TWO YEARS OF OPERATION OF SOLAR BRISE-SOLEILS AT GERMINARE INSTITURE IN BRAZIL: PERFORMANCE MONITORING AND BIMSOLAR SIMULATIONS

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ABSTRACT: This paper evaluates two years of operation of the photovoltaic brise-soleil system installed on all four façades of the Germinare Institute in São Paulo, Brazil. The 70.5 kWp BIPV installation uses 564 CIGS modules integrated into vertical shading elements. Daily inverter-level generation data (June 2023–October 2025) and irradiance measurements were analyzed to assess seasonal and annual performance. Updated BIMsolar simulations using detailed 3D geometry and PVGIS irradiation were compared with monitored results and with initial pre-installation estimatatives. The façades showed strong seasonal complementarity, with north-facing modules performing best in winter and south-facing modules in summer. BIMsolar provided improved accuracy over simplified models, though still overestimating outputs due to higher satellite-based irradiance in some months. The study reinforces the potential of façade-integrated photovoltaics in Brazil.
Keywords: BIPV (Building-Integrated PV), Analysis, Design tools and software, Facade systems, Functional integration, Monitoring and diagnostics.

1 INTRODUCTION

Buildings have the potential to not only enhance their energy efficiency but also generate clean and renewable energy. Among the various sources, photovoltaic (PV) solar energy is particularly notable for its adaptability to buildings and the urban environment. In Brazil, solar energy account for 99% of distributed generation, with 89,4% of the photovoltaic generators installed on rooftops and slabs of residential and commercial sectors [1]. Despite this expressive number, PV modules are still mostly applied in existing buildings without compromising aesthetics, either composing rows on flat slabs, or simply placed on existing sloped roofs.

However, an emerging market is centered on multifunctional PV module solutions that can be integrated into buildings as coatings, roofs, and brises, enabling the so-called building-integrated photovoltaic (BIPV) systems [2]. On BIPV systems, energy is generated at the point of consumption and without using any added area, since PV modules are either overlapping or playing the role of skin elements in buildings [3,4].

The International Energy Agency (IEA) encourages and facilitates the adoption of PV modules by architects and engineers as a design element by presenting guidelines and inspiring them through good examples of high-quality architectural integration [5,6]. Knowledge on the concurrent, and sometimes conflicting, consequences between the way in which modules are installed and the associated energy generation then becomes a matter of technical, scientific, as well as of economic interest [7-9].

In a pioneering example of solar-integrated architecture, photovoltaic brise-soleils were installed on all four façades, combining energy generation with thermal and visual comfort at the Germinare Institute of J&F, located in São Paulo, Brazil, a six-story educational building focused on business education for youth.

Recognized by national media and highlighted in international forums, the project has become a notable reference for solar-integrated architecture in Brazil, demonstrating the growing interest in façade-integrated photovoltaic solutions.

This BIPV solution was developed through a multidisciplinary collaboration between Edo Rocha Arquiteturas, Arquitetando Energia Solar, and Garantia Solar BIPV(Figure 1).

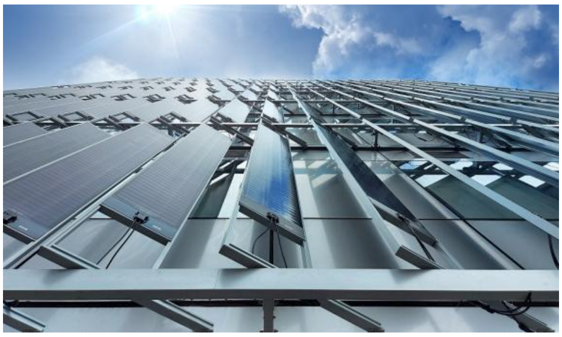

Figure 1: Germinare building with photovoltaics brise-soleils in São Paulo, Brazil.

This paper presents a technical evaluation of the brise-soleil system after two years of operation, analyzing measured data to assess each façade's contribution and comparing expected simulated energy with real outputs.

2 BIPV OVERVIEW

The BIPV system consists of 564 CIGS modules (125 W each), totaling 70.5 kWp, connected to eight string inverters, as shown in Table I.

Table I: Configuration of the Germinare brise-soleils PV system.

