PV technologies comparison in Tahiti after 1 year of installation

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1. Introduction

Historically, French Polynesia has relied heavily on hydrocarbon imports to meet their energy needs, a trend that has continued as recent as 2022.
Fossil fuels account for 67% of their electricity generation, with the rest coming from renewable energies. Of this 33%, solar energy accounts for only 7% while the rest comes from hydropower. Despite government-backed initiatives to increase the penetration of renewable energy into the electricity grid, the percentage of electricity mix covered by renewable energies remains low despite its continuous growth.
In addition, a more homogeneous distribution of solar projects is critical considering in 2019 Tahiti accounted for 71% of the electricity consumed in French Polynesia as per the Agency for the Development and Management of Energy.
Due to the high solar resource available in the region, the use of bifacial modules presents an important opportunity for the development of photovoltaic energy.

2. Installation

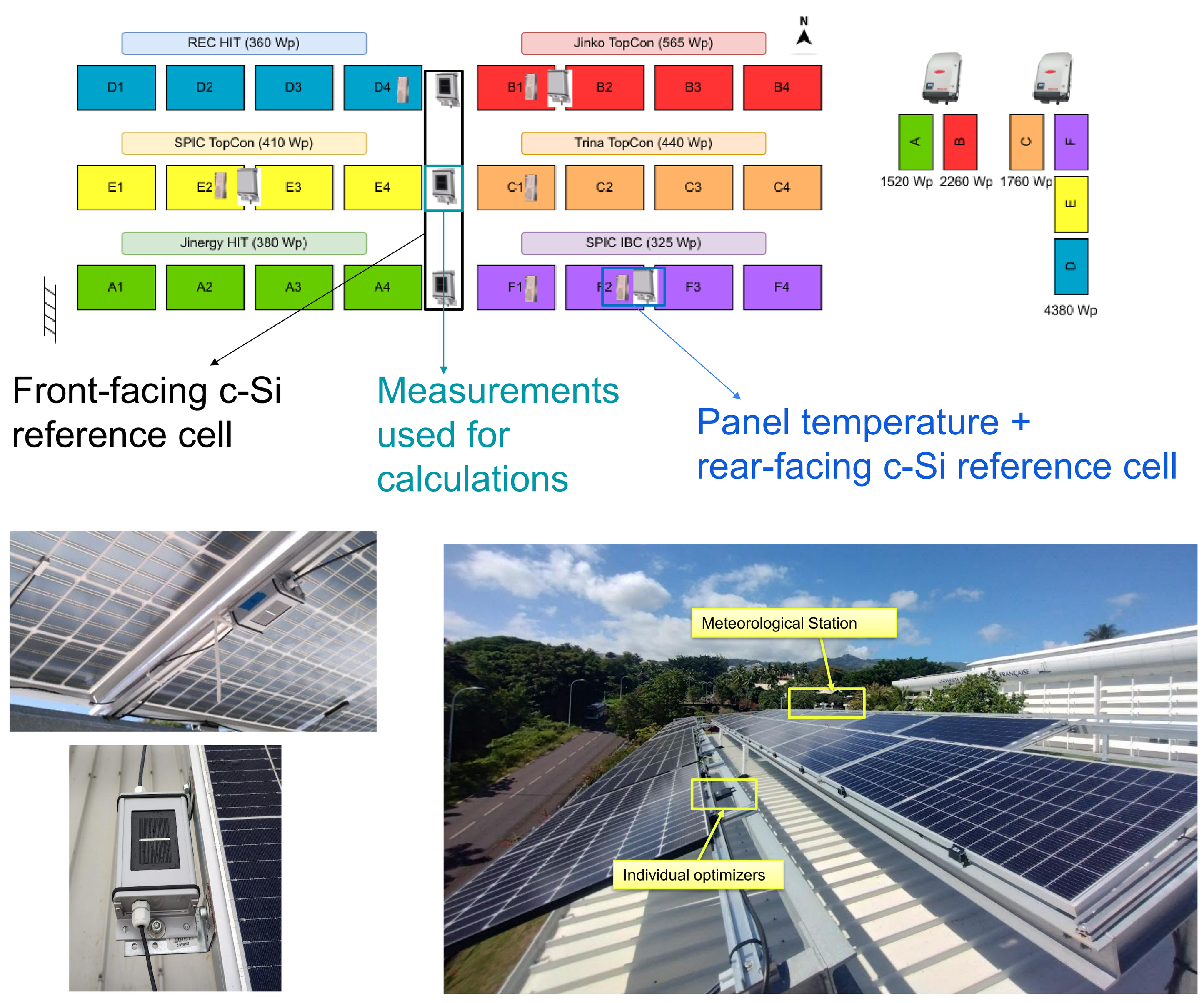


Figure 1 Layout of photovoltaic installation located on the campus of the French Polynesia University in Tahiti

