



Introduction

Shading of PV strings is a common issue in China. One reason is design criteria requiring strings to avoid shading between 9:00 AM and 3:00 PM during the winter solstice, leaving them prone to shading outside these hours. Another reason is the increasing use of terrain-based PV systems due to land resource constraints. Figure 1 illustrates a typical large-scale PV site. Improving performance under shading is a key concern for O&M engineers.



Fig. 1. A terrain PV system in northeast China

Modelling

LONGi has developed two software (GSE Challenger and Master), one is using to find/classify/quantify PV system faults, the other is PV power simulation tool which considering cell-level shading condition.

A. Identifying Severely Shaded String Modelling

GSE Challenger software is a PV system fault detection tool. It calculates string health performance by comparing power generation data with relative strings. One string with a strong seasonal performance decline (e.g., close to zero in winter) is identified as severely shaded (Figure 2).

B. Real-Time P-V Curve Calculation

GSE Master software is a 3D modeling and cell-level shadow simulation tool. It calculates P-V curve data for each MPPT in real time, considering different shading scenarios.

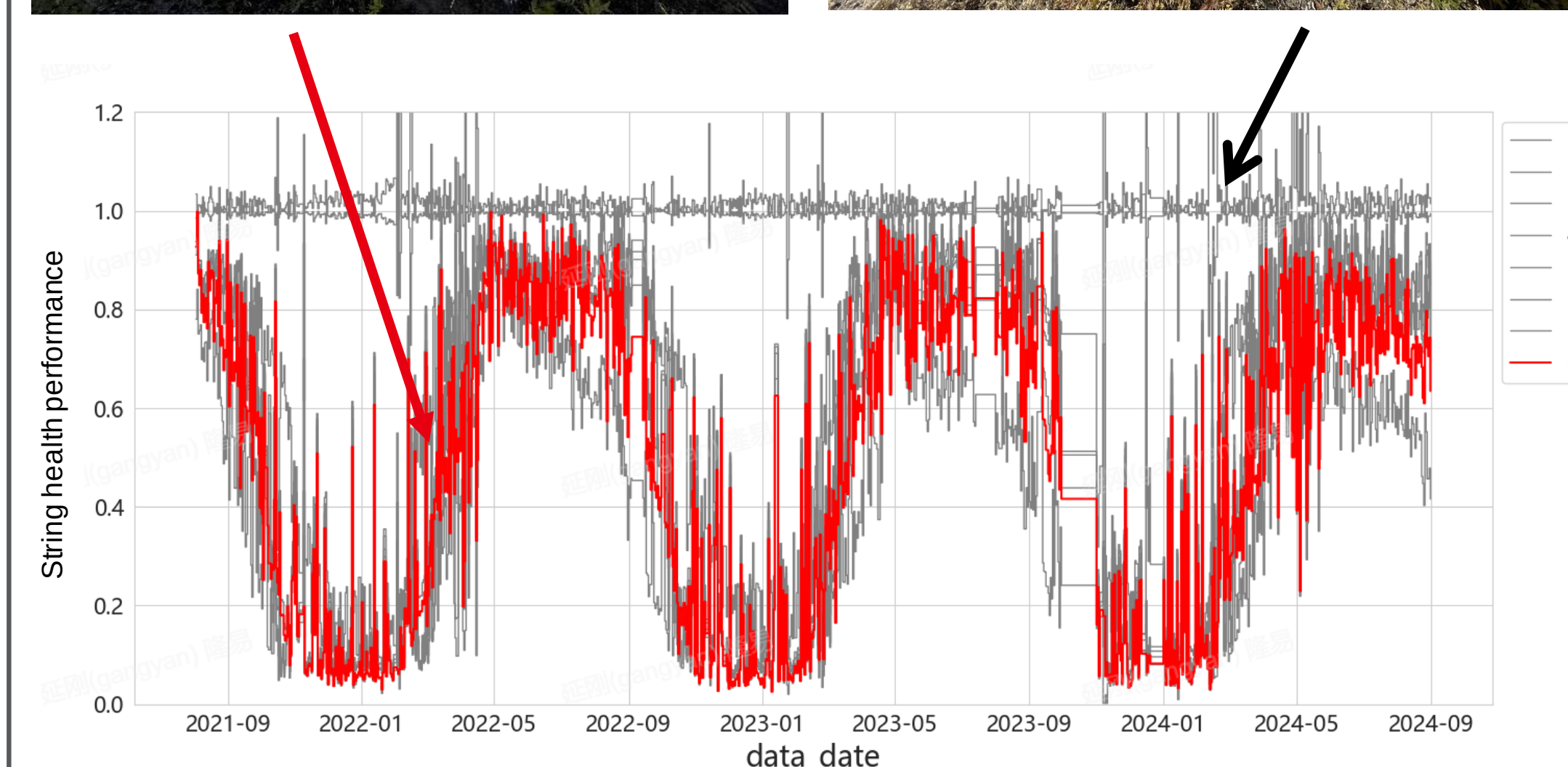


Fig. 2. Using GSE Challenger to identify severely shaded strings

Method

Three methods are proposed to improve Inverter Performance Under Shading Conditions :

a) **Method 1 - Cable Connection Adjustment:** Changing the C-type connection to a straight-line connection is suitable for two-portrait installations with full-cell modules.

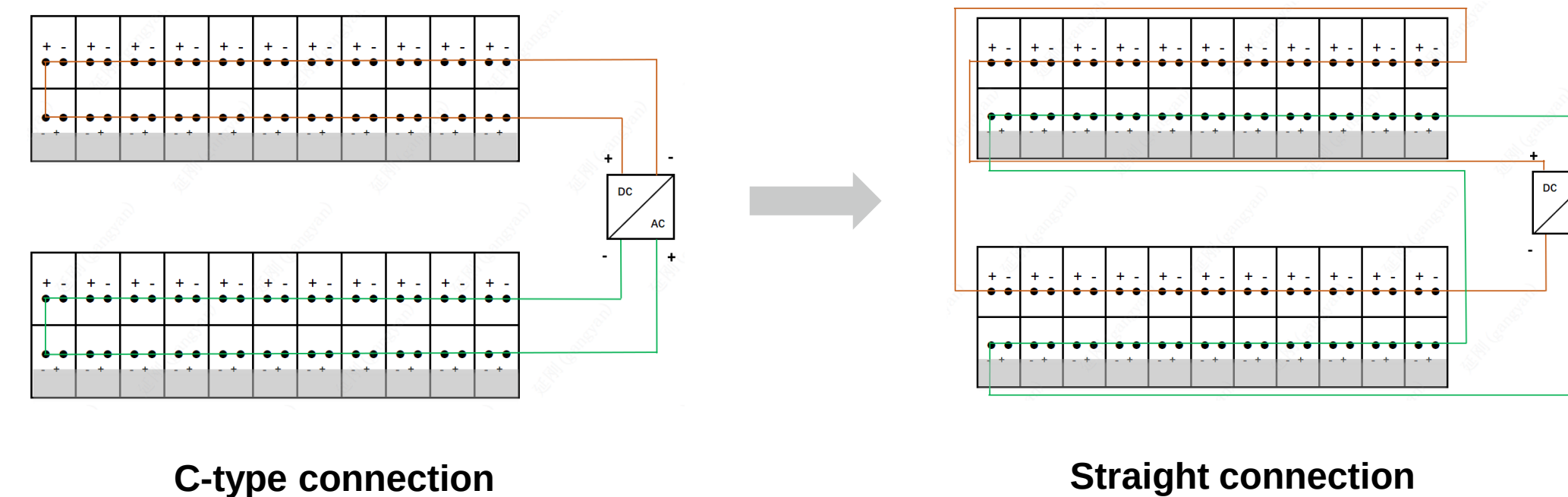


Fig. 3 Cable connection modification

b) **Method 2 - Eliminating the Second Peak:** By using light-blocking materials on shaded bottom modules, diffuse light can be minimized, ensuring a single peak point on the P-V (power-voltage) curve.