System configuration					
Inverter	Number of PV modules	Nominal Power (W)	Installed capacity (kWp)	Inverter Power (kW)	Overload
North #1	112	125	14	12	117%
North #2	26	125	3.25	2	163%
East #1	90	125	11.25	12	94%
East #2	66	125	8.25	12	69%
West #1	90	125	11.25	12	94%
West #2	42	125	5.25	3.6	175%
South #1	112	125	14	12	117%
South #2	26	125	3.25	2	163%
Total	564	125	70.5	67.6	104%

The modules were integrated into custom vertical brises (3.3 m × 0.35 m), tilted at 30°, and spaced 66 cm apart across all four façades (North, South, East, and West). The brises are supported by fixed aluminum structures with ACM backplates, anchored to continuous façade beams through custom top-and-bottom framing. This configuration ensures structural stability while preserving the visual lightness of the building envelope (Figure 2).

Figure 2: Structure of the photovoltaics brise-soleils.

3 METHOD

This study employed a sequential workflow composed of five main stages, ranging from the acquisition of measured operational data to simulation-based modeling and comparative analysis.

3.1 Energy data collection

The first stage involved acquiring generation data from the FusionSolar monitoring platform, which records the operation of each inverter. Daily energy generation values were extracted for the period June 2023 to October 2025.

Data were obtained individually for each inverter, enabling the identification of seasonal trends, detection of operational anomalies, and the association of performance variations with module orientation.

3.2 Irradiance data

To represent the real solar resource at the site, this study used global horizontal irradiance (GHI) measurements from the INMET São Paulo – Mirante A701 weather station.

3.3 Performance analysis

Performance analysis was carried outat daily, monthly, and annual basis to obtain a comprehensive understanding of the system's behavior over time.

Generation values were segmented by inverter and by orientation, as shown in Figure 3, allowing the identification of performance variations resulting from installation geometry, shading patterns, and orientation-specific irradiance availability.

3.4 Simulation

Before the system was implemented, an initial computer simulation was carried out using satellite-based irradiation data, transposed to the tilted module orientations and applied to the energy generation model. In 2025, with the release of the new BIMsolar [10,11] software, the Germinare BIPV system was simulated again.

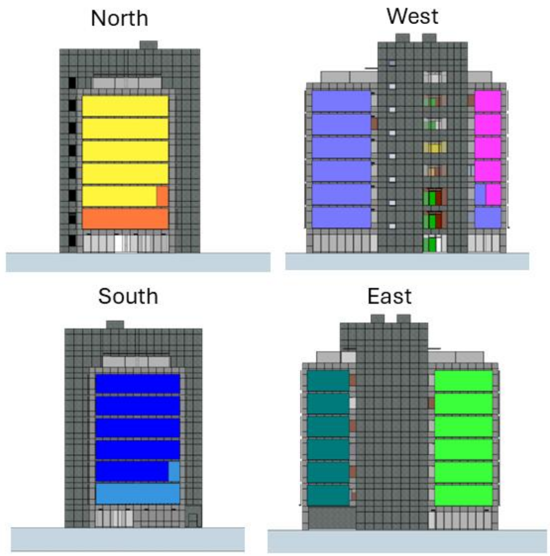

Figure 3: Subsystem configuration. Each color represents one inverter.

The simulation involved a detailed system modeling in BIMsolar, incorporating architectural geometry, orientations, inclinations, and potential shading obstructions.

The models were driven by solar radiation data sourced from PVGIS, which provides long-term climatological irradiance for the region.

Simulation outputs were used to estimate theoretical energy production for each subsystem, establishing a benchmark for comparison with field measurements and enabling the assessment of the influence of shading, orientation, and electrical configuration on system performance.

3.5 Comparison of measured and simulated results

The final stage consisted of a direct comparison between measured and simulated irradiation (INMET vs. SWERA and PVGIS) and measured energy with simulated energy outputs.

This comparison aimed to evaluate the degree of alignment between real and theoretical values and to identify deviations related to model assumptions.

4 RESULTS

4.1 Energy generation, available irradiation, and performance analysis

The system began operating in June 2023; however, it remained offline from the middle of July 2024 to January 2025 due to infrastructure issues in the building's electrical grid.

Considering the total system, the average of monthly energy generation was 2,422 kWh/month; the average of monthly global horizontal irradiation was 137 kWh/m²/month; and the annual yield of the system was 466.1 kWh/kWp.

4.2 Seasonal performance per façade orientation

To evaluate the system's performance by façade orientation, four months were selected to represent each season: March, June, September, and December.

