Shade Management

Efficient operation of partially shaded PV plants with OptiTrac Global Peak

Content

It is not always possible to prevent dormers, chimneys, or trees from casting their shadows on PV plants.

However, in order not to jeopardize the economic viability of a PV plant, the loss of output due to shade must be minimized already in the planning phase.

Influential factors such as the arrangement of the PV modules, their connection, and in particular the choice of the right inverter play an important role.

By observing some important planning rules, these factors can be adapted to the PV plant so that their energy supply can be used almost completely.

1 Effects of partial shade on the PV plant

Each PV generator has an individual operating point where it can provide the highest electrical power, the Maximum Power Point (MPP). The amount of power depends mainly on the irradiation. If individual PV modules of a string within the PV generator are shaded, its electrical properties change significantly: the PV generator now has several operating points of different operating quality.

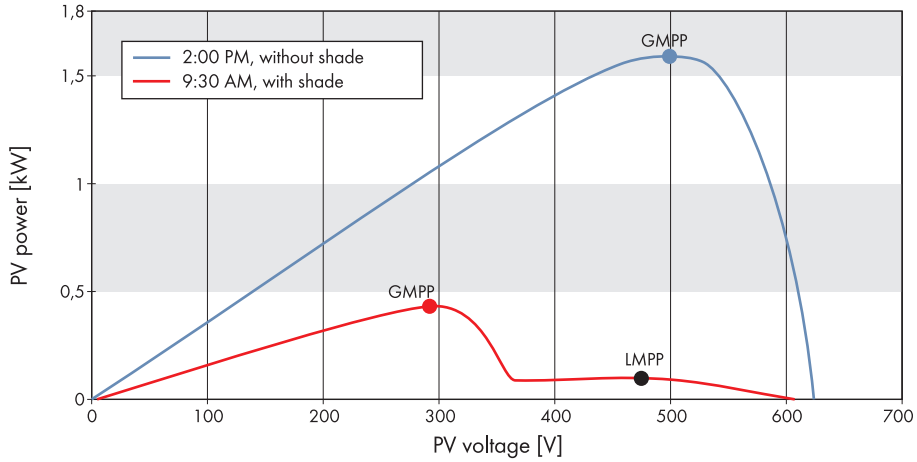

Fig. 1: Power-voltage diagram of the represented PV generator at two different times of day (with and without partial shade). The curves show that there are two different "good" MPPs when there is shade, with the power at the local MPP being significantly lower than that at the global MPP.

2 Shade: A special task for the inverter

Each PV inverter has a so-called MPP tracker. This ensures that the PV generator is continuously operated at its optimum operating point. Controlled in this way, the PV generator can use the available power at certain level of solar irradiation as well as possible. For the SMA inverters, the OptiTrac operation control takes on this task and so ensures maximum energy yield.

But if, as described above, the shading of individual PV modules of a PV-generator creates two different operating points, the connected inverter must now decide on which of these two operating points - the local MPP (LMPP) or the global MPP (GMPP) - it should now operate the PV generator.

However, since conventional MPP trackers only observe the vicinity of the current operating point, an alternative operating point may not be noticed, so that no energy is unnecessarily lost in the search. The current output of the PV plant can thus be significantly smaller than it should be because of the shade.

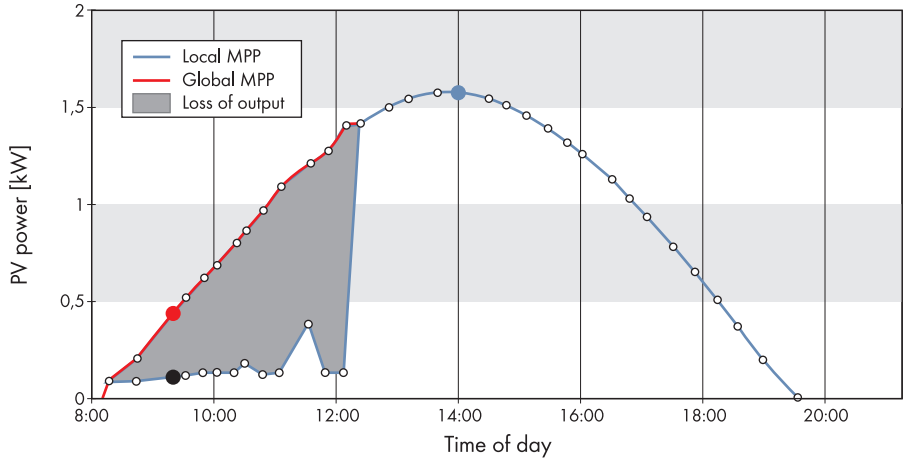

Fig. 2: Course of the global and local MPP power of a partial generator of a PV plant with morning shade. The gray area shows the loss of output that would be caused by setting the local MPP instead of the global one.