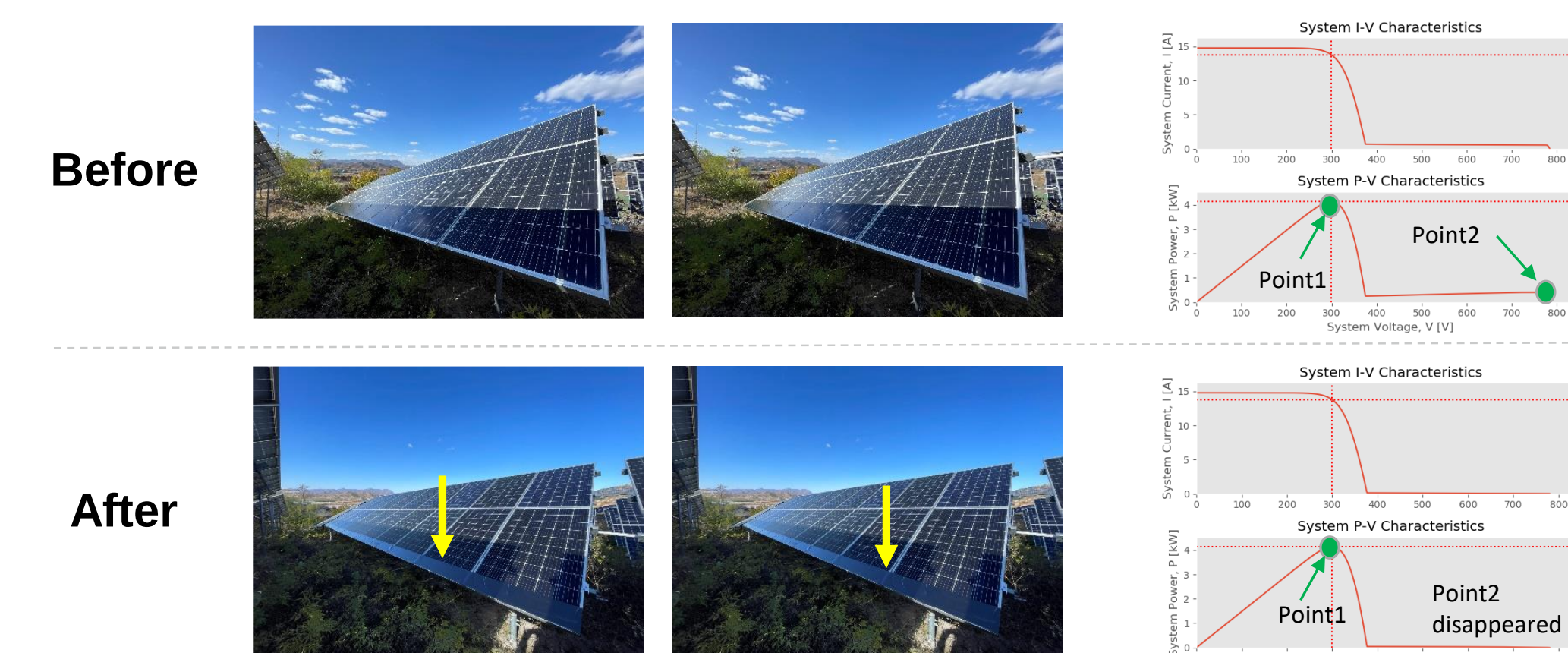


Fig. 4 Cable connection modification
(One MPPT connected two strings)

c) **Method 3: Inverter Global Scan Optimization:** Using inverter global scan functionality to find the maximum peak point only when necessary avoids the power losses associated with time-based scanning.

Experiments

The experiments were conducted on a 20 MW terrain PV plant located in northeast China. The detailed plant information is provided in Table 1.