As shown in Figure 4, energy generation varies by season and façade orientation. During autumm and spring, the east façade produced the highest energy, while in winter the north façade dominated. In summer, the south façade showed the highest generation. Figure 5 presents the daily energy generation on selected clear-sky days of each season.

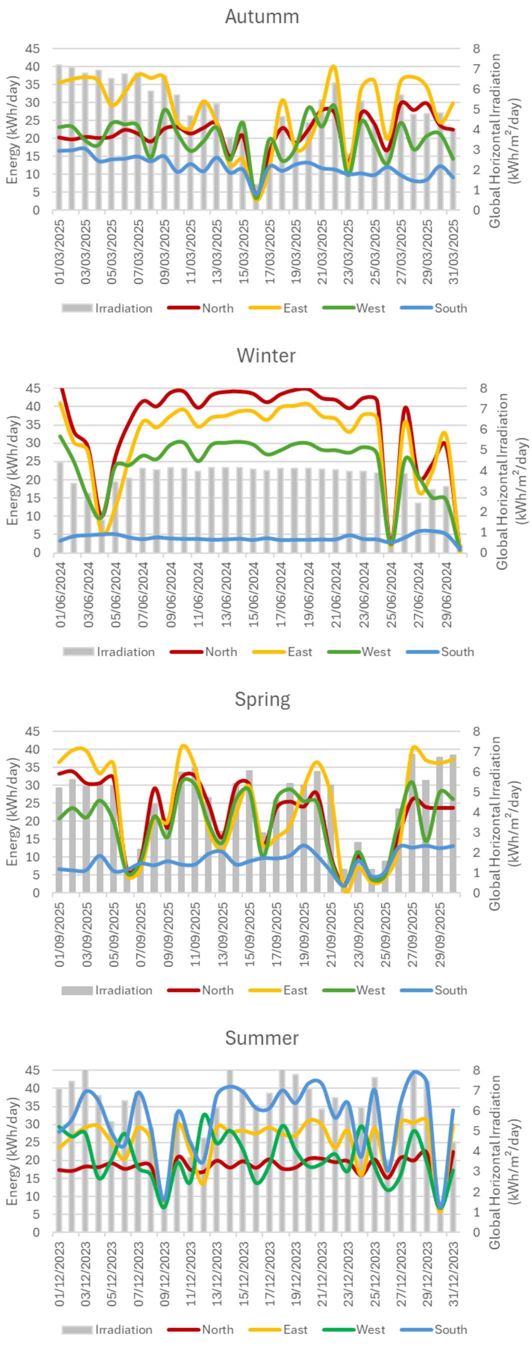

Figure 4. Daily energy generation in four seasons.

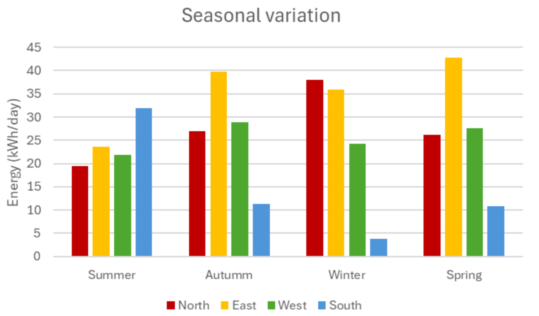

Figure 5. Daily energy generation on selected clear-sky days of each season.

To normalize energy generation by installed capacity, a yield analysis was performed. On a monthly basis, the north façade generated substantially more energy than the others façades from March to October. However, during the summer months, the south façade presented the highest yield, as can be seen in Figure 6.

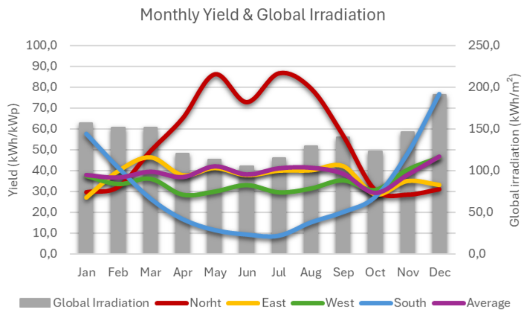

Figure 6. Daily energy generation on selected clear-sky days of each season.

On an annual basis, the north façade achieved the highest annual yield (647.3 kWh/kWp), followed by the east (449.8 kWh/kWp), west (412.8 kWh/kWp), and south (359.2 kWh/kWp) (Figure 7).

