Impact of Orientation on Thermal Performance of Building-Integrated Photovoltaic Ventilated Facades in Hot Climates

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Abstract

Building-integrated photovoltaic (BIPV) systems represent a promising approach for creating a sustainable built environment by incorporating photovoltaic surfaces directly into the building envelope, effectively replacing conventional construction materials and building elements. These systems can be seamlessly integrated into a variety of components, including roofs, facades, windows, and shading devices. Among the various configurations, ventilated BIPV facades are increasingly recognized for their dual role in enhancing energy efficiency and generating clean energy. Despite their growing global relevance, the thermal performance of BIPV ventilated facades, particularly their heat loss factor (U-value), remains insufficiently explored in extremely hot climates, such as those in the Middle East. This work aims to identify the optimal heat loss factor for simulating the energy yield of ventilated BIPV facades in Dubai. The factor was calibrated using one year of measurements from facades facing south, east, and west. The parametric simulations were conducted using PVsyst software. The analysis reveals that the heat loss factor is influenced not only by the mounting configuration but also by the orientation. The recommended thermal loss constant for semi-integrated solutions is 20 W/m^2K. However, it was found that the optimum values for the east, south, and west facades are 13, 17, and 27 W/m^2K, respectively. With these values, the simulations exhibit excellent agreement with the measured energy yields, with the absolute difference and mean bias difference both below 0.3%, and the root mean square difference under 5%. This study further validates the importance of calibrating the thermal parameters to the specific facade construction and climatic context, as it leads to enhanced simulation accuracy. Additionally, this study made evident that heat loss coefficients from PV modules in facades are influenced not only by wind and the free space behind them but also by facade orientation.