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Thermal comfort analysis of building assisted with Photo Voltaic Trombe wall

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Abstract. Maintaining indoor climatic conditions of buildings compatible with the occupant comfort by consuming minimum energy, especially in a tropical climate becomes a challenging problem for researchers. This paper aims to investigate this problem by evaluating the effect of different kind of Photovoltaic Trombe wall system (PV-TW) on thermal comfort, energy consumption and CO_2 emission. A detailed simulation model of a single room building integrated with PV-TW was modelled using TRNSYS software. Results show that 14-35% PMV index and 26-38% PPD index reduces as system shifted from SPV-TW to DGPV-TW as compared to normal buildings. Thermal comfort indexes (PMV and PPD) lie in the recommended range of ASHARE for both DPV-TW and DGPV-TW except for the few months when RH%, solar radiation intensity and ambient temperature were high. Moreover PV-TW system significantly reduces energy consumption and CO_2 emission of the building and also 2-4.8 °C of temperature differences between indoor and outdoor climate of building was examined.

1 Introduction

High economic growth in developed countries led to more dependence on high energy-consuming equipment for providing thermal comfort inside the buildings. Depending on previous studies buildings account for 40% of the total global energy consumption [1]. Within this, about 76% of energy is used only to provide heating and cooling, humidity control and comfort to the occupants [2]. According to BS EN ISO 7730 [3], thermal comfort is the mind condition to express satisfaction within the particular environment and depends on many factors. Factors include metabolic rate [For seating, light work etc. 58 W/m^2 [3]], air temperature [20-23.5°C for winter and 23-26°C for summer], and relative air velocity [0.1 m/s [3]]. Therefore, to reduce energy consumption without compromising with the comfort of the occupants, building integrated solar passive systems [4] are increasingly encouraged by national regulations. Solar passive systems heat, cools, ventilate or light buildings, without the need for electricity or mechanics [5]. Most typical solar passive systems used nowadays are Trombe walls [6]. Trombe-wall (TW) consist of thick thermal wall with a transparent outer glazing cover with an air duct in between [7]. By affixing photovoltaic (PV) cells on the transparent cover glazing a novel Trombe structure known as a (PV-TW) was designed by Ji et al. [8] that use solar energy not only for heating and cooling purposes, but also to harness electricity by photovoltaic cells. The PV-TW uses a PV panel that hinders the penetration of solar rays into the air space between the walls and glazing [9]. Therefore, the efficiency of the TW is enhanced in terms of cooling potential and thermal performance of Trombe wall was reduces up to 17 % [9]. PV walls implemented in buildings located at three different cities of china were chosen to simulate the thermal performance and cooling load. It was found that a PV wall reduces 33–50% cooling load as compared to normal wall depending on the local weather conditions [10]. He and Ji [11] conducted simulation study on building integrated with PV/T wall for summer season of Hong Kong (May-October) and found that the heat gain through a south-facing PV/T wall was 27 kWh/ m^2 less as compared to normal wall for same thickness. Yang et al [12] numerically investigated the effect of implementation of PV-wall on buildings and found that PV-wall structures significantly reduced heat gain in summer, thereby reduces cooling load of the building. Jinqing et al [13] numerically compared normal wall with south facing PV wall for summer climate of Hong Kong and found that PV wall reduces 51% of heat gain. Results also explain that PV wall not only reduces heat gain in morning but also reduces heat loss at nighttime. Energy consumption reduction of building equipped with PV wall for each square meter was 52.1kWh. Wei et al [14] compare energy performance among see-through amorphous-silicon PV (photovoltaic) glazing and traditional glazing for different climatic condition of China. Results shows that the a-Si PV glazing reduces cooling energy consumption higher than the traditional glazing. PV electricity yield is relatively small, but the glazing still save 6.5% (low transmittance) and 4.9% (high transmittance) of total energy consumption on average.

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