The OptiTrac Global Peak behaves quite differently: in order to always find the optimum operating point even in partially shaded PV plant, an additional function was added to the standard MPP tracking of the SMA inverters. OptiTrac Global Peak can temporarily operate the PV generator at a great distance from the known operating point. With the help of this tool, the inverter can always find the operating point with the currently highest performance and in this way can almost completely use the energy supply of the PV modules under all conditions [1].

With this procedure, losses during searching are unavoidable. However, OptiTrac Global Peak is a search procedure specialized in keeping losses in times without shade at a maximum of 0.2 % when searching for a possible second power maximum. To keep these search losses even lower, it may be useful to adapt and reduce the frequency of searches (cycle time), individually for PV plants with slowly appearing shadows [2].

3 Designing partially shaded PV plants

In order not to jeopardize the economic viability of partially shaded PV plants, the loss of output due to shade must be minimized already in the planning phase.

To assist the system designer, the most important planning rules are presented below.

3.1 Selection of roof area

The minimization of energy losses in partially shaded module strings is always based on enabling the inverter to electrically bypass shaded solar cells and thus to optimally use the unshaded PV modules of the same series-connected string. The power of the shaded solar cells, which is diminished anyway, cannot be used at this time. Therefore, when selecting the roof area for a PV plant, you should make sure that no permanent shadows fall on the PV generator, and especially in times of high irradiation (noon, summer months) no shadows should fall on it at all, if possible. To estimate the properties of the shadows, such as their size and how they change over the course of a year, special simulation programs can be used.

3.2 Selecting the system connection

The connection of the PV generator significantly influences the obtainable energy yield. SMA Solar Technology AG has therefore prepared and published the rules of "Shadow Management" [3]. The analysis of the course of shadows is always carried out at the beginning of a system design. The proportion of the shaded PV modules in relation to the total generator and the course of shadows over time are important characteristics of a PV plant with partial shading. The following recommended actions are important when dealing with partially shaded PV plants:

- When a single PV module or a very low portion of the PV modules (e.g. < 10 % of the total number) is shaded, the shadow can be distributed evenly on the strings. Since the MPP voltage is always near the nominal MPP voltage in these cases,a special operation control (OptiTrac Global Peak) is not necessary.
- If shading is severe, it makes sense to operate the shaded and unshaded PV modules separately. Take note:
  - Group together generator parts with similar irradiation.
  - No parallel connection of strings with different irradiation; rather, provide a separate MPP tracker for each string. Many small inverters or ones with multistring technology can be used for this.
  - OptiTrac Global Peak is necessary to maximize the energy yield.

But even with the slight shading described above, the concentration of the shaded PV modules on its own MPP tracker represents an alternative to evenly distributing the shadow over all strings. Even this system design requires OptiTrac Global Peak to minimize yield losses.

3.3 Selecting the inverters

As described in the "Shadow Management" [3], the choice of the inverter also influences yield losses due to shade. Three points are to be observed when selecting the inverter:

- Inverters with a broad input voltage range can still adjust the optimal operating point despite shade and the resulting decline in MPP voltage.
- Using an inverter with a single-string control a partially shaded PV generator can operate optimally and avoid most losses.
- To yield losses due to shade to a minimum, it is necessary to use an inverter for partially shaded strings whose MPP tracking recognizes the existence of several operating points (e.g. OptiTrac Global Peak).

The multistring inverters Sunny Boy 4000TL and 5000TL, developed by SMA Solar Technology AG, with their broad input voltage range and their new OptiTrac Global Peak operation control, are therefore ideally suitable for high-efficiency operation of partially shaded PV plants.

4 OptiTrac Global Peak

The SMA inverters Sunny Boy 3000TL, 4000TL, and 5000TL are serially equipped with OptiTrac Global Peak from firmware version 3.01 (from April 2010). Previously installed inverters of this device family can be retrofitted via firmware update. The firmware update is available free of charge in the download area of www.SMA.de/en.

OptiTrac Global Peak is an additional function of the standard MPP tracking OptiTrac and is deactivated by default. To assist the installer with the activation and setting of OptiTrac Global Peak, the download area under www.SMA.de/en contains the technical description "OptiTrac Global Peak" in the category "Technical description" of the respective inverter.

5 Sources

[1] J. Iken: "Leistungsgipfel mit Geheimnissen" (Performance peak with secrets); Sonne Wind & Wärme, 17/2009, p. 160 (only available in german)

[2] SMA Solar Technology AG: "SUNNY BOY 3000TL / 4000TL / 5000TL - Parameters and measured values", www.SMA.de/en

[3] G. Bettenwort, J. Laschinski: "Schattenmanagement – Der richtige Umgang mit teilverschatteten PVGeneratoren" (Shadow management – The correct handling of partially shaded PV generators); 23. Symposium Photovoltaische Solarenergie, 2008, Bad Staffelstein, Germany (only available in german)

[4] SMA Solar Technology AG: Technical description "OptiTrac Global Peak - SUNNY BOY 3000TL / 4000TL / 5000TL", www.SMA.de/en