

**TUTORIEL PVSYST SA** 

# PVsyst 7

## Grid Connected Systems My first project



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### 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 first chapter describes the basic aspects of creating your first grid-connected project.

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" entry in the menu, by pressing the F1 key or by clicking on the help icons ? inside the windows and dialogs.

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#### **Chapter 1: Basic Approach - My First Project**

#### 1.1 First contact with PVsyst

When opening PVsyst, you get to the main page:

6	PVsyst 7.2 - LICENSED	—		х
File	Preliminary design Project Settings Language License Help			
	🙀 Welcome to PVsyst 7.2			
	Project design and simulation			
	共 Grid-Connected         L Stand alone         L Pumping			
	Utilities			
	Databases Tools Measured Data			
T	Recent projects     Documentation			
l	党 DEMO Residential system at Geneva  Open PVsyst Help  Open PVsyst Help	(F 1)		
l	Q, F.A.Q.	Video	tutorials	
l	The contextual Help is available within by typing [F1]. There are also many questionmark but specific information.	the whole so tons for mor	oftware e	
	PVsyst user workspace			
	C: \PVsyst_Workspaces\Test_Workspace\PVsyst7.0_Data	1 	Switch	
		÷	Exit	

Figure 1: Main page of PVsyst 7.2.

This gives access to four main parts of the program:

1. "Project design and simulation" 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.

2. "Recent projects" will allow you to quickly find and modify your recent projects.

3. "Documentation" will assist you in implementing different simulations with the help of PDF tutorials, videos and a FAQ.

4. "Pvsyst user Workspace" contains all data created by the user. The default place is C:\Users\<username>\Pvsyst7.0\_Data but this can be changed by the user.

#### 1.2 Full study of a sample project

#### 1.2.1 Project specifications and general procedure

To introduce the development of a project design in PVsyst, we will walk through a full project step-bystep. As an example, we consider a farm located in Switzerland close to Geneva. The building in question is illustrated in Figure 2:



Figure 2: Project sketch.

The roof of the farm is facing south, a roof surface of 125  $m^2$  is available and we plan to cover 50  $m^2$  of the roof with mono-crystalline PV modules.

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



*Figure 3: Starting a grid-connected project.* 

oject	🛨 New 📂	Load 💾 Save 🔯 Project settings 📋 🛛	glient		
oject's name	New Project			Client name Not defined	
e File				🗟 📂 主	
teo File			$\checkmark$		
		Please choose the geographical site.			
ariant	E New	Save import Delete	age		
riant n° VCO	: New simulation variant		Results overview System kind	No 3D scene defined, no shadings	
ain parameters	Optional	Simulation	System Production	0.00 kWh/yr	
Orientation	Horizon	Run Simulation	Specific production Performance Ratio	0.00 kWh/kWp/yr	
System	Near Shadings		Normalized production Array losses	0.00 kWh/kWp/day 0.00 kWh/kWp/day	
Detailed losses	Module layout	C Advanced Simul.	System losses	0.00 kWh/kWp/day	
<ul> <li>Self-consumption</li> </ul>	<ul> <li>Energy management</li> </ul>	Report			
Storage	<ul> <li>Economic evaluation</li> </ul>	Detailed results			

When you choose a "Grid connected" project, the following project management dashboard appears:

Figure 4: Project management dashboard.

The dashboard has two parts:

- 1. 'Project': The central object that allows the basic definition of your project in which you will construct different variants (also called system configurations or calculation variants) of your system. 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 PVsyst workspace, it will get a filename with the extension \*.PRJ.
- 2. 'Variant': Each system variant contains all the detailed definitions of your system, which will result in a simulation calculation. These definitions include the choice and number of solar 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 such as VCO, VC1, VCA, etc. You can define up to 936 Variants per project.

#### Steps in the development of a project.

When developing a project in PVsyst, you are advised to proceed in small incremental 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, i.e., 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 Help context by pressing F1. Sometimes you will also see a little blue question mark button ?. Clicking on the button will lead to more detailed information on the topic in the Help section.

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

#### 1.2.2 Defining the Project

In the project dashboard, click on "New project" and define the project's name.

Then, click on "Site and Meteo".

