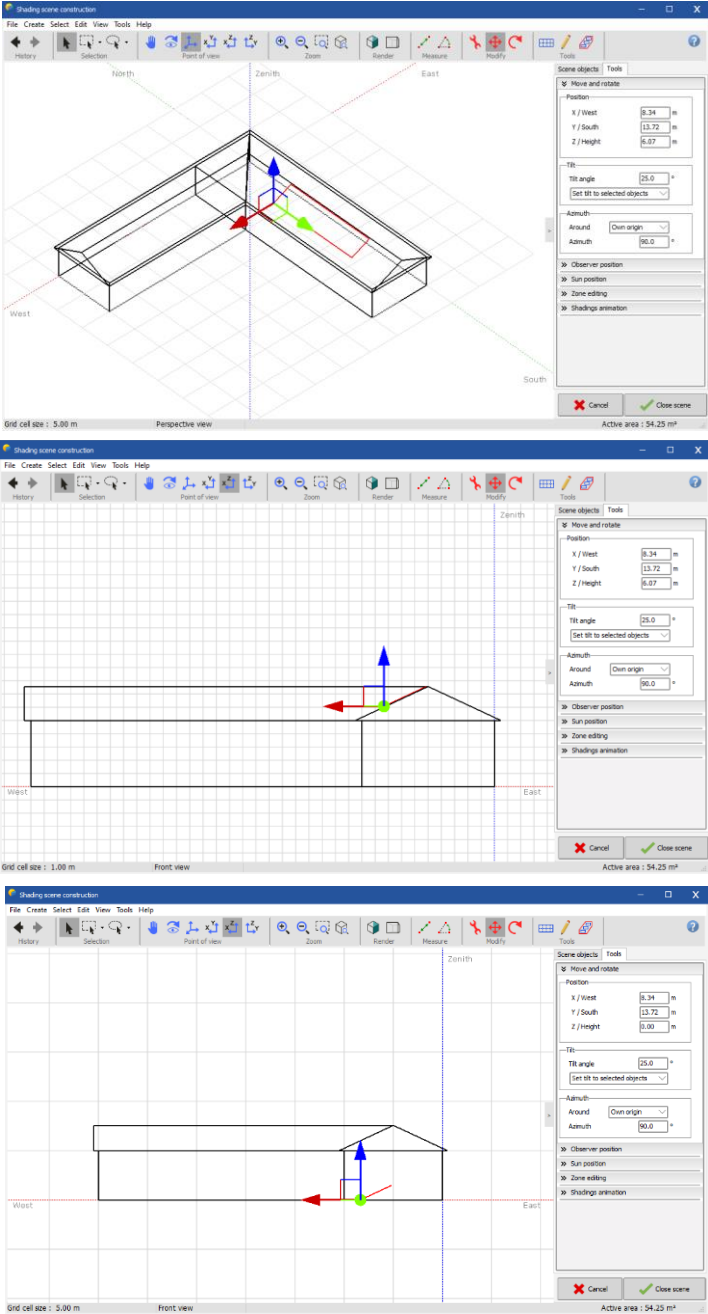
Figure 23: Checking the position with the 3D button.