Using GSE Challenger, 417 severely shaded strings were identified.

TABLE I PV plant information

Items	Detail information
Module	LONGi, Mono 285Wp, Full cell module
String	22 pcs module a string, 3210 strings
Inverter	Sungrow, SG50KTL, 391 units, 3MPPT, 3 strings/MPPT
Capacity	20.21 MWp
Grid connections date	2017
Installation manner	Fixed rack 22°, 2 rows portrait
Location	Northeast China

Results

Method 1: Cable Connection Adjustment

Using GSE Challenger, 417 severely shaded strings were identified. The connections of 67 inverters were changed from C-type to straight-line connections (Figure 3). The power generation increased significantly, as shown in Figure 5.

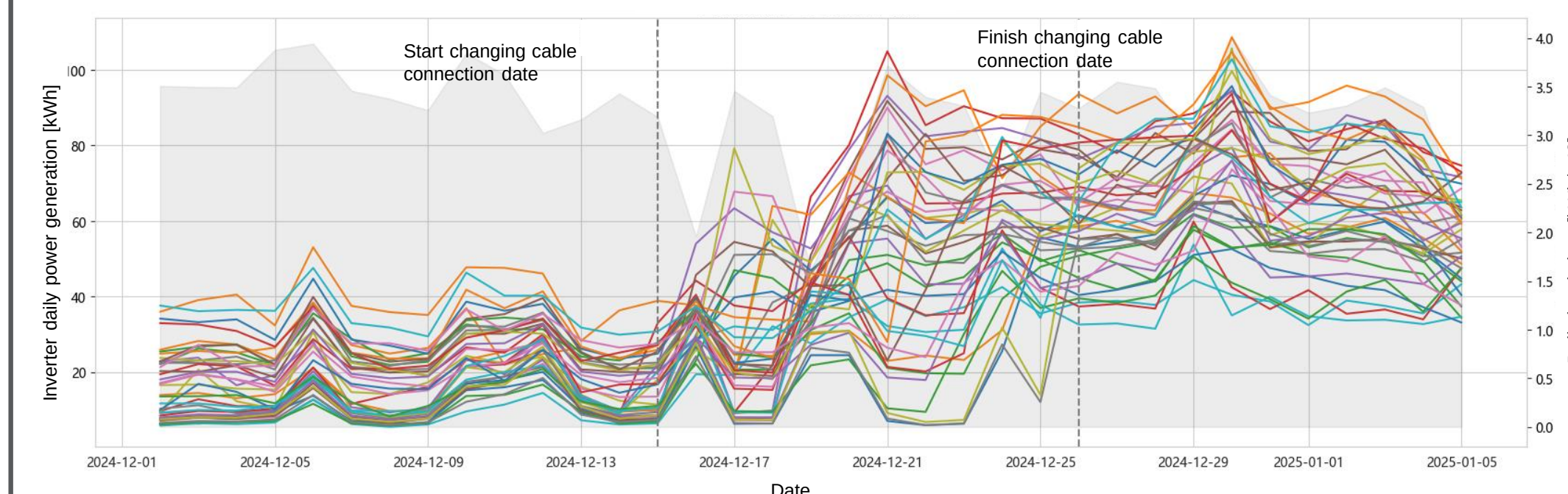


Fig. 5 Inverter daily power variation before and after cable modification

Method 2: Eliminating the Second Peak

Black materials were applied to shaded strings in one inverter MPPT with three strings. The power and current improved, but the power not to 50% of a non-shaded string's performance. The startup voltage limitation (300 V) of the inverter constrained the results (Figures 6 and 7).