Choosing a geographical site			- 0	х
	Current geographic Click	al site: Geneva_Cointrin (Original PVsyst data on OK to transfer to the project area.	base)	
	Search geneva	All countries	$\sim$	
Eie anna Tra		Data source		_
Galiyare	livare Sweden	MeteoNorm 7.2 static	20	-
Gallup Muni/Clarke Gall Gambell Gambell Gan	lup Muni/Clarke United Sta mbell United Sta	tes MeteoNorm 7.2 static tes MeteoNorm 7.2 static	יזי ח חנ	Î
Gangca/Shaliuhe Gan	ngca/Shaliuhe China	MeteoNorm 7.2 statio		
Ganzhou Gan	nznou Cnina pua Burkipa Fa	MeteoNorm 7.2 static	20	
Garden Island Gar	rden Island Australia	MeteoNorm 7.2 static		
Garissa Gari	rissa Kenya	MeteoNorm 7.2 statio	n	
Garze Garz	rze China	MeteoNorm 7.2 statio	n	
Gaviotas Gav	viotas Colombia	MeteoNorm 7.2 static	n	
Gaziantep Gazi	ziantep Turkey	MeteoNorm 7.2 statio	n	
Geisenheim Geis	senheim Germany	MeteoNorm 7.2 statio	n	
Gela Gela	a Italy Maxim	MeteoNorm 7.2 static	on 	
Gen. Heriberto Jara Gen Geneva/Cointrin	n. Heriberto Jara Mexico	d MeteoNorm 7.2 static		
Gera/ eumpitz Gera	ra/leumnitz Germany	MeteoNorm 7.2 static		
Geraldton Airport Gera	raldton Airport Australia	MeteoNorm 7.2 static		
Geyberga Island Gey	yberga Island Russian Fe	ederation MeteoNorm 7.2 statio	n	
Giessen Gies	ssen Germany	MeteoNorm 7.2 static	n	
Gifu Gifu	u Japan	MeteoNorm 7.2 static	n	
Gifu Gifu	u Japan	MeteoNorm 7.2 static	n	
Giles Met Station Giles	es Met Station Australia	MeteoNorm 7.2 static	n	
Giswil Gisv	wil Switzerlan	d MeteoNorm 7.2 statio	n	
Giza/Al Jizan Giza	a/Al Jizan Egypt	MeteoNorm 7.2 statio	on Na	
Glod Haven Airport Glod	dman Point Arport Canada	MeteoNorm 7.2 static		
Glasnow Airport Glas	snow Airport United Kin	ndom MeteoNorm 7.2 static		
Glasgow Intl Arot Glas	snow Intl Arnt United Sta	tes MeteoNorm 7.2 static		
Glentipy Glen	ntipy Australia	MeteoNorm 7.2 statio	20	
Glenview Nas Glen	nview Nas United Sta	tes MeteoNorm 7.2 statio	n	
Goa/Dabolim Goa	a/Dabolim India	MeteoNorm 7.2 static	n	
Goa/Panjim Goa	a/Panjim India	MeteoNorm 7.2 statio	n	
Godhavn God	dhavn Greenland	MeteoNorm 7.2 static	on 	$\sim$
Set favorites	Export New	Delete Cope	n 🗙 Cancel 🗸 OK	

Figure 5: Dashboard to choose a geographical site.

You can either choose a site from the built-in database, which holds around 2,550 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.

N.B.: If you start by choosing a meteo file, you have the possibility to copy the site associated to this file.

In the project dashboard, you can click on the button "Project settings" (Figure 6) that will give you access to the common project parameters, namely the Albedo values, the design conditions, design limitations and interface preferences.

ject settings			—		
Design conditions Other limitations	Preferences				
Albedo values		Usual values for	albedo		
Monthly values		Urban situation Grass	0.14-0.22 0.15-0.25		
Jan. 0.20 July 0.20 Feb. 0.20 Aug. 0.20		Fresh Grass Fresh snow Wet snow	0.26 0.82 0.55 - 0.75		
Mar. 0.20 Sep. 0.20	-Set a common value Common value 0,20	Dry asphalt Wet asphalt	0.09 - 0.15 0.18		
May 0.20 Nov. 0.20	(Default: albedo = 0.2)	Concrete Red tiles Aluminium	0.25 - 0.35 0.33 0.85		
June 0.20 Dec. 0.20	🖌 Set	New galvanised ste Very dirty galavanis	el 0.35 ed ste 0.08		
		🗙 Cancel		ОК	

Figure 6: Project settings to access common project parameters.

In general, you will never modify the Albedo factor. The value of 0.2 is a standard value most commonly. Nevertheless, if for example your site is in the mountains, you can define a higher Albedo factor like 0.8 for the months with significant snow cover.

The second tab in the project parameters dialog contains the "Design Conditions" page, see Figure 7.



Figure 7: Design conditions for project settings.

This page defines sizing temperatures, which may be site dependent. These are only used during the sizing of your system, and they are not involved in the simulation. The "Lower temperature for Absolute Voltage Limit" in this tab 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).

#### 1.3 Saving the Project

When you are finished (i.e., you have gone to the Variant choices), you will be prompted to save the project. The dialog that comes up (Figure 8) 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.

ect: Geneva_Cointrin_Project.	RJ		- 0
Site Variant			
Project		📩 New 📂 Load 💾 Save 🔯 Project settings 🏢 Delete L Glent	
roject's name	at Geneva	Client name Not defined	
ite File Gene	va/Cointrin	MeteoNorm 7.2 station Switzerland	🗟 📂 主
leteo File	eva_MN71_SYN.MET	Meteonorm 7.1 (1991-2010) Synthetic 6 km	
		Selected Meteo file: "Geneva_MI71_SYNLMET". Please save the project.	
/ariant		👚 New 🔛 Save 🔎 Import ᡝ Reorder 👘 Delete	
'ariant ariant n° VCO	: New simulation variant	New Bave Import Acorder      Delete      System kind	v No 3D scene defined, no shadings
<b>∕ariant</b> ariant n° VCO Main parameters	: New simulation variant		No 3D scene defined, no shadings on 0.00 kWh/yr ion 0.00 kWh/kWp/yr
dariant n° ⊻CO Main parameters () Orientation	: New simulation variant Optional	Leve La Save Import Leverder Delete      System kind      System Froduct      Specific product      Speci	No 3D scene defined, no shadings           ion         0.00         kWh/yr           ion         0.00         kWh/kWp/yr           ibio         0.00         kWh/kWp/day
/ariant       ariant n°     VCO       Main parameters	: New simulation variant Optional Horizon Near Shadings	Leve Results overview System Finducts Simulation Run Simulation Simulation Run Simulation Simu	No 3D scene defined, no shadings           on         0.00         kWh/yr           ion         0.00         kWh/kWp/yr           to         0.00         kWh/kWp/gay           uction         0.00         kWh/kWp/day           0.00         kWh/kWp/day         0.00
/ariant n° VCO Main parameters Orientation  System  System  Detailed losses	: New simulation variant  Optional  Horizon  Near Shadings  Module layout		No 3D scene defined, no shadings           on         0.00 kWh/yr           ion         0.00 kWh/kWp/yr           ioo         0.00 kWh/kWp/day           uction         0.00 kWh/kWp/day           0.00 kWh/kWp/day         0.00 kWh/kWp/day
Variant ariant n° VCO Wain parameters  Orientation  System  System  Detailed losses  Self-consumption	: New simulation variant Optional		No 3D scene defined, no shadings ion 0.00 kWh/yr ion 0.00 kWh/kWp/yr io 0.00 kWh/kWp/day 0.00 kWh/kWp/day 0.00 kWh/kWp/day

