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Impact on the daily energy yield curve for vertical bifacial systems at different orientations

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→ Introduction

Vertically mounted bifacial solar panels are described in various papers as an interesting alternative approach to conventional PV system design. However, mostly east-west (E-W) orientation of vertical panels is studied in detail as this is supposed to maximize the energy production in kWh/kWp.

In this presentation, we report on field data from vertically mounted bifacial PV panels which are installed in four different orientations: east-west (E-W); north-south (N-S); southest–northwest (SE-NW); southwest-northeast (SW-NE). The test site is located close to Berlin (Germany). All data shown are recorded at a nice German summer day and we do not yet have full-year data.

We discuss the daily production profiles and also show the impact of the ground albedo. Special attention is paid on what energy production profiles can be achieved by combining panels in different orientations. Finally we discuss the potential advantages of vertically mounted bifacial PV panels to optimize self-consumption and to better meet the grid demand.

Experimental Setup

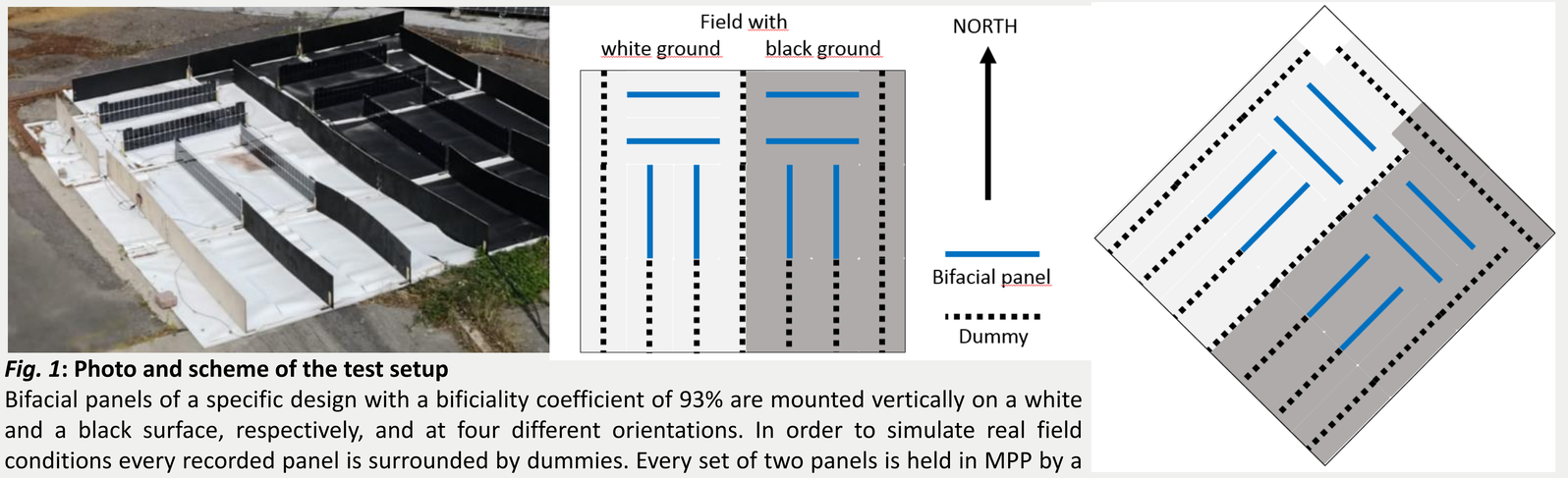
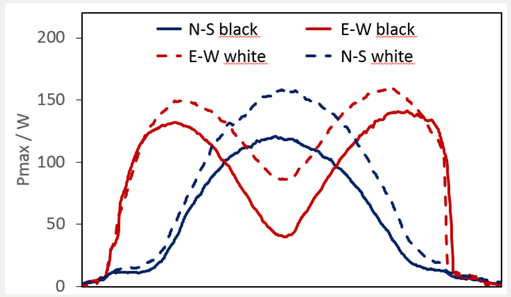


***Fig. 1*: Photo and scheme of the test setup**
Bifacial panels of a specific design with a bificiality coefficient of 93% are mounted vertically on a white and a black surface, respectively, and at four different orientations. In order to simulate real field conditions every recorded panel is surrounded by dummies. Every set of two panels is held in MPP by a commercial *SolarEdge* power optimizer which also provides recording of the energy production data.

Results and analysis of energy production data



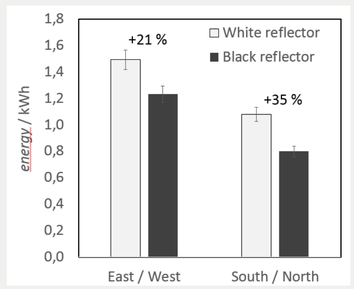


***Fig. 2*: Impact of ground albedo**
On the left side typical daily energy production curves of E-W oriented (red) and N-S oriented (blue) bifacial panel are given, both for white (dotted line) and black (full line) ground albedo. For a summer day (when the sun is high at noon) the impact of ground albedo is much higher for N-S (+35%) than for E-W (+21%) orientation. We suppose that in other seasons the albedo will have less impact for N-S modules because more direct sunlight will hit the south-oriented panels.

