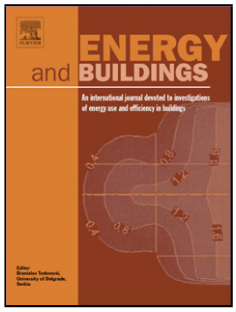

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Author: M.S. ElSayed

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Optimizing Thermal Performance of Building-Integrated Photovoltaics for Upgrading Informal Urbanization

M. S. ElSayed [a,1]

[a] *Department of Construction and Architectural Engineering, The American University In Cairo, AUC Avenue, 11835 New Cairo, Cairo, Egypt.*

Abstract

Optimizing building-integrated photovoltaic envelopes (BIPV) to retrofit multistory residential buildings in an informal urban settlement, heat transfer and energy harnessed are key parameters for an efficient upgrade. Firstly, simplified calculation model is deduced for the heat transfer across the PV wall via average outdoor temperature. Secondly, the thermal effect of gap depth and geometry on the performance of a BIPV is parametrically optimized and evaluated for a range of envelope shapes. The numerical model results were validated by Energy simulations of TRNSYS and EnergyPlus; CFD simulation by PHOENICS software to explain the thermal behavior of the air in the Gap. At constant conditions For a Flat vertical PV wall with an air gap from 3 cm to 40 cm with 3 cm increment, the increase of air gap till 22 cm depth reduced the heat gain through the envelope, at wider air gaps heat gain increased due to Laminar convective heat flow. PV cooling by natural convection optimizes at smooth flow air gap geometries improving PV efficiency 40%, for altering depth air gaps, overheating areas of PV modules occur decreasing energy harnessed. Upgrading to optimized BIPV envelope of 80° slanted depth air gap can reduce heat transferred through the envelope by 132 kWh/m^2 annually and reduce cooling load components by 50% decreasing the CO^2 emissions monthly by 250–300 kg.

Keywords: Building integrated photovoltaic; Heat gain; solar radiation; Urban Upgrade; Informal Urbanization; Building Envelope; sustainability.

1. Introduction

According to the International Energy Agency (IEA), the pattern of energy consumption by end-use in Egypt was 47% for industry, 29% for transport, 20% for buildings, 2% for agriculture and 2% for other sectors [1]. The rapid growth of population especially in Cairo and major cities aided by the immigration from rural areas multiplied the built mass of informal urbanization. Egypt's primary energy demand grows by 2.6%/annum reaching 209 TW h by 2030, while the

[1] Corresponding author. Tel.: +20 1008055688.
E-mail address: archmsayed@gmail.com (Mohamed ElSayed).