Figure 8: Saving the project.

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

After defining 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 two buttons marked in red: "Orientation" and "System", see Figure 9. 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 must be defined for any variant, 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.

ject: Geneva_Contri	n_Project.PRJ	-	
at Site Variant			
Project		🛨 New 📂 Load 💾 Save 🔯 Project settings 🏢 Delete  🛓 Glent	
Project's name	Farm at Geneva	Client name Not defined	
Site File	Geneva/Cointrin	MeteoNorm 7.2 station Switzerland 🔯 📂 🕇	
Meteo File	Geneva_MN71_SYN.MET	Meteonorm 7.1 (1991-2010) Synthetic 6 km 🕥 🛛 🥥	
		The orientation is not defined.	
Variant		🚹 New 💾 Save 🕒 Import 🕕 Reorder 👘 Delete	
/ariant nº	VC0 • New cimulation variant	Results overview	_
		System kind No 3D scene defined, no shadi	ings
		System Production 0.00 kWh/yr	
-Main parameters	Optional	Simulation Specific production 0.00 kWh/kWp/	/yr
<ul> <li>Orientation</li> </ul>	(  Horizon	Run Simulation Normalized production 0.00 kWh/kWp	/day
System	Near Shadings	Array losses 0.00 kWh/kWp/	/day
		System losses 0.00 kWh/kWp/	/day
Detailed losses	Module layout	ET Advanced Simul	
Detailed losses	Module layout	a Advanced Simul.	
<ul> <li>Detailed losses</li> <li>Self-consumptio</li> </ul>	Module layout     Second	. Report	
<ul> <li>Detailed losses</li> <li>Self-consumptio</li> <li>Storage</li> </ul>	Module layout	. Report	

Figure 9: Two basic Variants -"Orientation" and "System".

First, click on "Orientation". You will get the orientation dialog where you will have to supply values for the type of field for the solar installation and tilt and azimuth angles, see Figure 10.



#### Figure 10: Orientation dialog.

The solar panels in our example will be installed on a fixed tilted plane. From the project's drawing in Figure 2, we get the plane tilt and azimuth angles (25° and 20° west respectively). The azimuth is defined by the angle between the South direction and the direction where the panels are facing. Angles to the west are considered positive, while angles to the east are considered 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".

**Pre-sizing Help:** From the system description, we recall that we have an available area of around 50 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 300 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 7 kW or more.*"

id system definition, Variant VCO: "New simulation variant"					-	
ub-array			•	List of subarrays		ę
Sub-array name and Orientation ame PV Array Tilt Irient. Fixed Tilted Plane Azimuth	25° 20° ✓ Resize • or ava	Enter planned power O 9.3 kV ailable area(modules)	/p 🕜	★ AB ✓ A III Name	#Mod #Inv.	#Strin #MPP
elect the PV module Available Now V Filter All PV modules V Seneric V 300 Wp 27V Silmono M Use optimizer Sizing voltages : Wmp	Aono 300 Wa 60 cells 5ince 2020 (60°C) 26.7 V	Maximum nb. of modules 30	Q Open	- PV Array Generic - Mono 300 Wp 60 cells	1 1	1
Wailable Now Inverter Info Wanufacturers Info umber of inverters Info Use multi-MPPT fixedumdary unused Input maximum vo	: 300-600 V Global Inverter altage: 0 V	s power 0 kWac	<ul> <li>✓ 50 Hz</li> <li>✓ 60 Hz</li> <li>Q Open</li> </ul>			
Available Now V Inverter Info Available Now V Inverter Info All manufacturers V U Use multi-MPPT fixedzmedary unused Input maximum vo Hain input	: 300-600 V Global Inverter	s power <b>0</b> kWac	<ul> <li>✓ 50 Hz</li> <li>✓ 60 Hz</li> <li>Q Open</li> </ul>			
Available Now Inverter Info All manufacturers  Inverter Info Inverters I  Coperating voltage: Use multi-MPPT fixedamdary unused Input maximum vo Main input  Secondary esign the array Number of modules and strings d. in series I C C C C C C C C C C C C C C C C C C C	: 300-600 V Global Inverter itage: 0 V Operating conditions Vmpp (60°C) 27 V Vmpp (20°C) 33 V Voc (-10°C) 43 V	s power 0 kWac Please choose the Inverter m The total power should be 7.0 kW more	So Hz 60 Hz Q Open optimal) or	Global system summary Nb. of modules 1		
Available Now Inverter Info Valable Now Inverter Info Winardacturers Inter of inverters 1 Correction of the array Number of inverters Secondary esign the array Number of modules and strings od. in series 1 Correction only possibility 1 >. strings 1 Correction of the array inverters 1 Correction of the array Secondary od. in series 1 Correction of the array Secondary Od. In series 1 Correction of the array Secondary Od. In series 1 Correction of the array Secondary Od. In series 1 Correction of the array Secondary Od. In series 1 Correction of the array Od. In series 1 Correction of the array Od. Secondary Od. S	: 300-600 V Global Inverter stage: 0 V Operating conditions Vmpp (c0°C) 27 V Vmpp (20°C) 33 V Voc (-10°C) 43 V Plane irradiance 1000 W/m <sup>2</sup> Impp (STC) 9.5 A Isc (STC) 9.9 A	s power 0 kWac Please choose the Inverter m The total power should be 7.0 kW more Max. operating power at 1000 W/m <sup>2</sup> and 50°C) 0	SO Hz SO Hz C Open del. 1 optimal) or S KW	Global system summary Nb. of modules 1 Module area 2 m <sup>2</sup> Nb. of inverters 1 Nominal PV Power 0.3 kWp Maximum PV Power 0.3 kWDc		

