Economic system design with Fronius Symo Hybrid

White Paper

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INTRODUCTION AND EXECUTIVE SUMMARY

Nowadays the amortization of a newly installed PV system depends on the initial investment as well as the self-consumption ratio. The feed-in limitations as well as non-existing feed-in tariffs resulted the max. efficiency rate becoming less important.

This paper addresses the question whether the max. DC current from the PV generator ($I_{pv,sc}$) can be much higher than the max. input current of the inverter ($I_{dc,max}$) and what kind of effect can be expected.

Even if the max. DC current is much higher than the max. input current of the inverter according to the data sheets, the yield losses are insignificant. The explanation for this is simple:

- **Due to the relatively low radiation in Central Europe plus the rare occurrence of radiation higher than 900 W/m² directly on the module surface, the max. input current of the inverter is not exceeded. Even on a PV system with oversized array this happens on very rare occasions only.**

- **However, if the DC current is exceeding the max. input current of the inverter, the inverter will react by shifting the operating point (MPP). In fact the DC current will be restricted to the max. input current of the inverter and at the same time the voltage of the new operating point will increase. This behaviour compensates most of the initially assumed losses of current limitation.**

CURRENT OVERSIZING OF THE INVERTER RESPECTIVELY THE MPP-TRACKER

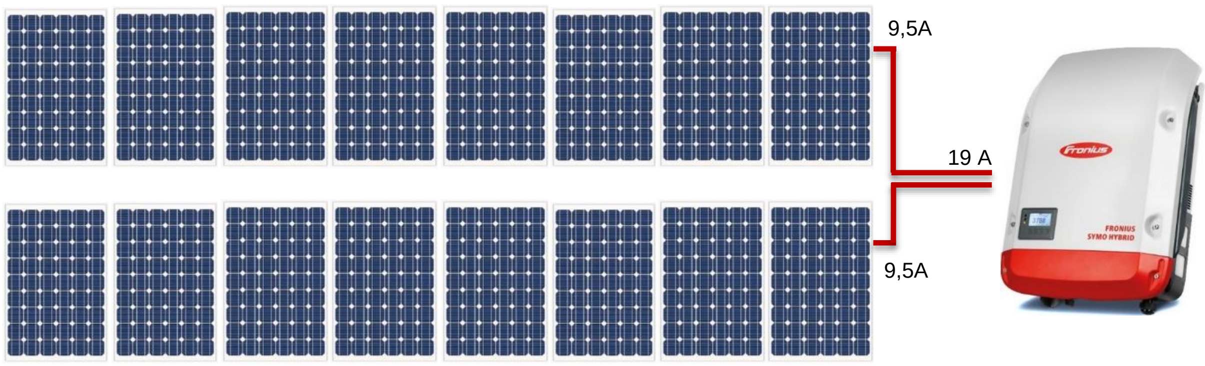
The DC inputs of inverter/MPP-trackers (MPPT) are characterized resp. limited by various different parameters. It is not uncommon that the max. MPP-current of the PV generator exceeds the max. input current of the inverter resp. the MPP-tracker when multiple strings are connected in parallel. In that case, we talk about current oversizing. ($I_{mpp,stc}$ of PV-generator > $I_{cd,max}$ of inverter/MPPTs).

The Fronius SnapINverter series (Fronius Galvo / Symo / Symo Hybrid / Primo / Eco) shows an extremely high resilience regarding current and power oversizing. The current oversizing can be at least 50%, some types can handle even more (see data sheets “max. short-circuit current module” = $I_{pv,max}$). So the max. short-circuit current of the PV-generator ($I_{sc,stc}$) can be 50% over the $I_{dc,max}$ of the inverter without voiding the warranty or damaging the inverter.

Current oversizing does not necessarily lead to dramatic yield losses. This kind of system design actually makes economically sense because its losses are negligible.