2.1.5 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 shading scene construction, select "Create"/ "Elementary shading object". Then select "Portion of cylinder" under shape type. According to the drawing, define Radius = 3m, Aperture angle = 360°, Nb of segments = 16, Height = 12m, see Figure 24. Click "Close Object".
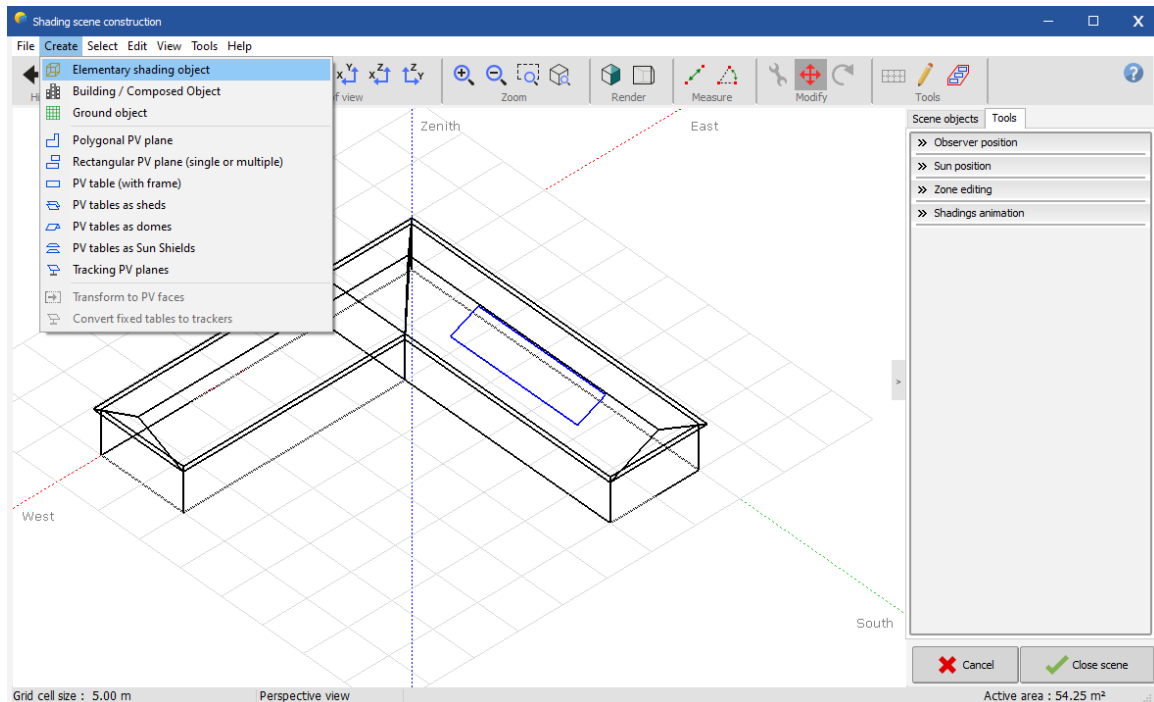
Figure 25: Creating elementary shading object.
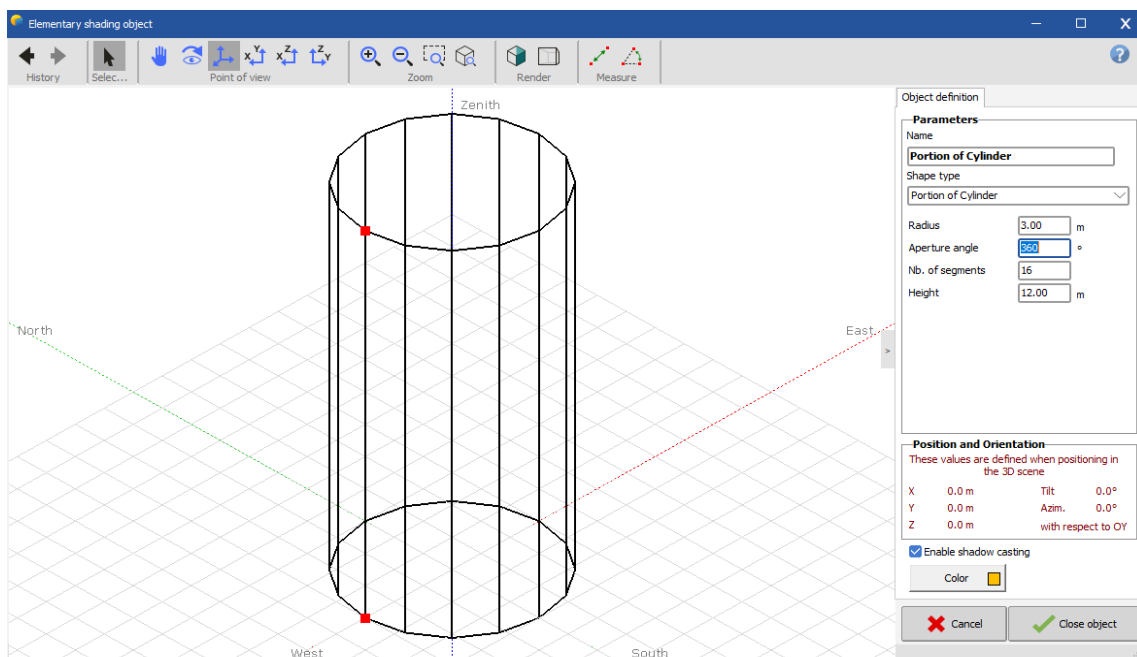
Figure 24: Defining the cylinder.

In the main scene, make 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).
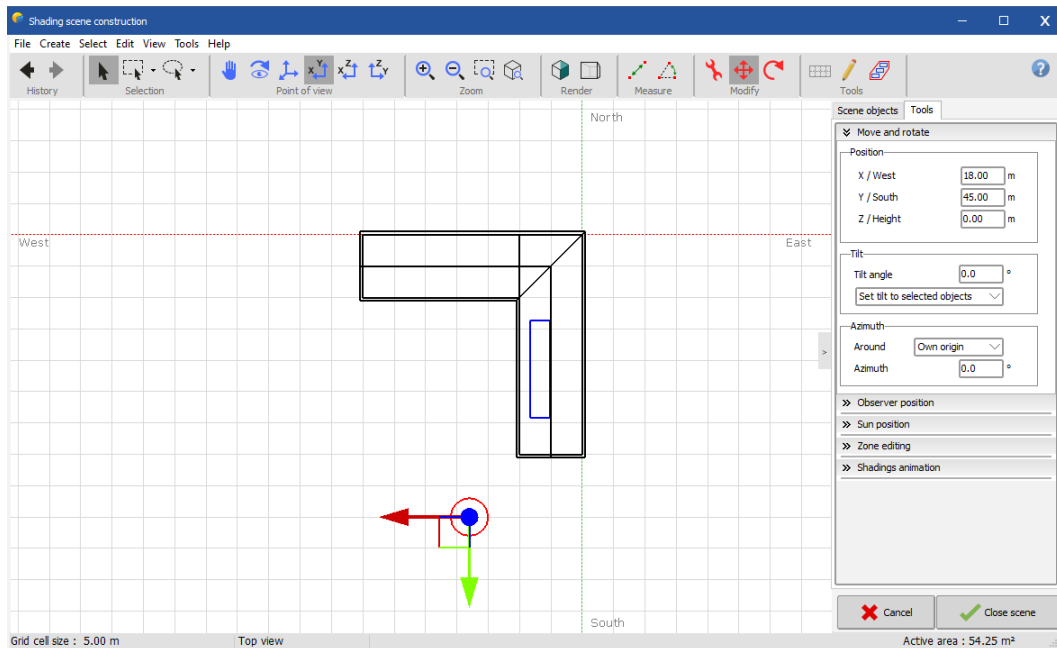
Figure 26: Positioning the silo.