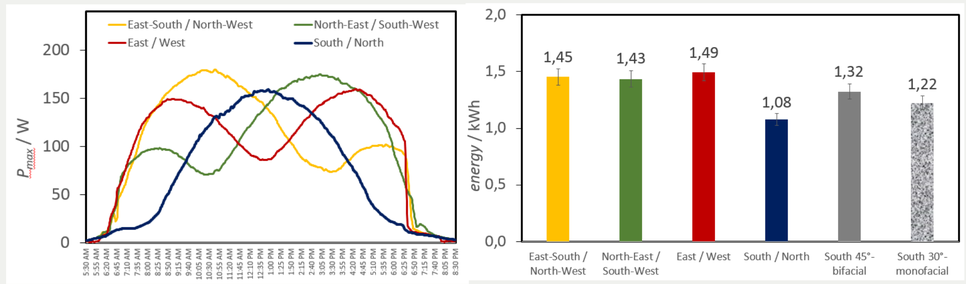


***Fig. 3*: Daily energy production of all 4 orientations (plus references)**
The left graph shows the energy production characteristics for all 4 orientations (with white ground). Interesting to note is that the SE-NW and the SW-NE orientations show the exact same early-start and late-end behavior that the E-W panels. Their characteristics is much more similar to E-W than to N-S orientation.
Pay attention to the small peak in the early morning for N-S orientation: this is attributed to direct sunlight onto the north-oriented side.
The right graph displays the daily energy production. Three different orientations basically show the same yield. It is even higher than for south-tilted reference panels.

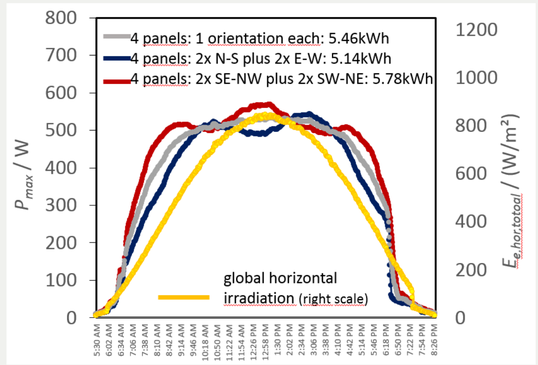


***Fig. 4*: Numerical simulation of superposition of different orientations**
By combining panels with different orientations into one system a fairly broad and constant daily energy production characteristic can be achieved. Best result is for combining SW-NE and SE-NW.

Effect on the grid and to self-consumption by systems design variations

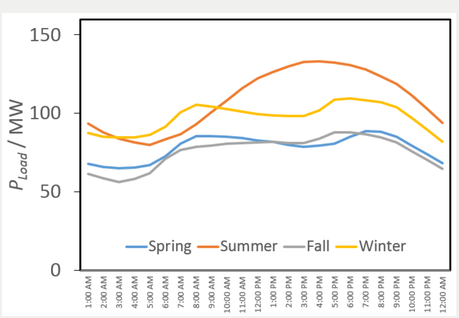
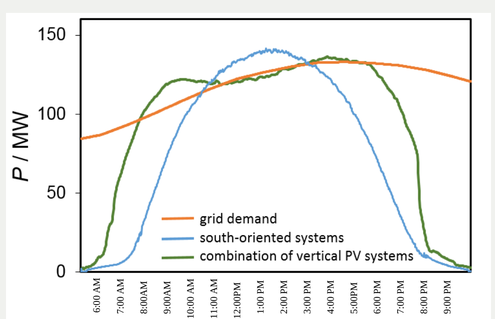


***Fig. 5 (left)* : Grid load**
The left graph shows average daily demand curves for a grid section at the US East coast. Demand is highest in summer – when solar can mostly contribute.

Source: https://www.pjm.com

***Fig. 6 (right)*: Daily demand peak in summer**
A zoom into the day grid demand in summer and the energy production curves of different PV systems.
Vertical bifacial PV systems show a significantly broader production characteristic than south-tilted panels.
This is of value especially in late afternoon when around 5 PM the grid demand peaks. Also, in case that batteries are used to store some energy from the day into the evening less storage capacity will be required.



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→ Conclusions

- on sunny days vertically mounted bifacial systems with a high albedo outperform any kind of south-oriented PV system
- For any module orientation between SE-NW (through EW) and SW-NE the overall daily energy production in kWh remains almost constant but the daily production profile changes significantly
- By installing vertical bifacial modules in different orientations a broader and much more stable energy production curve over the day can be achieved. A mix of SE-NW and SW-NE oriented panels seems to provide the highest energy production and also has the broadest generation profile.
- PV systems with vertically mounted bifacial modules can be designed in a way that the production profile better meets the daily demand curve, thus increasing self-consumption at the PV-system´s site and/or help the grid to meet the peak demand.