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A New Double-Layer Photovoltaic Installation:
Illustration of the Basic Idea and First Performance Tests

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ABSTRACT

Conventional photovoltaic installations use land inefficiently, even when built with the latest generation cell technologies. Based on an Italian patent granted in 2025 and an international patent application, this work introduces a dynamic double-layer PV installation made on the basis of two distinct, overlapping bifacial generation layers, each able to operate with its own independent solar tracking. A self-built scaled prototype was operated on-field and compared with a conventional monofacial single-layer installation occupying the same land area. The first measured results show that the proposed architecture increases the land-use efficiency by more than +40% with respect to the conventional single-layer installation.

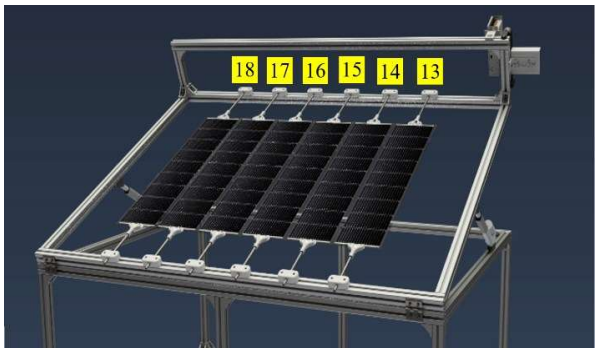
1 The Concept

Two distinct bifacial PV layers are vertically stacked on the same surface. PV modules are placed side by side without any inter-row space, to maximise the PV power density. Each layer can be driven (or not) by its own solar tracker. Mutual shadings are actively managed and the captured irradiance (incident, reflected and diffused) can be maximized, on the occupied land.

2 The Scaled Prototypes

Self-built scaled bifacial double-layer prototype

- 12 custom bifacial PV modules (6 on the bottom layer and 6 on the top-layer)
- fully adjustable in azimuth and tilt
- Each module: 9 half-cut bifacial cells in series, ≈ 36 Wp, Voc ≈ 6.4 V, Isc ≈ 7 A
- Total installed power ≈ 432 Wp, PV power density ≈ 400 Wp/m²
- Each module can be rotated by one independent NEMA23 stepper motor,
- Motor control and current acquisition are handled by an Arduino Giga R1 WiFi and a custom-designed PCB



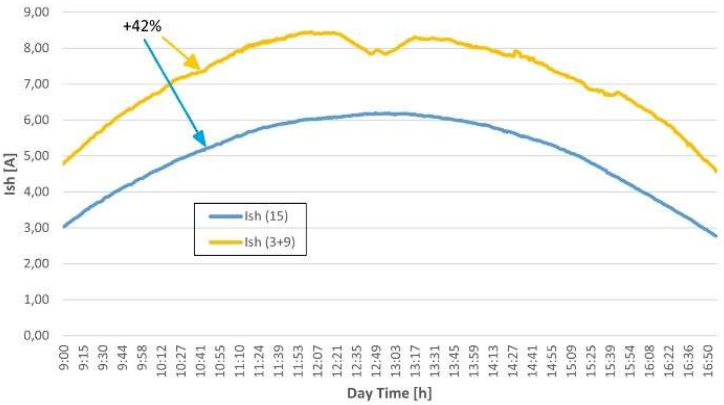
Monofacial single-layer reference prototype: PV power density ≈ 200 Wp/m²

3 Method

Both prototypes were installed north–south at 20° tilt and tested on cloudless days. The short-circuit current, Ish, of each PV module was acquired and used as a load-independent index of generation capability. At this first stage, only the PV modules of the top-layer were rotated in accordance with an unconventional "parallel solar tracking" logic that lets the incident rays pass through to reach the fixed bottom layer almost entirely. The bottom-layer PV modules stayed fixed, as the single-layer reference prototype. To avoid peripheral effects, generation is evaluated and compared basing on the central modules only: Ish(3+9) for the bifacial double-layer prototype and Ish(15) for the reference monofacial single-layer prototype.

4 Experimental Results

+42% More daily electricity than a conventional monofacial single-layer plant with the same occupied surface.



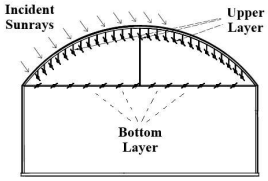
Daily short-circuit current waveforms:

- Ish(3+9) *for the PV modules 3 and 9 of the bifacial double-layer prototype*
- Ish(15) *for the PV module 15 of the monofacial single-layer prototype*

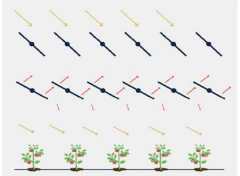
The experiment was repeated on several cloudless days, giving almost identical results.

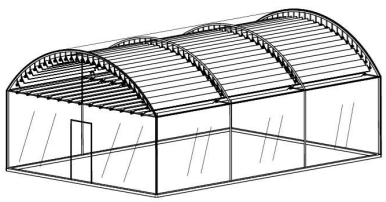
5 Conclusions and future work

As first test on a prototype of a new dynamic double-layer PV installation, a "parallel solar tracking" logic has been implemented. Although both the top and bottom layers of the prototype have independent solar trackers, only the modules of the top layer have been rotated, while those of the bottom layer stayed fixed, as on the single-layer reference prototype. So, the potential of the double-layer PV installation has not yet been fully exploited. By also rotating the bottom layer modules, more sophisticated AI-based control logics could also enable dynamic control of interior lighting, shading and microclimate. This could promote the widespread deployment of the proposed double-layer PV installation in BIPVs, as in next generation PV greenhouses.



High-Efficiency Electricity Generation
+
Dynamic Control of Lighting, Shading and of the Microclimate





Planned PV greenhouse integrating the double-layer PV installation