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Optimizing energy efficiency in mediterranean single-family homes: A parametric study of building typology, orientation, and BIPV integration

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Abstract

The energy efficiency of residential buildings is a critical concern, especially in regions with challenging climatic conditions like the Mediterranean. Despite numerous studies on energy-efficient design, there is a lack of specificity in how building typology, orientation, and Building-Integrated Photovoltaics (BIPVs) interact to influence energy performance. This study addresses this gap by conducting a parametric investigation of single-family houses, focusing on variations in building typology and orientation, both with and without BIPV integration. The parameters evaluated include energy consumption for heating, cooling, lighting, and domestic hot water, using simulations performed with iSBEM-Cy, the official tool for energy performance calculations in Cyprus. The results reveal that building orientation can reduce energy consumption, while BIPV integration contributes additional energy savings. Terraced houses with only Building-Applied Photovoltaics (BAPVs) showed the best energy balance (−38.20 kWh/m²/yr), while detached houses had the highest energy consumption (71.24 kWh/m²/yr). With BIPVs, energy balances improved significantly across all typologies, with terraced houses reaching −78.20 kWh/m²/yr, demonstrating the strong potential of BIPV integration. These findings highlight the importance of considering context-specific factors when integrating renewable energy systems, offering insights for architects and urban planners.