Guide to Modeling Enphase Microinverter Systems with PVsyst v6

This document provides guidance for installers and designers using PVsyst v6 (<u>www.pvsyst.com</u>) to model Photovoltaic (PV) system expected performance using Enphase Microinverters.

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Solar electric PV systems with Enphase Microinverters have one utility-interactive microinverter per PV module that converts low voltage DC to utility grid-compliant AC output. The Enphase Microinverter System out-performs string or central inverters (with or without optimizers) by eliminating the limiting impact of module mismatch losses and shade experienced by string and central inverter systems.

Project developers and system design engineers around the world widely accept PVsyst expected PV system performance calculations. While using the software is generally straightforward for central or string inverter PV system architectures, it requires special model input parameter considerations when you use microinverter module-level power electronics (MLPE) in a system design.

The PVsyst software model input adjustments described in this document allow the calculations performed by the model to more accurately reflect the improved energy harvest from PV modules that are individually controlled by a single microinverter.

The following assumes user familiarity with the PVsyst software and is not a complete PVsyst guide.

Note: Always make sure to download the latest module and inverter database from PVsyst to ensure that your model is using the latest technical data.

System Sizing

When sizing an Enphase System in PVsyst, make sure that the number of inverters and modules match in the **System** input parameters.

Project's designation The Project includes mainly the geographic SI Project's name Enphase System	ITE definition, and the associated METED hourly fill Dat	e ?
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Mandatory	Horizon Horizon Near Shadings Module layout C Economic eval Miscellaneous tools	Simulation and results Simulation Results Save variant Cleate variant

Project overview - Click System to adjust input parameters

Grid system definition, Variant "New simulation variant"				
Global System configuration	-Global system su	ummary		
1 Number of kinds of sub-arrays	Nb. of modules	325	Nominal PV Power	97.5 kWp
	Module area	533 m²	Maximum PV Power	88.1 kWdc
? Simplified Schema	Nb. of inverters	325	Nominal AC Power	81.3 kWac
PV Array				
Sub-array name and Orientation	Presi	zina Heln		
Name PV Array	0	No Sizir	Enter planned power	kWn
Orient. Fixed Tilted Plane Azim	Tilt 10* outh 0*		or available area (533	m²
Select the PV module Available Now Sort modules	ower 🜔 Techn	olog	Approx. needed modules	325
LG Electronics	LG 300 N1C-A3	Since 201	4 Manufacturer 2C 💌	🚯 Open
Select the inverter Available Now ▼ Soft inverters by P Enphase ▼ 0.25 kW Nb. of inverters 325 ÷ 0 perating Volk	ower 🚫 Voltag Tr 60Hz C250- age: 15 -	ge (ma 72-2LN/S2 48 V Global 60 V	Since 2015 💽	✓ 50 H ✓ 60 H M Open
Design the array	r vokage.	00 *		
Number of modules and strings	Operating conditi	ions		
· · · ·	Vmpp (60°C)	27 V		
Mod. in series 1 🐳 Vonly possibility 1	Vinpp (20 C)	44 V		
Nbre strings 325	Plane irradiance	1000 \u//m²	May in data	STC
325	Impo (STC) 30	164 A	Max. operating power	87.5 kW
Phom ratio 1.20	Isc (STC) 32	73 A	at 1000 W/m² and 50°C)	0.10 km
Nb. modules 325 Area 533 m ²	lsc (at STC) 32	40 A	Array nom. Power (STC)	97.5 kWp
😰 System summary		🗶 Car	icel	• ок

System definition – Set Nb. of inverters equal to number of modules

Hidden Parameters

PVsyst requires adjustment of the following Hidden PVsyst Parameters for Enphase system modeling.

Low Limit Power Threshold

Enphase Microinverters can convert available energy of a PV module at very low power levels with higher conversion efficiency due to a feature called "burst mode". This feature captures the available energy from a PV module at very low light levels (for example, during dawn and dusk) and bursts this energy into the grid when enough energy is available for one or more full AC cycles. This takes advantage of the available PV module energy when the light conditions are too low to operate the microinverter in the MPPT operating range. PVsyst has a hidden parameter that discards any power production in the model output that is below a certain low limit threshold of the nominal power rating of the inverter. The default value in PVsyst is 0.5%.

Set the **Power Threshold / PNom lower limit** parameter to 0.01% so that the PVsyst calculations include power production to essentially zero output for Enphase systems.