*Figure 11: Grid system definition dialog on selecting the PV module.* 

**Select the Inverter:** For the installation in our example, we can choose a monophase inverter of around 7 kW. We choose the Generic 7.5 kW inverter, and PVsyst proposes a complete configuration for the system: 1 inverter, 2 strings, each with 15 modules connected in series.

Grid system definition, Variant VCO: "New simulation variant"		-	□ X
Sub-array	List of subarrays		?
Sub-array name and Orientation Presizing Help			
Name         Image: PV Array         O No sizing         Enter planned power         O 9.3         kWp           Orient.         Fixed Tilted Plane         Tilt 30°         Image: Resize         or available area(modules)         \$50         m²	Name	#Mod #Inv.	#String #MPPT
Select the PV module	PV Array		
Available Now V Filter All PV modules V Maximum nb. of modules 30	Generic - Mono 300 Wp 60 cells Generic - 7.5 kWac inverter	15 1	2
Generic 🗸 300 Wp 27V Si-mono Mono 300 Wp 60 cells Since 2020 Typical 🏹 📿 Open			
Use optimizer			
Sizing voltages : Vmpp (60°C) 26.7 V			
Voc (-10°C) 42.9 V			
Select the inverter			
Available Now Voltage 230 V Mono 50Hz			
Generic         7.5 kW         150 - 750 V         TL         50/60Hz         7.5 kWac inverter         Since 2020         Q         Q         Open			
Nb of MPPT inputs 2 🗘 🗹 Operating voltage: 150-750 V Inverter power used 7.5 kWac			
Use multi-MPPT feature Input maximum voltage: 900 V inverter with 2 MPPT			
Design the array			
Number of modules and strings Operating conditions			
Vmpp (60°C) 400 V Vmpp (20°C) 489 V	Global system summary		
Mod. in series 15 0 between 6 and 21 Voc (-10°C) 643 V	Nb. of modules 30		
Nb. strings 2 🗘 🗹 only possibility 2 Plane irradiance 1000 W/m <sup>2</sup> O Max. in data 💿 STC	Nb. of inverters 1		
Overload loss 0.0 % Show sizing () Impp (STC) 18.9 A Max. operating power 8.0 kW	Nominal PV Power 9.0 kWp		
Phom ratio 1.20, 120 0.00 H 0.1000 H/m 0.000 U/	Maximum PV Power 8.4 kWDC		
hb. modules 30 Area 49 m <sup>2</sup> Isc (at STC) 19.8 A Array nom. Power (STC) 9.0 kWp	Nominal AC Power 7.5 kWAC		
Q System overview	sketch 🗶 Cancel	-	ок

Figure 12: Grid system definition dialog on selecting the inverter.

After defining module type, the inverter and the design of the array, 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 short moment for the message to adapt to the changes you make).

We have now defined all mandatory 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 greyedout button means "has not been defined").

#### 1.4 Executing the first simulation

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

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

Simulation
Run Simulation
🗘 Advanced Simul.
📊 Report
Metailed results

Figure 13: Run simulation button.

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

Simulation, Variant "First simulation"	– 🗆 X
-Simulation parameters	
Variant First simulation	
Project         DEMO Residential system at Ge         PV module         Mono 300 Wp 60 cells         Im           Site         Geneva/Cointrin         Unit power         300 Wp         Un           Horizon         Free Horizon         Nb. modules         30         Nb           System         Grid-Connected         Array Power         9.00 kWp         Pn	verter 7.5 kWac inverter it power 7.5 kW . inverters 1 om AC 7.50 kWac
Preliminary definitions Simulation dates	
Optional further definitions, For refined data analysis Output File These dates correspondence of the the these dates correspondence of the the these dates correspondence of th	ond to the dates of your not be overcome.
Hourly data storage         Batch simulation           Image: Hourly data storage         Image: Hourly data storage	90 V Meteo beginning
Special graphs Optimization tool NB: 1990 indicates a doesn't correspond	generic year, i.e. which to really measured data for a
Q Comparisons ( Ageing Tool Output File .csv	
Enable output file	
Simulation Results	- Close

Figure 14: Simulation variant dialog.