You can now add a tree in the courtyard by selecting "Create" / "Elementary shading object". Then select "Tree" under shape type. To define shape and size of the tree, select "Front view" from the toolbar, and then click on the red points and drag them to adjust shape and size of the tree.
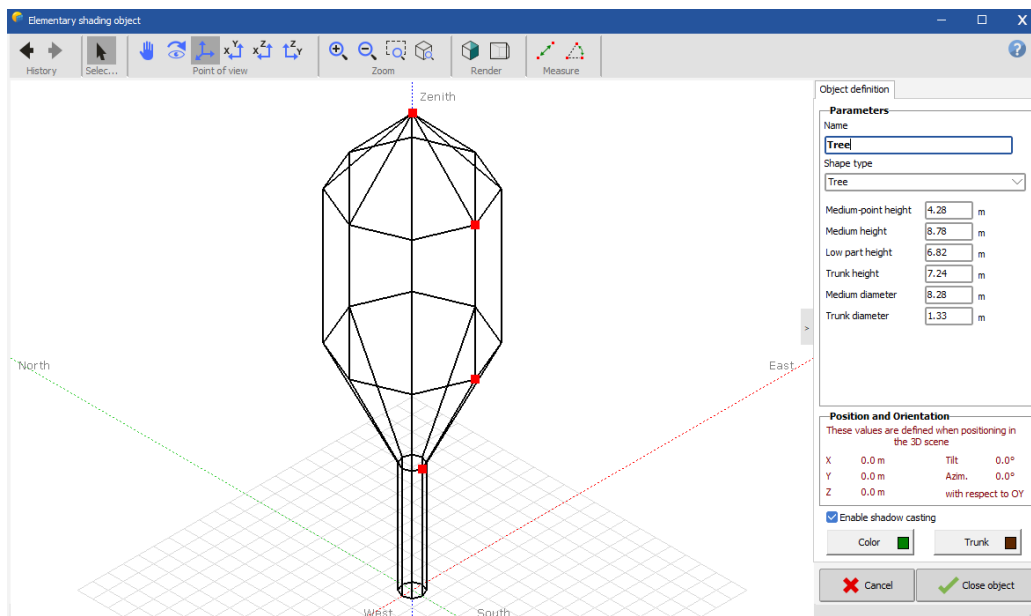
Figure 27: Defining a tree.

When you are done, position the tree to your liking in the courtyard (For your future projects, always remember that a tree does not have a definitive size, thus the shading may vary as the tree grows!)
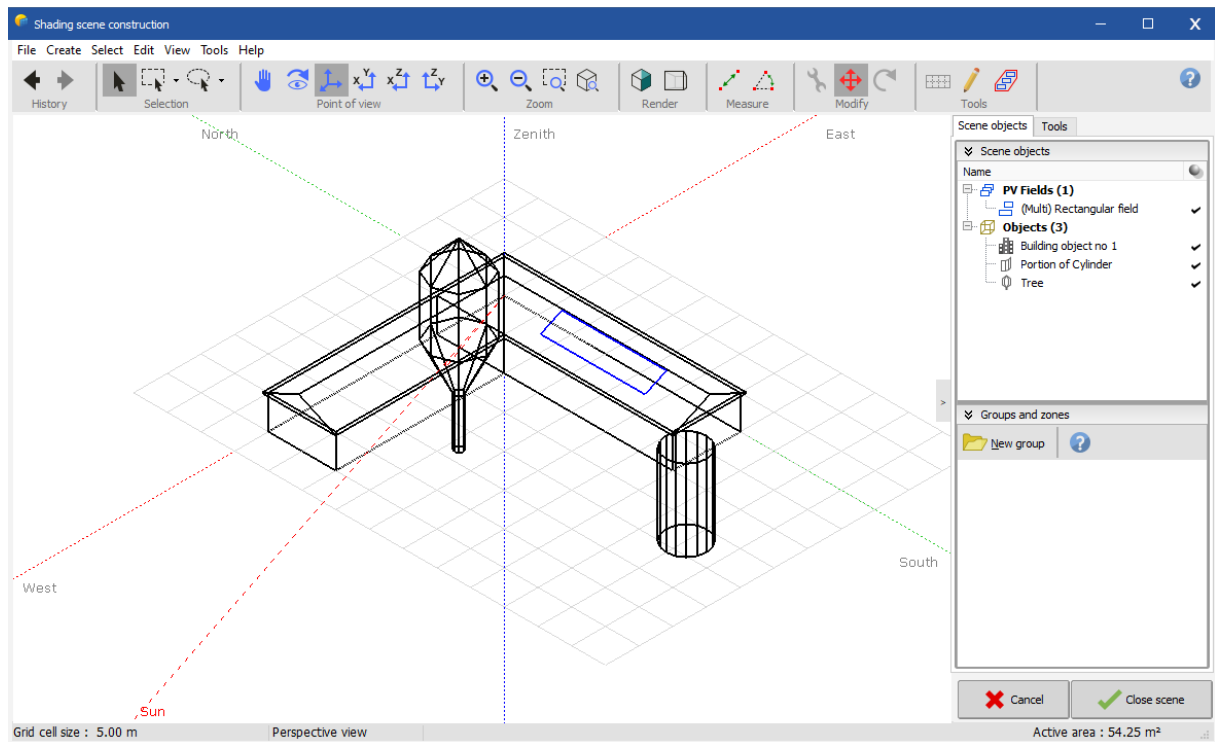
Figure 28: Positioning the shading objects.

2.1.6 Positioning with respect to the cardinal direction

Generally, you first construct a scene in the reference coordinate system that is used in the drawings 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, see Figure 29). This will rotate the whole scene by 20° towards west.