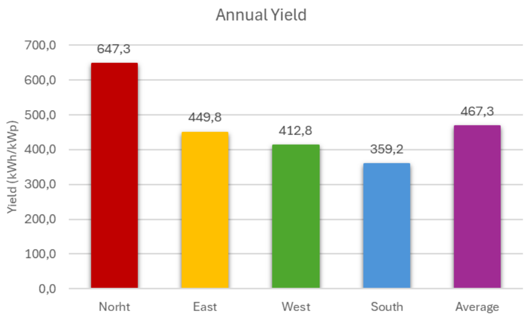

Figure 7. Annual yield per façade orientation.

4.3 Computer Simulations

Figure 8 presents some steps of BIM Solar modelling and energy simulations.

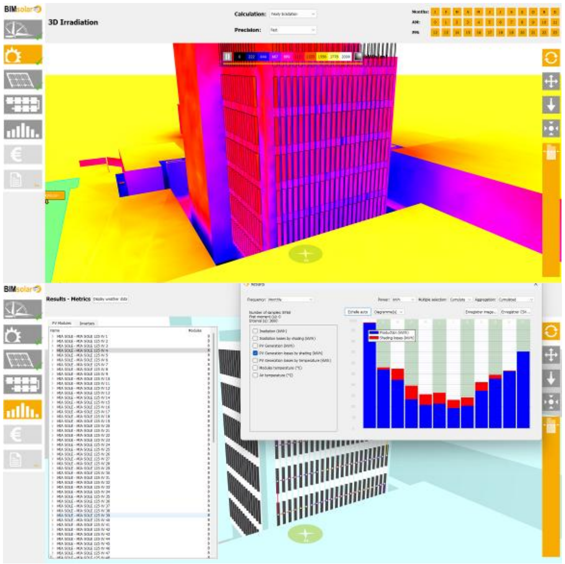

Figure 8. BIMsolar simulation for the Germinare brise-soleil system.

The initial simulations were then compared with the updated BIMsolar simulations, and both simulations were compared with the measured total energy generation, and the results are presented in Figure 9.

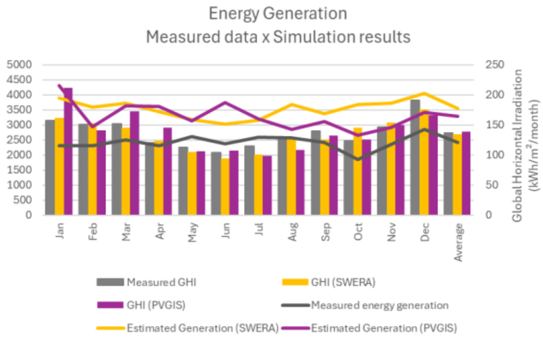

Figure 9. Comparison between simulated and measured total energy generation.

Additionally, Figure 10 shows the comparison between BIMsolar simulated results and measured data for each façade orientation.

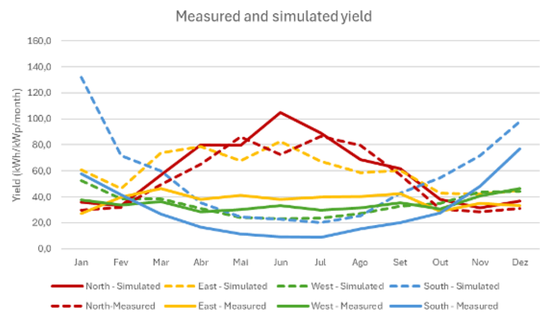

Figure 10. Simulated vs. measured energy generation per façade orientation.

As can be seen in Figure 9 and Figure 10 the formula-based simulation predicted 7% more energy than the BIMsolar simulation, while the BIMsolar results were 36% higher than the measured data.

One possible reason for this output is that PVGIS irradiation data for January and April were 35% and 20% higher, respectively, than the measured irradiation values.

5 CONCLUSIONS

The Germinare BIPV project demonstrates both the architectural and technical feasibility of integrating photovoltaic brise-soleils into building façades in Brazil. Although some orientations are traditionally considered more favorable for energy generation, all façades contributed meaningfully throughout the year. A clear seasonal complementarity was observed, with south-facing modules compensating during periods of lower northern irradiance, and vice versa.

The comparison between pre-installation energy simulations performed using a simplified energy-generation formula and the new BIMsolar BIPV software showed that BIMsolar provides more accurate results, as it incorporates a wider range of input parameters.

This study reinforces the potential of façade-integrated photovoltaics in institutional buildings and provides a valuable case study for future BIPV applications in Brazil.

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