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

Progression, clapsed unic. 15	
Executes the simulation by steps of one hour	
Simulation 20/06/90	
Abort	

Figure 15: Progress bar.

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

#### 1.4.1 Analyzing the results

The "Results" dialog shows on the top a short summary of the simulation parameters that you should quickly check to make sure that you made no obvious mistakes in the input parameters. On the right is a frame with six values that summarize at one glance the main results of the simulation. They only give a very rough idea 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.

On the bottom part of the dialog, you will see several diagrams that provides detailed information about the general behavior of the system. The "Daily Input/Output diagram" displays the energy that was injected to the grid as a function of the global incident irradiation in the collector plane for a daily basis.

- 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.



Figure 16: Results dialog.

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 consist of only six pages for this first simple variant (for simulations with more detail you can get up to 11 pages of report). In this report you will find the:

- **Cover page:** Various aspects of the simulation project and variant name including the PVsyst version number and information about the system kind, size and location.
- **Second page**: A high level summary of the project system and results of the simulation variant. A fully defined geographical site and meteo properties. Table of contents of the report is also provided.
- **Third page:** General underlying parameter of the simulation: the system kind plane orientation, general information about shadings (horizon and near shadings), components used and array configuration, loss parameters.
- **Fourth page**: The main results of the simulation: energy production, specific production and performance ratio.
- **Fifth page**: The PVsyst arrow loss diagram, showing an energy 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.
- **Sixth page**: Special graphs on the simulation. Daily input/output diagram and the distribution of power injected to the grid are shown.

#### 1.4.2 Analyzing the report

#### Fourth page: main results

For our first system: three relevant quantities are defined:

- 1. Produced Energy: The basic result of our simulation.
- 2. Specific production: The produced energy divided by the Nominal power of the array (Pnom at STC). This is an indicator of the potential of the system, taking into account irradiance conditions (orientation, site location, meteorological conditions).
- 3. Performance ratio: An indicator of the quality of the system itself, independently of the incoming irradiance. We will give its definition below.

		Main	results	
Syst	tem Production	11.57 MWh/year	Specific production	1285 kWh/kWp/year
Prode	uced Energy		Performance Ratio PR	87.79 %

Figure 17: Main results of the simulation from the report.

The bottom of this page contains a table (Figure 18: Table of main variables and its results., given as monthly values and the overall yearly value. The yearly value can be an average (i.e., for the temperature), or a sum (i.e., for the irradiation or energies). The definition 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.
- Globlnc: 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.

	GlobHor	DiffHor	T_Amb	Globinc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	ratio
January	33.4	20.36	1.85	50.8	49.0	0.442	0.431	0.944
February	56.1	31.33	2.59	76.6	74.2	0.664	0.650	0.943
March	105.7	44.56	6.67	131.4	127.7	1.093	1.072	0.906
April	138.8	63.42	10.57	154.0	149.5	1.257	1.233	0.890
Мау	168.3	73.80	14.58	171.7	166.9	1.368	1.341	0.868
June	187.7	85.93	19.11	184.5	179.1	1.446	1.419	0.854
July	187.2	74.13	21.34	188.0	182.7	1.448	1.420	0.839
August	160.5	62.96	20.35	174.7	169.9	1.355	1.329	0.845
September	119.0	55.25	15.68	141.3	137.3	1.127	1.106	0.869
October	72.0	39.11	11.43	92.8	89.8	0.764	0.749	0.897
November	38.5	21.86	5.96	56.8	54.8	0.481	0.470	0.919
December	26.7	15.70	2.73	41.7	40.2	0.359	0.349	0.930
Year	1293.9	588.41	11.12	1464.3	1421.1	11.804	11.569	0.878

#### Balances and main results

Figure 18: Table of main variables and its results.

The monthly graphs on the fourth 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.
- Yf, Final System yield: Energy to the grid.
- Lc= Yr Ya: Array capture losses.
- Ls= Ya Yf: System losses.
- PR = Yf / Yr: Performance Ratio = E\_Grid / (GlobInc Pnom(nameplate)).



#### Performance Ratio PR



Figure 19: Normalized performance indexes.

PR

Performance Ratio

#### Fifth page: arrow loss diagram

This is the PVsyst way of reporting the systems' 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 (starting point from meteo value).
- 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  $\cdot$  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.



Figure 20: Loss diagram.

Note that there are different types of arrows on the diagram:

- The outward facing arrows represent losses of energy from the simulation. The size of the arrows is proportional to the loss amount of the system.
- The inward facing arrows represent energy gained of the system and the percentage are noted with a positive sign (+).

The report can be sent to a printer or copied to the clipboard. These options are accessible through the Print button Print.

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

Report options		- 🗆 X
🔛 Header, language 🗹 General options 📋 Clipboard options		
Selection of available pages	1	Units of the loss diagram
Section		<ul> <li>Automatic</li> </ul>
Simulation parameters		⊖ kWh
Main results		MWh
Special graphs		
Loss diagram		2 🗘 Nb. decimals
	Global This report Draws the '	weather corrected PR graph
	Column #7	~
	Column #8 Performa	ance Ratio 🗸
	Column #9	$\sim$
	Column #10	
	Res	et to default
	System kind	
	Customize the propo	osed system kind text
	No 3D scene defined	d, no shadings
	X Cance	е 🗸 ОК

Figure 21: Report options.