If you need to re-position or add a new object in the scene later on, it might be easier to rotate back to the original coordinate system. To do so, select an object that is aligned with the coordinate system in which you would like to work, click "Edit" / "Rotate Whole Scene" and put a value of 0° or 90° into the "New Azimuth" field. Perform the modifications and then apply the reverse rotation.
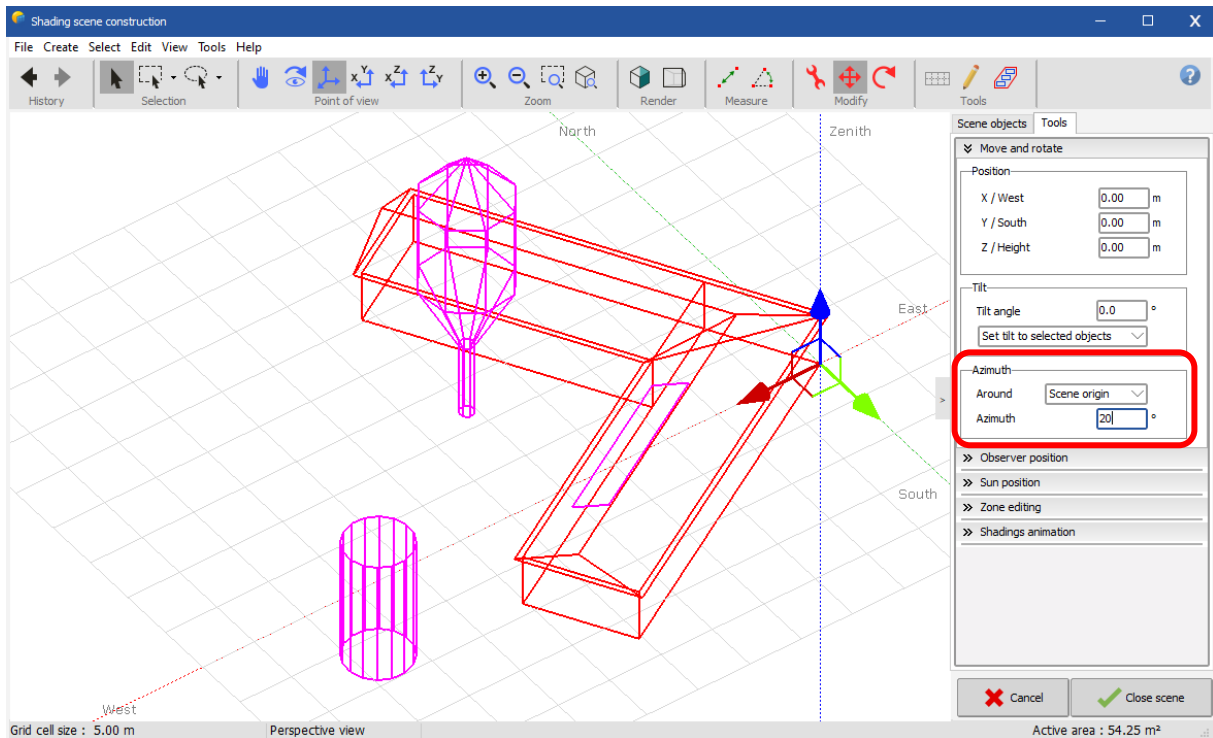
Figure 29: Rotate scene.

2.1.7 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 panel and choose Shadings animation sub panel.
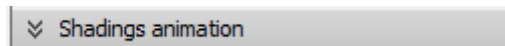
Figure 30: Shading animation subpanel.

The "Shadow animation" tool will expand and here you click on "Run animation". The shadows will be shown for the whole selected day. After execution, you have a scrollbar to review one or the other situation.
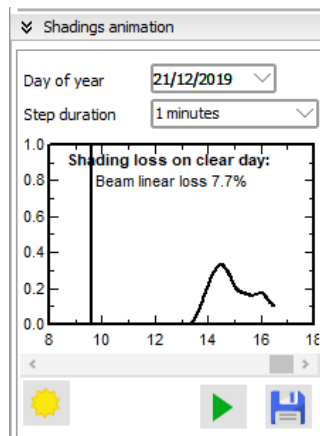
Figure 31: Shadows of a selected day.

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 of the year, the two extreme situations being June 21st and December 21st.
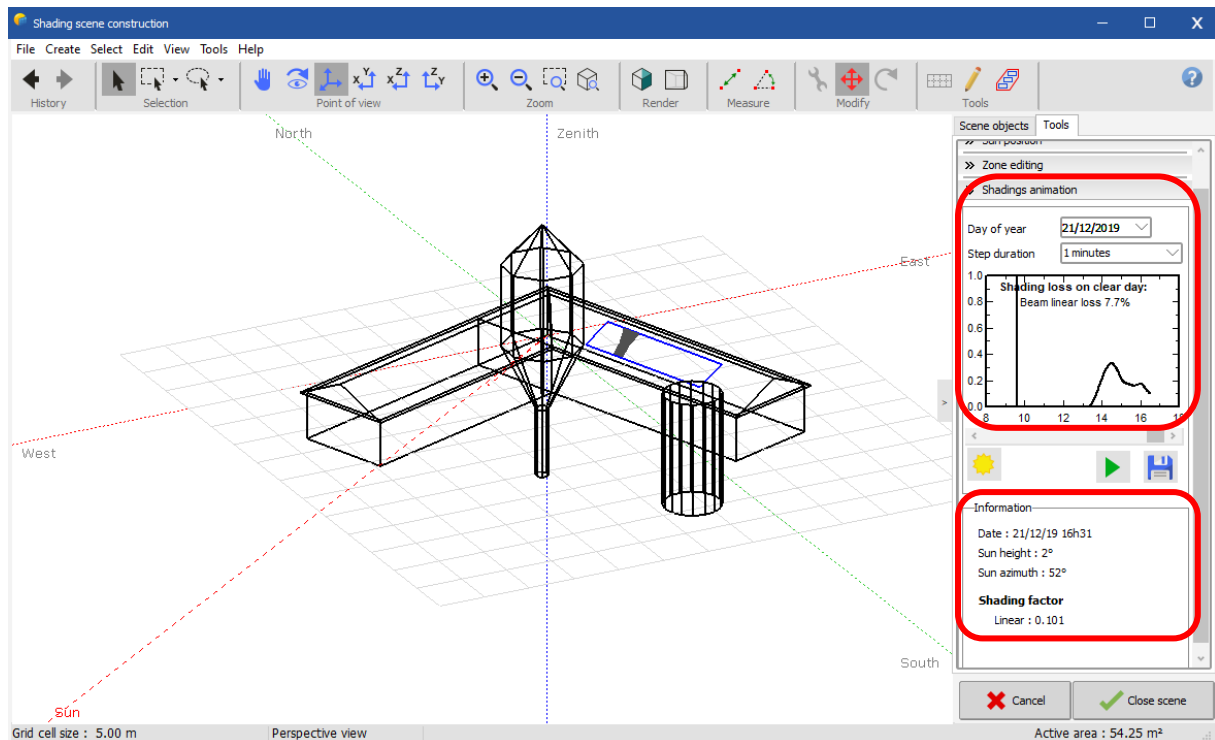
Figure 32: Choosing different dates of the year and its shadow information.