- From the main page click on **Preferences** and select **Edit hidden parameters**.
- Select the **Regulators and converters** from the **Category** drop down menu.
- Scroll to the bottom and change the **MPPT converters: Power Thresh./ PNom lower limit** value to 0.01 %. The default check mark will disappear.

Set this value back to default when modeling non-Enphase systems.

Maximum DC to AC Ratio

When modeling systems with a DC to AC ratio of greater than 1.3 of PV module STC rating to nominal microinverter output power, you must adjust the **Maximum PnomRatio for inverter sizing** parameter. The default value in PVsyst is 1.3.

- From the main page click on **Preferences** and select **Edit hidden parameters**.
- Select the System design parameters from the Category drop down menu.
- Adjust the **Maximum PnomRatio for inverter sizing** parameter to a higher value (for example, 1.5 or 1.6).

Detailed Losses

After you have defined your System input parameters:

• Click **Detailed Losses** to modify the input values to accurately represent performance calculations when using Enphase Microinverters.

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M Delete project	r variants	te and Meteo 🗮 Albedo - settings
ystem Variant (calculation ver	rsion)	TV New sector
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System		
System Detried lance	Module layout	
System Detailed losses Net metering	Module layout Economic eval.	ଜ라 Save variant

Project Overview - Click Detailed losses input parameter

Adjust Ohmic Losses

Since each microinverter converts the DC source from one PV module to AC at the location of the module, the electrical collection and distribution from the array to the point of interconnection is no longer using direct current (DC), but instead alternating current (AC). You must adjust the ohmic losses to accommodate for this difference from traditional string and central inverters systems.

DC Circuit Losses

Because one Enphase Microinverter is connected to each PV module and mounted directly under the module, there are no long DC runs to the inverter. This eliminates any DC wire losses. To adjust for this:

- Click on the Ohmic losses tab in the Detailed losses parameter window.
- Adjust the value for **DC circuit: ohmic losses** for the array to 0%. This causes the **Default** check box to become unchecked automatically.
- Adjust the **Global wiring resistance** value to 0 mOhm.

Global wiring resistance 0.0 m	Calculated
or in loss fraction at STC 0.0 %	C Default ?
C circuit: inverter to injection point	External transformer
Significant length, to be accounted for	External transformer present def
Length Inverter to injection 0.0 m	Iron loss (constant value) 0.10 % 0.09 kW
Loss fraction at STC 0.00 %	Resistive/Inductive losses 0.00 % at STC
Voltage drop at STC 52V	(quadratic, R * I², R = 0.0 m0hm
Voltage drop at STC 52V	(quadratic, R * P, R = 0.0 m0.hm

Ohmic losses – Set the DC circuit: ohmic losses to 0%

AC Circuit Losses for Microinverter Systems

AC circuit ohmic losses are unique to every system and based on conductor selection (type and size) and on distances from the AC connections within the array and the interconnection point. PVsyst deals with AC ohmic losses with a single adjustment factor. It is therefore necessary to use an average loss factor of the system's AC distribution system.

• To adjust the model for AC circuit losses, in the **Ohmic losses** tab, select the check box **Significant length, to be accounted for** in the **AC Circuit: inverter to injection point** section.

General Approach

• For preliminary analysis, enter 1.75% for Loss fraction at STC.

PVsyst equates the **Loss Fraction at STC** to "Voltage drop at STC". We always recommend Enphase systems to be designed and installed with a 2% or lower AC voltage drop from the last microinverter on an AC branch circuit to the point of interconnection (injection point, per PVsyst).

Since the highest recommended voltage drop is 2% for the furthest AC branch circuit from the injection point and since there are AC branch circuits in any system with shorter wire runs (adequately sized conductors and lower losses), we recommend entering 1.75% or lower for **Loss Fraction at STC**.

