Design and modeling of PV-integrated Double Skin Facades and application to retrofit buildings

Somil Yadav[1], Caroline-Hachem Vermette[2], Md.Nadim Heyat Jilani[2], Gilles Desthieux [3]

[1] Department of Civil and Infrastructure Engineering, Indian Institute of Technology, Dharwad, India
[2] Department of Building, Civil and Environmental Engineering, Concordia University, Montreal, Canada
[3] Haute École du Paysage d'Ingénierie et d'Architecture de Genève (HEPIA), University of Applied Sciences and Arts Western Switzerland (HES-SO), Switzerland

Abstract

Double Skin Façade (DSF) system comprises two glazing layers with a ventilated cavity. Integrating photovoltaic (PV) modules within the outer layer of DSFs offers an efficient method for electricity generation. Current tools for modeling and analyzing DSF systems are complex and resource-intensive, lacking the capability to evaluate the performance of innovative PV-DSF systems during the early design stage. This study develops a mathematical model to evaluate the electrical and thermal performance of PV-DSF systems, considering architectural design elements such as PV color and relative orientation. Based on an energy balance approach, the model is particularly suited for designing PV-DSF systems in heritage buildings, which often have color and relative orientation constraints. The model is applied to assess the performance of PV-DSF systems with conventional clear glass PV and colored front glass PV modules under the climatic conditions of Montreal, Canada. Results indicated that conventional clear glass PV module exhibit higher PV cell temperature than colored PV modules due to greater transmissivity, with peak temperature differences at noon of 5.5 °C, 6.2 °C, and 6.5 °C for orange, blue, and gray PV modules, respectively. On the contrary, the influence of PV's color front glass on room air temperature is non-significant. Furthermore, the optimal orientation for maximum energy yield is not always south-facing; it depends on the hourly distribution of the beam, diffuse solar irradiation, and ambient air temperature. For Montreal, west-facing DSFs produce more electrical and thermal energy on a summer design day because the hourly distribution of beam radiation is skewed towards afternoon hours.

Keywords: Double skin façade, PV-DSF systems, Coloured PV modules, Energy balance approach, Early design stage, Mathematical model

---

The paper was published in Solar Energy Advances as part of the EuroSun 2024 select papers.

https://doi.org/10.1016/j.seja.2024.100067