2.1.8 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.
- If you define your own colors, store them as "personalized color" in order to 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.
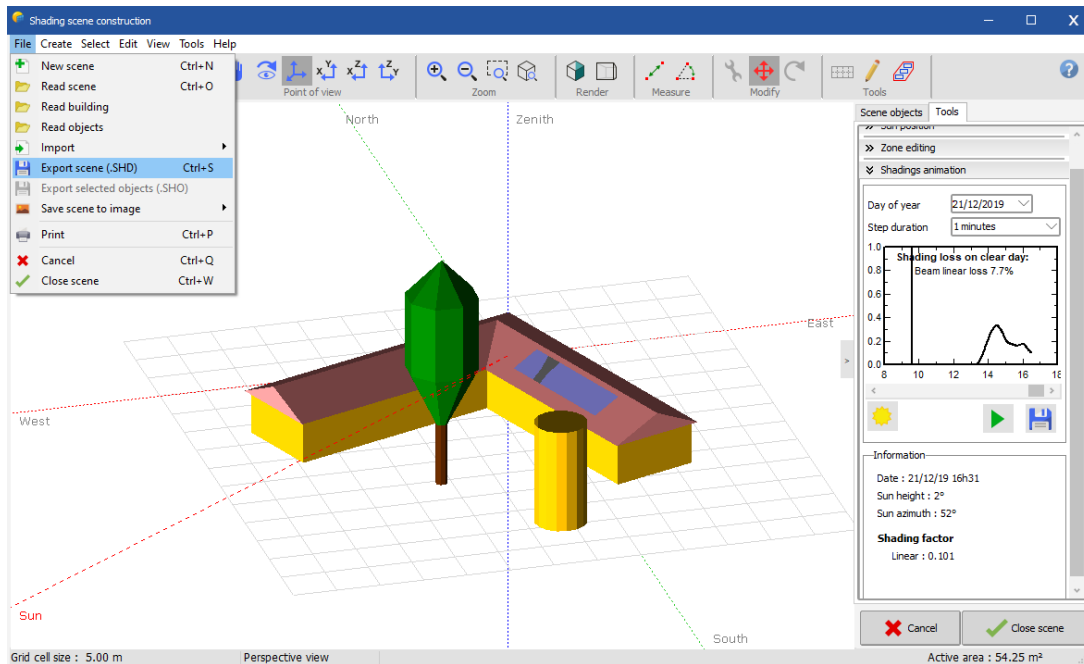
Figure 33: Exporting a scene.

Please note that 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 with "View" / "Save this view for the report".
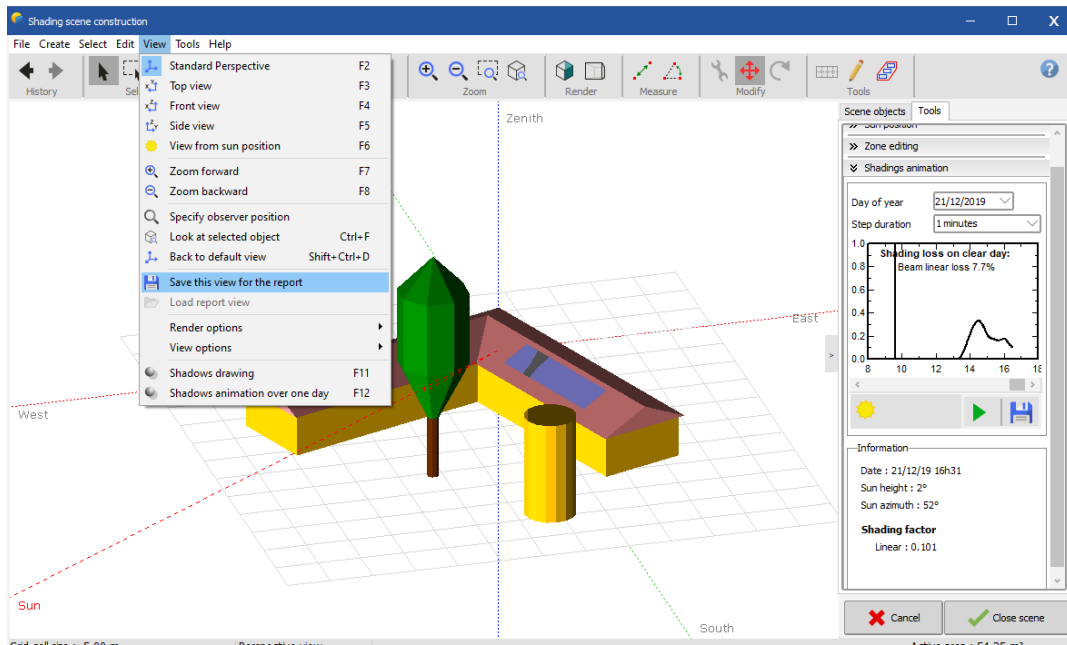
Figure 34: Saving a specific view for the report.

2.2 Use of the 3D scene in simulations

2.2.1 Linear Shadings

Your shading scene is now ready for the simulation.