3. Methodology

$$Y_M = \frac{\sum P_{meas}}{P_{STC}} \quad (1)$$

Module Yield

$$Y_R = \frac{\sum G_{meas}}{G_{STC}} \quad (2)$$

Reference Yield

$$Performance\ Ratio(PR) = \frac{Y_M}{Y_R} \quad (3)$$

$$Bifacial\ Gain\ (BG) = \frac{Y_B - Y_M}{Y_M} * 100 \quad (4)$$

(bifacial: Y_B; monofacial: Y_M)

Temperature correction

$$P_{corr} = \frac{P_{meas}}{1 + \gamma(T_{meas} - T_{STC})} \quad (5)$$

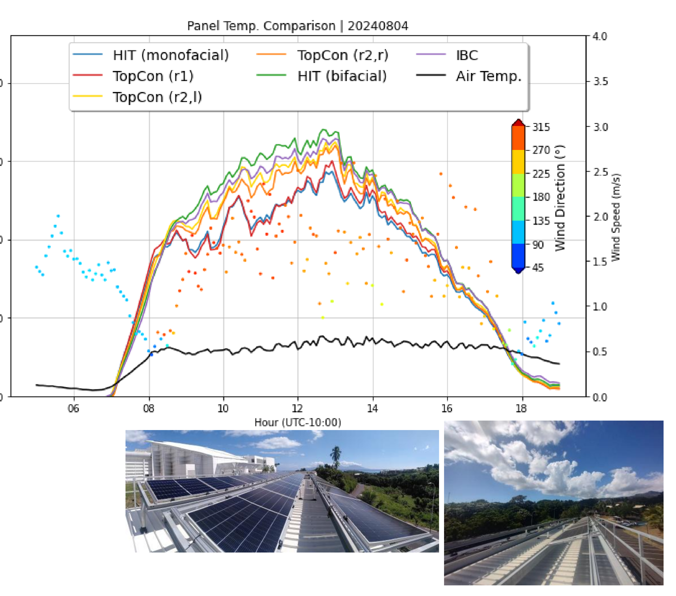
$$Y_{Mc} = \frac{\sum P_{corr}}{P_{STC}} \quad (6)$$

$$(PRc) = \frac{Y_{Mc}}{Y_R} \quad (7)$$

P_{meas} : module power output (W)
P_{STC} : power output under STC conditions (Wp)
G_{meas} : measured plane-of-array irradiance (W/m²)
G_{STC} : irradiance uner STC conditions (1000 W/m²)
T_{meas} : measured module temperature (°C)
T_{STC} : module temperature under STC conditions (°C)
γ: power temperature coefficient (1/°C)

4. Results

Figure 2 Comparison of module temperature curves (solid lines) and wind direction throughout a sunny day.



The morning and afternoon breeze (before 08h and after 18h) comes from the mountain (south-east) and during the day it comes from the ocean (north-west). This causes the modules on the first row to be cooler than the rest.