• If the exact voltage drop, averaged across all AC branch circuits, is known for your design, use this number in this field.

rcuit: ohmic losses for wiring resistance or in loss fraction at STC	the array 0.0 0.0	mOhm %	Calculated	💐 Detailed computatio	on
wiring resistance or in loss fraction at STC	0.0	mOhm %	Calculated	💐 Detailed computatio	on
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	refer to injection poin inficant length, to be acco er to injection 92.7 totion at STC 1.75 KW, Vac = 432 V III, I = rop at STC 7.6 V (1.8)	refter to injection point ificant length, to be accounted of er to injection 92.7 50 mm² ction at STC 1.75 X HKW, Vac = 432 V HI, I = 125 A rop at STC 7.6 V	refter to injection point Externificant length, to be accounted of inficant length, to be accounted of er to injection 92.7 50 mm² ▼ ction at STC 1.75 1KW, vac = 432 ∨ 1m, l = 125 A rop at STC 7.6 ∨ (1.8 %)	refter to injection point inficant length, to be accounted for et to injection 92.7 50 mm² ction at STC 1.75 XW, vac = 432 V In; I = 125 A rop at STC 7.6 V (1.8 %)	Kerter to injection point ificant length, to be accounted or External transformer present into injection 92.7 50 mm² • ction at STC 1.75 % itkw, vac = 432 v Int, I = 125 A ? rop at STC 7.6 V (1.8 %)

Ohmic losses – Set the AC circuit losses to 1.75% or less

AC circuit loss considerations for string or central inverter systems

When running a performance model for a string (with or without optimizers) or central inverter system, designers should enter a general AC loss fraction of 1.0% unless the specific AC circuit losses are known. Keep in mind that the AC circuit losses depend on the total current, size of the conductors, and wire distances of that AC circuit.

External Transformer Losses

You need to adjust the **External transformer** parameters only for PV systems with external transformers between the inverter and interconnection point. Isolation transformers and auto-transformers are different types of transformers with different loss fractions. Auto-transformers have much lower losses than isolation transformers. Check with the manufacturer about losses to expect from a transformer used in the specific system application.

Adjust Module Mismatch Losses

Enphase Microinverters eliminate the PV module mismatch losses that otherwise affect a string. Since one module is connected to one inverter in an Enphase Microinverter system, the maximum amount of energy can be harvested from each module. String or central inverters operate PV modules in series strings, in which the lowest performing module limits the performance of all the other modules in its string and parallel strings that are connected on the same DC input bus.

- To adjust the module mismatch losses for an Enphase System, in the **Module quality LID -Mismatch** tab, and the **Mismatch Losses** section, enter 0 (zero) in the **Power Loss at MPP** field.
- Both **Module Quality** and **LID** parameters are limitations of the module. Leave these values at the module manufacturer's default settings.

	Thermal parameter Uhmic Lo Module quality Module efficien Deviation of the average efficiency by respect specificati (negative value indic LID - Light Induced I LID los: Degradation of crystalline the first operating hours t manufacturing flash tes	ssses Module quality - LID - Mis default icy loss -0.8 a effective module to manufacturer ates over-performance) Degradation default s factor 0.0 0.0 % silicon modules, in oy respect to the t STC values.	Mismatch Losses Power Loss at MPP Loss when running at fixed vo Not relevant when MPPT c	Auxilianes Unavailability
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Module Mismatch Losses - set the Mismatch Losses to 0 %

Adjust Soiling Loss

PV module soiling depends on the geographic region and the local environment. While an Enphase System does not impact the degree of soiling on a module or string, it does mitigate some of the loss by maximizing the performance of each individual module independently and preventing modules compromised by snow, dirt, or debris from dragging down the performance of other modules.

Enphase assumes that soiling in a PV system can be largely non-uniform. Such variance in soiling across a string or entire array creates module mismatch much like direct shading. Accordingly, to capture the impact of Enphase Microinverters on soiling mitigation, we recommend designers take into account the impact of mismatch due to soiling and roughly halve the losses. A representative table of soiling losses changes for different soiling rates follows:

Soiling Loss Factor for String Inverter	Enphase-Adjusted Soiling Loss Factor	Difference
2 %	0.8 %	-1.2%
5 %	3 %	-2 %
8 %	4.8 %	-3.2 %
10 %	6 %	-4 %

• To adjust this parameter, select the **Soiling Loss** tab and change the **Yearly loss factor** to the adjusted loss factor.

PV field detailed losses parameter		- • ×
Thermal parameter Ohmic Losses Module quality - LID - Mismatch Yearly soiling loss factor Vearly loss factor Default Define monthly value ?	Soiling Loss IAM Losses	Auxiliaries Unavailability
Losses graph	X Cancel	√ 0K

Soiling Loss - Set Yearly loss factor to the adjusted value