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Innovative Dynamic Solar Shading System for Transparent Facades

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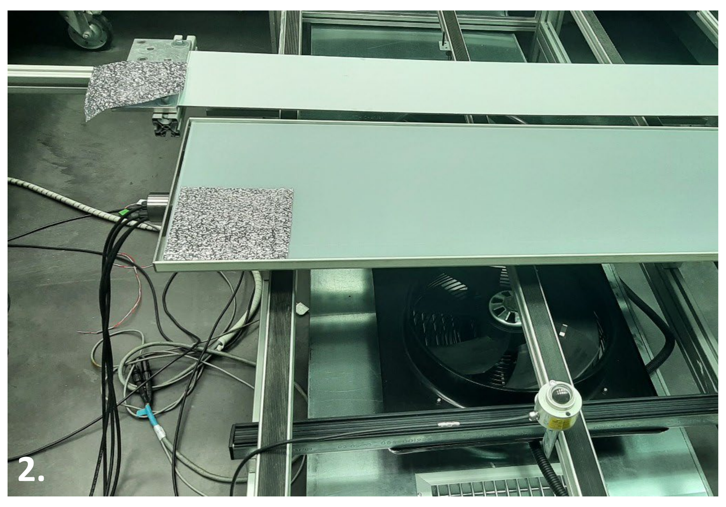
Abstract

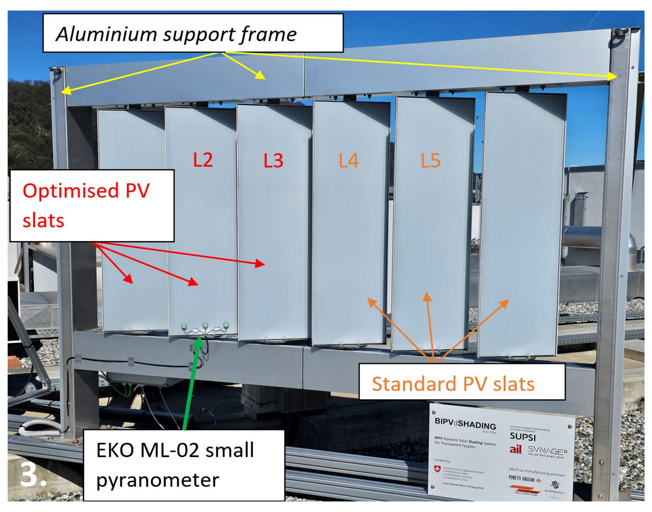
The project demonstrates the market for a highly aesthetic and prefab BIPV dynamic shading technology by realizing the system in a real building and facilitating a technical and economic appraisal with activities aimed at validating the market introduction of the product. Starting from a TRL5 and validating cost-effectiveness, energy efficiency and reliability of the product, the technology innovation of this BIPV solution will demonstrate the technology consistency with low process and maintenance costs in the real full-scale building and in compliance with a TRL7. Demonstrating the aesthetic, energy and economic benefit ratio, this BIPV system will also be capable of attracting users' interest for high replicability.

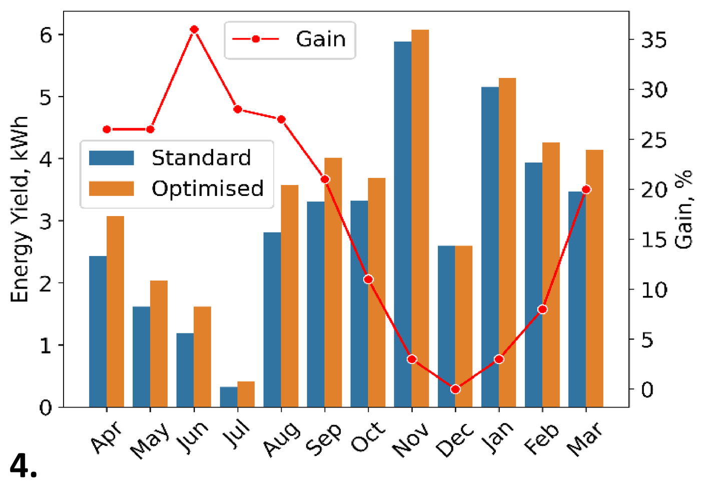
The project's scope is to **enhance technological readiness and demonstrate the substantial implementation of vertical PV dynamic solar shadings by optimizing the technical and economic aspects for a TRL7**. To this end, the following goals were set: i) Holistic technology assessment towards a cost reduction; ii) Technology validation (from TRL 5 to TRL 6); iii) Technology demonstration (from TRL 6 to TRL 7); iv) Replicability and market exploitation strategies.