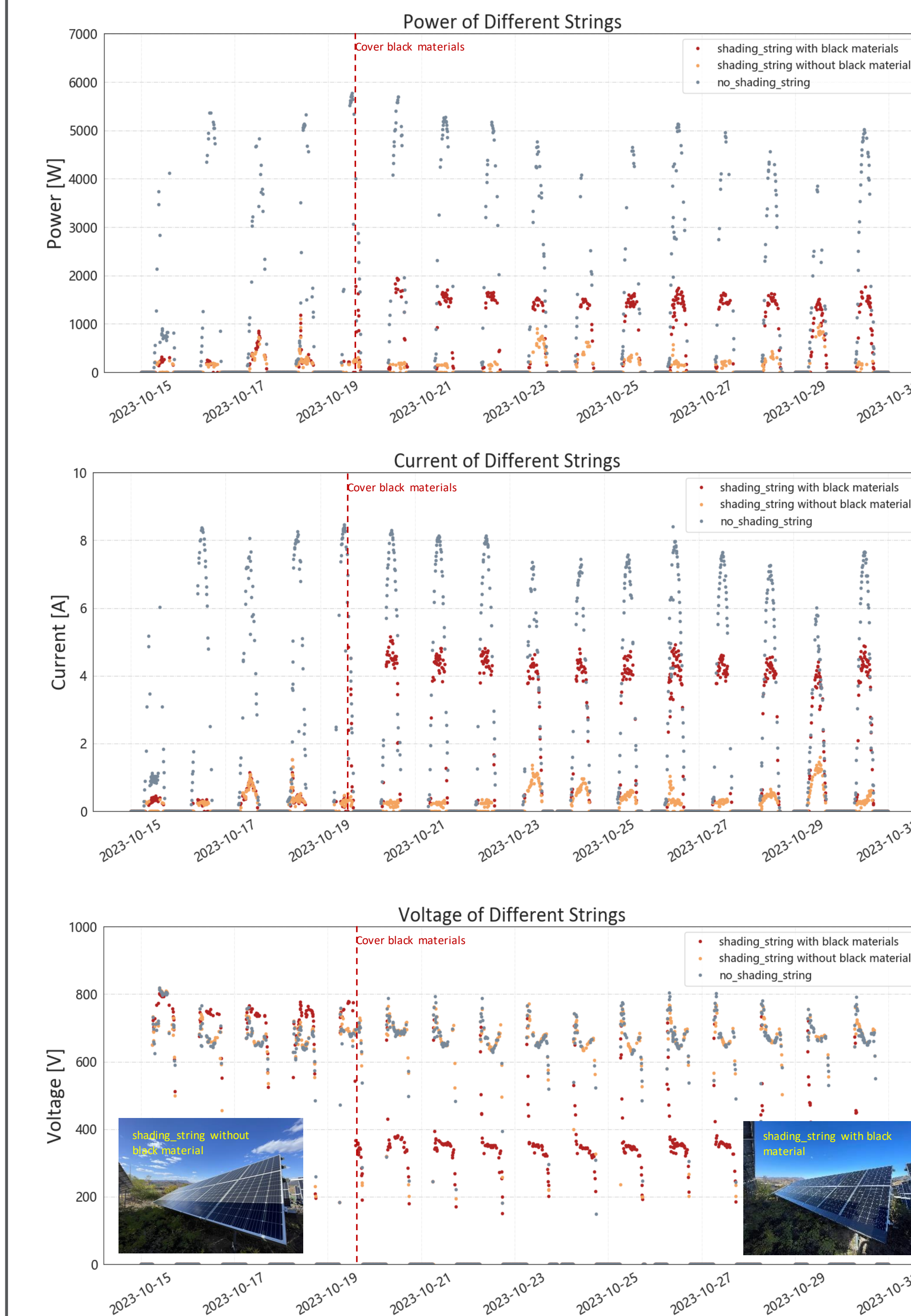


Fig. 6. Power, current, and voltage changes before and after black material application