#### Saving the simulation

Take the habit to "Save" your different variants for further comparisons. Choose a meaningful title 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 "DEMO\_Residential\_Geneva\_First Simulation.VCO". 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. To open previous simulations of the project, you just have to select a variant in the drop-down list.

#### 1.5 Adding further details to your variant

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

#### 1.5.1 Far shadings, Horizon profile

The horizon profile is only suited for shading objects that are located sufficiently far away from your PV system, so that the shadings may be considered global on your array. This is the case when the distance of 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 for the site of the project.

Figure 22: Horizon line drawing.

You can define the horizon line manually. For this, the values (Height, Azimuth set of points) have to be 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. To create a new point, right-click anywhere. To delete 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 (Figure 23). You can either read a horizon line that you have previously saved in PVsyst, or you can import a predefined format from external sources.

Horizon profile reading / importation	—		х
😝 Horizon profile - Source		(	•
Horizon from files     PVsyst internal file     Standard CSV file (*.csv, *.txt, *.hor)     Meteonorm Software (*.hor)			
Horizon from web sources       O PVGIS Horizon from web       Version       5.2       O Horizon from Meteonorm web service			
Imported file name:			
Description:			
•		7 Choose	
Please choose the source file PVsyst internal file	×	Cancel	
		ОК	

Figure 23: Horizon profile reading/importation dialog.

#### 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 "SkyOx\_PVsyst.hor" file! This is an obsolete format 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 geo-referred free software (including altimetry data), that creates 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 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. These values decrease as you move away from the equator.

#### Using the horizon in the simulation

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



Figure 24: Horizon definition and sun graph.

now have an additional page. On the fourth 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:



Figure 25: Far shadings effect on loss diagram.

#### 1.5.2 Near shadings, 3D construction

The near shadings treatment (shading of near objects) requires a full 3D representation of the PV system. Details on the construction of the near shadings is described in the next chapter "3D Near Shadings Construction".

#### 1.5.3 Detailed losses

Finally, there are several parameters that are initialized by PVsyst with reasonable default values for the first simulation, but that you should modify according to the specificities of your system to add more accuracy to the simulation. These parameters are accessible with the button "Detailed losses" in the project dashboard.

Main parameters
Orientation
System
Detailed losses
Self-consumption
Storage

Figure 26: Main parameters for detailed loss.

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

- Thermal Parameters.
- Ohmic Losses.
- Module Quality LID Mismatch.
- Soiling Loss.
- IAM Losses.
- Auxiliaries.
- Ageing.
- Unavailability.
- Spectral correction.

In what follows, we will go through all these tabs and give a brief explanation of the different parameters and options.

#### Thermal parameters

The thermal behavior of the array is computed in each simulation step by a thermal balance. This establishes the instantaneous operating temperature used for the modeling of the PV modules.

The thermal balance involves the "Heat loss factor"  $U = Uc + Uv \cdot WindSpeed [W/m^2 \cdot K]$ . 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 Uv is not well known. Therefore, we put Uv = 0 and include an average wind effect in the constant term.

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

- Uc = 29 W/m<sup>2</sup>K for completely free air circulation around the collectors (free-standing collectors).
- Uc =  $20 \text{ W/m}^2\text{K}$  for semi-integrated modules with an air duct on the back.

- Uc = 15 W/m<sup>2</sup>K for integrated modules (back insulated), as only one surface participates to the convection/radiation cooling.

ermal parameter	Ohmic Losses	Module quality - LID - Mismatch	Soiling Loss	IAM Losses	Auxiliaries	Ageing	Unavailability	Spectral correction	
Field Thermal L	You can define	either the Field thermal Loss fact the program gives the e	or or the stand quivalence! -NOCT equiv	dard NOCT co alent factor	efficient:				
hermal Loss facto onstant loss facto /ind loss factor U - <b>Default value</b>	r U = pr Uc 20 v 0.1 acc. to mount	0         W/m %           0         W/m % m/s           ting         W/m % m/s	NOCT (Nomina often specified Itself. This is a U-value definit applied to the <b>Don't use th</b>	al Operating C d by manufact n alternative i tion which doe operating arr e NOCT appr	ell temperatu urers for the nformation t sn't make se ay. roach. This	re) is module o the nse when is quite	2		
"Free" mount     Semi-integrat     Integration w	ed modules with ed with air duct l ith fully insulated	air circulation behind d back		See the NC	ICT anyway		]		

Figure 27: PV field detailed losses parameter dialog.

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  $W/m^2K$ .

NB: up to PVsyst version 5.1, the default value for Uc 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



Figure 28: Thermal loss effect in the loss diagram.

reaches in equilibrium for very specific surrounding and operating 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 from a realistic module operation. PVsyst only mentions it for completeness and for comparison with the manufacturer's specifications.

#### **Ohmic 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.

mal parameter	Ohmic Losses	Module quality - I	.ID - Mismatch	Soiling Loss	IAM Losses	Auxiliaries	Ageing	Unavailability	Spectral corre	ction		
cincuite obmis	loccos for th	0.38931										
Specified by-	. 103563 101 01	carray					_					
Global wiring	resistance	381.2 mΩ	Calculated	0	etailed comput	ation 📢						
Loss fraction	at STC	1.50 %	🗹 Default									
tage Drop acros	ss series diode	0.0 V	Default									
			- Contract									
losses after t	he inverter											
circuit: inver	ter to injectio	on point										
Uses AC circui	t ohmic loss											
nath Inverter t	o injection		Wire section									
ee fraction at S	TC	0.00 %	6 mm2									
33 11000011003		0.00 //	0 1111-									
<pre>FC: Pac = 9 kW,</pre>	Vac = 230 V Mo	ono, I = 38 A		0								
oitage drop at S		0.0 V (0.0%)										
Uses one or s	everal MV transf	formers										
Uses a HV tra	nsformer											
						ee graph		¥ .	ancel			
					Los:	ca graph			on cen	1	UN	

Figure 29: Ohmic loss parameter.

