Techno-Economic Analysis of a Building-Integrated Photovoltaic (BIPV) system in Peru

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The present study conducts a techno-economic analysis of the domestic implementation of a Building-Integrated Photovoltaic (BIPV) system in Peru. The research aims to evaluate the feasibility and long-term performance of a residential photovoltaic installation in three distinct climatic and geographic regions of the country: Puno (-15.85°, -70.03°), Junín (-12.08°, -75.23°), and Loreto (-3.75°, -73.29°). These locations were selected to represent the Andean highlands, central plateau, and Amazon rainforest, respectively, thereby capturing diverse solar resource conditions across the national territory.

Using the Solargis simulation platform, the solar energy potential and expected annual electricity generation for each region were estimated. The analysis incorporated site-specific irradiance data, temperature profiles and solar geometry. Additionally, the tool was configured to determine the optimal tilt angle of the panels to maximize energy production. Both monocrystalline and polycrystalline silicon technologies were considered for installation on a typical 100 m² residential rooftop, in alignment with average household dimensions in each region.

The results indicate a clear regional disparity in photovoltaic performance. Puno exhibited the highest annual energy yield due to its elevated solar irradiance and lower cloud cover, outperforming Junín and Loreto (**Figure 1**). The difference in performance reflects the geographic variation in global horizontal irradiance (GHI), confirming findings from similar studies on solar potential in the Andes region [1]. Despite its vast territory, Loreto presented the lowest yield due to its tropical climate and persistent cloudiness.

From a techno-economic standpoint, the BIPV system demonstrates promising investment metrics, particularly in regions with higher insolation. The Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) was the highest in Puno (**Table 1**), followed by Junín and then Loreto. EBITDA in Puno was 45.4% higher than in Loreto, while Junín exceeded Loreto by 66.95%. Despite differences in solar potential, all three locations presented a projected energy output degradation of approximately 10% over a 25-year lifespan (**Figure 2**), consistent with known degradation rates for silicon-based PV technologies [2].

Furthermore, the integration of BIPV systems into residential buildings offers additional advantages beyond electricity generation, such as architectural functionality and reduced land use. These characteristics are particularly beneficial in urban or semi-urban areas where space is limited. The study also emphasizes the importance of smart orientation and design optimization to enhance the efficiency and cost-effectiveness of the system, highlighting the role of digital tools like Solargis in renewable energy planning.

This study underscores the viability of deploying BIPV systems in various Peruvian climates and contributes valuable data for decentralized renewable energy strategies. The findings support ongoing national efforts to increase solar penetration and improve energy access, especially in rural and off-grid communities, aligning with Peru's long-term sustainability goals [3].

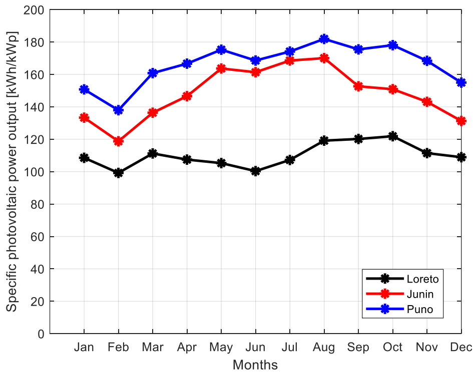

Figure 1. Average monthly specific photovoltaic power output.

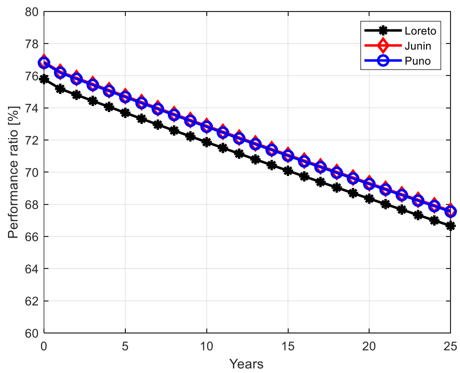

Figure 2. Performance ratio degradation over 25 years.

Table 1. Earnings Before Interest, Taxes, Depreciation, and Amortization.

	Loreto	Junin	Puno
Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) [USD]	46193.7	67166.5	77118.7

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