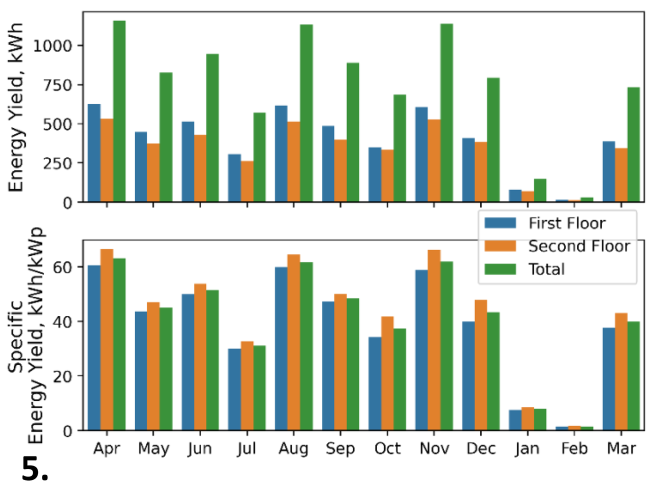
Fig. 1: Franklin University Switzerland dynamic solar shading system, Sorengo. Credits: Flaviano Capriotti Architetti.

Technology validation and demonstration









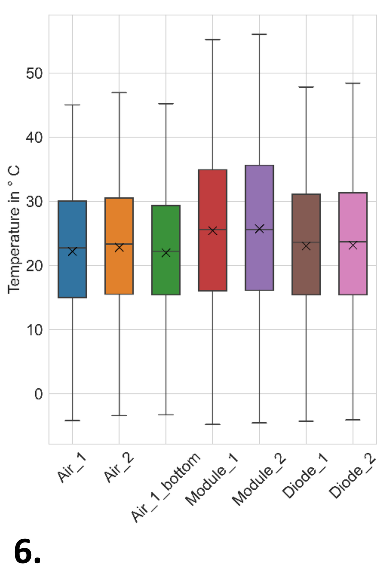


Fig. 2: Indoor test under unconventional shading situations; **Fig. 3:** Mock-up installed at the rooftop test facility of SUPSI; **Fig. 4:** Monthly energy yield for mock-up; **Fig. 5:** Monthly energy and specific yield for the pilot installation; **Fig. 6:** Descriptive statistics of left) temperature components and right) relative humidity measurements for slat 104.

Following preliminary indoor validation at the SUPSI PVLab (Fig. 2), a mock-up was installed on the rooftop testing facility of SUPSI at Mendrisio to assess the outdoor performance of an innovative PV and dynamic shading device (Fig. 3). The mock-up allowed for comprehensive **outdoor validation** and was monitored for one year. The collected datasets, including temperature, humidity, and electrical measurements of PVSD, were analyzed. Two PV module types have been used to compare the energy performance and the shading tolerance:

- **Optimized PV slats**: the internal circuit is divided vertically into two electrically independent strings; this configuration is the one implemented on the pilot building.
- **Standard PV slats**: the internal circuit isn't divided, the cells are connected in series.

The "optimized PV slats" shading and mismatch tolerance are proven by **reduced temperatures and improved energy performance of more than 20%** during spring and summer, boosting the energy yield during months with higher solar altitude (Fig. 4).

The monitoring of the pilot installation aims to **demonstrate the technology** in a relevant environment by showcasing the system's progression from TRL6 to TRL7, indicating reliable and replicable technology in full-scale buildings. Activities involve tracking and comparing the PV slats' temperatures (diodes, airgap, and cells) with those of the mock-up and energy yield measurements (Fig. 5). One-year temperature and energy measurements are analyzed. **No extreme temperature or humidity measurements** were recorded for the monitored slats, indicating reduced additional risks associated with the long-term application in real buildings (Fig. 6). The temperature trends of the pilot installation are consistent with those observed in the mock-up, successfully demonstrating the technology readiness transition from 6 to 7.

Assessment of cost reduction for enhanced replicability

The analysis of the construction site identified 37 key stakeholders involved in its construction. In Scenario 1 (new project under current conditions), a **20% reduction in labor and a 21% reduction in material costs** were anticipated, resulting in a price of 1'870 CHF/m². In Scenario 2 (new project after technology maturation), projected reductions of 35% in material costs and 39% in labor costs lower the price to 1'480 CHF/m² (Tab. 1). A targeted **5% reduction in maintenance costs** has been successfully achieved through Scenario 0 (Pilot installation) and Scenario 1. This improvement underscores the importance of strategically managed maintenance practices.

Tab. 1: Component cost reduction across three analysed scenarios

COMPONENT	UNIT	SCENARIO 0	SCENARIO 1	SCENARIO 2
		Pilot installation	Future scenarios	
Total investment cost	CHF	545'253	430'004	340'621
Initial O&M cost	CHF/year	2'726	2'150	1'703
Planned O&M cost	CHF/year	1'679	1'679	1'679
O&M cost reduction	%	38.4	21.9	1.4

Conclusions

The project demonstrated the implementation of an innovative and dynamic PV shading system that combines the function of renewable electricity generation with solar protection. The PV modules have been engineered to **increase the shading tolerance** and avoid mismatching due to the slats' self-shading. The optimization of the PV slat allowed to achieve a **gain of more than 20%** during spring and summer, boosting the energy yield during months with higher solar altitude. Throughout the mock-up and pilot installation, **no extreme temperature or humidity measurements were recorded**, successfully demonstrating the technology readiness transition from 6 to 7. The cost breakdown of the construction process highlights **significant cost reduction** for future installations, with a decrease of ca. 20% for labor, 21% for material supply, and 5% for O&M activities.