- Choose "File" / "Close Scene". You return in the near shadings dialog.
- Choose "Linear shadings" in the "Use in simulation" box.
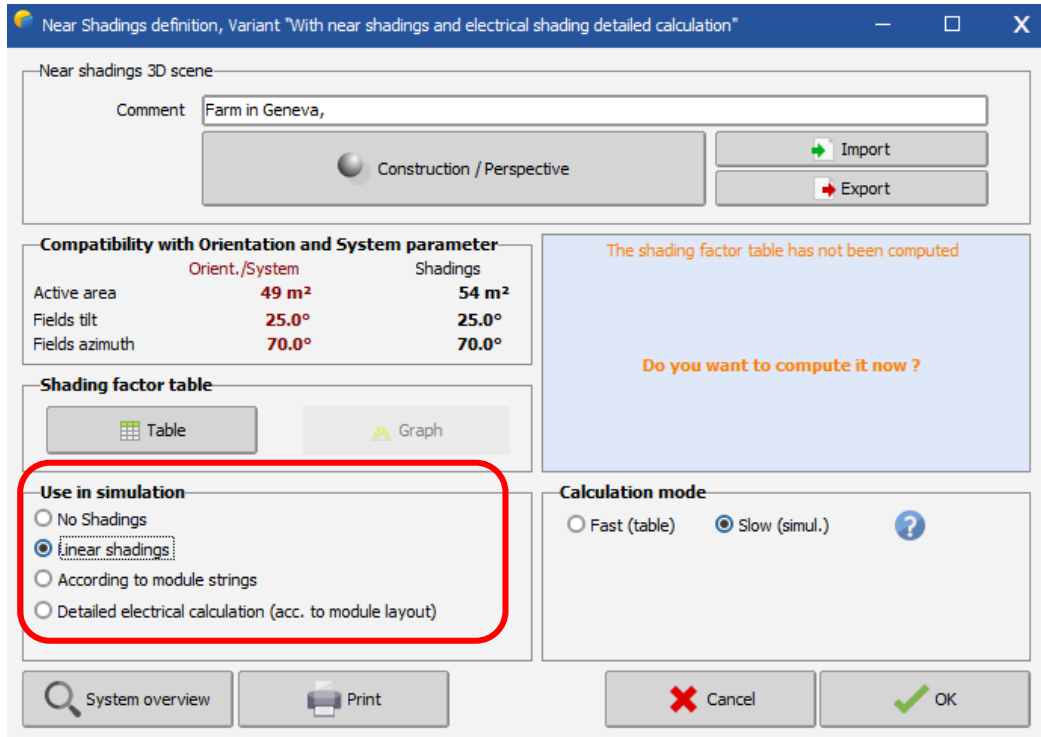
Figure 35: Linear shading definition.

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 quick test to check 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.

Figure 37: Computing the shading factor table.

Figure 36: The shading factor table.

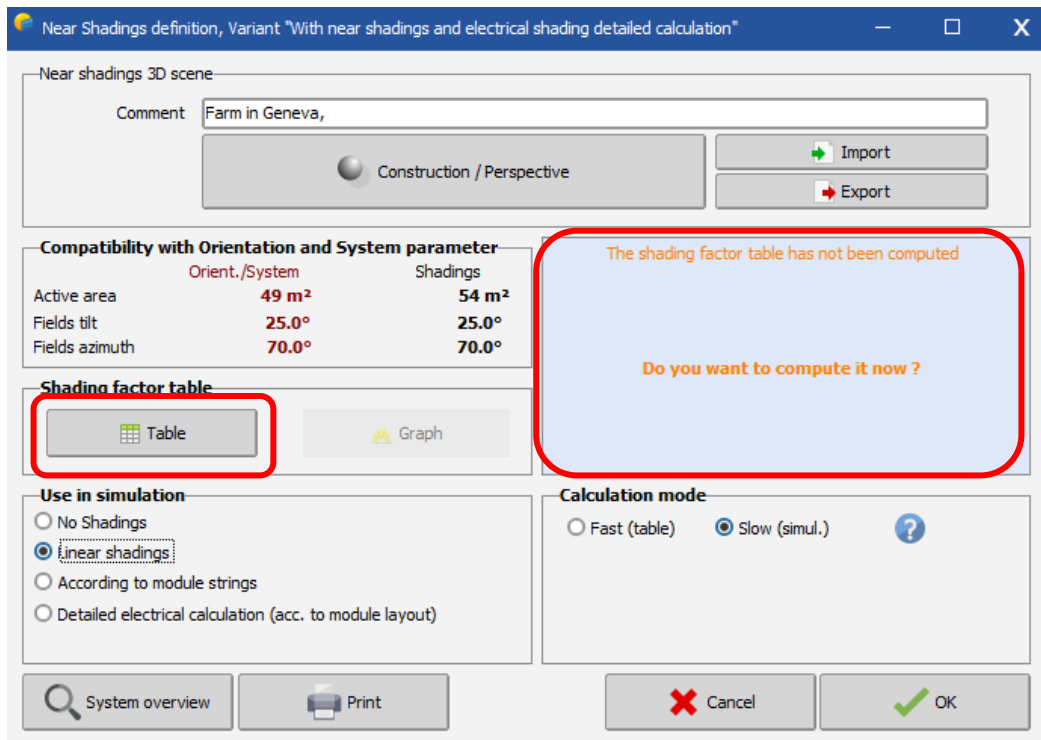| Azimuth Height	-180°	-160°	-140°	-120°	-100°	-80°	-60°	-40°	-20°	0°	20°	40°	60°	80°	100°	120°	140°	160°	180°
90°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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
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
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	0.069	0.069	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	0.000	0.000	0.227	0.517	0.428	0.010	0.000	0.000	0.000	0.000
30°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.240	0.534	0.433	0.010	0.000	0.000	0.000	0.000
20°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.089	0.231	0.485	0.409	0.000	0.000	0.000	0.000	0.000
10°	0.001	0.000	Behind	Behind	Behind	Behind	0.000	0.000	0.000	0.012	0.597	0.168	0.261	0.259	0.000	0.000	0.001	0.004	0.001
2°	0.002	Behind	Behind	Behind	Behind	Behind	Behind	0.000	0.000	0.012	0.597	0.086	0.100	0.100	0.282	0.642	0.734	0.759	0.002

