

Analysis of Electrical Shading Effects in PV Systems

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Abstract

In a PV system, partial shading leads to extra mismatch losses due to shaded PV cells limiting the current of a string. We investigate these so-called electrical shading losses, with two models available in PVsyst: a complete IV-curve-based model, and a simplified model. These are applied to PV shed systems with different string layouts and PV module types. Common configurations are shown to be compatible with the simplified model, after adapting the number of string partitions. We also derive some general strategies for minimizing electrical shading losses.

Methodology



Reference model: module layout

Submodules



Behaviour for sheds (rows)



Further assumptions:

- No minimum inverter
- voltage
- Sheds layout
- Fixed GCR = 0.65- Fixed tilt = 20°
- South orientation

Effect on irradiance components

Beam:

- Linear: shaded area ratio
- Electrical: according to models
- **Diffuse and albedo:** integral of view factor

The circumsolar component is included in the diffuse.

IV behavior depends on **submodules**, not individual cells.

IV curve composition, 1 string



Simultaneous shading of submodules: Landscape (L): 1/3 of the submodules. **Portrait (P):** all submodules.

3 or more strings per MPPT: electrical shading losses dominated by mismatch between strings.

Simplified model for sheds (rows)



Electrical effect



Assumption: «plateau» behaviour based on module layout results for at least three strings per MPPT.

Detailed hourly results

Satisfactory partitioning

Example 1: strings on one row, 2 strings per MPPT (2L)



Unsatisfactory partitioning

Example 2: strings on 2 rows, 2 strings per MPPT (2LU)



Impact of inverter minimum voltage

Losses from inverter voltage threshold not taken into account in this study. PV curve example



Model yearly results

Yearly results: standard partitioning



Summary and Outlook

Configurations with low electrical losses (without inverter voltage threshold):

- Fewer strings on each MPPT: decreases the mismatch between strings.
- Higher number of rows \rightarrow fewer electrical losses.
- Normal modules should be positioned in landscape.
- Twin half-cells in portrait: similar behavior to normal modules in landscape.
- U-shape may be acceptable for landscape configuration only.

The simplified model needs a well-chosen partitioning to match the reference model.

Improvements in future PVsyst versions:

Yearly results: new partitioning

- Improve accuracy of simplified model, refine step definition.
- Module layout calculation on part of the system, extrapolated to full system.

This study was based on PVsyst 7.2.5.