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 to establish and optimize the ohmic losses (click on the "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 just have to define the distance and the loss will also appear in the loss diagram.

AC circuit: inverter to inje	ction point						
Uses AC circuit ohmic loss							
Length Inverter to injection	10.0 m	Wire section					
Loss fraction at STC	1.05 %	6 mm² 🗸					
STC: Pac = 9 kW, Vac = 230	V Mono, I = 38 A	0					
Voltage drop at STC	2.4 V (1.0%)	•					
Uses one or several MV transformers							
Uses a HV transformer							
Uses a HV transformer	ansionners						

*Figure 30: Losses between output of the inverter and the injection point.* 

In addition, there is an 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.

AC losses after the inverter	
AC Wire loss Inverter to transfo	Medium Voltage external transformer
Uses AC circuit ohmic loss	MV Transformer(s), full system
Length Inverter to Transformer     10.0     m     Wire section       Loss fraction at STC     1.05     %     6 mm <sup>2</sup>	Number of MV transfos
STC: Pac = 9 kW, Vac = 230 V Mono, I = 38 A           Voltage drop at STC         2.4 V (1.0%)	Reference Pac(STC)     8.8 kW       Iron loss (constant value)     0.10 % 0.01 kW v default       Copper (resistive) loss     1.00 % at STC v default
Uses one or several MV transformers	Transfo equivalent resistance 3 x 59.82 mΩ
Medium Voltage line	Uses datasheets data
MV line voltage 20.0 kV Length MV Transfo to injection 250.0 m Wire section	Iron losses (no load loss)
Loss fraction at STC 0.00 % 10 mm <sup>2</sup>	Copper (resistive) loss at PNom         N/A         kVA           Global loss at PNom         N/A         kVA
STC: Pac = 9 kW, Vac = 20.0 V Mono, I = 0.4 A           Voltage drop at STC         0.4 V (0.00%)	Global efficiency at PNom N/A %

Figure 31:Losses due to external transformer.

#### 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



Figure 32: Module efficiency loss.

diagram". The reason for this is that this parameter is defined with respect to the Standard Test Conditions (STC) while the 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.

LID - Light Induced Degradation	default % 🔽	?
Degradation of crystalline silicon modules	, in the first oper	rating
hours by respect to the manufacturing fl	lash test STC val	ues.

Figure 33: Light Induced Degradation.

#### 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.

-Module Mismatch Losses		default	0
Power Loss at MPP	1.0	% 🔽	•
Loss when running at fixed voltage Not relevant when MPPT operation	2.5	% 🔽	
Detailed computation	on		

Figure 34: Module mismatch loss.

The "Detailed computation" button 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.

$^{\sim}$ Graphic tool for the array's electrical behaviour study in various conditions,	- 0	х
Mismatch	modules	
in an array. Basic PV module	Q Open	
Group of       External conditions         © Cells       15       units in series            Modules       2       chains in parallel         Cells/modules in series sorted according to ISC       Cell temperature         Mismatched modules parameter distribution         Short-circuit current       Isc=         Isc=       10.00 A         0.50 A       5.0 ↓ %         Open circuit voltage       Voc=         Normal (Gaussian) distribution         Square distribution		
Show histogram	- Close	

Figure 35: Detailed computation of mismatch loss.

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 temperate-climate residential situations.

Yearly soiling loss factor	-Monthly soiling values				
Vearly loss factor 3.0 %	Jan. Feb.	10.0	]%  %	July Aug.	0.0 % 0.0 %
C Define monthly values	Mar. Apr.	0.0	]% ]%	Sep. Oct.	0.0 %
	May	0.0	%	Nov.	5.0 %
	June	0.0	]%	Dec.	10.0 %
		✓ Set all as year			

Figure 36: Soiling loss.

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 consider 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).

#### **Auxiliaries**

The auxiliary consumption is the energy used to manage the system. This may be fans, air conditioning, electronic devices, lights, or any other energy consumption which must be deducted from the generated PV energy that is injected into the grid.

Auxiliaries energy losses	0
✓ Auxiliaries consumption de → Auxiliaries during operation (day)	fined
Continuous auxiliary loss (fans, etc.) from inverter output power threshold	100 W 0.8 kW
Proportionnal to the inverter output power from inverter output power threshold	0.0 W/kW 0.0 kW
Night auxiliaries losses Night auxiliaries consumption excluding inverter night loss :	0.04 kW
The auxiliary energy may be fans, air conditionin lighting,, or any other energy which should be su the grid.	g, monitoring or other electronics, ibstracted from the energy sold to

Figure 37: Auxiliary energy loss.