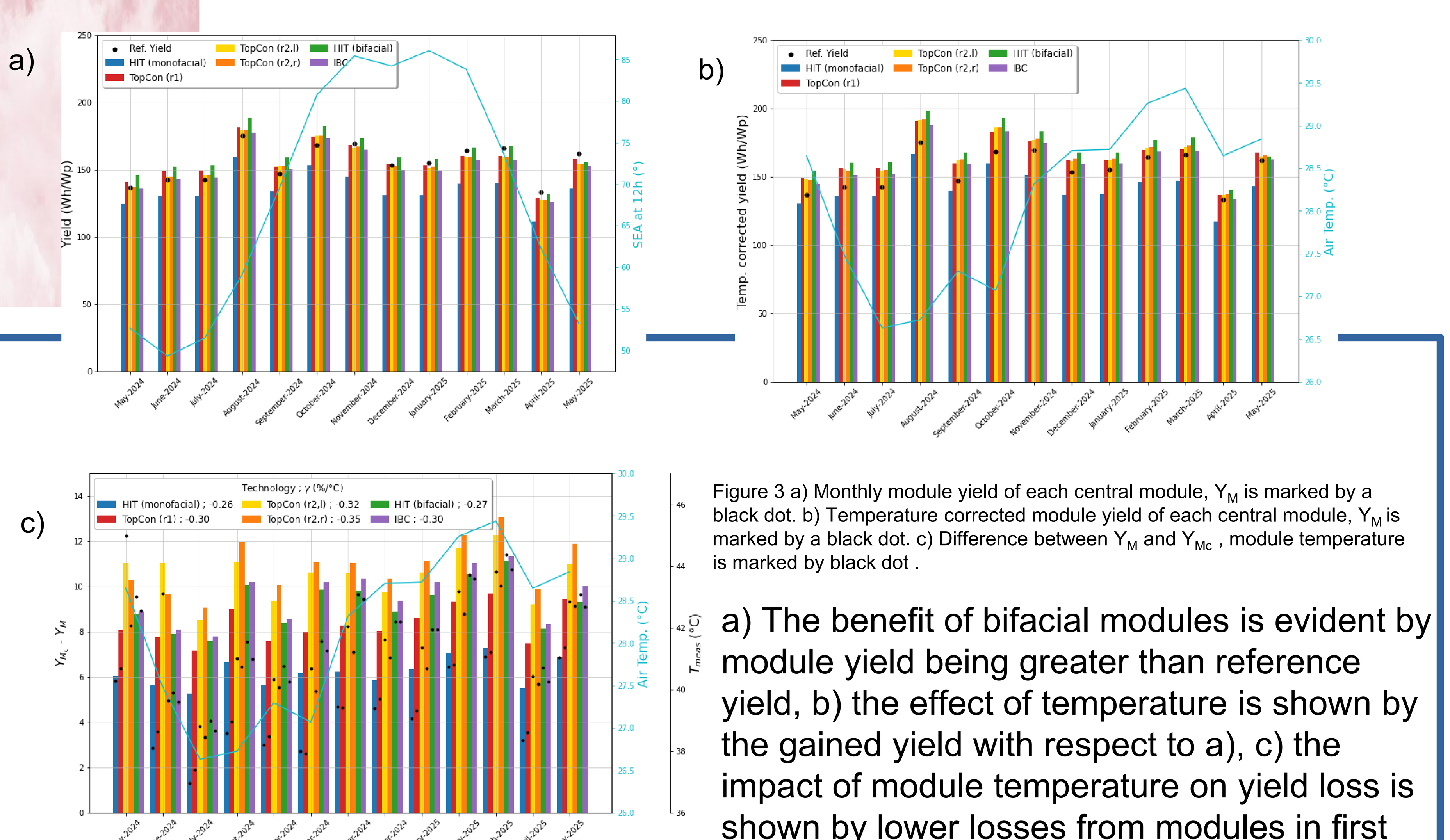


Figure 3 a) Monthly module yield of each central module, Y_M is marked by a black dot. b) Temperature corrected module yield of each central module, Y_M is marked by a black dot. c) Difference between Y_M and Y_{Mc} , module temperature is marked by black dot .

a) The benefit of bifacial modules is evident by module yield being greater than reference yield, b) the effect of temperature is shown by the gained yield with respect to a), c) the impact of module temperature on yield loss is shown by lower losses from modules in first row and highest loss from module with highest temperature coefficient.