Shading factor for diffuse: 0.072 and for albedo: 0.245

The shading factor table illustrated Figure 36 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 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's 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.
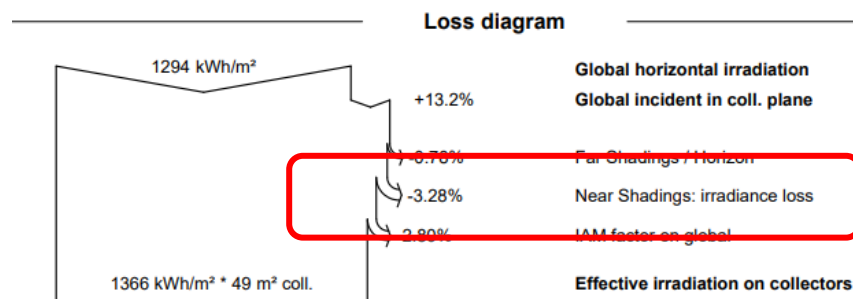

Figure 38: Near shading in the loss diagram.

2.2.2 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 PVsyst. PVsyst assumes that when a string is hit by a shade, the whole string is considered "inactive" concerning the beam component, alloying to define the 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) that represents the electrical effect.

More realistic simulation "According to module strings":
In this section, we are going to improve the PV module by partitioning the modules into strings. Start by saving a new Variant.

- Go back to the Near Shadings definition and click on the "Construction/Perspective" button.
- Click the button "Partition in module chains" [image] 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.
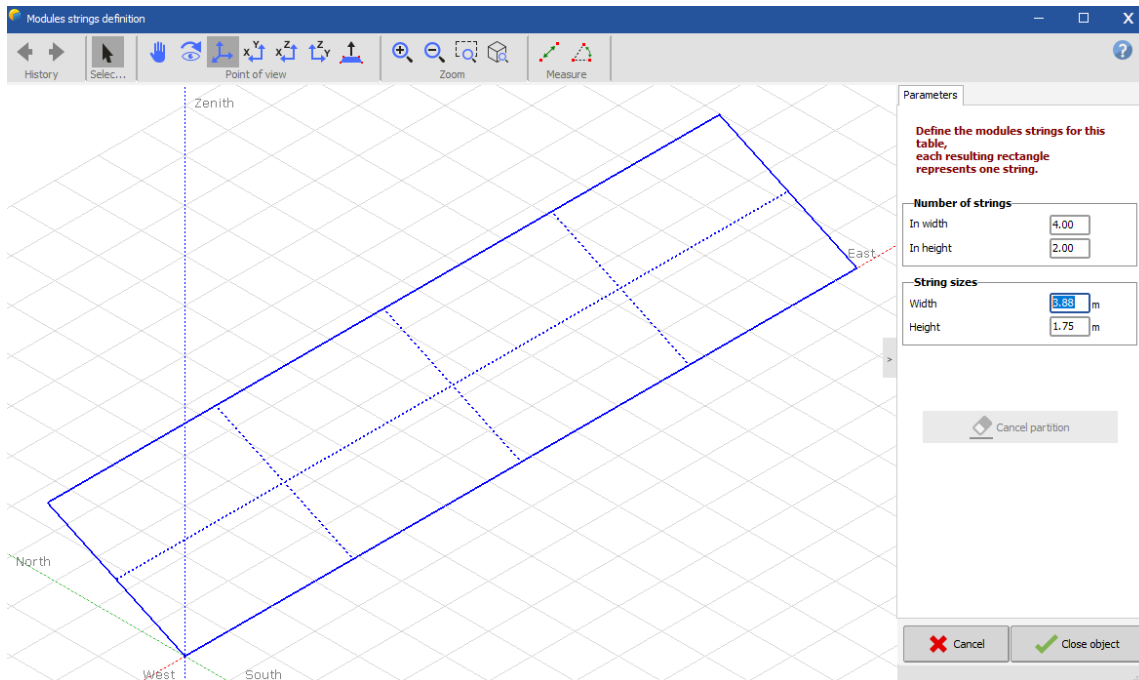

Figure 39: Partitioning PV modules to strings.

PVsyst limits the string definition as simple rectangles. 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.
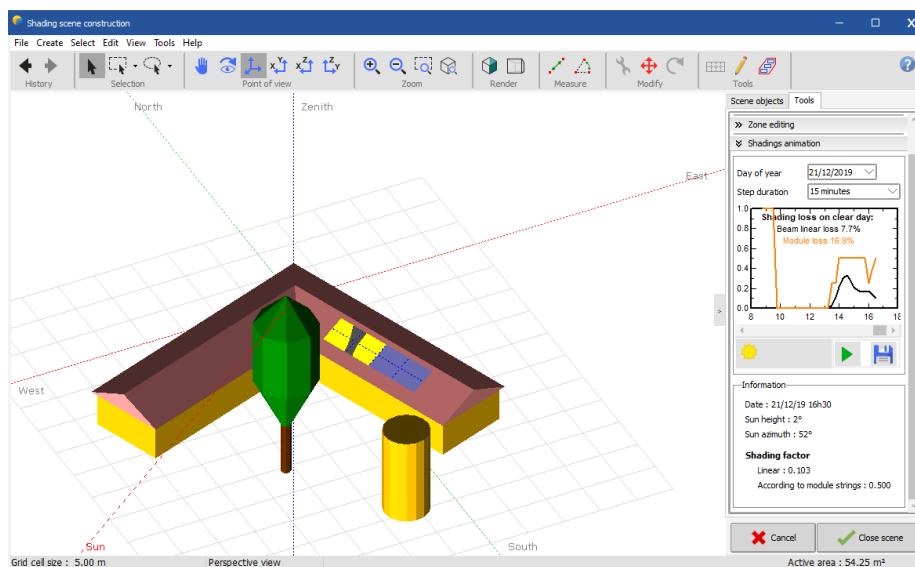

Figure 40: Partially shaded rectangles represented in yellow.