/ **Example: Fronius Symo Hybrid 5.0-3-S ($I_{dc,max}$ = 16A) with 2 module strings with an $I_{mpp,stc}$ = 9,5A each**
The PV current with 19A is therefore **18,75%** higher than the max. input current of the inverter ($I_{dc,max}$ = 16A). But this design **reduces the annual yield** by **less than 0,75%.**

/ The same calculation for a module with $I_{mpp,stc}$ = 8,8A (2 strings are 17,6A) reduces the annual yield by only **0,25%.**

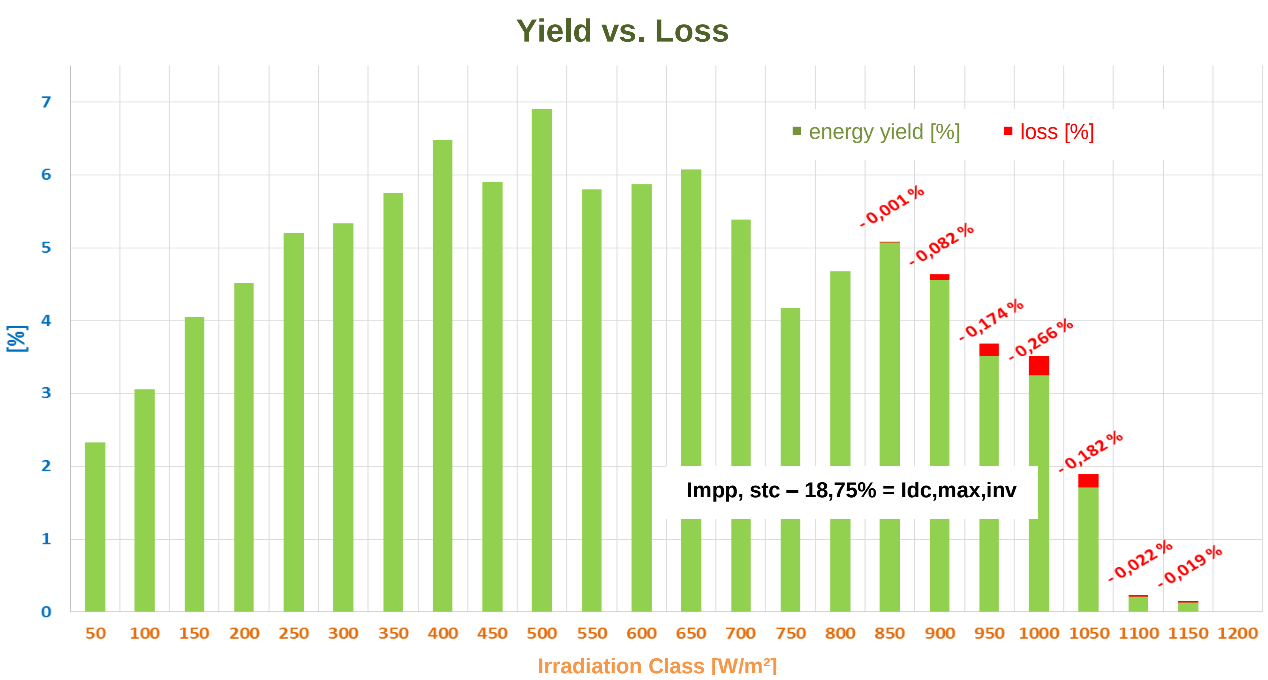


Picture 1; Installation of a Fronius Symo Hybrid with two parallel string of 9,5A (total = 19A) each.

HOW TO EXPLAIN THESE EXCELLENT RESULTS?