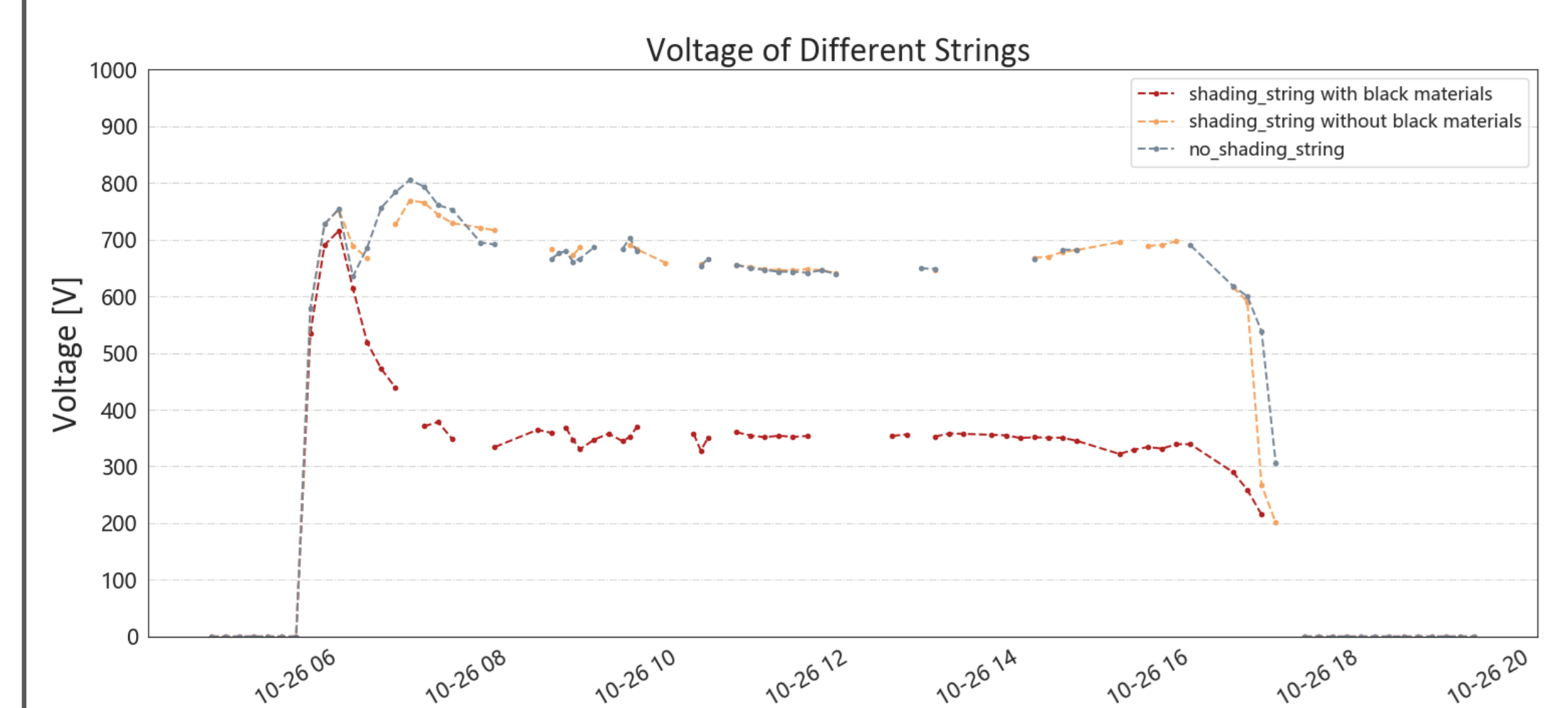


Fig. 7. Voltage variation over a day

Method 3: Inverter Global Scan Optimization

This method is under preparation for experimentation.

Conclusion

The proposed methods improve inverter performance under severe shading conditions. Method 1 is practical and effective, while Method 2 has limited applicability due to the inflexibility of light-blocking materials. Method 3 shows potential and will be further validated experimentally.

Reference

- [1] Roland BRUENDLINGER1, Benoît BLETTERIE1, et al., Optimization of Perturb and Observe Maximum Power Point Tracking Method. 2005 .
- [2] <https://github.com/SunPower/PVMismatch>