#### Aging

People often use the Manufacturer's warranty as loss reference when designing PV systems, which is usually a loss of efficiency of around 20% after 25 years. However, the Manufacturer's warranty should be understood as a lower limit for any individual PV module.

nermal parameter Ohmic Losses Module quality	- LID - Mismatch Soling Loss IAM Losses Auxiliaries Ageing Unavailability Spectral corre	ection
Vess degradation in the simulation Vess degradation in the simulation Vess degradation in the simulation Simulation for year no Individual PV modules: Global degrad. factor Mismatch degrad. factor Mismatch degrad. factor Notel - VV module ageing parameters Aver, degradation factor Imp RMS dispersion 0.40 © kWh/yr Imp RMS dispersion 0.40 © kWh/yr	Use in simulation Use in simulation Use in simulation Basic degradation With annual increasing mismatch 70 5 10 15 20 Year	25 30 @ Efficiencies
Store the Monte Carlo values Monte-Carlo values Monte-Carlo values Monte-Carlo values Monte-Carlo values Mismatch 10 years 	Used for this evaluation       Year       Wodule warranty         Sub-array       15 Modules in series       Year       0 Warranty (38.00 % F         2 Strings in parallel       Year       10 Warranty (48.00 % F         Monte-Carlo calculation       Year       25 Warranty (48.00 % F         100 Trails       10 Years Random evaluation       27% Aver. Mismatch loss         1.06% Mismatch loss RMS       Steps       Uterance.	Pnom ✓ Linear interpol. Linear interpol. Pnom Average -0.729/oyear e value (usually around tsponds to the LID or initi

Figure 38: Aging loss.

In this tool, we define an average degradation rate (for a set of modules). This loss value may be much lower than this degradation limit. Some experimental studies mention degradation rates of the order of -0.3%/year measured as an average on several modules (and measured with very old modules manufactured in the 80-90's, with old technologies). Long-term degradation rate measurements are relatively scarce.

#### 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 number of days. As this is usually unpredictable, you have the possibility to define specific periods of unavailability of the system and generate these periods in a random way. The effective energy loss depends on the season and the weather during the unavailability periods. Therefore, the unavailability loss has only a statistical meaning

—Unavailability of the system—		Unavailability periods	
Unavailability time fraction 2.0	default 🕜	Beginning Date / Hour	duration
Unavailability duration 7.30 Number of periods 3	days/yr	28/01/1990 ∨       14:00: 0         27/06/1990 ∨       21:00: 0         25/10/1990 ∨       01:00: 0	58 hour 58 hour 58 hour

Figure 39: System unavailability.

#### Spectral correction

The spectral correction takes into account the changes in the solar spectrum due to scattering and absorption in the atmosphere. These changes depend on the water content in the atmosphere, the aerosols and the traveling distance of the light, expressed in Air Mass (AM). There are several models implemented in PVsyst to describe the spectral correction:

- 1. The CREST model that is used for amorphous silicon modules. This correction is applied automatically.
- 2. The spectral correction for PV modules in the Sandia database. This correction is applied automatically.
- 3. The FirstSolar spectral correction model that is disabled by default, and can be turned on by the user.

Use spectral correction in simulation						
-FirstSolar	model					
🖂 Ac	cording to PV mod	lule technology				
C0:	0.8591400	Coefficient Set	Default			
C1:	-0.0208800	Monocrystalline Si				
C2:	-0.0058853	Meteo input	Precipitable water is not available in the Meteo variables			
C3:	0.1202900					
C4:	0.0268140	PV modules	PV module model: Mono 300 Wp 60 cells			
C5:	-0.0017810					

Figure 40: Spectral correction.

#### 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 that represent the upper limit of the system performance. For each selected loss you will get a curve in a different color.



Figure 41: Losses graph.

#### 1.5.4 Loss diagram examples

After running the simulation with different variants, it is possible to compare the results between different variants directly from the report. The differences between the reports are highlighted to give a direct overview of the differences. Figure 42 illustrates the loss diagram comparison between two different variants. The left diagram is the results with the horizon and linear shadings whereas the right diagram is the one of the first simulation without further details in the variant. Note that the report for the horizon and linear shadings now has 8 pages instead of 6. The additional pages include information on the horizon definition with the sun path diagram, which is now in page 4, and the near shadings parameter with its associated iso-shading diagram, which is now included in page 5.

Now, referring to the loss diagram in Figure 42, the differences between the losses are highlighted and can be spotted immediately. On the left, the loss diagram for the variant with horizon and linear shadings, the far shadings and near shadings losses are now incorporated and we observe changes on the effective irradiation on collectors and other energy that follows.



Figure 42: Loss diagram comparison between two different variants.

We illustrate some other eventual examples of losses.

#### Example 1:



In this example, we see a 3% loss in soiling factor. This is due to accumulation of dirt on the system that further affects the performance. The definition of soiling loss factors can be defined in PVsyst in monthly values.

We also observe a +0.13% of gain from spectral correction. The spectral correction considers the changes in the solar spectrum due to scattering and absorption in the atmosphere where a set of coefficients is defined by default when the spectral correction is enabled for a simulation.

Example 2:



Figure 44: Loss diagram example 2.

In this second example, another branch of energy flux balance appears in the loss diagram, representing the loss in the self-consumption with storage strategy. This strategy consumes its own energy produced by the PV and draws minimum energy from the grid. The diagram gives information on the battery's lifetime and the cost of the stored energy that will be highly dependent on the sizing of the system.

#### 1.6 Conclusion

In this document, we demonstrated the basic approach to run a first simulation project on PVsyst using an example, starting from the project specifications, saving the project, executing and analyzing the results on the report and adding further details to the project variant.

The next chapter demonstrates the basics of near shading construction for grid-connected systems.