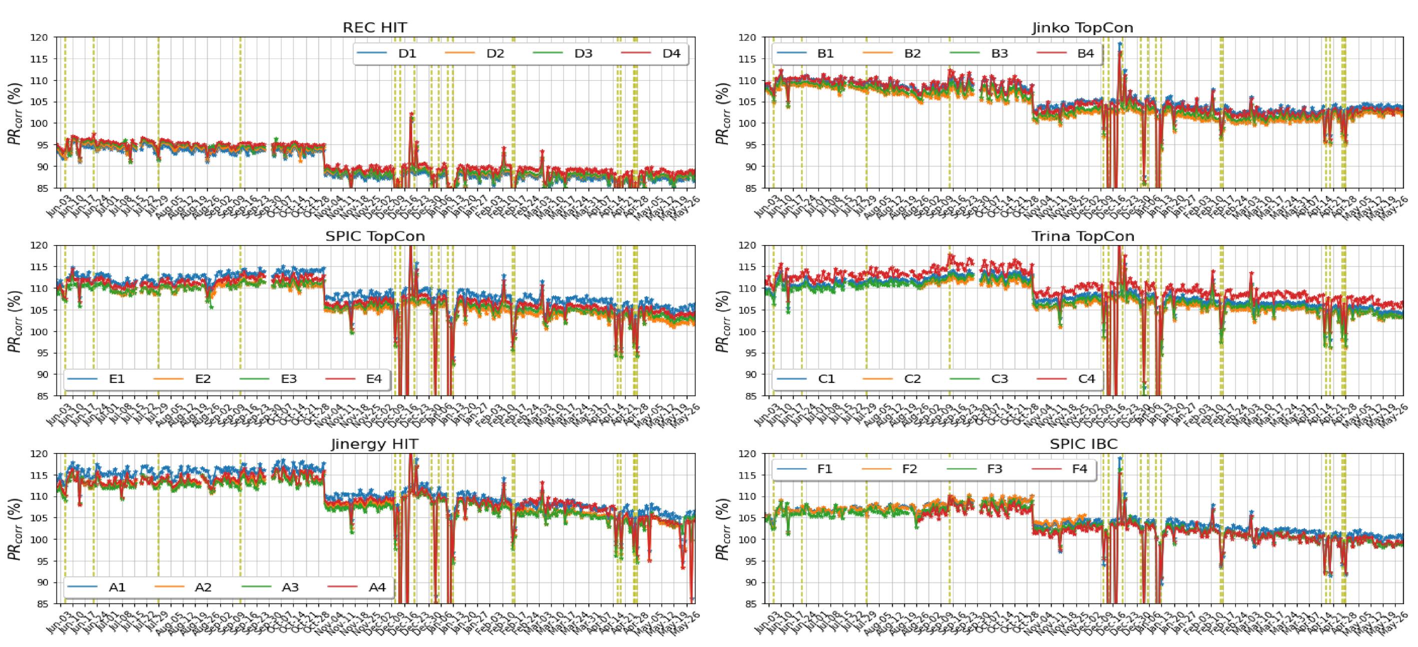


Figure 5 Daily averaged temperature-corrected performance ratio of each module. Green dotted lines correspond to significant rain events.

The PR_{corr} for modules on the outer edges is 1-2% higher due to lack of obstacles.
The PR_{corr} for bifacial modules is 15-20% higher than for monofacial ones.
No significant rain for 2-3 weeks leads to dust accumulation on the panels and consequently a drop in PR which will be reversed after an important rain event.