Use in the simulation

Click "Close Scene" to go back to the "Near shadings" dialog and choose "According to module strings" in "Use in simulation".

You will be asked once more to compute the shading factor tables like in Figure 41, after which you can open the iso-shading graph to compare the results of the improved shadings with the "Linear shadings" case.
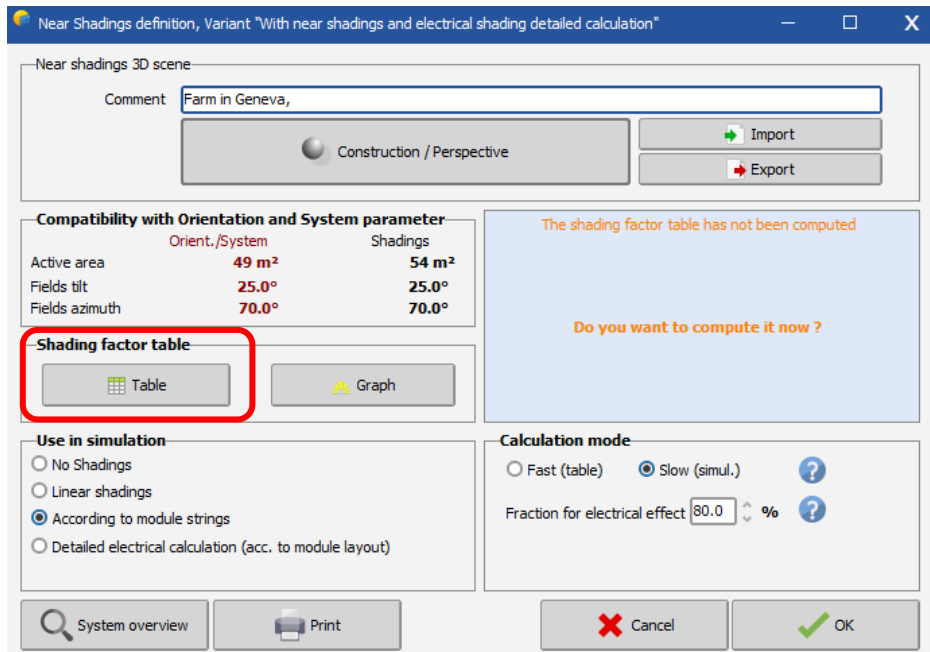

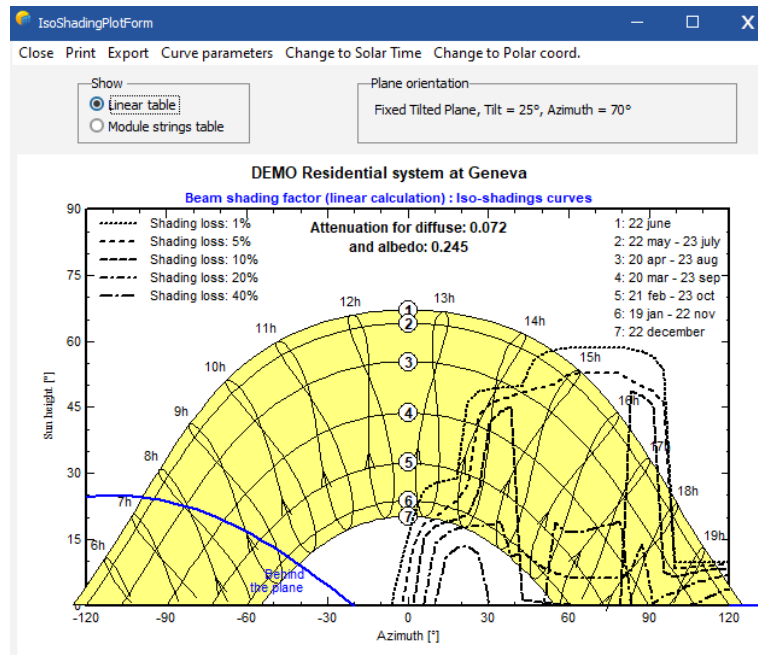Figure 41: Compute shading factor table once again.

Figure 42: Isoshading curves.

The "Fraction for Electrical effect" in calculation mode indicates the way 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.
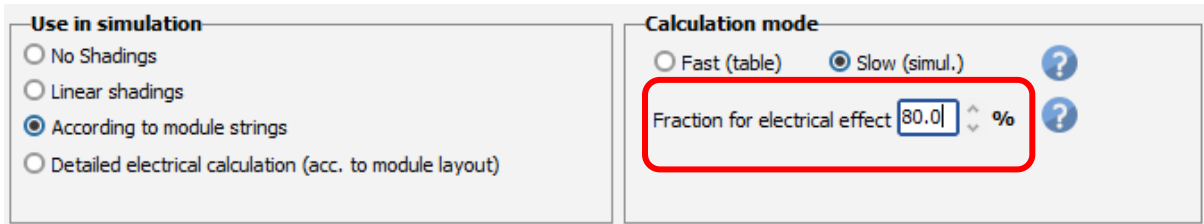

Figure 43: fraction for electrical effect.

For the simulation that you will present to your end-customer, you can fix a different value to get closer to reality. Currently, 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

For the first step of the simulation, the program will evaluate the beam component according to the horizon line, resulting in full or zero beam depending on whether 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 for the beam component, 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 in the beam component.

Note that the diffuse component is also affected by the near shadings and the horizon. The diffuse light gets only slightly changed by the horizon line and there will still be near shading losses on the remaining diffuse contribution.

2.3 Conclusion

In this document, we demonstrated the basics of construction 3D near shadings starting from defining the 3D scene (constructing a building, adding objects, positioning and shading tests) to using the 3D scene in a simulation.

In the next chapter, we will be presenting the data management for meteorological files.