1) Rarity of high irradiation directly on the module

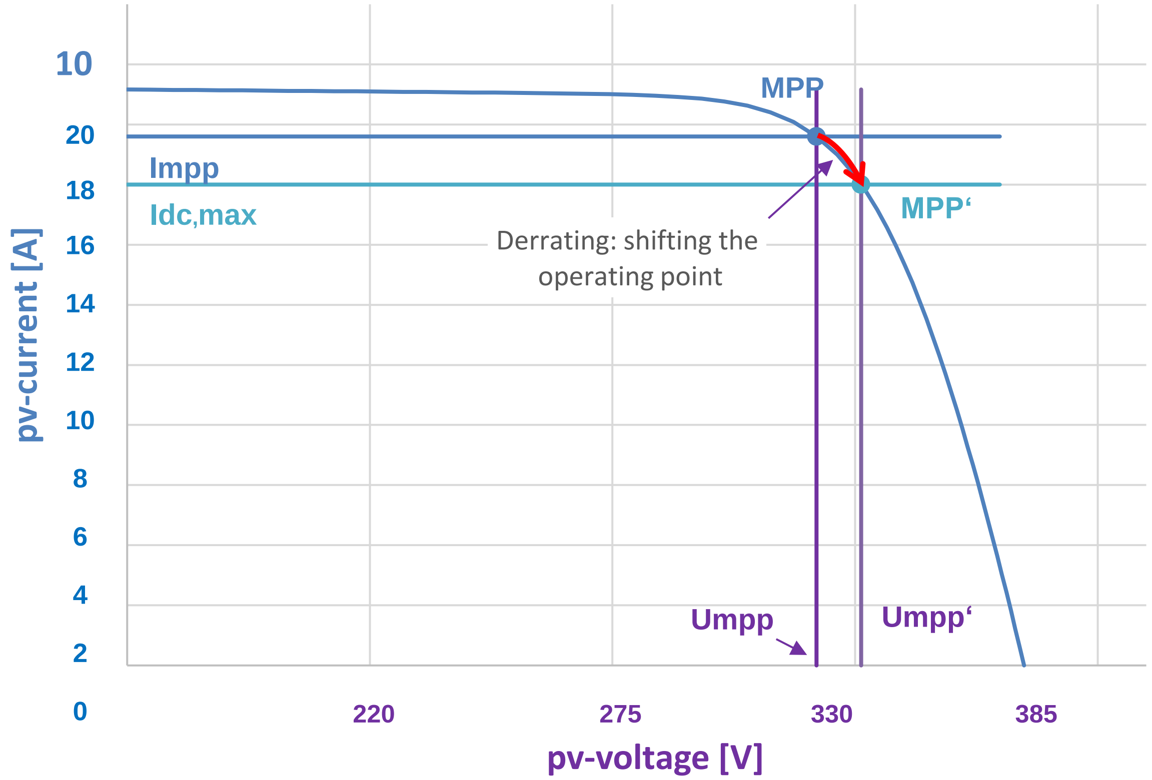
In reality, a very high and direct radiation onto the PV array is quite rare (think of weather, time, roof orientation, position of the sun, seasons) compared to the standard test conditions (STC) which calculate with an irradiation of 1000 W/m². For this reason the theoretically producible electricity from a module data sheet is met only in rare cases. Which means that even though the current is limited there are hardly any losses in yield.



Picture 2; Yield per radiation category in one year (Munich/south orientated roof)

2) Shifting the operating point when the input current is reached

In case the current of the PV generator exceeds the maximum input current of the inverter the MPPT of the inverter will shift the maximum power point (MPP) towards the direction of open circuit voltage (higher voltage). This behaviour is similar to power derating due to limited export requirement.
Due to the higher input voltage the input power pulled from the inverter is increased and the losses can largely be compensated.



Picture 3: PVcurrent limitation by shifting the operating point

3) Feed-in limitations in the markets

In addition to the above mentioned facts there are feed-in limitations in many markets e.g. the 60/70% regulation in Germany. Around midday the time of day when the current from the PV generator is the highest, many PV system owners aren't using much of their energy so that they end up with a very low self-consumption rate. Due to feed-in limitations PV systems have to limit feed-in power which makes yield losses even more negligible due to current limitation.

Note: max. short-circuit current $I_{pv,max}$

The so called $I_{pv\ max}$ is the max. short-circuit current (I_{sc} under STC). The PV generator's I_{sc} must not exceed the value ($I_{pv\ max}$) of the inverter's maximum power point tracker (MPPT). Just like there is a limit for the max. occurring voltage which is the $U_{dc\ max}$ (theoretically max. open circuit voltage with average radiation and low temperature) there is also a max. allowed current which must not be exceeded. Unlike with $U_{dc\ max}$ the I_{sc} occurs in case of a worst case scenario malfunction only. All relevant components in the inverter have to be able to withstand this possible short-circuit current. A DC disconnector - integrated in a Fronius SnapINverter - has to be able to cut off the short-circuit current safely.

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Solar Energy

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