Bifaciality Factor

	75%
69%	74%
87%	65%

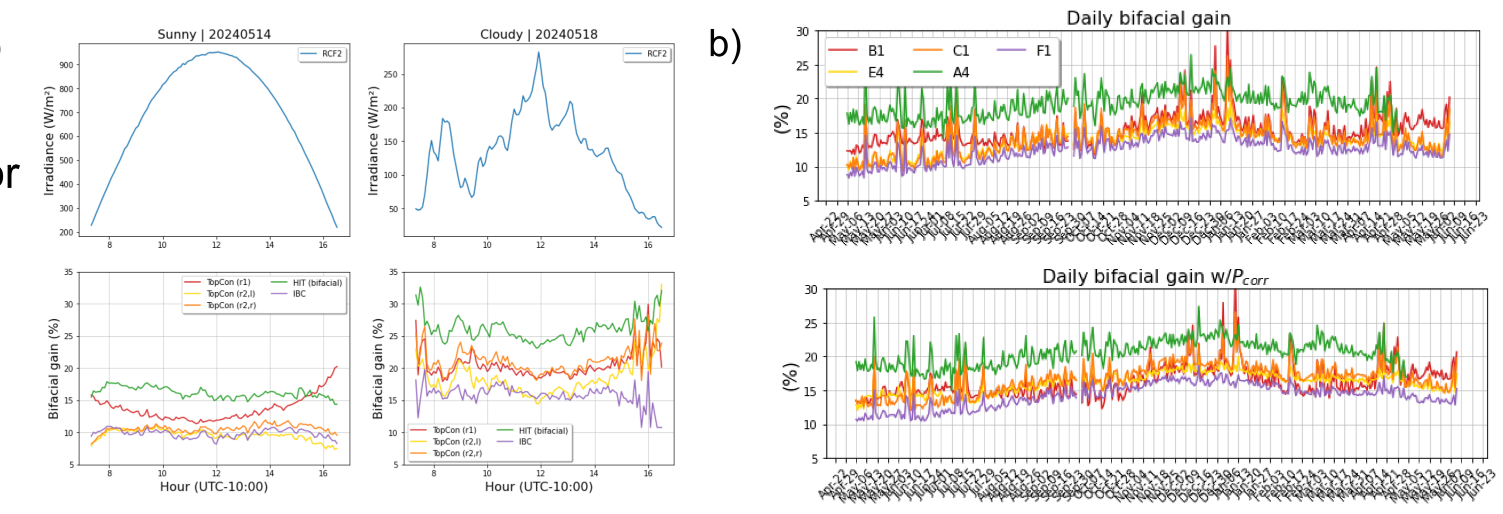


Figure 4 a) Bifacial gain for each central module during a sunny and cloudy day, b) bifacial gain of central modules for the entire period of study. Bifacility factor of each module is provided with box color corresponding to line color in figure..

When it's sunny, theTopCon module in the first row has a higher gain since it has no obstacles infront of it and thus receives more irradiance, even more so when the elevation of the sun is low as in the example presented. The gain increases when it's cloudy due to the higher reflected irradiance available.
Throughout the period of study the daily bifacial gain does not vary by more than 7% depending on the technology. When considering temperature corrections, the increase in gain does not surpass 4%.

5. Conclusion

For Tahiti the use of bifacial modules is greatly beneficial. While there is ~9% of solar resource not exploited by a monofacial per month, a bifacial module will receive up to 5% extra irradiance above the reference yield from reflected irradiance. The sun trajectory plays a significant role as it will impact mostly the panels on the first row by increasing or decreasing it.
The constant and significant air currents on the island help improve the efficiency of the modules and thus reduce temperature losses.
Overall, bifacial modules have a higher performance ratio of up to 20% with respect to monofacial ones. Modules on the edges have a performance higher than the rest of the row by 1-2% due to lack of obstacles.
The varied values of bifacial gain is due to the different bifaciality factor of each manufacturer, going from 10-25% but within the same technology, the variation remains under 7%.

Acknowledgments

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